Remedial Investigation Work Plan (RIWP)

213 Meadow Street
Brooklyn, New York 11237

MTA Facilities Project Site #C224433

November 2, 2026

Prepared for:

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Table of Contents

Certifications iii

1. Introduction 1
   - 1.1 RIWP Document Organization 1
   - 1.2 Project Team and Contact Information 1

2. Background 3
   - 2.1 Site Description and Setting 3
     - 2.1.1 Utilities 3
     - 2.1.2 Topography 3
     - 2.1.3 Wetland Areas and Surface Water Bodies 4
     - 2.1.4 Soil and Lithology 4
     - 2.1.5 Groundwater 4
     - 2.1.6 Neighboring Properties and Zoning 4
   - 2.2 Site History 4
   - 2.3 Environmental Conditions/Results of Previous Environmental Investigations 5
     - 2.3.1 Phase I ESA, prepared by Langan on behalf of GO Quay, LLC, dated March 11, 2022 5
     - 2.3.2 Phase II Environmental Investigation Report, prepared by Langan on behalf of GO Quay, LLC, dated March 11, 2022 6
     - 2.3.3 Addendum to 11 March 2022 Phase I ESA, prepared by Langan on behalf of GO Quay, LLC, dated October 26, 2023 6
     - 2.3.4 Identification of Areas of Concern (AOCs) Based on Previous Investigations / Remediation 7

3. Preliminary Conceptual Site Model, RI Work Plan Objectives, Scope, and Rationale 8
   - 3.1 Preliminary Conceptual Site Model 8
     - 3.1.1 Potential Sources, Target Analytes, Transport Pathways and Receptors 8
   - 3.2 Objectives 10
   - 3.3 RI Scope 10
     - 3.3.1 Site Reconnaissance 11
     - 3.3.2 Soil Investigation 11
     - 3.3.3 Groundwater Investigation 12
     - 3.3.4 Soil Vapor Investigation 12
     - 3.3.5 Management of Investigating Derived Waste 13
   - 3.4 Green and Sustainable Remediation (GSR) 13
   - 3.5 Fish and Wildlife Resources Impact Analysis (FWRIA) 14

4. Quality Assurance/ Quality Control (QA/QC) 15

5. Health and Safety 16

6. Reporting and Schedule 17

Table of Contents (Continued)

Tables (Embedded in Text)

1. Proposed Soil Sample Locations, Analyses, and Rationale
2. Proposed Groundwater Sample Locations, Analyses, and Rationale
3. Proposed Soil Vapor Sample Locations, Analyses, and Rationale

Figures

1. Site Location Map
2. Site Plan
3. Soil Sample Results
4. Groundwater Sample Results
5. Soil Vapor Results
6. Proposed Sample Locations

Appendices

A. Quality Assurance Project Plan/Field Sampling Plan

B. Site Specific Health and Safety Plan

C. Community Air Monitoring Plan

Certifications

I, Jessica L. Taylor, certify that I am currently a qualified environmental professional and a NYS registered Professional Geologist and that this Remedial Investigation Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10) and DER Green Remediation (DER-31).

Jessica L. Taylor, P.G.	November 2, 2026	
Professional Geologist NY #000320	Date	Signature

1. Introduction

Roux Environmental Engineering and Geology, D.P.C. (Roux), on behalf of GO Quay, LLC (Go Quay), has prepared this Remedial Investigation Work Plan (RIWP) to investigate the 1.29-acre 213 Meadow Street Metropolitan Transportation Authority (MTA) Facilities Project Site located at 213 Meadow Street in the Borough of Brooklyn, New York (Site; Figure 1). Go Quay entered into a Brownfield Cleanup Agreement (BCA), Index No. C224433-10-2025, with the New York State Department of Environmental Conservation (NYSDEC) as a Volunteer on March 22, 2026. As of the time of the BCA, the Site was divided into three tax lots known as Block 2951, Lots 45, 1, and 5 on the New York City (NYC) Tax Map and the BCA only accepted the former Lot 45 into the Brownfields Cleanup Program (BCP). The three tax lots were merged into one lot (Lot 1) as of February 12, 2026, and NYSDEC confirmed via email on March 24, 2026, that they will accept the addition of the two former Lots 1 and 5 into the BCP. Amendment No. 1 to the BCA to reflect the lot merger for the Site was executed by NYSDEC on September 24, 2026.

The proposed redevelopment of the Site consists of the construction of an approximately 143,000 square foot MTA facility that will house the MTA's mobile wash unit vehicles, materials storage facility, and MTA's emergency response unit. The facility will consist of storage, vehicle parking, and administrative space and will comprise 3 stories with slab on grade construction. The anticipated use is to relocate the current NYC Transit Authority Mobile Wash Unit and Material Control Unit facility located at 40 Quay Street and the NYC Transit Authority Emergency Response Unit from 65 Commercial Street. This project is a public-private partnership between MTA and GO Quay and has been in the planning stages for years.

The purpose of the RI will be to determine the nature and extent of contamination at the Site, characterize environmental media, qualitatively assess the potential exposure of receptors to Site contaminants, and develop any other additional data necessary to support the development of a Remedial Action Work Plan (RAWP).

1.1 RIWP Document Organization

This RIWP contains a background information describing the Site, its history, and results of previous environmental investigations (Section 2); the objectives and scope of the RI (Section 3); Sections 4 and 5 describing the project operations plans (e.g., Quality Assurance/Quality Control, Health and Safety); and the reporting requirements and the proposed project schedule are discussed in Section 6. Figures are provided to illustrate Site conditions and the locations of proposed investigation activities.

1.2 Project Team and Contact Information

A list of names, contact information, qualifications and roles of the principal Roux personnel who will participate in the investigation are included below and in the Quality Assurance Project Plan/Field Sampling Plan (QAPP/FSP) in Appendix A.

Roux Personnel	Title	Contact Information
Jessica Taylor, P.G. Principal Hydrogeologist	Project Principal	(631) 232-2600 jtaylor@rouxinc.com
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Marilyn Villacres	Field Manager	(631) 232-2600 Mvillacres@rouxinc.com
Douglas Ferraiolo	Quality Assurance Officer	(631) 232-2600 Dferraiolo@rouxinc.com

The name and contact information for the Volunteer is:

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Phone: 212-716-2536

Email: smaleh@gothamorg.com

Contact information for the major subcontractors involved in the investigation (driller, data validator and laboratory) are also included below and in the QAPP/FSP.

Subcontractor	Company Name	Contact Information
Laboratory Analysis	Eurofins Environment Testing Northeast, LLC	(203) 308-0880
Data Usability Summary Report Preparation	Judy Harry of Data Validation Services, North Creek, NY	(518) 251-4429
Drilling	Coastal Environmental Solutions	631-256-6974
NYS Licensed Surveying	Nova Geophysical Services	(347) 261-15277

Eurofins Environment Testing Northeast, LLC, a New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP)-certified laboratory, will be used to analyze all samples collected during the RI. Drilling and other subcontracted services have not been selected as part of the preparation of this RIWP. This information will be provided to the NYSDEC prior to the start of field activities.

2. Background

This section provides pertinent background information, including a description of the Site and its setting, the history of the Site, and the results of previous environmental work conducted at the Site.

2.1 Site Description and Setting

A Site location map is included as Figure 1 and a Site plan is included as Figure 2.

Property Location	
Property Name:	213 Meadow Street MTA Facilities Project Site
Property Address:	213 Meadow Street
Property Town, County, State:	Brooklyn, Kings County, New York
Property Tax Identification:	Block 2951; Lots 1, 5, and 45, which are approved for merger into Lot 1 by the City of New York
Property Topographic Quadrangle:	USGS-Brooklyn, New York
Nearest Intersection:	Ten Eyck Street and Varick Street to the northwest, Stewart Avenue and Meadow Street to the southeast, and Varick Avenue and Meadow Street to the southeast.
Site Description:	The Site encompasses an area of 1.29-acres and is paved with concrete and contains three open air structures with metal roofing that are partially or fully enclosed by chain link fence and/or metal siding located on the eastern portion of the Site and used for general storage or vehicle maintenance. These are not occupied structures and there are no Certificates of Occupancy issued for them. The Site is occupied by Castle Sanitation for truck storage and repairs, a demolition business by Titan Industrial Services and Roma Scaffolding for scaffolding storage.

Property Information	
Property Acreage:	1.29 acres
Property Shape:	L-shaped
Improvements:	Several storage and maintenance structures at the southeast corner.

2.1.1 Utilities

The Site is connected to a public water and sanitary sewer system which is serviced by New York City Department of Environmental Protection.

2.1.2 Topography

The grade of the Site is generally flat. The average elevation of the Site is approximately 15 feet above mean sea level (ft amsl) as shown in the USGS 7.5 Minute Series (Figure 1 of the Langan Phase I ESA).

2.1.3 Wetland Areas and Surface Water Bodies

The nearest surface water bodies are Newton Creek and English Kills, a tributary of Newton Creek, to the north and west. English Kills is recognized as a mapped tidal wetland located approximately 0.13 miles west of the Site. The Site is also partially in a flood zone. The northwest corner of the Site is located in a Zone X flood area. A Zone X area designation includes areas with a 0.2% annual chance flood, areas with a 1% annual chance of flood with average depths of less than one foot or with drainage areas less than one square mile, and areas protected by levees from a 1% annual chance flood.

2.1.4 Soil and Lithology

Based on the Langan Phase II EIR, the Site stratigraphy in the western portions of the Site consists of a 1- to 2-foot-thick layer of concrete underlain by an approximate 4- to 6-foot layer of historic fill followed by native sand and silty sand. The central portion of the Site consists of up to a 2-foot-thick layer of concrete underlain by an approximately 6-foot layer of historic fill underlain by native sand and silty sand. The eastern portion of the Site consists of a 2-foot-thick layer of concrete, underlain by an 8- to 15-foot layer of fill followed by native sand, silt, and clay. The top of a peat layer was also encountered between 18.5-19.5 feet below land surface (ft bls) in some borings. All borings completed as part of the Langan Phase II EIR were advanced to approximately 20 ft bls and bedrock was not encountered.

2.1.5 Groundwater

As reported in the Langan Phase II EIR, groundwater was encountered between 9.5 and 11.5 ft bls in monitoring wells. Based on Site/area topography, groundwater flow is anticipated to be to the west, toward English Kills, a tributary of Newton Creek.

2.1.6 Neighboring Properties and Zoning

Historical and current uses of surrounding properties include a private garage with truck repair, paint room, gasoline tank, wire product manufacturing, an oil/fuel company, metals stamping and metal products manufacturing between 1951 and 2007; a vinyl plastics company, and a chemical products company with manufacturing facilities between 1965 and 2007; gasoline storage between 1933 through 1988, auto wrecking between 1965 and 1977; automobile repair facility between 1933 and 1987; and filling stations and an oil terminal between 1933 and 1968. Numerous adjoining facilities were identified in environmental databases, including one listing of small quantity generators, several non-generator/non-RCRA waste facilities, multiple sites with manifesting of waste, one facility with an underground storage tank (UST) and two with above ground storage tanks (ASTs).

The Site is located in a Manufacturing District (M1-3) within the North Brooklyn Industrial Business Zone (IBZ); therefore, the commercial project is consistent with the current zoning and is “as of right.” The area surrounding the Site is similar with mixed commercial and industrial zoning.

2.2 Site History

According to the previous environmental investigations, the Site was operated for oil truck parking, junk yards, and auto wrecking on the western portion of the Site as of 1965. In the early 1980s, the east side of former Lot 45 was used for truck parking, a repair shop, and storage and the west side of former Lot 45 was previously a temporary C&D transfer station from approximately 1985 until it was shut down around 1995. The current use of the Site is for truck storage and repairs and the Site’s property listings in the City Directory Abstract consist of auto wrecking and demolition and salvage companies. Former Lot 1 was an

auto wrecking junk yard and is now used for scaffolding storage. Former Lot 5 was previously known to be vacant and is now used for scaffolding storage.

2.3 Environmental Conditions/Results of Previous Environmental Investigations

This section provides an overview of previous environmental-related activities completed at the Site, based on the following environmental reports available for review:

- Phase I ESA, prepared by Langan on behalf of GO Quay, LLC dated March 11, 2022;
- Phase II EIR, prepared by Langan on behalf of GO Quay, LLC dated March 11, 2022; and
- Addendum to March 11, 2022 Phase I ESA by Langan on behalf of GO Quay, LLC dated October 26, 2023.

A summary of the findings from assessments of the Site is provided below.

2.3.1 Phase I ESA, prepared by Langan on behalf of GO Quay, LLC, dated March 11, 2022

The Phase I ESA was prepared for the entire Site, which at that time was subdivided into Block 2951, Lots 1, 5 and 45. The following Recognized Environmental Condition (REC) was identified in association with the Site:

- Presence of Contaminated Historic Fill: Findings from the Langan 2022 Phase II EIR, identified contaminated fill with elevated concentrations of metals and semi-volatile organic compounds (SVOCs) above NYSDEC Commercial Soil Cleanup Objective (CSCOs), Industrial SCOs (ISCOs), and Protection of Groundwater Soil Cleanup Objectives (PGWSCOs) at the Site representing a REC.

The following Historical Recognized Environmental Condition (HREC) was identified in association with the Site:

- NYSDEC Spill Case #9315532: The Site was identified in the NY Spills database for a release reported on March 31, 1994, and assigned NYSDEC Spill Number 9315532. A tank truck spilled approximately 5-gallons of diesel fuel onto the concrete while cleanup was in progress. The case was administratively closed on March 31, 1994.

The following *de minimis* condition was identified in association with the Site:

- Motor Oil Release: Evidence of a small, isolated oil release was identified on the concrete in the southeastern lot of the Site during Langan's Phase I ESA Site reconnaissance. Staining was observed and Speedy Dry had been placed on the stained concrete. No cracks or gaps in the concrete were observed.

No Controlled RECs (CRECs) were identified in connection with the Site.

The following Business Environmental Risks (BERs) were identified in connection with the Site:

- Current and Historical Site Operations: Historical uses of concern at the Site included oil truck parking, auto wrecking, and a junk yard between 1960 and 2007 and as a solid waste transfer facility for yard waste and residential, institutional, and commercial waste from at least 2004 through 2012. Current Site use includes truck storage and repairs including three in-service 275-gallon ASTs and one out-of-service AST.

- Potential Presence of Undocumented USTs: No evidence of USTs were observed during the Site inspection or noted in the ESA, however, historical Site use included operation for automotive-related purposes which may have utilized USTs.

2.3.2 Phase II Environmental Investigation Report, prepared by Langan on behalf of GO Quay, LLC, dated March 11, 2022

Langan completed seven soil borings to 20 ft bls, four monitoring wells, and collected four soil vapor samples. The conclusions of the Phase II EIR were:

- Historic fill was observed extending to the terminal depth of 6 ft bls on the western and central portions of the Site and 15 ft bls to the eastern side of the Site.
- Soil samples including one duplicate were collected from seven borings at the Site; four soil samples were collected from 2-4 ft bls, three samples collected from 4-6 ft bls, one collected from 4-7 ft bls, two collected from 8-10 ft bls, and one collected from 15-17 ft bls. Elevated photoionization detector (PID) readings were identified at each of the soil borings with exception to LSB-3. No evidence of staining was identified during sample collection.
- Analytical data indicated soils at the Site are impacted with SVOCs and metals above CSCOs), ISCOs, and PGWSCOs at intervals ranging from 2 to 10 ft bls. Perfluorooctanesulfonic acid (PFOS) was detected in exceedance of the proposed regulatory PGWSCO.
- SVOCs and metals were identified above NYSDEC Ambient Water Quality Standards and Guidance Value (SGVs) in multiple monitoring wells. Analytical results from all four monitoring wells identified per- and polyfluoroalkyl substances (PFAS) in exceedance of the screening values provided in the Sampling, Analysis, and Assessment of PFAS under NYSDEC's Part 375 Remedial Programs (June 2021; has since been updated from the time the Phase II EIR was issued). All concentrations are total metals.
- No exceedances in soil or groundwater were detected for polychlorinated biphenyl (PCBs), pesticides, and herbicides.
- Acetone, a volatile organic compound (VOC) and a common laboratory artifact, was identified in soil above the PGWSCO in the 15-17 ft bls interval of LSB-5. Acetone was also detected in groundwater above the NYSDEC SGVs in LMW-1.
- Concentrations of VOCs in soil vapor were detected above laboratory reporting limits at sampling locations and included chlorinated VOCs (CVOCs). Comparison to the applicable NYSDOH Guidance Values did not identify detections that would require mitigation.

Previous sample data from the Langan Phase II EIR is shown on Figure 3, Figure 4, and Figure 5. The soil exceedances depicted on Figure 3 have been updated to reflect the NYCRR Part 375 SCOs effective December 31, 2025.

2.3.3 Addendum to 11 March 2022 Phase I ESA, prepared by Langan on behalf of GO Quay, LLC, dated October 26, 2023

Following submission of the March 11, 2022, Phase I ESA prepared by Langan, additional records were received related to the Site. A copy of the completed User Questionnaire and an Acknowledgement of Notice of Intent for Coverage under State Pollutant Discharge Elimination System (SPDES) Multi-Sector General Permit for Stormwater Discharge Associated with Industrial Activities was received by one of the property owners. The additional records provided by the owner did not change the conclusions of the Langan Phase I ESA.

2.3.4 Identification of Areas of Concern (AOCs) Based on Previous Investigations / Remediation

Based on the findings of the prior investigations, the following AOCs that will be further investigated as part of this RIWP include:

- Presence of contaminated historic fill; and
- Current and historical operations.

3. Preliminary Conceptual Site Model, RI Work Plan Objectives, Scope, and Rationale

Roux, on behalf of the Volunteer, has developed a RI scope of work that satisfies NYSDEC BCP requirements. Data collected during the RI will determine the basis for remedial actions for the Site.

Standards, Criteria, and Guidance (SCGs) for soil at BCP sites are the numerical SCOs presented in Part 375. The SCOs are categorized into unrestricted use criteria and restricted use (residential, restricted-residential, commercial, or industrial) criteria, as well as criteria for protection of groundwater and ecological resources. The applicability of each category of SCOs is determined based upon the current and reasonably anticipated future use of the Site, as well as cleanup tracks being evaluated. The anticipated redevelopment of the Site will include operations related to warehousing and storage and NYSDEC has determined that ISCOs are appropriate for the Site.

The SCGs for groundwater are the NYSDEC Ambient Water-Quality Standards and Guidance Values (AWQSGV)s for Class G groundwater – Technical & Operational Guidance Series (TOGS) 1.1.1 (groundwater is not and will not be used for drinking water, as the Site will be connected to the public water supply and groundwater use as potable water is restricted within New York City).

SCGs for evaluating Soil Vapor Intrusion (SVI) are the NYSDOH's Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York, October 2006, Revised February 2024 (NYSDOH SVI Guidance). Potential soil vapor impacts identified in accordance with the NYSDOH SVI Guidance will be considered.

3.1 Preliminary Conceptual Site Model

This section describes the Preliminary Conceptual Site Model (PCSM) developed for the Site. The PCSM is a tool used to evaluate and identify potential sources of contamination, target analytes, potential entry and mechanisms for transport in the subsurface environment and into the Site structures, potential exposure routes, and the environmental media and locations most likely to have been impacted by the target analytes.

3.1.1 Potential Sources, Target Analytes, Transport Pathways and Receptors

Based on previous investigations and historical documentation including Sanborn Fire Insurance Maps and the City Directory, the Site was operated for oil truck parking, junk yards, and auto wrecking on the western portion of the Site as of 1965. Four one-story storage buildings were identified from 1965 through 1977. In 1977, only one storage building remained until it was shown as removed in 1986 and remained undeveloped. The Site was used for junk and auto wrecking and oil truck parking through 1986 with the presence of temporary storage buildings. In 2001, portions of the Site were depicted as a lumber yard. City Directory listings for the Site consisted of auto wrecking and demolition and salvage companies. The demolition company that occupied the Site was identified in the Solid Waste Facilities/Landfill Sites database as an inactive C&D processing facility and classified as a landfill facility between 2004 and 2012.

During the 2022 reconnaissance performed by Langan as part of the Phase I ESA, the Site was observed to be occupied by a demolition company which also leased portions of the Site for truck parking, storage, and scaffolding storage. A shed was identified for truck repair on former Lot 45. Multiple ASTs were present

on Lot 45 and reported to contain waste oil, motor oil and hydraulic oil. There were fourteen 55-gallon drums identified on secondary containment containing degreasers, motor oil, and hydraulic oil. In the area of the truck repair, stained concrete was identified along with the presence of several suspected drains and open-hold sumps identified under metal plates with purpose unconfirmed. The EDR database report identified a release on March 31, 1994 (NYSDEC Spill No. 9315532) associated with a release of 5-gallons of diesel from a tank truck, but the exact location of the spill was not documented in the historical records. Cleanup was in progress at the time the spill was reported and the spill was administratively closed the same day on March 31, 1994. There are no open spills for the Site.

On October 29, 2026, Roux conducted a Site reconnaissance to verify the continued presence of features identified in the 2022 Langan Phase I ESA. Based on observations of accessible areas and discussions with the tenant, Roux confirmed that two active 275-gallon ASTs remain near the truck repair area on former Lot 45. One tank stores hydraulic oil, and the other stores motor oil. Adjacent to the two ASTs were eight drums placed on secondary containment being used for spent oil products. All storage containers appeared to be intact, and minor staining was observed on the concrete surrounding the ASTs and drum storage area. The locations of these features are included in Figure 2. No piping structures, sumps, or drains were observed during Roux's October 2026 Site reconnaissance.

The primary environmental AOCs and potential sources of contamination associated with the Site are the historic fill and current and historical operations at the Site. Langan's Phase II EIR indicated soils at the Site are impacted with one VOC above its UUSCO and PGWSCO. SVOCs and metals were detected above Unrestricted Use SCOs (UUSCOs), PGWSCOs, and ISCOs, and PFAS above UUSCOs and PGWSCOs. PCBs were all below UUSCOs, PGWSCOs, and ISCOs and pesticides were not detected. Groundwater samples were collected from four monitoring wells. SVOCs and metals were in groundwater above AWQSGVs. PFAS were detected above NYSDEC screening values as reported herein. The concentrations of SVOCs and metals are typical of urban sites where fill material was placed in the area and are not indicative of any other potential source or historical activity. Soil vapor samples were collected from four locations at the Site. Concentrations of VOCs in soil vapor were detected above laboratory reporting limits, however, not at concentrations that would warrant mitigation.

Based on the target analytes present and the media in which these contaminants were identified, the following potential transport mechanisms were identified for the Site:

- Target analytes may potentially remain sorbed to soil (soil impacts);
- Leaching of target analytes from soil to groundwater (groundwater impacts);
- Transport of target analytes in the dissolved-state through groundwater flow; and
- Volatilization of target analytes from soil and groundwater into soil pore space and potentially into surface structures (vapor intrusion).

The following potential exposure routes for target analytes have been identified for the Site:

- Inhalation of VOCs/CVOCs from soil vapor;
- Dermal contact and incidental ingestion of soil; and
- Dermal contact with groundwater is also considered minimal risk as groundwater is not used for drinking water or irrigation purposes.

The Site remains occupied and the majority of the Site is covered with building materials and large trucks to support the tenant's operation. There are no land uses within close proximity of the Site that are sensitive human receptors. Figure 2 includes relevant Site features. Section 3.5 discusses ecological receptors.

3.2 Objectives

The objective of the RI is to further assess the nature and extent of contamination associated with the following AOCs:

- Presence of contaminated historic fill; and
- Current and historical operations.

The RI will evaluate soil, groundwater, and soil vapor impacts on-Site and at the property boundary to provide the basis for refining the PCSM and remedial action selection and to determine the general potential for off-Site impacts. Environmental data collected during the RI will be used to qualitatively assess the potential exposure of receptors to Site contaminants and develop the information necessary to support the development of a RAWP.

3.3 RI Scope

The scope of the RI will include the collection of sufficient Site investigation data so that, together with the historical data, the entire Site will be sufficiently characterized to support the development of the RAWP.

To accomplish this, the scope of work for the RI will include the following:

- The performance of Site reconnaissance to confirm proposed sampling locations;
- The advancement of soil borings, collection of soil samples, installation of permanent groundwater monitoring wells, collection of groundwater samples from new monitoring wells, installation of soil vapor points, and sampling of new soil vapor points;
- The collection of soil, groundwater, and soil vapor data sufficient to define the nature and extent of impacted media and current Site conditions and to evaluate potential off-Site groundwater and/or soil vapor migration;
- The collection of a synoptic round of groundwater level measurements and the collection of additional land survey data as needed for developing a groundwater elevation contour map; and
- The performance of a qualitative human health exposure assessment (QHHEA) to identify existing and potential exposure pathways and evaluate contaminant fate and transport.

All investigation activity will be conducted in accordance with the applicable requirements of the NYSDEC DER-10.

Soil samples from all soil borings and all groundwater samples collected from the investigation described in detail below for soil and groundwater, respectively, will be analyzed for the target compound list (TCL)/Part 375 plus 30/target analyte list (TAL) (TCL + 30/TAL) list of parameters including:

- TCL/Part 375 VOC + 10 Tentatively identified compounds (TICs);
- TCL/Part 375 Base neutral acids (BNA)/SVOCs + 20 TICs;
- TCL/Part 375 Pesticides;
- TCL/Part 375 Herbicides;

- TCL/Part 375 PCBs;
- TAL/Part 375 Metals (including hexavalent chromium);
- Total Cyanide; and
- Emerging Contaminants (ECs) list includes 1,4-Dioxane and all Per- and Polyfluoroalkyl Substances (PFAS) compounds listed in the NYSDEC April 2023 "Sampling, Analysis, and Assessment of PFAS." PFAS in soil and groundwater will be analyzed by United States Environmental Protection Agency (USEPA) Method 1633A and 1,4-Dioxane in groundwater will be analyzed by USEPA Method 8270D SIM and 1,4-Dioxane in soil will be analyzed by USEPA Method 8270D.

Soil samples will also be collected for geologic logging in accordance with the Unified Soils Classification System (USCS) and for organoleptic inspection (for evidence of contamination including staining and/or odors) as well as using a PID with a 10.6 electron volt (eV) lamp.

All soil vapor samples will be analyzed for VOCs using USEPA Method TO-15.

All data will be produced in accordance with NYSDEC Analytical Services Protocol (ASP) Category B deliverables and will be reviewed and validated by Data Validation Services, Inc. (DVS), an independent data validator. Data Validation Services will prepare a Data Usability Summary Report (DUSR) before data is incorporated into the RI Report (RIR) for the Site. All data will be submitted to NYSDEC in electronic format, in accordance with DER-10, Section 1.15.

The overall scope of each component of the RI is discussed in the following subsections. Detailed field sampling procedures are provided in the Quality Assurance Project Plan/Field Sampling Plan (QAPP/FSP; Appendix A of this RIWP). The proposed sampling locations are shown in Figure 6 of this RIWP for soil, groundwater, and soil vapor. Additional information, including intervals to be sampled and sample rationale, is provided in embedded Tables 1, 2 and 3 for soil, groundwater, and soil vapor, respectively.

3.3.1 Site Reconnaissance

An inspection of the existing Site conditions will be conducted to confirm conditions described by the previous investigations and determine final locations of soil borings and monitoring wells based on actual field conditions.

3.3.2 Soil Investigation

To evaluate soil conditions on Site and determine extent of contamination both vertically and horizontally across the Site, twelve borings (RX-1 through RX-12) will be advanced to 20 ft bls at the locations shown in Figure 6. Six of the proposed soil borings (RX-1 through RX-05) will be advanced at the locations shown in Figure 6 for the installation of co-located groundwater monitoring wells as described below. It is anticipated groundwater will be encountered approximately 9.5 to 11.5 ft bls. Four of the proposed soil borings (RX-7 through RX-10) will be advanced at the locations shown in Figure 6 for the installation of co-located soil vapor points as described below.

At each borehole location utility clearances will be performed prior to advancement of soil borings using hand tools and/or vacuum excavation to a minimum of five ft bls to confirm that no subsurface utilities are present. Should a utility or other feature be observed during pre-clearance activities, the sampling location will be relocated. Soil samples will be collected by utilizing a Geoprobe direct-push drill rig. Soil samples

will be collected continuously from grade to the terminal depth of each soil boring while continuously inspecting soil for evidence of contamination and logging soil lithology. All soil borings will be surveyed for horizontal coordinates and land surface elevation.

At each soil boring, the proposed sample depth intervals are 2-4 ft bls (or shallowest available interval beneath concrete layer) and 8-10 ft bls (or the 2 ft interval located above observed groundwater level). Each soil sample will be analyzed for TCL + 30/TAL and ECs list of analytes. If odor/ visual evidence of contamination or elevated PID readings are noted, an additional sample will be collected from the interval that exhibits the highest contamination.

3.3.3 Groundwater Investigation

To evaluate groundwater quality conditions across the Site, six permanent monitoring wells (RX-1 through RX-6) will be installed in converted soil boring locations. Roux will collect a groundwater sample from each newly installed monitoring well location, as shown in Figure 6. All monitoring wells will be surveyed for horizontal coordinates, land surface elevation, and measuring point elevation.

Monitoring wells will be constructed of 2-inch inside diameter, Schedule 40 polyvinyl chloride (PVC) casing and 0.020 inch slot, machined screen. Well construction will be as follows:

- Well screens will be 10 ft long, and will be installed with approximately three ft above and seven ft below the water table.
- A sand pack will be placed around the well screen, extending two ft above the top of the screened zone.
- A minimum two-foot thick bentonite pellet seal will be placed above the sand pack. Once the pellets have been allowed to hydrate, cement bentonite grout will be pumped into the remaining annular space from the bottom up.
- The wells will be completed using locking well plugs, and flush mounted, bolt down, watertight, manhole covers cemented into place.

Each monitoring well will be developed to ensure proper hydraulic connection with the aquifer and to reduce/eliminate turbidity of the groundwater. The wells will be developed using a submersible pump, which will be surged periodically until well yield is consistent and has turbidity below 50 nephelometric turbidity units (NTUs), if possible. Detailed procedures regarding well development can be found in the QAPP/FSP (Appendix A).

Prior to sampling, the depth to groundwater in each monitoring well will be measured using an electronic water level meter. At least one week following redevelopment, all on-Site wells will then be sampled consistent with USEPA low-flow sampling requirements, and one round of groundwater samples will be collected in accordance with the QAPP/FSP. Field parameters (e.g., pH, dissolved oxygen, oxidation-reduction potential [ORP], etc.) will also be collected using a water quality meter during purging and prior to sampling. Each groundwater sample will be analyzed for TCL + 30/TAL (including total and dissolved metals) and ECs list of analytes.

3.3.4 Soil Vapor Investigation

To evaluate soil vapor and the potential for SVI into the proposed building, Roux will install four soil vapor points (RX-7 through RX-10) in converted soil boring locations using a Geoprobe® direct-push rig to be installed approximately two ft above where groundwater is observed in each boring (estimated to be

between 7.5-9.5 ft bls). One soil vapor sample will be collected from each point. New Teflon®-lined tubing will be attached to an expendable soil vapor sampling point with a 6-inch stainless steel screen. The soil vapor points will be backfilled with #2 Morie sand to approximately one foot above the screen. The remainder of the borehole will be backfilled with a concrete/bentonite slurry to grade.

In accordance with the NYSDOH Guidance for Evaluating SVI, the integrity of each soil vapor sampling point seal will be checked following installation to verify that the soil vapor sample will not be compromised by inadvertent introduction of ambient air into the sample. The soil vapor samples will be collected using pre-cleaned (batch certified) 6-liter summa canisters with regulators calibrated to collect samples over a 2-hour period and analyzed using USEPA Method TO-15 for VOCs. The proposed soil vapor sampling locations are shown in Figure 6. Additional details regarding soil vapor sampling methods are provided in the QAPP/FSP (Appendix A).

3.3.5 Management of Investigating Derived Waste

Management of investigation derived waste will be completed in accordance with NYSDEC DER-10, Section 3.3 (e).

All waste materials (drill cuttings, decontamination water, etc.) generated during the RI will be consolidated, and stored in appropriate labeled bulk containers (drums), and temporarily staged at an investigation derived waste storage area onsite. Roux will then coordinate waste characterization and disposal by appropriate means.

3.4 Green and Sustainable Remediation (GSR)

Green remediation principles and techniques will be implemented to the extent feasible in the design, implementation, and Site management of the remedy using best practives described in DER-31: Green Remediation. For each phase of the remediation, starting from the RI through RAWP preparation, the environmental footprint analysis tool, SiteWise™, will be utilized. During the RI phase specifically, green remediation principles and techniques will be implemented to the extent feasible which may include but is not limited to carpooling of field staff and drilling staff, limiting the number of equipment and laboratory drop-offs, utilizing vendors with operation centers local to the Site, limiting water and energy usage, keeping equipment on-Site instead of mobilizing and demobilizing daily, and turning off equipment when not in use.

The Site is entering the program at the investigation Stage; therefore, a Climate Change Screening or Vulnerability Assessment is not applicable or required at this time. The remedial design will include a climate change vulnerability assessment to evaluate the impact of climate change on the project site and the proposed remedy. Potential vulnerabilities associated with extreme weather events (e.g., hurricanes, lightning, heat stress and drought), flooding, and sea level rise will be identified, and the measures to minimize the impact of climate change on potential identified vulnerabilities will be implemented. The reduce the flood potential, ground improvements will be made to raise the first floor and associated utilities above the design flood elevation. The proposed redevelopment and remediation of the Site will not have an adverse impact on any existing natural resources. The proposed redevelopment is not expected to generate more than 50 tons of solid waste per week and therefore will not have a significant adverse impact to the NYC solid waste management systems. On-Site reuse of NYSDEC-approved material will be prioritized during remediation to minimize waste generation and greenhouse gas emissions due to truck traffic.

3.5 Fish and Wildlife Resources Impact Analysis (FWRIA)

A FWRIA Part 1: Resource Characterization will be performed as part of the RIR to determine whether contamination at the Site poses actual or potential ecological risk to fish, wildlife, or sensitive habitats. As stated above, the Site is located in proximity to the water body English Kills, which is a tributary of Newtown Creek.

4. Quality Assurance/ Quality Control (QA/QC)

The goal of the QA/QC aspect of the RI is to ensure that suitable and verifiable data results from sampling and analyses are performed. To accomplish this, a QAPP/FSP has been prepared and is provided as Appendix A.

5. Health and Safety

A site-specific Health and Safety Plan (HASP) has been prepared for the Site and is provided in Appendix B. A site-specific Community Air Monitoring Plan (CAMP) has been prepared for the Site and is provided as Appendix C within the HASP document.

6. Reporting and Schedule

The following will be provided to the NYSDEC during the course of the RI work.

Daily Progress Reports

Daily progress report submittals will be provided to the NYSDEC during RI field activities and will include the following.

- Discovery of any previously unknown contaminated media during RI activities will be promptly communicated to NYSDEC's project manager;
- A Site map will be provided to identify locations discussed in progress reports provided to NYSDEC;
- An update of progress made during the reporting day;
- Locations of work keyed to a map of the Site;
- A summary of CAMP results, including any potential exceedances;
- An explanation of notable Site conditions; and
- Photos of the work.

Daily reports are not intended to be the mode of communication for notification to the NYSDEC of emergencies (accident, spill), requests for changes to the RIWP or other sensitive or time critical information. However, such conditions must also be included in the daily reports. Emergency conditions and changes to the RIWP will be addressed directly to NYSDEC Project Manager via personal communication.

Monthly Reports

Monthly reports will be submitted to NYSDEC and NYSDOH Project Managers by the 10th of the month following the end of monthly reporting period. Monthly reports will commence upon approval of the RIWP and will include:

- Activities relative to the Site during the previous reporting period and those anticipated for the next reporting period;
- Description of approved activity modifications, including changes of work scope and/or schedule;
- Sampling results received following internal data review and validation, as applicable; and
- An update of the remedial schedule including the percentage of project completion, unresolved delays encountered or anticipated that may affect the future schedule, and efforts made to mitigate such delays.

Remedial Investigation Report

A RIR will be prepared for the Site, which will summarize the results and findings of the investigations on the BCP Site. The RIR will be prepared in accordance with the NYSDEC requirements for the BCP and will meet the technical requirements of DER-10.

Schedule

The following schedule outlines the major milestones for the Site:

Timeframe	Description
June 2025	Submit BCP Application
March 2026	Executed Brownfield Cleanup Agreement
May 2026	Finalize Citizen Participation Plan
November 2026	Finalize Remedial Investigation Work Plan
November 2026	Remedial Investigation Implementation
December 2026	Submit Remedial Investigation Report
December 2026	Submit Remedial Action Work Plan
April 2027	Remedial Action Work Plan approved, and Decision Document Issued
May 2027	Begin Construction and Remedial Action
May – October 2027	Remedial Action and Construction
October 2027	Submit Environmental Easement
December 2027	Submit Draft Site Management Plan
February 2028	Submit Draft Final Engineering Report
April 2028	Submit Approvable Final Engineering Report and Record Easement
May 2028	Receive Certificate of Completion

Respectfully submitted,

ROUX ENVIRONMENTAL ENGINEERING AND GEOLOGY, D.P.C.



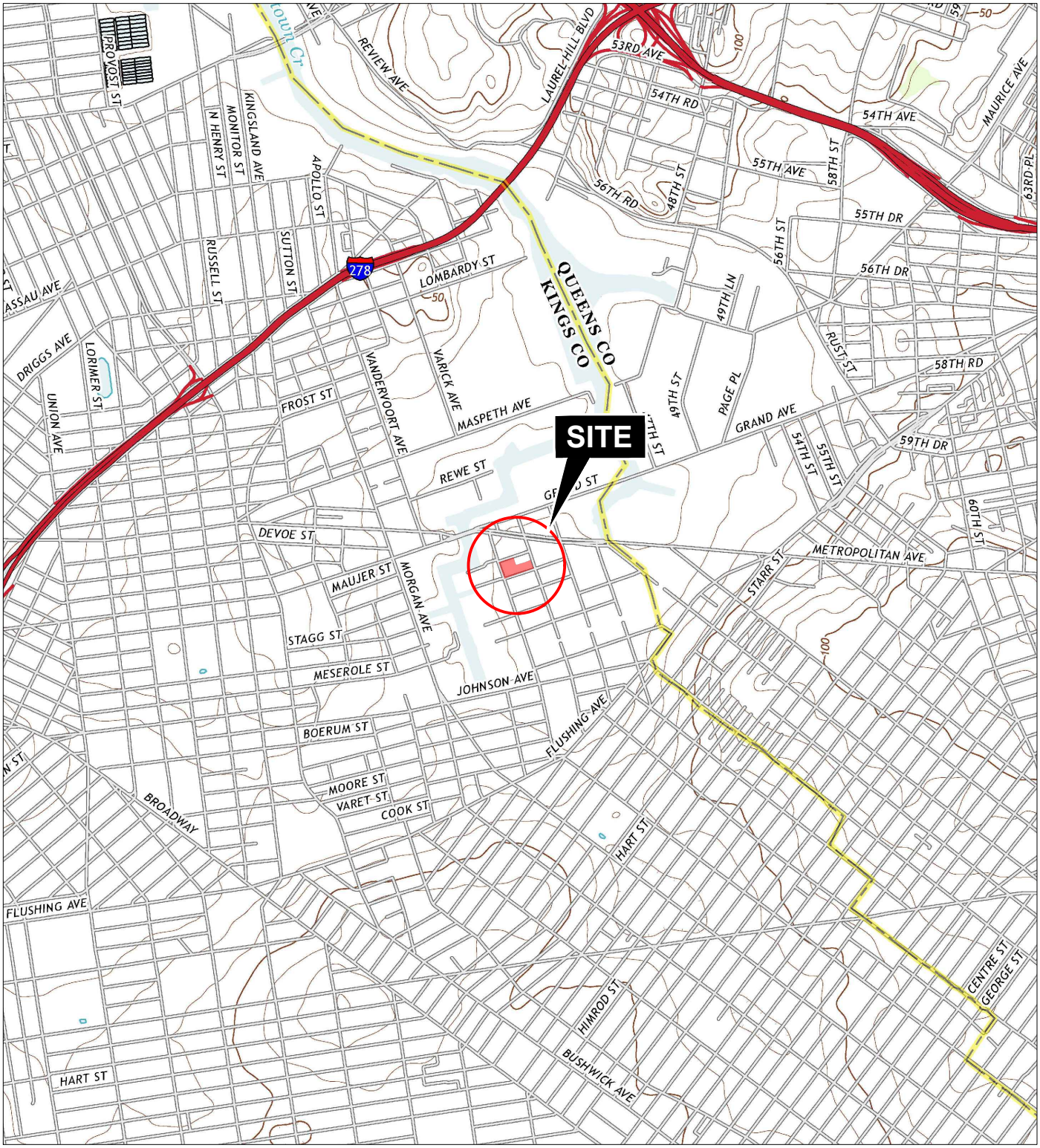
Levi Curnutte
Senior Scientist



Jessica L. Taylor, P.G.
Principal Hydrogeologist

FIGURES

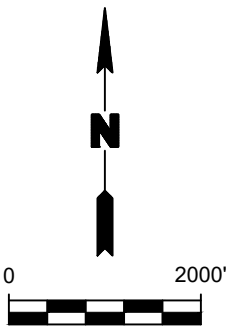
1. Site Location Map
2. Site Plan
3. Soil Sample Results
4. Groundwater Sample Results
5. Soil Vapor Results
6. Proposed Sample Locations



QUADRANGLE LOCATION



SOURCE:
USGS, 2013, Brooklyn, NY
7.5 Minute Topographic Quadrangle



Title:

SITE LOCATION MAP

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: T.B.	Date: 4/16/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	1
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.02.DWG		

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LEGEND

SITE BOUNDARY

FORMER LOT LINES

NOTE

LOTS WERE MERGED FROM BLOCK 2951 LOTS 1, 5, 45 TO LOT 1. SEE BROWNFIELDS CLEANUP AGREEMENT AMENDMENT #1 EXECUTED 9/24/2026.

N

40' 0 40'

Title:

SITE PLAN

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: T.B.	Date: 11/2/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	2
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.01.DWG		

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LSB-1	2/4/2022	2/4/2022
Depth (ft bls)	2-4	4-6
Metals		
Arsenic	**41.8**	ND
Barium	**452**	NE
Copper	**445**	NE
Lead	**1,420**	NE

LSB-3	2/3/2022	2/3/2022	2/3/2022
Depth (ft bls)	2-4	4-6	8-10
VOCs			
Acetone	**0.031**	NA	NA
SVOCs			
Benzo(a)anthracene	NE	NE	**5.09 D**
Benzo(b)fluoranthene	NE	NE	**3.62 D**
Benzo(g,h,i)Perylene	NE	NE	**2.89 D**
Benzo(k)fluoranthene	NE	NE	**3.57 D**
Chrysene	**1.02 D**	NE	**5.43 D**
Dibenz(a,h)anthracene	NE	NE	**0.823 D**
Indeno(1,2,3-cd)pyrene	**0.52 D**	NE	**2.26 D**
Phenanthrene	**NE**	**1.74 D**	**1.4 D**
Metals			
Barium	466 J	NE	NE
Copper	303	NE	NE
Lead	**531**	**88.2**	**114**
Mercury	**0.868**	**1.23**	**0.632**

LSB-2	2/3/2022
Depth (ft bls)	2-4
VOCs	
Acetone	**0.035**
SVOCs	
Benzo(a)anthracene	**10.3 D**
Benzo(a)pyrene	7.76 D
Benzo(b)fluoranthene	**6.54 D**
Benzo(g,h,i)Perylene	**3.94 D**
Benzo(k)fluoranthene	**6.45 D**
Chrysene	**10.4 D**
Dibenz(a,h)anthracene	**1.31 D**
Indeno(1,2,3-cd)pyrene	**3.73 D**
Phenanthrene	**24.7 D**
Metals	
Copper	**137**
Lead	**385**
Mercury	**1.17**
Zinc	**275**



LSB-5	2/4/2022	2/4/2022
Depth (ft bls)	4-7	15-17
VOCs		
Acetone	NA	**0.067**
SVOCs		
Benzo(a)anthracene	**1.61 D**	ND
Benzo(a)pyrene	**1.49 D**	ND
Benzo(b)fluoranthene	**1.25 D**	ND
Benzo(g,h,i)Perylene	**1.19 D**	ND
Benzo(k)fluoranthene	**1.23 D**	ND
Chrysene	**1.48 D**	ND
Indeno(1,2,3-cd)pyrene	**1.45 D**	ND
Phenanthrene	**1.81 D**	ND
Metals		
Barium	**1,140**	NE
Copper	378	NE
Lead	**741**	NE
Mercury	**1.25**	NE
Zinc	**625 B**	NE

LSB-6	2/4/2022
Depth (ft bls)	8-10
VOCs	
Acetone	**0.033**
Metals	
Arsenic	**32.3**
Copper	**200 J**
Lead	**131**

LSB-7	2/4/2022	2/4/2022 DUP
Depth (ft bls)	2-4	2-4
SVOCs		
Benzo(a)anthracene	**11.6 D**	**7.76 D**
Benzo(a)pyrene	9.58 D	8.35 D
Benzo(b)fluoranthene	**7.91 D**	**5.93 D**
Benzo(g,h,i)Perylene	**3.89 D**	**3.72 D**
Benzo(k)fluoranthene	**7.8 D**	**5.92 D**
Chrysene	**11.7 D**	**7.86 D**
Dibenz(a,h)anthracene	**0.79 D**	**1.27 D**
Indeno(1,2,3-cd)pyrene	**4.42 D**	**4.14 D**
Phenanthrene	**23.8 D**	**15.7 D**
Metals		
Copper	NE	**54 J**
Lead	**87.6**	**107**
Mercury	**0.556**	**0.469**

LSB-4	2/3/2022
Depth (ft bls)	4-6
SVOCs	
Benzo(a)anthracene	**3.97 D**
Benzo(a)pyrene	**3.01 D**
Benzo(b)fluoranthene	**2.68 D**
Benzo(g,h,i)Perylene	**3.94 D**
Benzo(k)fluoranthene	**2.65 D**
Chrysene	**3.55 D**
Dibenz(a,h)anthracene	**0.772 D**
Indeno(1,2,3-cd)pyrene	**1.84 D**
Phenanthrene	**24.7 D**
Metals	
Copper	**253**
Lead	**172**
Zinc	**257**
PFAS	
Perfluorooctanesulfonic acid (PFOS)	**0.0107**

LEGEND

SITE BOUNDARY

LSB-1 PREVIOUS SOIL BORING/MONITORING WELL LOCATION

40' 0 40'

Parameter	NYSDEC Part 375 Unrestricted SCO	NYSDEC Part 375 Protection of Groundwater SCO	NYSDEC Part 375 Industrial SCO	Units
VOCs				
Acetone	**0.03**	0.03	1000	mg/kg
SVOCs				
Benzo(a)anthracene	**1**	1	37	mg/kg
Benzo(a)pyrene	**1**	22	3.7	mg/kg
Benzo(b)fluoranthene	**1**	2.1	37	mg/kg
Benzo(g,h,i)Perylene	**0.64**	1000	78	mg/kg
Benzo(k)fluoranthene	**0.8**	2	78	mg/kg
Chrysene	**1**	1	78	mg/kg
Dibenz(a,h)anthracene	**0.33**	1000	3.7	mg/kg
Indeno(1,2,3-cd)pyrene	**0.5**	6.6	37	mg/kg
Phenanthrene	**1.1**	1000	1000	mg/kg
Metals				
Arsenic	**13**	16	16	mg/kg
Barium	**410**	820	10000	mg/kg
Cadmium	**2.5**	7.5	4.4	mg/kg
Copper	**50**	1720	10000	mg/kg
Lead	**63**	450	3900	mg/kg
Mercury	**0.18**	0.73	1.1	mg/kg
Zinc	**109**	2480	10000	mg/kg
PFAS				
Perfluorooctanesulfonic acid (PFOS)	**0.00088**	0.001	0.44	mg/kg

mg/kg – MILLIGRAMS PER KILOGRAM
NYSDEC – NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
SCO – SOIL CLEANUP OBJECTIVE
J – ESTIMATED VALUE
D – DILUTION
B – ANALYTE WAS ALSO DETECTED IN THE ASSOCIATED LABORATORY BLANK
DUP – DUPLICATE SAMPLE
VOCs – VOLATILE ORGANIC COMPOUNDS
SVOCs – SEMIVOLATILE ORGANIC COMPOUNDS
PFAs – PER– AND POLYFLUOROALKYL SUBSTANCES
NE – NO EXCEEDANCE
ND – NO DETECTION
NA – NOT ANALYZED
FT BLS – FEET BELOW LAND SURFACE

Title:

SOIL SAMPLE RESULTS

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: L.C.	Date: 4/17/2026	FIGURE 3
Prepared by: G.M.	Scale: AS SHOWN	
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.01.DWG		

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LMW-1	2/7/2022	2/7/2022 DUP
VOCs		
Acetone	**127 D**	**135 D**
Tert-Butyl Methyl Ether	NE	**11.4**
SVOCs		
Benzo(a)anthracene	**0.5 J**	**0.7 J**
Benzo(a)pyrene	**0.48 J**	**0.83 J**
Benzo(b)fluoranthene	**0.39 J**	**0.77 J**
Benzo(k)fluoranthene	**0.38 J**	**0.66 J**
Chrysene	**0.59 J**	**0.86 J**
Indeno(1,2,3-cd)pyrene	**0.3 J**	**0.48 J**
Metals (Total)		
Iron	**44,900**	**45,200**
Lead	**31.3**	NE
Magnesium	**94,500**	**94,900**
Manganese	**1,030**	**1,060**
Sodium	**412,000**	**406,000**
PFAS		
Perfluorooctanesulfonic acid (PFOS)	**0.0111**	**0.00973**
Perfluorooctanoic acid (PFOA)	**0.0759**	**0.0819**

LMW-3	2/8/2022
Metals (Total)	
Iron	**14,300**
Lead	**57.2**
Magnesium	**42,500**
Manganese	**774**
Sodium	**53,200**
PFAS	
Perfluorooctanesulfonic acid (PFOS)	**0.115**
Perfluorooctanoic acid (PFOA)	**0.0608**

LMW-4	2/8/2022
SVOCs	
1,4-Dioxane (P-Dioxane)	**1.18**
Benzo(a)anthracene	**0.0778**
Benzo(a)pyrene	**0.0778**
Benzo(b)fluoranthene	**0.0667**
Benzo(k)fluoranthene	**0.0667**
Chrysene	**0.0778**
Metals (Total)	
Iron	**4,050**
Lead	**92.5**
Magnesium	**64,200**
Sodium	**63,200**
PFAS	
Perfluorooctanesulfonic acid (PFOS)	**0.0794**
Perfluorooctanoic acid (PFOA)	**0.0948**

LMW-2	2/7/2022
SVOCs	
1,4-Dioxane (P-Dioxane)	**1.92**
Metals (Total)	
Iron	**4,910**
Magnesium	**52,000**
Sodium	**80,000**
PFAS	
Perfluorooctanesulfonic acid (PFOS)	**0.114**
Perfluorooctanoic acid (PFOA)	**0.135**

Parameter	NYSDEC AWQSGV	Units
VOCs		
Acetone	**50**	µg/L
Tert-Butyl Methyl Ether	**10**	µg/L
SVOCs		
1,4-Dioxane (P-Dioxane)	**1**	µg/L
Benzo(a)anthracene	**0.002**	µg/L
Benzo(a)pyrene	**0**	µg/L
Benzo(b)fluoranthene	**0.002**	µg/L
Benzo(k)fluoranthene	**0.002**	µg/L
Chrysene	**0.002**	µg/L
Indeno(1,2,3-cd)pyrene	**0.002**	µg/L
Metals (Total)		
Iron	**300**	µg/L
Lead	**25**	µg/L
Magnesium	**35000**	µg/L
Manganese	**300**	µg/L
Sodium	**20000**	µg/L
PFAS		
Perfluorooctanesulfonic acid (PFOS)	**0.0027**	µg/L
Perfluorooctanoic acid (PFOA)	**0.0067**	µg/L

µg/L – MICROGRAMS PER LITER
NYSDEC – NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
AWQSGVS – AMBIENT WATER–QUALITY STANDARDS AND GUIDANCE VALUES
D – DILUTION
J – ESTIMATED VALUE
DUP – DUPLICATE SAMPLE
VOCS – VOLATILE ORGANIC COMPOUNDS
SVOCS – SEMIVOLATILE ORGANIC COMPOUNDS
PFAS – PER–AND POLYFLUOROALKYL SUBSTANCES
NE – NO EXCEEDANCES

LEGEND

SITE BOUNDARY

LSB–2/LMW–1 PREVIOUS SOIL BORING/MONITORING WELL LOCATION

40' 0 40'

Title:

GROUNDWATER SAMPLE RESULTS

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: L.C.	Date: 4/17/2026
Prepared by: G.M.	Scale: AS SHOWN
Project Mgr: L.C.	Project: 3084.0003Y000
File: 3084.0003Y1001.01.DWG	

FIGURE 4

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LSV-1	2/8/2022
VOCs	
Acetone	**40 J**
Benzene	**2.12 J**
Carbon Tetrachloride	**0.279 J**
Chloromethane	**1.16 J**
Cyclohexane	**0.508 J**
Dichlorodifluoromethane	**2.19 J**
Ethyl Acetate	**1.17 J**
Isopropanol	**4.03 J**
M,P-Xylene	**1.47 J**
Methyl Ethyl Ketone (2-Butanone)	**1.48 J**
Methyl Methacrylate	**0.726 J**
Methylene Chloride	**4.67 J**
n-Heptane	**0.848 J**
n-Hexane	**1.61 J**
Toluene	**4.29 J**
Trichloroethene (TCE)	**0.397 J**
Trichlorofluoromethane	**1.16 J**

LSV-2	2/8/2022
VOCs	
1,2,4-Trimethylbenzene	**8.31 J**
1,3,5-Trimethylbenzene (Mesitylene)	**4.29 J**
4-Ethyltoluene	**6.44 J**
Acetone	**12.7 J**
Carbon Disulfide	**31.3 J**
Cyclohexane	**468 J**
Ethylbenzene	**6.16 J**
M,P-Xylene	**7.58 J**
Methyl Ethyl Ketone (2-Butanone)	**5.15 J**
n-Hexane	**74.2 J**
o-Xylene (1,2-Dimethylbenzene)	**4.5 J**
Toluene	**5.96 J**



LSV-3	2/8/2022
VOCs	
1,2,4-Trimethylbenzene	**5.06 J**
1,2-Dichlorobenzene	**6.6 J**
1,4-Dichlorobenzene	**28.9 J**
Acetone	**12.7 J**
Benzene	**3.07 J**
Carbon Disulfide	**2.35 J**
Cyclohexane	**244 J**
Ethylbenzene	**9.24 J**
Isopropanol	**12.8 J**
M,P-Xylene	**8.64 J**
Methyl Ethyl Ketone (2-Butanone)	**2.63 J**
Methylene Chloride	**6.2 J**
n-Heptane	**81.3 J**
n-Hexane	**260 J**
o-Xylene (1,2-Dimethylbenzene)	**3.28 J**
Toluene	**8.02 J**

LSV-4	2/8/2022	2/8/2022 DUP
VOCs		
1,1-Dichloroethane	ND	**21.7 J**
1,2,4-Trimethylbenzene	**2.54 J**	ND
Acetone	**33.3 J**	**32.2 J**
Carbon Disulfide	**6.28 J**	**6.51 J**
Cyclohexane	**9.26 J**	**8.49 J**
Dichlorodifluoromethane	**36.8 J**	ND
Ethylbenzene	**3.59 J**	**3.26 J**
Methyl Ethyl Ketone (2-Butanone)	**8.08 J**	**7.75 J**
Methylene Chloride	ND	**4.47 J**
n-Heptane	**400 J**	**372 J**
n-Hexane	**707 J**	**653 J**
Tert-Butyl Methyl Ether	**7.09 J**	ND
Toluene	ND	**2.43 J**

LEGEND

SITE BOUNDARY

LSB–2/LMW–1 PREVIOUS SOIL BORING/MONITORING WELL LOCATION

CONCENTRATIONS IN $\mu g/m^3$

$\mu g/m^3$ – MICROGRAMS PER CUBIC METER

VOCS – VOLATILE ORGANIC COMPOUNDS

ND – COMPOUND WAS ANALYZED FOR BUT NOT DETECTED DUP – DUPLICATE

J – ESTIMATED VALUE

40' 0 40'

Title:

SOIL VAPOR SAMPLE RESULTS

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: L.C.	Date: 4/17/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	5
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.01.DWG		

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LEGEND

- SITE BOUNDARY
- LSB-1 — PREVIOUS SOIL BORING LOCATION
- LSB-2/LMW-1 — PREVIOUS SOIL BORING/MONITORING WELL LOCATION
- LSV-1 — PREVIOUS SOIL VAPOR POINT LOCATION
- RX-11 — LOCATION OF PROPOSED SOIL BORING
- RW-1 — LOCATION OF PROPOSED SOIL BORING AND GROUNDWATER MONITORING WELL
- RX-7 — LOCATION OF PROPOSED SOIL BORING AND SOIL VAPOR POINT

N

40' 0 40'

Title:

PROPOSED SAMPLE LOCATIONS

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: T.B.	Date: 11/2/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	6
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.01.DWG		

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APPENDICES

A. Quality Assurance Project Plan/Field Sampling Plan
B. Site Specific Health and Safety Plan
C. Community Air Monitoring Plan

APPENDIX A

Quality Assurance Project Plan/Field Sampling Plan

Quality Assurance Project Plan/Field Sampling Plan (QAPP/FSP)

213 Meadow Street
Brooklyn, New York 11237

MTA Facilities Project Site #C224422

November 2, 2026

Prepared for:

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Table of Contents

1. Introduction 1
   1.1 Purpose 1
2. Sampling Objectives 2
3. Project Organization 3
4. Sample Media, Locations, Analytical Suites, and Frequency 4
   4.1 Soil Sampling 4
   4.2 Groundwater Sampling 5
   4.3 Soil Vapor Sampling 5
5. Field Sampling Procedures 7
   5.1 Soil Sampling 7
   5.2 Groundwater Sampling 8
   5.3 Soil Vapor Sampling 8
6. Sample Handling and Analysis 9
   6.1 Field Sample Handling 9
   6.2 Sample Custody Documentation 9
   6.3 Sample Shipment 9
   6.4 Quality Assurance/Quality Control 10
7. Site Control Procedures 12
   7.1 Decontamination 12
   7.2 Waste Handling and Disposal 12

Tables

1. Field and Laboratory QC Summary
2. Remedial Investigation Sampling Summary
3. Remedial Investigation Boring Matrix
4. Preservation, Holding Times, and Sample Containers

Figures

1. Proposed Sample Locations

Attachments

1. Professional Profiles
2. Laboratory's Standard Operating Procedures
3. Roux's Standard Operating Procedures
4. NYSDEC PFAS Sampling Guidance

1. Introduction

Roux Environmental Engineering and Geology, D.P.C. (Roux), on behalf of GO Quay, LLC (Go Quay), has prepared this Quality Assurance Project Plan/Field Sampling Plan (QAPP/FSP). Go Quay entered into a Brownfield Cleanup Agreement (BCA), Index No. C224433-10-2025, with the New York State Department of Environmental Conservation (NYSDEC) as a Volunteer on March 22, 2026. The purpose of this QAPP/FSP is to describe the measures that will be taken to ensure that the data generated during performance of the Remedial Investigation (RI) for the property located at 213 Meadow Street in the Borough of Brooklyn, New York (Block 2951, Lot 1; Site) are of quality sufficient to meet project-specific data quality objectives (DQOs). This QAPP/FSP also includes field sampling procedures.

This QAPP/FSP was prepared in accordance with the guidance provided in NYSDEC Technical Guidance DER-10 Technical Guidance for Site Investigation and Remediation (DER-10), the NYSDEC Brownfield Cleanup Program (BCP) Guide, and the United States Environmental Protection Agency's (USEPA's) Guidance for the Data Quality Objectives Process (EPA QA/G 4).

1.1 Purpose

The QAPP/FSP describes in detail the field sampling and quality assurance/quality control (QA/QC) methods to be used during soil, soil vapor, and groundwater sampling tasks performed during the RI.

This QAPP/FSP provides guidelines and procedures to be followed by field personnel during performance of sampling during the RI. Information contained in this QAPP/FSP relates to:

- Sampling objectives (Section 2);
- Project organization (Section 3);
- Sample media, sampling locations, analytical suites, sampling frequencies and analytical laboratory (Section 4);
- Field sampling procedures (Section 5);
- Sample handling, sample analysis, and quality assurance/quality control (Section 6); and
- Site control procedures and decontamination (Section 7).

2. Sampling Objectives

The objective of the RI is to further assess the nature and extent of contamination associated with the following AOCs:

- Presence of contaminated urban fill; and
- Current and historical operations.

An inspection of the existing Site conditions will be conducted to determine final locations of soil borings, monitoring wells, and vapor sampling points based on actual field conditions.

Sampling procedures are discussed in Section 5 of this QAPP/FSP. A discussion of the DQOs and quality assurance/quality control is provided in Section 6.

3. Project Organization

A general and generic summary of the overall management structure and responsibilities of project team members are presented below. Professional profiles for the team are provided in Attachment 1.

Project Principal

Jessica Taylor, P.G. will serve as Project Principal. The Project Principal is responsible for defining project objectives and bears ultimate responsibility for the successful completion of the investigation.

Project Manager

Levi Curnutte will serve as Project Manager. The Project Manager will provide overall management for the implementation of the scope of work and will coordinate all field activities. The Project Manager is also responsible for data review/interpretation and report preparation.

Field Team Leader

Benjamin Weintraub will serve as Field Team Leader. The Field Team Leader bears the responsibility for the successful execution of the field program. The Field Team Leader will direct the activities of the technical staff in the field, as well as all subcontractors. The Field Team Leader will also assist in the interpretation of data and in report preparation. The Field Team Leader reports to the Project Manager.

Laboratory Project Manager

Elizabeth Flannery will serve as the Laboratory Project Manager at Eurofins Environment Testing Northeast, LLC. The Laboratory Project Manager is responsible for sample container preparation, sample custody in the laboratory, and completion of the required analysis through oversight of the laboratory staff. The Laboratory Project Manager will ensure that quality assurance procedures are followed and that an acceptable laboratory report is prepared and submitted. The Laboratory Project Manager reports to the Project Principal and Project Manager.

Quality Assurance Officer

Douglas Ferraiolo will serve as Quality Assurance Officer (QAO) . The QAO is responsible for conducting reviews, inspections, and audits to ensure that the data collection is conducted in accordance with the FSP and QAPP. The QAO's responsibilities range from ensuring effective field equipment decontamination procedures and proper sample collection to the review of all laboratory analytical data for completeness and usefulness. The QAO reports to the Project Manager and makes independent recommendations to the Field Team Leader.

4. Sample Media, Locations, Analytical Suites, and Frequency

The media to be sampled during the RI includes soil, groundwater, and soil vapor. Sampling locations, analytical suites, and frequency vary by medium. The scope of the RI will include the collection of sufficient Site investigation data so that, together with the historical data, the entire Site will be sufficiently characterized to determine BCP eligibility as well as support the development of the Site-wide Remedial Action Work Plan (RAWP).

A discussion of the sampling schedule for each medium is provided below, and field and laboratory QC sampling as well as the proposed number of field samples to be collected for each medium is shown in Tables 1 and 2, respectively. The proposed sampling locations for each media are provided in Figure 1 (Figure 6 of the RIWP) and are also summarized on a boring matrix in Table 3. Specifics regarding the collection of samples at each location and for each task are provided in Section 5 of this QAPP/FSP.

Soil samples from all soil borings and all groundwater samples collected from the investigation described in detail below for soil and groundwater, respectively, will be analyzed for the target compound list (TCL)/Part 375 plus 30/target analyte list (TAL) (TCL + 30/TAL) parameters including:

- TCL/Part 375 VOC + 10 Tentatively identified compounds (TICs);
- TCL/Part 375 Base neutral acids (BNA)/SVOCs + 20 TICs;
- TCL/Part 375 Pesticides;
- TCL/Part 375 Herbicides;
- TCL/Part 375 PCBs;
- TAL/Part 375 Metals (including hexavalent chromium);
- Total Cyanide; and
- Emerging Contaminants (ECs) list includes 1,4-Dioxane and all Per- and Polyfluoroalkyl Substances (PFAS) compounds listed in the NYSDEC April 2023 “Sampling, Analysis, and Assessment of PFAS.” PFAS in soil and groundwater will be analyzed by United States Environmental Protection Agency (USEPA) Method 1633A and 1,4-Dioxane in groundwater will be analyzed by USEPA Method 8270D SIM and 1,4-Dioxane in soil will be analyzed by USEPA Method 8270D.

4.1 Soil Sampling

Soil samples are to be used to characterize the soil conditions for the AOCs at the Site, and to collect data sufficient to define the nature and extent of impacted soils. A total of 24 soil samples from 12 soil borings will be collected in a manner consistent with this QAPP/FSP (not including QA/QC).

At each soil boring, the proposed sample depth intervals are 2-4 feet below land surface (ft bls; or shallowest available interval beneath concrete layer) and 8-10 ft bls (or the 2 ft interval located above observed groundwater level). Each soil sample will be analyzed for TCL + 30/TAL and ECs listed above. If odor/ visual evidence of contamination or elevated photoionization detector (PID) readings are noted, additional samples will be collected from the interval that exhibits the highest contamination.

4.2 Groundwater Sampling

To evaluate groundwater quality conditions across the Site, six permanent monitoring wells (RX-1 through RX-6) will be installed in converted soil boring locations. Roux will collect a groundwater sample from each newly installed monitoring well location totaling six samples (not including QA/QC). All monitoring wells will be surveyed for horizontal coordinates, land surface elevation and measuring point elevation.

Monitoring wells will be constructed of 2-inch inside diameter, Schedule 40 polyvinyl chloride (PVC) casing and, 0.020 inch slot, machined screen. Well construction will be as follows:

- Well screens will be 10 feet long, and will be installed with three feet above and seven feet below the water table.
- A sand pack will be placed around the well screen, extending two feet above the top of the screened zone.
- A minimum two-foot-thick bentonite pellet seal will be placed above the sand pack. Once the pellets have been allowed to hydrate, cement bentonite grout will be pumped into the remaining annular space from the bottom up.
- The wells will be completed using locking well plugs, and flush mounted, bolt down, watertight, manhole covers cemented into place.

Each monitoring well to be sampled will be developed to ensure proper hydraulic connection with the aquifer and to reduce/eliminate turbidity of the groundwater. The wells will be developed using a submersible pump, which will be surged periodically until well yield is consistent and has turbidity below 50 nephelometric turbidity units (NTUs), if possible.

At least one week following redevelopment, all on-Site wells will then be sampled consistent with USEPA low-flow sampling requirements using a peristaltic pump and one round of groundwater samples will be collected in accordance with the QAPP/FSP. Prior to sampling, the depth to groundwater in each monitoring well will be measured using an electronic water level meter and a groundwater contour map will be developed using the survey data. Field parameters (e.g., pH, dissolved oxygen, oxidation-reduction potential [ORP], etc.) will also be collected using a water quality meter during purging and prior to sampling. Each groundwater sample will be analyzed for TCL + 30/TAL and ECs list of analytes including total and dissolved metals.

4.3 Soil Vapor Sampling

To evaluate soil vapor and the potential for soil vapor intrusion (SVI) into the proposed building, Roux will install four soil vapor points (RX-7 through RX-10) in converted soil boring locations by hand or by using a Geoprobe® direct-push rig. One soil vapor sample will be collected from each point for a total of four samples (not including QA/QC). New Teflon®-lined tubing will be attached to an expendable soil vapor sampling point with a 6-inch stainless steel screen. The soil vapor points will be backfilled with #2 Morie sand to approximately one foot above the screen. The remainder of the borehole will be backfilled with a concrete/bentonite slurry to grade.

In accordance with the NYSDOH Guidance for Evaluating SVI, the integrity of each soil vapor sampling point seal will be checked following installation to verify that the soil vapor sample will not be compromised by inadvertent introduction of ambient air into the sample. The soil vapor samples will be collected using

pre-cleaned (batch certified) 6-liter summa canisters with regulators calibrated to collect samples over a 2-hour period and analyzed using USEPA Method TO-15 for VOCs.

5. Field Sampling Procedures

This section provides a detailed discussion of the field procedures to be used during sampling of the various media being evaluated as part of the RI (i.e., soil, groundwater, and soil vapor). As discussed, the sample locations are shown on Figure 1. Additional details regarding sampling procedures and protocols are described in Roux's relevant Standard Operation Procedures (SOPs), which are provided in Attachment 3.

5.1 Soil Sampling

At each borehole location utility clearance will be performed prior to advancement of soil borings using hand tools and/or vacuum excavation to a minimum of 5 ft bls at each location to confirm that no subsurface utilities were present. Should a utility or other feature be observed during pre-clearance activities, the sampling location will be relocated.

Soil borings will be advanced using a Geoprobe direct-push drill rig. Samples of the soil profile will be collected continuously from land surface to a maximum depth of approximately 10 feet below the water table for borings with co-located groundwater monitoring wells or 10 ft bls for borings with co-located soil vapor points.

The soil from each five-foot interval will be observed for lithology and evidence of contamination (e.g., staining, odors, and/or visible free product) and placed immediately thereafter into large plastic Ziploc® bags or equivalent for recording headspace using a PID. After a minimum of 15 minutes for equilibration with the headspace in the plastic bag, each sample will be screened for organic vapors using a PID equipped with a 10.6 eV lamp. Samples for possible VOC analysis will be placed in a laboratory-supplied jar or encore sampler prior to screening, due to the potential for loss of VOCs through volatilization. Soil samples will be collected at depths described in Section 4. As part of the RI, 24 soil samples will be collected. Additional samples may be collected if odor/ visual evidence of contamination is observed. Samples will be placed in the laboratory-supplied containers and shipped to the laboratory under chain of custody procedures in accordance with Roux's SOPs in Attachment 3.

Soil samples will also be analyzed for the NYSDEC-required ECs. Additional necessary precautions will be taken when sampling for ECs in the field including, but not limited to:

- Using the proper field clothing or personal protective equipment (i.e., no materials will contain Gore-Tex or Tyvek);
- Avoid using sampling equipment components/containers making contact with aluminum foil, low density polyethylene (LDPE), glass, or polytetrafluoroethylene materials;
- Following PFAS field sampling guidelines (i.e., using sampling materials made from high density polyethylene [HDPE], silicon, or stainless steel and avoid using equipment containing Teflon and using sharpies, permanent markers, adhesives, and waterproof/plastic clipboards and notebooks); and
- Utilizing regular ice for sample preservation and only "PFAS-free" water and Alconox for decontamination.

Contaminated soil cuttings, if encountered, will be placed in sealed and labeled U.S. Department of Transportation (DOT) approved 55-gallon drums pending characterization and off-Site disposal at a permitted facility.

5.2 Groundwater Sampling

Prior to sampling, depth to water will be measured at each well using an electronic water level meter with an accuracy of +/ 0.01 feet. All wells will then be purged and sampled consistent with USEPA low-flow sampling requirements. Field parameters (i.e., pH, dissolved oxygen, ORP, etc., as described in the USEPA low-flow sampling requirements) will be collected using a water quality meter with flow-through cell until parameters stabilize before samples are collected. Five groundwater samples will be collected as part of the RI. Samples will be analyzed for TCL + 30/TAL and ECs including total and dissolved metals as shown on Table 2.

Monitoring wells will also be analyzed for same parameters listed in Section 4.1. Similarly to the collection of soil samples for ECs, additional necessary precautions will be taken when groundwater sampling for ECs in the field including, but not limited to:

- Using the proper field clothing or personal protective equipment (i.e., no materials will contain Gore-Tex or Tyvek);
- Avoid using sampling equipment components/containers making contact with aluminum foil, low density polyethylene (LDPE), glass, or polytetrafluoroethylene materials;
- Following PFAS field sampling guidelines (i.e., using sampling materials made from high density polyethylene [HDPE], silicon, or stainless steel and avoid using equipment containing Teflon and using sharpies, permanent markers, adhesives, and waterproof/plastic clipboards and notebooks); and
- Utilizing regular ice for sample preservation and only “PFAS-free” water and Alconox for decontamination.

All groundwater samples will be collected and placed in the laboratory-supplied containers and shipped to the laboratory under chain of custody procedures in accordance with Roux’s field sampling SOPs included as Attachment 3.

5.3 Soil Vapor Sampling

The soil vapor samples will be collected from two feet above the water table. New Teflon® lined tubing will be attached to an expendable soil vapor sampling point with a 6-inch stainless steel screen inside the rods, to prevent infiltration of ambient air. The soil vapor points will be backfilled with #2 Morie sand to approximately one foot above the screen. The remainder of the borehole will be backfilled with a cement/bentonite slurry to grade.

Prior to sample collection, the Teflon®-lined tubing will be purged of approximately two volumes of the tubing using a vacuum pump set at a rate of 0.2 liters per minute. A tracer gas (i.e., helium) will be used to enrich the atmosphere in the immediate vicinity of the sampling location in order to test the borehole seal and verify that ambient air is not being drawn into the sample in accordance with the procedures outlined in the NYSDOH Guidance. Following purging and verification with the tracer gas, the tubing will be connected to the pre-cleaned (batch-certified) laboratory supplied summa canister. All soil vapor samples will be collected using the canisters with regulators calibrated to collect samples over a 2-hour period and analyzed using USEPA Method TO-15 for VOCs.

6. Sample Handling and Analysis

To ensure quality data acquisition and collection of representative samples, there are selective procedures to minimize sample degradation or contamination. These include procedures for preservation of the samples, as well as sample packaging, shipping procedures, and QA/QC.

6.1 Field Sample Handling

A discussion of the proposed number and types of samples to be collected during each task, as well as the analyses to be performed, can be found in Section 4 of this QAPP/FSP. The types of containers, volumes, and preservation techniques for the aforementioned testing parameters are presented in Table 4.

6.2 Sample Custody Documentation

The purpose of documenting sample custody is to ensure that the integrity and handling of the samples is not subject to question. Sample custody will be maintained from the point of sampling through the analysis (and return of unused sample portion, if applicable).

Each individual collecting samples is personally responsible for the care and custody of the samples. All sample labels should be preprinted or filled out using waterproof ink. The technical staff will review all field activities with the Field Team Leader to determine whether proper custody procedures were followed during the field work and to decide if additional samples are required.

All samples being shipped off-Site for analysis must be accompanied by a properly completed chain of custody form. The sample numbers will be listed on the chain of custody form. When transferring the possession of samples, individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to/from a secure storage area, and to the laboratory.

Samples will be packaged for transfer and dispatched to the appropriate laboratory for analysis with a separate signed custody record enclosed in each sample box or cooler. The preferred method of transfer to the laboratory is for a courier to pick up samples and deliver them to the laboratory with a vehicle. Shipping containers, if needed, will be locked and/or secured with strapping tape in at least two locations for shipment to the laboratory.

6.3 Sample Shipment

Samples are typically picked up from the Stie and delivered to the laboratory by courier service. If sample shipment is necessary, sample packaging and shipping procedures are based upon USEPA specifications, as well as DOT regulations. The procedures vary according to potential sample analytes, concentration, and matrix and are designed to provide optimum protection for the samples and the public. Sample packaging and shipment must be performed using the general outline described below.

All samples will be shipped within 24 hours of collection and will be preserved appropriately from the time of sample collection. A description of the sample packing and shipping procedures is presented below:

1. Prepare cooler(s) for shipment:
    - tape drain(s) of cooler shut;

- affix “This Side Up” arrow labels and “Fragile” labels on each cooler; and
- place mailing label with laboratory address on top of cooler(s).

2. Arrange sample containers in groups by sample number.
3. Ensure that all bottle labels are completed correctly. Place clear tape over bottle labels to prevent moisture accumulation from causing the label to peel off.
4. Arrange containers in front of assigned coolers.
5. Place packaging material approximately at the bottom of the cooler to act as a cushion for the sample containers.
6. Arrange containers in the cooler so that they are not in contact with the cooler or other samples.
7. Fill remaining spaces with packaging material.
8. Ensure all containers are firmly packed in packaging material.
9. If ice is required to preserve the samples, ice cubes should be repackaged in Ziploc® bags and placed on top of the packaging material.
10. Sign chain of custody form (or obtain signature) and indicate the time and date it was relinquished to courier as appropriate.
11. Separate chain of custody forms. Seal proper copies within a large Ziploc® bag and tape to inside cover of cooler. Retain copies of all forms.
12. Close lid and latch.
13. Secure each cooler using custody seals.
14. Tape cooler shut on both ends.
15. Relinquish to overnight delivery service as appropriate. Retain air bill receipt for project records. (Note: All samples will be shipped for “NEXT A.M.” delivery).

6.4 Quality Assurance/Quality Control

The primary intended use for the RI data is to characterize Site conditions, determine BCP eligibility, and aid in the preparation of the RAWP. The primary DQO of the soil, groundwater, and soil vapor programs, therefore, is that data be accurate and precise, and hence representative of the actual Site conditions. Accuracy refers to the ability of the laboratory to obtain a true value (i.e., compared to a standard) and is assessed through the use of laboratory QC samples, including laboratory control samples and matrix spike samples, as well as through the use of surrogates, which are compounds not typically found in the environment that are injected into the samples prior to analysis. Precision refers to the ability to replicate a value and is assessed through both field and laboratory duplicate samples.

Sensitivity is also a critical issue in generating representative data. Laboratory equipment must be of sufficient sensitivity to detect target compounds and analytes at levels below NYSDEC standards and guidelines whenever possible. Equipment sensitivity can be decreased by field or laboratory contamination of samples, and by sample matrix effects. Assessment of instrument sensitivity is performed through the analysis of reagent blanks, near-detection-limit standards, and response factors. Potential field and/or laboratory contamination is assessed through use of trip blanks, method blanks, and equipment rinse blanks (also called “field blanks”). A laboratory SOP for analysis of PFAS is included in Attachment 2.

Table 1 lists the requirements for field and laboratory QC samples that will be analyzed to assess data accuracy and precision, as well as to determine if equipment sensitivity has been compromised. Table 2

lists the number/type of field and QA/QC samples that will be collected during the RI. Table 4 lists the preservation, holding times and sample container information.

All RI “assessment” analyses (i.e., TCL plus 30/ TAL and TO-15) will be performed in accordance with the NYSDEC Analytical Services Protocol (ASP), using USEPA SW 846 methods.

All laboratory data are to be reported in NYSDEC ASP Category B deliverables and will be delivered to NYSDEC in electronic data deliverable (EDD) format as described on NYSDEC’s website (http://www.dec.ny.gov/chemical/62440.html). A Data Usability Summary Report (DUSR) will be prepared meeting the requirements in Section 2.2(a)1.ii and Appendix 2B of DER-10 for all data packages generated for the RI. Judy Harry of Data Validation Services will review the analytical data for quality assurance and quality control in accordance with NYSDEC standards. The professional profile for Judy Harry is provided in Attachment 1.

7. Site Control Procedures

Site control procedures, including decontamination and waste handling and disposal, are discussed below. Site control procedures have been developed to minimize both the risk of exposure to contamination and the spread of contamination during field activities at the Site. All personnel who come into designated work areas, including contractors and observers, will be required to adhere strictly to the conditions imposed herein and to the provisions of a Site-Specific Health and Safety Plan (HASP). The HASP is included as Appendix D to the RIWP.

7.1 Decontamination

In an attempt to avoid the spread of contamination, all drilling and sampling equipment must be decontaminated at a reasonable frequency in a properly designed and located decontamination area. Detailed procedures for the decontamination of field and sampling equipment are included in Roux's SOPs for the Decontamination of Field Equipment located in Attachment 3. The location of the decontamination area will be determined prior to the start of field operations. The decontamination area will be constructed to ensure that all wash water generated during decontamination can be collected and containerized for proper disposal. Only "PFAS-free" water will be used for decontamination of sample equipment on-Site. Only Alconox will be used as decontamination detergent (Liquinox shall not be used).

7.2 Waste Handling and Disposal

All waste materials (drill cuttings, monitoring well development purge water, decontamination water, etc.) generated during the RI will be consolidated, and stored in appropriately labeled bulk containers (drums, etc.), and temporarily staged at an investigation derived waste storage area on-Site. Roux will then coordinate waste characterization and disposal by appropriate means.

TABLES

1. Field and Laboratory QC Summary
2. Remedial Investigation Sampling Summary
3. Remedial Investigation Boring Matrix
4. Preservation, Holding Times, and Sample Containers

Table 1. Field and Laboratory QC Summary

QC Check Type	Minimum Frequency	Use
Field QC		
Duplicate	1 per matrix per 20 samples or SDG*	Precision
Trip Blank	1 per VOC cooler	Sensitivity
Field Blank	1 per matrix per 20 samples, 1 per day when sampling for PFAS	Sensitivity
Equipment Blank	1 per day when sampling for PFAS	Sensitivity
Laboratory QC		
Laboratory Control Sample	1 per matrix per SDG	Accuracy
Matrix Spike/Matrix Spike Duplicate/Matrix Duplicat	1 per matrix per SDG	Accuracy/Precision
Surrogate Spike	All organics samples	Accuracy
Laboratory Duplicate	1 per matrix per SDG	Precision
Method Blank	1 per matrix per SDG	Sensitivity

* SDG - Sample Delivery Group - Assumes a single extraction or preparation
** Provided to lab by field sampling personnel
PFAS - Per- and Polyfluoroalkyl Substances

Table 2. Remedial Investigation Sampling Summary

Sample Medium	Target Analytes	Field Samples	Duplicates[1]	Trip Blanks[2]	Field Blanks[1]	Equipment Blanks[3]	Matrix Spikes[1]	Spike Duplicates[1]	Total No. of Samples
Soil	TCL VOCs +10	24	2	6	2	-	2	2	38
	TCL SVOCs +20	24	2	-	2	-	2	2	32
	TAL Metals	24	2	-	2	-	2	2	32
	Mercury	24	2	-	2	-	2	2	32
	PCBs	24	2	-	2	-	2	2	32
	Herbicides	24	2	-	2	-	2	2	32
	Pesticides	24	2	-	2	-	2	2	32
	PFAS	24	2	-	2	-	2	2	32
	1,4-Dioxane	24	2	-	2	-	2	2	32
	Total Cyanide	24	2	-	2	-	2	2	32
	Hexavalent Chromium	24	2	-	2	-	2	2	32
Groundwater	TCL VOCs +10	6	1	1	1	-	1	1	10
	TCL SVOCs +20	6	1	-	1	-	1	1	10
	TAL Metals (Total)	6	1	-	1	-	1	1	10
	TAL Metals (Dissolved)	6	1	-	1	-	1	1	10
	Mercury	6	1	-	1	-	1	1	10
	PCBs	6	1	-	1	-	1	1	10
	Herbicides	6	1	-	1	-	1	1	10
	Pesticides	6	1	-	1	-	1	1	10
	PFAS	6	1	-	1	1	1	1	11
	1,4-Dioxane	6	1	-	1	-	1	1	10
	Total Cyanide	6	1	-	1	-	1	1	10
	Hexavalent Chromium	6	1	-	1	-	1	1	10
Soil Vapor	TO-15 VOCs	4	1	-	-	-	-	-	5

Totals are estimated based on scope of work as written, actual sample quantities may vary based on field conditions. QA/QC sample quantities will be adjusted accordingly.

[1] Based on 1 per 20 samples

[2] Based on 1 cooler per day

[3] Based on 1 per day PFAS sampling occurs

TCL - USEPA Contract Laboratory Program Target Compound List

TAL - USEPA Contract Laboratory Program Target Analyte List

USEPA - United States Environmental Protection Agency

VOCs - Volatile Organic Compounds

SVOCs - Semivolatile Organic Compounds

PCBs - Polychlorinated Biphenyls

PFAS - Per- and Polyfluoroalkyl Substances

Table 3. Remedial Investigation Boring Matrix

Sample Location ID	Soil Boring/Sampling	Groundwater Monitoring Well Installation/Sampling	Soil Vapor Point Installation/Sampling
RX-01	X	X	-
RX-02	X	X	-
RX-03	X	X	-
RX-04	X	X	-
RX-05	X	X	-
RX-06	X	X	-
RX-07	X	-	X
RX-08	X	-	X
RX-09	X	-	X
RX-10	X	-	X
RX-11	X	-	-
RX-12	X	-	-

Table 4. Preservation, Holding Times and Sample Containers

Analysis	Matrix	Bottle Type	Preservation(a)	Holding Time(b)
TAL Metals (total & dissolved) SW-846 6020B/7471B	Soil Water	8 oz wide mouth glass, teflon lined cap 250 mL plastic, teflon lined cap	Cool to 4°C Nitric acid	180 days, Hg 28 days
Mercury SW-846 7470A	Soil Water	5 gram Plastic 250 mL Plastic	Cool to 4°C Nitric acid	28 days from sample collection 28 days from sample collection
Hexavalent Chromium\Trivalent Chromium(calculate SW-846 7196A\6010C	Soil Water	2 oz wide mouth glass, teflon lined cap 500 mL Plastic	None	180 days 24 hours from sample collection
Total Cyanide SW-846 9012B	Soil Water	4 oz wide mouth glass, teflon lined cap 250 mL Plastic	Cool to 4°C NaOH	14 days from sample collection 14 days from sample collection
1,4-Dioxane SW-846 8270D GS/MS SIM/Isotope Dilution	Soil Water	8 oz wide mouth glass, teflon lined cap 2 x 500 mL amber wide mouth glass	Cool to 4°C Cool to 4°C	14 days from sample collection 7 days from sample collection
Per- and Polyfluoroalkyl Substances (PFAS) EPA 1633	Soil Water	8 oz plastic container (non teflon lined) 2 - 250 mL plastic	Cool to 4°C Trizma	28 days from sample collection 14 days from sample collection
Volatile Organic Compounds (VOCs) TO-15	Air	6 liter Summa Canister for 2-hr sampling	None	14 days from sample collection
Target Compound List (TCL)				
TCL Volatile Organic Compounds (VOCs) + 10 TICS SW-846 8260C	Soil Water	Encore 40mL voa vial, teflon lined cap	Cool to 4°C Hydrochloric Acid	24 hours from sample collection 14 days from sample collection
TCL Semivolatile Organic Compounds (SVOCs) +20 SW-846 8270D	Soil Water	8 oz wide mouth glass, teflon lined cap 1 liter amber glass, teflon lined cap	Cool to 4°C	14 days to extract, 40 days to analysis 7 days to extract, 40 days to analysis
TCL Polychlorinated biphenyls (PCBs) SW-846 8082A	Soil Water	8 oz wide mouth glass, teflon lined cap 1 liter amber glass, teflon lined cap	Cool to 4°C	14 days to extract, 40 days to analysis 7 days to extract, 40 days to analysis
TCL Pesticides SW-846 8081	Soil Water	4 oz wide mouth glass, teflon lined cap 2 x 8 oz amber glass or plastic, teflon lin	Cool to 6°C Cool to 6°C	14 days to extract, 40 days to analysis 7 days to extract, 40 days to analysis

(a) All soil and groundwater samples to be preserved in ice during collection and transport

(b) Days from date of sample collection.

TAL - Target Analyte List

TCL - USEPA Contract Laboratory Program Target Compound List

Gas chromatography-mass spectrometry (GC/MS) in selected ion monitoring (SIM) mode

FIGURES

1. Proposed Sample Locations



LEGEND

- SITE BOUNDARY
- LSB-1 — PREVIOUS SOIL BORING LOCATION
- LSB-2/LMW-1 — PREVIOUS SOIL BORING/MONITORING WELL LOCATION
- LSV-1 — PREVIOUS SOIL VAPOR POINT LOCATION
- RX-11 — LOCATION OF PROPOSED SOIL BORING
- RW-1 — LOCATION OF PROPOSED SOIL BORING AND GROUNDWATER MONITORING WELL
- RX-7 — LOCATION OF PROPOSED SOIL BORING AND SOIL VAPOR POINT

N

40' 0 40'

Title:

PROPOSED SAMPLE LOCATIONS

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: T.B.	Date: 11/2/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	1
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.01.DWG		

V:\CAD\PROJECTS\3084Y\0003Y\1001\3084.0003Y1001.01.DWG GMILTON

ATTACHMENTS

1. Professional Profiles
2. Laboratory's Standard Operating Procedures
3. Roux's Standard Operating Procedures
4. NYSDEC PFAS Sampling Guidance

ATTACHMENT 1

Professional Profiles

PROFESSIONAL PROFILE



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EDUCATION
BS, Geology, Binghamton University, 2005

PROFESSIONAL LICENSES
Professional Geologist, New York, 2017

Jessica L. Taylor, PG

Principal Hydrogeologist

EXPERIENCE SUMMARY
Nineteen years of experience: Principal, Senior, Project, and Staff Hydrogeologist, Roux, Islandia, New York; Staff Hydrogeologist and Intern at GSC | Kleinfelder.

TECHNICAL SPECIALTIES
Project Management and Field Management for large-scale soil excavation and remediation projects, including site assessment, remediation implementation, and construction activities. Negotiation with NYSDEC Brownfield Clean-up Program (BCP) and NYCOER E-Designation/Voluntary Clean-up Program. Coordination and management of large-scale demolition and renovation support. Performance of sampling and direction of field sampling teams for the following media: soil, groundwater, surface water, soil vapor, sludge, and sediment. Soil characterization, coordination with construction management teams, disposal brokers, and facilities for cost-effective disposal of contaminated and clean soils from complex, large-scale projects.

REPRESENTATIVE PROJECTS

- **Project Principal, Remediation of two Parcels as part of the NYSDEC Brownfield Cleanup Program, Inwood, Manhattan, New York.** This project included due diligence environmental assessment and investigation of a former grocery store and retail gasoline filling station/auto repair, development of NYSDEC-approved Remedial Investigation Work Plan and Remedial Action Work Plan, and remediation during construction an affordable housing development. Acted on behalf of developer to provide soil classification data and vet disposal facilities and manage registration and disposal of unknown USTs.
- **Project Principal, Large Redevelopment Project including Four Buildings with NYCOER E-Designations for Hazardous Materials, Brooklyn, New York.** The project encompasses 22 acres including the Barclays Center. Project responsibilities include coordination and oversight of in situ waste characterization sampling, excavation, and proper disposal of 500,000 CY of soil. Included sampling, classification, and coordination with construction managers and soil disposal facilities for disposal of soil impacted by petroleum contamination and TCLP hazardous levels of lead and corrosivity. Designed soil delineation sampling programs to limit boundaries of more contaminated soils to reduce disposal costs. Responsible for implementing and managing remediation work at several NYSDEC spill sites within the project footprint, including in situ chemical oxidation, UST removal, and soil excavation. Agency support for NYSDEC, NYCDEP, NYCOER, MTA (LIRR/NYCT), and ESDC.
- **Project Principal Providing Technical Guidance to Construction Management Team during the Excavation of NYSDEC Brownfield Cleanup Program Project, Yonkers, New York.** Coordinated with development team, their consultant, soil brokers, and disposal facilities to determine appropriate facilities and manage costs during disposal of approximately 30,000 tons of soil contaminated with TCSA-level PCBs, hazardous lead, and elevated VOCs triggering UHCs.
- **Project Principal, Remediation of Two Parcels as part of the NYSDEC Brownfield Cleanup Program, Hunter's Point South, Queens, New York.** This project included due diligence environmental assessment and investigation, development of NYSDEC-approved Remedial Investigation Work Plan and Remedial Action Work Plan, and remediation during construction of two mixed-use, affordable housing developments. Acted on behalf of developer to evaluate Change Order Request by contractor for disposal of soil with elevated PAHs and hazardous levels of lead. Designed delineation sampling program to limit costs associated with disposal of contaminated soil.

- **Project Principal, Remediation of a 0.66-acre Parcel in as part of a NYSDEC Brownfield Cleanup Program, Brooklyn, New York.** This project included due diligence environmental assessment and investigation, development of NYSDEC-approved RIWP and RAWP including an active sub-slab depressurization system, and remediation during construction of mixed- use affordable housing developments including full cellar. Also required coordination with NYCHPD and NYCDEP to meet regulatory requirements for funding. Continued support during the Site Management phase includes preparation of Periodic Review Reports and quarterly sampling and monitoring of an active sub-slab depressurization system.
- **Project Principal, Management of NYCOER E-Designation for Hazardous Materials during Excavation and Construction of a Hotel/Residential Building, Manhattanville, New York.** Responsibilities included negotiation with NYCOER to limit additional sampling required for Remedial Investigation, and soil management including performing in situ waste characterization, coordination with soil brokers, and oversight of disposal of 16,000 CY of soil.
- **Project Principal, Real Estate Acquisition Due Diligence for Industrial Properties, Queens and The Bronx, New York.** Prepared Phase I ESAs and designed and implemented Phase II ESAs to meet financing requirements while coordinating with selling parties. Provided technical and strategic support, including remedial cost estimates during short due diligence periods.
- **Project Principal, Redevelopment of Four Properties for a Supportive Housing Development with NYCOER to Address NYCDEP E-Designations, Brooklyn, New York.** Coordination with NYCOER to implement remedial investigation and develop RAP as part of the NYC VCP.
- **Senior Project Manager, Environmental Management of Asbestos Remediation during the Renovation of Nassau Coliseum, Uniondale, New York.** Responsible for coordinating inspections and delineation of ACM, preparing budgetary estimates, and bid support for full abatement. Also includes management of decommissioning and replacement of existing emergency generator UST.
- **Project Manager, Commercial Redevelopment Site, The Bronx.** Project work includes in situ waste characterization, management and coordination of excavation, community air monitoring, and development of NYCDEP-approved RAP.
- **Client Liaison and Full-time On-site Construction Manager, Redevelopment Site, Rego Park, New York.** Collection of 500 in situ waste characterization soil samples, oversight of 250,000 cubic yards of soil excavation and remediation, development of post-remediation sampling plan, and organization of waste manifests and hazardous waste documents to ensure proper disposal. Coordination of daily site activities with multiple construction contractors and other involved parties on behalf of client. Oversight and confirmatory soil sampling for on-site treatment of 75,000 cubic yards of hazardous lead-contaminated soil.
- **Project and Field Manager, Phase I and Phase II ESAs on a Portfolio of Retail Gasoline Stations, New York and New Jersey.** Responsibilities included drilling and sampling oversight and health and safety management, as well as writing Phase II ESA reports for over 40 sites.
- **Field Manager, Remediation System Installation, Brooklyn, New York.** Responsibilities included daily oversight of contractors excavating soil and installing piping within streets and sidewalks. Ensured compliance with client-specific Health and Safety Completed daily health and safety meeting and reports and attended weekly construction progress meetings.
- **Field Manager, Quarterly Groundwater Sampling Rounds at a Former Pesticides Manufacturing Facility, Dayton, New Jersey.** Responsibilities include direction of multiple sampling teams and coordination with subcontractors.
- **Field Manager, Site Investigation Activities at a Redevelopment Site, Staten Island, New York.** Responsible for oversight of subcontractor performing soil borings and soil and groundwater sampling.
- **Field Manager, Groundwater Monitoring Rounds at Former Oil and Fuel Distribution Terminals, Staten Island, Westchester, Glen Cove, and Oceanside, New York.** Activities include system operations and maintenance, supervision of multiple field personnel, performing water levels gauging, and collection of groundwater samples from site monitoring wells using a variety of equipment.
- **Field Manager, Site Investigation at a Former Chemical Manufacturer, Brooklyn, New York.** Responsibilities included oversight of subcontractor installation of monitoring wells, collection of soil and groundwater samples, and logging soil lithology.
- **Field Manager, Annual Groundwater Sampling at a Chemical Manufacturing Superfund Site, Delaware.** Involves the oversight and supervision of multiple teams of personnel for a weeklong gauging and sampling round.
- **Field Manager, Underground Storage Tank Closure, Queens, New York.** Provided health and safety supervision, collection of soil and groundwater samples, and oversight of subcontractor closure activities on behalf of client.
- **Field Manager, Long-term Remediation Project for the City of New York.** Includes quarterly groundwater sampling and soil vapor sampling as part of an NYSDEC-approved work plan, as well as oversight of soil sampling as part of subsurface investigations. Creation of tables and figures based on investigation results and as part of periodic reports submitted to NYSDEC.

- **Field Manager, Off-site Investigation at a Former Chemical Production Facility in Rensselaer, New York.** Investigation included the installation of piezometers, monitoring wells, and soil gas and environmental health and safety oversight.
- **Project and Field Manager, Implementation of a Phase II ESA Large Ongoing Redevelopment Project, New York.** Responsibilities included coordination and oversight of drilling, sampling, and excavation of soil. Drilling methods included sonic rotary, Geoprobe, hollow-stem auger, and air hammer/split spoon sampling. Includes oversight of Phase II ESA and waste characterization activities, coordination with laboratory contacts, as well as synthesis of lithology logs for over 100 soil borings. Project includes completion of Phase II ESAs (sampling of soil, groundwater, and soil gas) for over 50 properties.
- **Project and Field Manager, Brooklyn, New York.** Responsible for implementing and managing remediation work at several NYSDEC spill sites within the footprint of a large redevelopment project. Responsibilities included management and oversight of in situ chemical oxidation for treatment of petroleum-impacted groundwater.
- **Field Manager, Redevelopment Site, New Jersey.** Collection of waste characterization soil samples, post excavation confirmatory sampling, and groundwater off-site discharge sampling.

PROFESSIONAL TRAININGS

OSHA 40-Hour HAZWOPER Training, 2005

OSHA 10-Hour Construction Safety Training, 2008

PROFESSIONAL PROFILE



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EDUCATION
BS, Marine Science, Coastal Carolina University, 2011
MS, Environmental Studies, College of Charleston, 2013

Levi Curnutte

Senior Scientist I

EXPERIENCE SUMMARY
Twelve years of experience: Staff Scientist, Project Scientist, and Senior Scientist I at Roux, Islandia, New York.

TECHNICAL SPECIALTIES
Design, implementation, and management of remedial investigations and remedial actions for real estate and industrial sites in regulatory programs, including the New York State Department of Environmental Conservation (NYSDEC) Brownfields Cleanup Program (BCP), New York City Office of Environmental Remediation (NYCOER) E-Designation and Voluntary Cleanup Programs, New York City Department of Environmental Protection (NYCDEP), and New York State Spills Program; management of due diligence Phase I & II Environmental Site Assessments; and management of large-scale soil excavation projects including soil waste characterization implementation and construction, located primarily in the tri-state and surrounding areas. Additional technical skills include waterproofing, vapor barrier, sub-slab ventilation system installation inspections.

REPRESENTATIVE PROJECTS

- Project Manager for a large ongoing redevelopment project in Brooklyn, New York, including the Barclay's Center and the relocation of a nine-acre 100 year-old active rail yard. Project includes management of four buildings with NYCDEP "E" designations and the implementation of Remedial Action Work Plans (RAWPs), *in situ* soil characterization sampling, non-hazardous soil disposal, underground storage tank (UST) removals and NYSDEC spill remediation at multiple sites, and Site Management Plan (SMP) O&M task implementation. Achieved an NYCOER Notice of Satisfactions for all four properties. Agency support for NYSDEC, NYCDEP, NYCOER, MTA (LIRR/NYCT), and ESDC.

- Project Manager providing support for all soil and groundwater disturbances during development of a large 12.5-acre college campus located on Roosevelt Island, New York, New York. Management tasks include Agency support for NYCDEP and NYSDEC, CAMP and SWPPP implementation, soil characterization for reuse and disposal, UST removal adhering to NYSDEC regulations, asbestos abatement coordination, and submission of a NYCDEP Remedial Closure Report. Received NYCDEP letters of completion for all remedial activity requirements set forth for the site.

- Project Manager for remediation of a 1-acre parcel in the Sunset Park section of Brooklyn, New York. Site was issued RCRA Consent Decree violations and entered the NYSDEC BCP to satisfy violations and remediation requirements. This project included preparation of BCP Application submission, robust due-diligence environmental assessment and investigation, and development of NYSDEC-approved Remedial Investigation, Interim Remedial Measures, and Remedial Action Work Plans as well as Beneficial Use Determination (BUD) Application. Remedial actions included removal of hazardous and non-hazardous waste, *in situ* chemical oxidation (ISCO) application for groundwater remediation, and UST removal and NYSDEC spill remediation. Redevelopment will feature construction of office space and a large parking garage for use as commercial vehicle fleet storage and maintenance.

- Project Manager for on-going SMP O&M tasks and Field Manager for RAWP implementation at a NYSDEC BCP site in the Williamsburg neighborhood of Brooklyn, New York, completing extensive remediation of chlorinated VOC-impacted soil and groundwater to accommodate development of a mix-used building and underground parking garage. Primary contaminants of concern were PCE and TCE. Project responsibilities include management of zero-valent iron injections (ZVI) for a permeable reactive barrier (PRB), installation of SSDS,

waterproofing/vapor barrier inspections, groundwater monitoring and sampling, CAMP, coordination and tracking of hazardous and non-hazardous waste, and providing contractor work zone health and safety recommendations/oversight in accordance with OSHA guidance. Key contributor in the submissions of the Periodic, Annual, and Final Engineering Reports submitted to NYSDEC leading to Certificate of Completion. Project received by the NYC Brownfield Partnership's 2017 Big Apple Brownfield Award for Innovation. Project lead for maintaining compliance with ongoing SMP O&M and reporting requirements.

- Project Manager for remediation of two parcels in Queens, New York as part of NYSDEC BCP containing petroleum compounds and hazardous concentrations of heavy metals. This project included preparation of BCP Application submission, due-diligence environmental assessment and investigation, in situ waste characterization design and implementation, development of NYSDEC-approved Remedial Investigation Work Plans and RAWPs, and future remediation during construction of two mixed-use, affordable housing developments. Also required coordination with NYCHPD and NYCDEP to meet regulatory requirements for funding.
- Project Manager for an affordable housing redevelopment site in NYSDEC BCP in Brooklyn, New York also under NYCDEP oversight. The Site was formally used by Brooklyn Water Works and an automobile repair facility and contaminants of concern are petroleum compounds in soil and chlorinated solvents in soil gas. Project management roles include BCP Application submission, due-diligence assessment, and investigation activities, in situ waste characterization design and implementation, development of NYCDEP- and NYSDEC-approved Remedial Investigation and Remedial Action Work Plans. A conditional Track 1 Cleanup was completed for the site.
- Project Manager for former Manufactured Gas Plant (MGP) site in Gowanus neighborhood of Brooklyn, New York. Under NYSDEC regulation, O&M responsibilities include coordination of monitoring of recovery wells known to be former and current producers of coal tar (DNAPL) and DNAPL recovery and disposal and associated reporting.
- Project Manager for an 85-acre commercial site within the NYCOER Voluntary Cleanup Program (VCP) undergoing a 500K sq. ft. mall expansion. Project involved the construction of an adjacent building to the existing mall and a new above-grade parking structure. Manager for RAWP implementation and production of multiple Remedial Action Reports leading to two NYCOER Notices of Satisfactions for the client to date.
- Project Manager for six separate sites with NYCDEP "E" designations that are part of a large 21-acre affordable redevelopment project in Brownsville neighborhood of Brooklyn, New York. All sites are under NYCOER regulation with one site enrolled in the VCP. Project management includes NYCOER enrollment, design and implementation of remedial investigations and assessments, design, and implementation of Remedial Action Work Plans, in situ soil characterization sampling and soil removal (including hazardous soil), opening of a NYSDEC Spill and closure, and UST removal adhering to NYSDEC regulations. To date, NYCOER Notices of Satisfaction have been obtained for three of the sites.
- Project Manager for remedial investigation of a previously abandoned oil-water separator located at a NYSDEC-regulated 175-acre former petroleum refinery and terminal in Brooklyn, New York to delineate residual contamination. Responsibilities included the management of all field tasks, site management, property owner and tenant coordination, and investigation report.
- Project Manager for ongoing long-term O&M support and Field Manager for RAWP implementation at a NYSDEC BCP site in the Brownsville neighborhood of Brooklyn, New York. Previous use as a dry cleaner left residual contamination of PCE and TCE in soil and groundwater. Field management of remediation of chlorinated VOC-impacted soil and groundwater including source excavation and tracking of hazardous and non-hazardous waste, potassium permanganate (KMnO4) injections for groundwater treatment, installation of soil vapor extraction wells, groundwater monitoring and sampling, and CAMP.
- Field Manager of subset of field operations for a large scale, high profile investigation of 500 residential and sensitive-use properties located throughout Los Angeles County. As a result of lengthy aerial depositions of emissions originating from a former battery recycling facility in Vernon, California, soil was analyzed in situ for lead contamination on a real-time basis through the use of X-ray fluorescence (XRF) instruments. Helped coordinate and perform the rapid assessment of soils by multiple teams while under heavy scrutiny by the press, regulators, and homeowners.

PROFESSIONAL TRAININGS

OSHA 40-hour HAZWOPER Training

OSHA NYC Site Safety Training (SST) Certified

OSHA 8-hour HAZWOPER Refresher Training, Certificate Current

NYCOER Gold Certified Professional

PUBLICATIONS

Climate Change and Bemisia tabaci (Hemiptera: Aleyrodidae): Impacts of Temperature and Carbon Dioxide on Life History. Curnutte, L., Simmons, A. M., and S. Abd-Rabou. Ann. Ent. Soc. Amer. 107(5): 933-943. 2014.

JUDY V. HARRY
P. O. Box 208
120 Cobble Creek Rd.
North Creek, NY 12853

Occupation: Data Validator/Environmental Technical Consultant

Years Experience: 45

Education: B.S., Chemistry, Magna cum laude, 1976, Phi Beta Kappa

Certifications: New York State Woman-Owned Business Enterprise (WBE)

Relevant Work History:

Data Validation Services: September 1989 - present

Sole proprietor of Data Validation Services, a woman-owned small business registered with SAM, providing consultation/validation services to regulatory and commercial clients.

These services include the review of analytical laboratory data for compliance with respect to specific protocols, accuracy and defensibility of data, verification of reported values, and evaluation of quality parameters for analytical usability of results. Approved by USEPA, NYSDEC, NJDEP, NYSERDA, and NYCDEP as a data validator for projects, including USEPA Superfund, Brownfield, and lead sites, and those contracted through the NYSDEC Division of Hazardous Waste Remediation, Division of Solid Waste, and Division of Water Quality.

Performed validation for compliance with laboratory analytical protocols including USEPA OLM, USEPA OLC, USEPA ILM, USEPA DFLM, USEPA SOW3/90, USEPA SOW 7/87 CLP, USEPA SOW 2/88 CLP, USEPA SW846, RCRA, AFCEE, NYS 6 NYCRR Part 360, 40 CFR, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, including TO-15, 1989/1991/1995/2000/2005 NYSDEC ASPs, and 1987 NYSDEC CLP.

Performed validation according to the USEPA National and Regional SOPs and Functional Guidelines, AFCEE requirements, NYSDEC Validation Scope of Work, NYS DUSR, and NJDEP Division of Hazardous Site Mitigation/Publicly Funded Site Remediation SOPs.

Performed validation for USEPA Superfund Sites including Salem Acres, York Oil, Port Washington L-4 Landfill, Bridgeport Rental and Oil Services, GE-MRFA, MMR/ OTIS AFB, LCP, and Peter Cooper site; and for USEPA lead sites including SJ&J Piconne, Maska, Bowe System, Jones Sanitation, and Syossett Landfill, involving CLP, RAS, and SAS protocols.

Contracted for NYSDEC Superfund Standby Contracts with LMS Engineers/HDR, CDM Smith, Malcolm-Pirnie/ARCADIS, Ecology & Environment, Shaw Environmental/APTIM, CG&I, O'Brien & Gere Engineers, and EC Jordan, involving samples collected at NYS Superfund Sites and analyzed under the NYSDEC ASP.

Performed validation services for NYSDEC Phase II remedial investigations, RI/FS projects, Brownfield sites, and PRP over-site projects for hazardous waste sites.

Performed validation services for clients conducting RI/FS activities involving samples of many matrices, including waste, air, sludges, leachates, solids/sediments, aqueous, and biota.

Clients have included AECOM, ARCADIS, Barton & Loguidice, Benchmark Engineering, Bergmann Associates, Blasland, Bouck & Lee, Brown and Caldwell, CDM Smith, CB&I Shaw Environmental, C&S Consulting Engineers, Chazen Companies, Clough Harbour & Associates, Columbia Analytical Services, C.T. Male, Dames & Moore, Day Engineering, EA Engineering, EcolSciences, Ecology & Environment, Ecosystems, EC Jordan, Environmental Chemical Corporation, EHRT, ENSR Consulting, ELM, ERM-Northeast, Fagan Engineers, Fanning Phillips & Molnar, FluorDaniel GTI, Frontier, Foster Wheeler Environmental Corp, Frontier Technical, Galson Consultants, GEI, GE&R, Geomatrix Consultants, GZA Environmental, Handex of N, Hazard Evaluations, H2M Group, HDR, HRP, IT Corp, Jacques Whitford, JTM Associates, JMT, Labella Associates, Langan Engineers, Leader Environmental, Lockwood, Kessler & Bartlett, LMS Engineers, Malcolm-Pirnie, Metcalf & Eddy, NWEC&C, O'Brien & Gere Engineers, Pace, Parsons Engineering-Science, Plumley Engineering, Prescott Environmental, P. W. Grosser, Rizzo Associates, Roux Associates, Sear Brown Group, SECOR, Shaw Environmental, Stantec, ThermoRemediation Inc., TRC Environmental, Turnkey Environmental Restoration, TVGA Engineering, URS Consultants, Wehran Emcon, Weston, Wittman Geosciences, YEC, and private firms.

Provided consultation services to laboratories regarding analytical procedures and protocol interpretation, and to law firms for litigation support.

Provided services to firms involving audits of environmental analytical laboratories to determine analytical capability, particularly for compliance with NYSDEC ASP and AFCEE requirements.

Guest speaker on a panel discussing Data Review/Compliance and Usability, for an analysis workshop for the New York Association of Approved Environmental Laboratories, 1993.

Adirondack Environmental Services: June 1987 - August 1989

Senior mass spectroscopist for AES. Responsible for GC/MS analyses of environmental samples by USEPA and NYSDEC protocols, development of the GC/MS laboratory, initiating the instrumental and computer operations from the point of installation, and for implementing the procedures and methodologies for Contract Laboratory Protocol.

CompuChem Laboratories: May 1982 - January 1987

Managed a GC/MS production laboratory; developed, implemented, and supervised QA/QC criteria at three different levels of review; and was responsible for the development and production of the analysis of environmental and clinical samples. Directed a staff of 23 technical and clerical personnel, and managed the extraction and GC/MS labs and data review operations.

Research Triangle Institute (RTI): December 1979 - May 1982

Worked as an analytical research chemist responsible for development of analytical methods for the EPA Federal Register at RTI. This involved analysis of biological and environmental samples for priority pollutants, primarily relating to wastewaters and to human sampling studies. Method development included modification and interfacing of the initially developed Tekmar volatile purge apparatus to GC/MS, development and refinement of methods for entrapment and concentration of the air medium for subsequent volatile analysis, and the analysis and resolution/ identification of individual PCB congeners within Aroclor mixtures by capillary column and mass spectra.

Guardsman Chemical Company: February 1977 - November 1979

Performed all quality control functions for the manufacturing plant. Performed research and development on coatings and dyes.

Almay Cosmetics: May 1976 - December 1976

Product evaluation chemist. Responsible for analytical QC of manufactured products.

Publication

Pellizzzari, E.D., Moseley, M.A., Cooper, S.D., Harry, J.V., Demian, B., & Mullin, M. D. (1985). Recent Advances in the Analysis of Polychlorinated Biphenyls in Environmental and Biological Media. *Journal of Chromatography*, 334(3) 277-314.

ATTACHMENT 2

Laboratory's Standard Operating Procedures

1,4-Dioxane

By Gas Chromatography / Mass Spectrometry in Selected Ion Mode (GC/MS-SIM) with Isotope Dilution Modification

References:

EPA 8270E, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Revision VI (Phase II), June 2018.

EPA 8000C, SW-846,Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846. Update III, March 2003.

1,4-Dioxane Analytical Notes, Appendix II-B-4, WSC-CAM-II-B, Revision 1, July 2010, (Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup).

1. Scope and Application

Matrices: Aqueous, soil/sediment and non-aqueous waste matrices

Definitions: Refer to Alpha Analytical Quality Manual.

This method is applicable to the quantification of 1,4-Dioxane extracted from aqueous samples in methylene chloride and analyzed by GC/MS-SIM. The extraction method is listed below and should be referenced for more details. Detection limits will vary with instrument calibration range, and volume of sample analyzed. 1,4-Dioxane detected over the calibration ranges of the instrument it is being analyzed on will be diluted and re-analyzed for accurate quantification.

The following extraction method applies:

- *Extraction of Water Samples by Separatory Funnel* (SOP 2165)
- *Microscale Solvent Extraction (MSE)* (SOP 2172)
- *Organic Waste Dilution Extraction* (SOP 2265)

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the GC/MS-SIM and in the interpretation of GC/MS-SIM data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

250mL, 500mL or 1000mL of aqueous samples are serially extracted with methylene chloride in a 2 Liter Separatory Funnel (Method 3510) at a neutral pH. The extract is concentrated in MeCl2 to a 2.5mL to 10mL final volume respectively depending on the volume of sample extracted. Soil/sediment samples are extracted by Microscale Solvent Extraction (MSE Method 3570). Approximately 5g of sample is extracted and concentrated to a 4mL final volume. Non-aqueous waste samples are extracted by Organic Waste Dilution Extraction (Method 3580). Approximately 1g is diluted to 10mL

final volume.

Analytes are introduced into the GC/MS using a large volume injector and injecting 3ul of the calibration standards, quality control samples, and sample extracts into the GC equipped with a narrow-bore capillary column. The GC column is temperature programmed to separate the analytes, which are then detected with a mass spectrometer (MS) in selective ion mode. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact spectra of the calibration standards. Concentrations are determined using mean relative response factors from a multi-level calibration curve. Response factors for target analytes and surrogate compounds are determined relative to the internal standards.

Isotope dilution quantification is achieved by spiking 1,4-Dioxane-d8 at extraction which is then in turn used as both an internal standard (IS) and surrogate. For quantification, the 1,4-Dioxane-d8 IS quantifies 1,4-Dioxane in samples. An additional IS added prior to analysis, 1,4-Dichlorobenzene-d4, quantifies 1,4-Dioxane-d8 as a surrogate.

2.1 Method Modifications from Reference

SIM option with Isotope dilution is utilized to increase sensitivity for this analyte. Note that while this method may be used for the evaluation of 1,4-Dioxane in soil/sediment samples, the MA DEP CAM does not approve of this method for determining presumptive certainty for MA DEP cleanup sites. Method 8260 should be employed in these cases.

3. Reporting Limits

Concentrations for 1,4-Dioxane can be detected in water samples in the range of 150ng/L to 100,000ng/L. Soil/sediment samples can be detected in the range of 8ug/Kg to 8,000ug/Kg. Standard reporting limits for aqueous samples are 150ng/L and for soil/sediment samples 8ug/kg respectively.

4. Interferences

4.1 Phthalate esters can be a major source of contamination if any material containing plasticizers (phthalates) comes in contact with the sample during the extraction process. Use of plastic or any material containing plasticizers (phthalates) should be avoided during extraction or analysis.

4.2 The injection port of the gas chromatograph can become contaminated with high boiling compounds resulting in the loss of sensitivity. It may be necessary to replace the injection port liner routinely to prevent this loss of sensitivity. Clipping off approximately four inches of the column at the injection end may also increase sensitivity. Low instrument response can be detected during the daily tuning procedure by including pentachlorophenol and benzidine in the daily tuning mix.

4.3 Raw GC/MS data from all blanks, samples, and spikes must be evaluated for interferences or carryover. Contamination by carryover can occur whenever high-concentration and low-concentration samples are sequentially analyzed.

4.4 Solvents, reagents and glassware may introduce interferences. These must be demonstrated to be free of interferences by the analysis of a method blank. See the SOP *Reagent, Solvent and Standard Control* (G-008) and *Laboratory Glassware Cleaning* (G-002), for additional details.

4.5 It should be noted that there are some chromatographic consequences observed due to the acetone used in the MSE extraction process. This is characterized by a shift in retention time

for 1,4-Dioxane and the 1,4-Dioxane-d8 surrogate (~0.4minutes), as well as the presence of a large peak (likely acetone) in all chromatograms.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Solid samples; A minimum of 100grams of sample must be collected in a glass jar with a Teflon lined screw cap.

Water samples: A minimum of 0.25 to 1 liters of sample must be collected in amber glass bottles.

6.2 Sample Preservation

Solid samples: The sample must be refrigerated and maintained at 4±2 °C until extraction and analysis. Sediment samples can be frozen at -20±5 °C until extraction to extend hold time. The extracts must be refrigerated and maintained at 4±2 °C until analysis.

Water samples: The samples must not be preserved except by refrigeration at 4±2 °C until extraction and analysis. The extracts must be refrigerated and maintained at 4±2 °C until analysis.

Non-aqueous waste samples: Concentrated sample extracts must be stored in contaminant-free containers and preserved in a refrigerator when not used for more than four hours.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Solid samples: All solid samples must be extracted within 14 days from the date of collection. Frozen sample hold times are monitored up to 14 days from the date removed from freezer. The extracts must be refrigerated and maintained at 4±2 °C until analysis. Sample extracts must be analyzed within 40 days from date of extraction.

Water samples: All water samples must be extracted within 7 days from the date of collection. Sample extracts must be analyzed within 40 days from date of extraction.

Non-aqueous waste samples: Hold times do not apply to neat oils/NAPL/product samples.

7. Equipment and Supplies

7.1 Gas chromatograph – Programmable, heating range from 40C to 350C; splitless-type inlet system, (Hewlett Packard 6890N Series II or similar); mass selective detector (Hewlett Packard 5973, or similar); automatic injector (Hewlett Packard 7683B or similar).

7.2 Chromatography Column – Fused silica capillary column, 0.25mm ID x 60m length, 0.25um film thickness RTX-5, Restek Corporation, 5% diphenyl-95% dimethyl polysiloxane, Fused silica capillary column, 0.18mm ID x 60m length, 0.18um film thickness RTX-PCB, Restek Corporation, Fused silica capillary column, 0.25mm ID x 30m length, .25um film thickness (Zebron ZB-SemiVolatiles, Phenomenex Corporation, 5% Polysilarylene - 95% Polydimethylsiloxane) , or equivalent.

7.3 Gerstel Large Volume Injection System – Temperature programmable range from 0C to 350C; pressure programmable; capable of split or splitless injection; Injection volumes range from 1 to 50uL and Cryo cooling availability to allow for cold injections.

7.4 Agilent Split/Splitless injector System

7.5 Data Acquisition System - Computerized system for collecting, storing, and processing detector output (Hewlett Packard Enviroquant target software) or equivalent.

7.6 Gases - BIP Ultra high purity helium (99.9995%); Compressed nitrogen for N-Evap. Carbon dioxide (siphon type) for Gerstel.

7.7 Syringes – 10uL to 1.0mL

7.8 Vials- including 2ml, 4ml, 10ml, 40ml and other sizes as necessary.

7.9 Hamilton Gas tight Syringes - varying sizes

7.10 Gerstel Single baffle injection port liners- packed lightly with glass wool.

7.11 GC Injection Port Liner: Phenomenex Direct Connect Top Hole

7.12 Class A Volumetric flasks: Including 10ml, 20 ml, 50 ml, 100ml and other sizes as necessary

8. Reagents and Standards

Use reagent grade chemicals for all reagents. Deionized (DI) water is ASTM Type II laboratory reagent grade water.

8.1 Solvents: All solvent expirations determined as indicated by manufacturer guidelines

8.1.1 Methylene Chloride, ACS approved, Pesticide grade, see SOP *Reagent, Solvent and Standard Control* (SOP 1816) for additional details regarding solvent purity. Used to extract samples and prepare instrument/analytical standards.

8.1.2 Acetone, ACS approved, Pesticide grade, see SOP *Reagent, Solvent and Standard Control* (SOP 1816) for additional details regarding solvent purity. This water soluble solvent is used for surrogate and LCS/MS preparation.

8.1.3 Methanol, ACS approved, Pesticide grade, *Reagent, Solvent and Standard Control SOP* (SOP 1816) for additional details regarding solvent purity.

8.2 Analytical Standards: Standards should be stored at –10C or less, away from light when not in use. They should be discarded after 1 year unless the vendor expiration date states otherwise or, if degradation is observed. Stock standards are given a 1 year expiration from the preparation date or the expiration of the primary vendor solution, whichever occurs first. Working standards are given six month expiration from the preparation date or the expiration of the primary solution whichever occurs first. All analytical standards are made up in Methylene Chloride. All prep standards are made up in Acetone.

8.3 Surrogate/Internal Standard (IS):

8.3.1 A 1,4-Dioxane-d8 Primary neat standard is commercially obtained from Cambridge Isotope (Cat #DLM-28-10 or equivalent). A stock surrogate/internal standard solution is prepared by weighing 0.1 g of the primary neat standard and diluting volumetrically in 10 mls methylene chloride (or equivalent preparation) to obtain a concentration of ~10,000 ug/ml.

8.3.2 From this stock (Section 8.3.1), the Surrogate spiking solution is made by a serial dilution (1 ml diluted up in a 50 ml volumetric flask, followed by a 0.5 ml of this solution diluted up in a 20 ml volumetric flask or equivalent preparations) in Acetone to achieve a concentration of 5 ug/mL. Of this surrogate solution, 1 mL is spiked into each water sample, and 0.4 mL is spiked into each soil/sediment sample for a surrogate/IS concentration of 500 ng/mL in samples.

8.3.3 The initial stock solution (Section 8.3.1) is diluted volumetrically (250 uL diluted up in a 100 ml volumetric flask or equivalent preparation) in methylene chloride to obtain an IS solution at a concentration of 25 ug/ml for the spiking of only the analytical standards (i.e. calibration curve and continuing calibration).

8.4 Internal Standard: 1,4-Dichlorobenzene-d4 commercially obtained from Restek (Cat #31206 or equivalent). This primary solution is at 2000 ug/mL and contains other Semivolatile Internal standards, however this method only utilizes the 1,4-Dichlorobenzene-d4. This solution is diluted volumetrically (250 uL diluted up in a 50 ml volumetric flask or equivalent preparation) in methylene chloride to obtain a SIM-IS solution at a concentration of 25 ug/ml. All samples and standards are spiked with 20uL of internal standard before analysis. This IS is intended to be used for both quantitation (of the surrogate 1,4-Dioxane-d8) and the establishment of relative retention times.

8.5 Matrix Spike/Laboratory Control Spike Solutions (MS/LCS) – 1,4-Dioxane primary spike solution is commercially obtained from Restek at 2000 ug/mL (Cat #31853 or equivalent). To prepare the working spike solution, syringe measure 0.25 mL of stock and bring to 100 mL in acetone (or equivalent preparation) for a 5 ug/mL concentration. From this solution, 1 mL is spiked into each MS/LCS QC water sample and 0.4 mL is spiked into each soil/sediment sample. The final concentration in a 10 mL water extract and in a 4 mL soil/sediment sample will be 500 ng/mL.

8.6 Stock Calibration Standards are prepared from a primary standard commercially obtained from Restek at a concentration of 2000 ug/ml (Cat #31853 or equivalent). The primary standard is used to appropriately prepare a stock standard at a concentration of 10,000 ng/ml (125 uL diluted up in a 25 ml volumetric flask or equivalent preparation). The stock solution is generally made up in 25 ml increments. The stock solution then doubles as a high level standard for the calibration curve, as well as a stock solution by which to serially dilute to prepare the other calibration standards. Except for the high level standard, the calibration curve levels are generally each made at 10 ml. Refer to the table below for example calibration curve levels. All the calibration curve levels, once aliquoted at 1 ml increments for injection, have 20 ul of 1,4

Dichlorobenzene IS (SIM IS – Section 8.4) added as well as 20 uL of 1,4 Dioxane-d8 IS/Surrogate (Section 8.3.3) added.

8.7 Curve Preparation: The following 7 levels are the possible levels that can be analyzed for an ICAL.

Calibration Level	*Volume of Stock Std Added Into 10 ml of DCM*
Level 1 (10 ng/mL)	10 uL
Level 2 (50 ng/mL)	50 uL
Level 3 (100 ng/mL)	100 uL
Level 4 (500 ng/mL)	500 uL
Level 5 (1000 ng/mL) - CCV	1.0 mL
Level 6 (5000 ng/mL)	5.0 mL
Level 7 (10,000 ng/mL)	NA

8.8 The Independent Check Verification Standard is prepared from a Primary standard solution commercially obtained from Ultra (Cat NV-150-1 or equivalent) at a concentration of 100 ug/ml. The primary solution is diluted volumetrically (100 ul diluted up in a 10 ml volumetric flask or equivalent preparation) in methylene chloride to create a working ICV solution at a concentration of 1000 ng/ml. The working ICV solution is aliquoted into 1 ml increments as needed to inject with each calibration curve. Additionally, 20 ul of SIM IS (Section 8.4) and 20 ul of 1,4-Dioxane-d8 IS (Section 8.3.3) is added into the 1 ml aliquot.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

A method blank must be prepared once per every 20 samples or per extraction batch, whichever is more frequent.

Organic compounds of interest must not be detectable in the method blank at a concentration greater than the reporting limit.

Corrective Action: For contaminated blanks, all efforts must be made to identify and eliminate the source of contamination. The presence of analytes at concentrations at or above the reporting limit will warrant application of a “B” qualifier to that target compound(s) on all associated report forms, and perhaps re-extraction of all associated samples. Re-extraction of the method blank and all associated samples must be performed until the blank is in control. Surrogate recoveries must meet the QC limits for the method blank. Re-extraction must be initiated immediately so that minimum time is wasted before re-extraction can occur - if at all possible-this re-extraction should take place within holding time. Re-extraction *corrective action* that would exceed the sample holding time criteria should be discussed with the Organics Supervisor, Project Manager, client, and Operations Manager prior to implementation. Exceptions may be made with approval of the Organics Section Supervisor if the samples associated with an out of control method blank are non-detect for the affected compound(s) or if the concentration of the affected compound(s)in the sample is greater than 10x the blank level. In such cases, the sample results are accepted without corrective action for the high method blank result. The client must be notified, via the project narrative, of any method blank non-compliance associated with sample results

9.2 Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)

Laboratory control samples (LCS/LCSD) must be prepared once per every 20 samples or per extraction batch, whichever is more frequent, and spiked with 1,4 Dioxane spike solution (Section 8.5) and surrogate (Section 8.3.2) before extraction. The IS (Section 8.4) is spiked after extraction and before the analysis.

Acceptable Recovery limits are 40% - 140%. The relative percent difference (RPD) between the LCS/LCSD is 30%. Limits are adapted from MCP protocol and are generally monitored and documented in-house through control charts.

Corrective Action: Analysis must be repeated if an analytical error is suspected. If the LCS/LCSD recoveries and/or %RPD are still out of control, re-extract and re-analyze the LCS/LCSD and all associated samples. Samples cannot be reported until an acceptable LCS is obtained.

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.2.

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4.

9.5 Matrix Spike / Matrix Spike Duplicate (MS/MSD)

Matrix spike / matrix spike duplicate (MS/MSD) samples are performed upon project specifications. They are performed per client request. The sample is spiked with 1,4-Dioxane spike solution (Section 8.5) and surrogate (Section 8.3.2) before extraction. The IS (Section 8.4) is spiked after extraction and before the analysis. The recovery limits are 40% - 140% and the RPD limit is 30%. Limits are adapted from MCP protocol and are generally monitored and documented in-house through control charts.

Corrective Action: Analysis must be repeated if an analytical error is suspected. If the % recovery and/or %RPD still exceeds the control limits and the LCS/LCSD is compliant; include a project narrative with the results to client noting that there may be potential matrix effects on the accuracy or precision of the reported results as evidenced by MS/MSD recoveries and/or %RPD outside of QC limits.

9.6 Laboratory Duplicate

Duplicate analyses are performed upon client and/or workplan request. *For Organic analyses, the matrix duplicate is usually in the form of the matrix spike duplicate, see Section 9.5.*

Acceptable relative percent difference (RPD) of duplicates is 30%. Acceptance criterion is not applicable to sample concentrations less than 5 times the reporting limit. Calculate the RPD as follows:

$$RPD = \frac{R1 - R2}{\frac{[R1 + R2]}{2}} \times 100$$

where:

R1 = sample Replicate #1
R2 = sample Replicate #2

The RPD limits should be monitored and documented in-house through control charts and updated as needed.

Corrective Action: Analysis must be repeated if an analytical error is suspected.. If the % RPD still exceeds the control limits; include a project narrative with the results to client noting that there may be potential matrix effects on the precision of the reported results as evidenced by the matrix duplicate % RPD exceedence.

9.7 Method-specific Quality Control Samples

9.7.1 Surrogates

Surrogate spikes (Section 8.3.2 and Section 8.3.3) must be added to QC and field samples to evaluate the extraction method performance.

The acceptable surrogate recovery limits are 15% - 110%. Limits are adapted from MCP protocol.

Corrective Action: Analysis must be repeated if an analytical error is suspected. If the % recovery still exceeds the control limits the sample must be re-extracted and re-analyzed to confirm the sample matrix. If *obvious* matrix interferences are noted, consultation with the Organic Supervisor or Operations Manager may be in order to confirm the need for sample re-extraction. If no re-extraction occurs, the surrogate results and reasons for the decision not to re-extract must be discussed in the project narrative to the client. Due to the isotope dilution nature of this method, the analyst must pay close attention to surrogate recoveries and areas as this recovery is then used to surrogate correct (as an Internal standard) the response of 1,4-Dioxane.

9.7.2 Internal Standards

Internal standards must be added to all sample extracts, QC samples and standards for quantitation purposes. For sample extracts, only the 1,4-Dichlorbenzene-d4 IS (SIM IS – Section 8.4) should be added since the extraction surrogate is then used as an Internal Standard upon analysis. However, all Calibration standards must be spiked with both 1,4-Dichlorobenzene-d4 as well as 1,4-Dioxane-d8 (Section 8.3.3). In the sample extracts the area counts for 1,4-Dioxane-d8 will vary based on the extraction, however the 1,4-Dichlorobenzene-d4 area counts should remain fairly constant. The 1,4-Dichlorobenzene-d4 internal standard should also remain constant with respect to the continuing calibration analyzed at the beginning of the run. Sample IS areas must be –50% to +100% of the Internal Standards in the Continuing Calibration – applies only to 1,4-Dichlorobenzene-d4. Additionally, the IS retention times should not differ more than 30 seconds from the Continuing Calibration.

Corrective Action: Analysis must be repeated once unless there are obvious samples matrix interferences, i.e., the sample extract was very colored and viscous, or there are obvious chromatographic interferences. If *obvious* matrix interferences are noted, consultation with the Organic Supervisor or Operations Manager may be in order to confirm the need for sample re-analysis or re-extraction.

9.8 Method Sequence

- Tune
- CCV
- Method Blank
- LCS
- LCSD
- Samples

10. Procedure

10.1 Equipment Set-up

10.1.1 The instrument used for the analysis is a HP 6890N Series gas chromatograph. The HP system is equipped with a Gerstel large volume injection system, and a 7683B-type autosampler or equivalent. The mass spectrometer is an HP 5973 or 5975 with the HP Enviroquant data system. The method is modified for selective ion monitoring. The table below lists the ions monitored in one SIM window. This method must only be set up and analyzed by an experienced mass spectrometrist.

Compound	*Primary Ion*	*Secondary Ion*
1,4-Dioxane	88	58, 43
1,4-Dioxane-d8	64	96
1,4-Dichlorobenzene-d4	152	115

10.1.2 The basic GC parameters are as follows for the Gerstel Large Volume Injection System:

Oven Equib Time: 0.10 min
Oven Max: 325
Initial Temp.: 45°C
Initial Time: 6.00 min

Level	Rate (°C/min)	Final Temp. (°C)	Final Time (min)
1	19.00	120	1.0
2	11.00	150	1.00
3	19.00	305	4.00

Final Time: 26.83

10.1.3 The basic injection port parameters are as follows for the Gerstel Large Volume Injection System:

"Splitless" mode
Initial Temp: 46 °C
Initial Time: 0.30 min
Ramp Rate: 300°/second
Final Temp: 300°C
Final Time: 30.0
Cryo: ON
Cryo Use temp: 25 °C
Cryo Timeout: 30.0 min
Cryo Fault: ON
Purge Flow: 25 ml/min

Purge Time: 2.50 min
Gas Saver: off
Gas: Helium

Mode: Constant Pressure
Average Velocity: 30cm/sec
Initial flow: 1.3 ml/min

10.1.4 The basic GC parameters are as follows for the Agilent Split/Splitless injector System:

Oven Equib Time: 0.20 min
Oven Max: 325°C
Initial Temp.: 30°C

Level	Rate (°C/min)	Final Temp. (°C)	Final Time (min)
1	0	30	2.00
2	5	50	0.00
3	50	300	2.00

Final Time: 13.00

10.1.5 The basic injection port parameters are as follows for the Agilent Split/Splitless injector System:

:

Mode: Splitless
Temperatuire: 200 °C
Flow: 1.0 mL/min
Velocity: 36.074 cm/sec
Septum Purge: 3mL/min
Purge Flow to Split Vent: 60 mL/min at 0.3 min

10.1.6 MS Acquisition Information:

Tune file: dftpp.u
Acquisition Mode: SIM
Solvent Delay: 7.70 min
MS Source temp: 280°C

10.1.7 Tuning

10.1.7.1 Before the analytical standards are analyzed the mass spectrometer must be adjusted to meet the proper ion criteria for DFTPP. This is demonstrated by injecting into the GC/MS system 1uL of a 50ug/mL DFTPP solution. After the analysis of the DFTPP, evaluate the tune as follows:

- Enter into the “Environmental Data Analysis” (off-line) screen.
- Go to “File” and select the tune data file.
- Go into “Tuner” and select “Eval DFTPP”, then select “AutoFind DFTPP to Screen,” to evaluate the tune file, based on the pre-set SW-846 criteria**.** The software will evaluate the tune by selecting three scans of the DFTPP peak

and will display the ion intensities on the screen. That is, one scan at the apex, one scan directly preceding the apex and one scan following the apex and averages them, then takes one background subtracted scan, 20 seconds before the beginning of the DFTPP peak. If the criteria below are met, repeat, select "AutoFind to Printer", for a hardcopy of the tune evaluation for the record.

If the "AutoFind" tune evaluation does not meet the criteria below, manual evaluation of the tune can be performed by attempting either of the options below:

- Blow up the DFTPP peak on the screen and select either one single scan at the apex of the peak, or a scan immediately preceding or following the apex. Go into "Tuner" and select "Evaluate DFTPP to Screen," or "Evaluate DFTPP to Printer," as described above, OR,
- Take the average of the scans across the entire peak. Go into "Tuner" and select "Evaluate DFTPP to Screen," or "Evaluate DFTPP to Printer," as described above.

10.1.7.2 The following DFTPP mass intensity criteria should be used.

DFTPP KEY MASSES AND ABUNDANCE CRITERIA

Mass	m/z Abundance criteria
51	10-80 percent of mass 198.
68	Less than 2 percent of mass 69.
70	Less than 2 percent of mass 69.
127	10-80 percent of mass 198.
197	Less than 2 percent of mass 198.
198	Base peak, or >50 percent of Mass 442.
199	5-9 percent of mass 198.
275	10-60 percent of mass 198.
365	Greater than 1 percent of mass 198.
441	Present but less than 24 percent of mass 442.
442	Base Peak, or > 50 percent of mass 198.
443	15-24 percent of mass 442.

10.1.8 Tune acceptance should be verified at the beginning of every 12 hour analytical shift. The DFTPP may be combined with the calibration verification standard as long as both tuning and calibration acceptance criteria are met.

10.2 Initial Calibration

10.2.1 After the DFTPP passes criteria, a set of multi-level calibration standards listed in Section 8.7 are analyzed, from low concentration to high. A minimum of five calibration levels are analyzed. The calibration standards are stored in amber vials in the standards freezer. The labeling convention allows each standard to have a unique identifier which distinguishes it from field samples. The naming convention used throughout the laboratory identifies the standard as semivolatile, hydrocarbon, pesticide/PCB or volatile. An example of this would be SW042407E, meaning it is a semivolatile (S) working (W) standard made on April 24, 2007 and that it was the fifth standard made that day. All certificates of analysis that are shipped with standards are filed with their receipt ID written on it to insure traceability.

10.2.2 Once the standards have been analyzed, they are reduced by the search software of the Enviroquant data system. Once all the components are identified, a linear curve is calculated for the components. The criteria for evaluation are as follows:

10.2.2.1 The average RF for each compound must be greater than 0.05.

10.2.2.2 The %RSD of each compound must not exceed 20%. If they do this may be an indication that the chromatographic system is too reactive for analysis to begin. This indicates the instrument may need maintenance.

10.2.2.3 Alternatively, a linear regression model may be employed, provided that the coefficient of determination (COD or r2) is ≥0.99. Otherwise, construct a nonlinear calibration of no more than a third order equation. Statistical considerations in developing a non-linear calibration model require more data than the more traditional linear approach. A quadratic (second order) model requires six standards, and a third order polynomial requires seven standards. In setting model parameters, do not force the line through the origin. The COD or r^2 must be greater than or equal to 0.99.

10.2.2.4 Once the calibration curve is reviewed, an Initial Calibration Checklist must be completed.

10.2.3 All samples and standards are spiked with Internal Standards (IS) before analysis. Refer to section 8.4 for specific internal standard spiking information. The IS is intended to be used for both quantitation and the establishment of relative retention times. Internal standard acceptance criteria can be found in Section 9.7.2.

10.2.4 Independent check standards (Section 8.8) from a separate source or different lot are analyzed after every initial calibration for evaluation against calibration standard solutions. The % Difference (%D) should not be greater than ±30%.

10.3 Equipment Operation and Sample Processing

10.3.1 Tuning

A DFTPP standard must be analyzed and pass criteria before a continuing calibration verification standard or any samples are analyzed. The DFTPP may be combined with the calibration verification standard as long as both tuning and calibration acceptance criteria are met. A DFTPP tune standard must be analyzed before each 12 hour analytical shift. Please refer to Section 10.1.5 for tuning criteria and other information.

10.3.2 Daily Calibration

On a daily basis after the DFTPP has passed, a mid-level (usually 1000 ng/mL) continuing calibration standard which contains all of the analytes of interest is analyzed. The criteria for acceptance are:

10.3.2.1 All analytes must have response factors greater than 0.05.

10.3.2.2 The % D must be ±20% D from the initial calibration.

10.3.3 Sample Analysis

10.3.3.1 The prep lab staff will transfer the samples to the instrument laboratory. The samples are generally brought to a 10 mL final volume for liquids or 4 ml for soil samples; 1 mL is transferred and the remaining sample volume is archived. One aliquot of each sample is then placed in the sample extract holding refrigerator located in the instrument laboratory.

10.3.3.2 All of the samples at 1 mL (including the batch QC samples) are spiked with 20 uL

internal standard (see section 8.4 for specifics regarding the internal standard). The samples are shaken briefly after the internal standard is added to ensure mixing. A sample will need a dilution for target analytes that are over calibration.

10.3.3.3 After the daily tune and CCAL have passed criteria, the analyst places the samples onto the autosampler tray. (Generally, the samples will be analyzed in order of color (lightest to darkest.) with QC samples being analyzed first. The instrument sequence is typed into the HP Chemstation Software. Next run "Simulate Sequence" (also under the "Sequence" dropdown list) without clicking the "Overwrite Files" box. Compare the order of the vials on the instrument versus the sequence to confirm all the samples and standards are in the right places. Next click "Run Sequence" also under the HP Chemstation "Sequence" dropdown list.

10.3.3.4 After the samples have been analyzed, the data files from the MS are quantitated versus the proper quantitation method. The QCPRN1.MAC macro creates a form with which to easily check internal standard and surrogate criteria are met. The following should be reviewed initially:

10.3.3.4.1 Are all the surrogates within QC criteria? Please see Section 9.7.1 for surrogate information.

10.3.3.4.2 Is the internal standard- 1,4 Dichlorobenzene-d4, within 50-200% of the daily CCAL? If not, the samples should be checked for matrix interferences that may be causing these issues. The IS peaks should also be evaluated for peak splitting or incorrect integration by the software. A sample may not need to be reanalyzed if it can be determined (with guidance from a supervisor) that the QC is exceeded due to matrix interference.

10.3.3.4.3 Are all target analytes within calibration range? If not, the sample(s) should be diluted and re-analyzed. If a dilution is performed after the internal standard has already been added, it will be necessary to add additional IS in order to make up for the impact of the original IS added also being diluted. Conversely, if a sample has been over-diluted, it may need to be analyzed at less of a dilution to detect target analytes that may have been diluted out. Note: for this method, due to the isotope dilution, it is necessary to refer to area counts to determine if dilution is required. The area response for 1,4-Dioxane should be compared to the area of the highest level of the ICAL standard for that target. If the area of 1,4-Dioxane in the extract is greater than the area of 1,4-Dioxane in the Highest level of the Calibration Curve, then a dilution is necessary. The analyst **CAN NOT** use the concentration of 1,4-Dioxane found in the extract to determine if dilution is required because the concentration of 1,4-Dioxane in the sample is surrogate corrected in Chemstation based on the use of the extraction surrogate as an Internal Standard. Once it is determined based on the peak area that a sample requires a dilution, the analyst must pay attention to the concentration of IS in the dilution. Although the analyst will adjust the 1,4-Dichlorobenzene-d4 concentration by adding the appropriate amount of additional IS to the dilution, there is no way for the analyst to make up for the dilution of the extraction surrogate 1,4 dioxane-d8 (also used as internal standard). To account for this the analyst must change the concentration of the 1,4-Dioxane-d8 within the calibration table to a value which accounts for the dilution. (Example: If the analyst performs a 10x dilution then the concentration of 1,4-Dioxane–d8 must be changed within the ICAL to 50.) The analyst must ensure that only the diluted sample is calculated against this

value and that the method is returned to the proper concentration once the analysis of the dilution is complete.

10.3.3.4.4 Are all analyses within 12 hour tune time? If a sample is analyzed outside tune time, it will need to be re-analyzed in another tune clock.

10.3.3.4.5 The sequence should also be printed out from Chemstation, initialed and dated, and placed in the logbook.

10.3.3.4.5.1 If anything in the initial review of the data indicates that there should be a re-analysis, the reason for re-analysis should be noted on the sequence.

10.3.3.4.5.2 Also, note the time the tune standard was analyzed, the time of the last sample analysis. If there are samples analyzed outside tune time, the time the last sample within tune time ran should be noted, as well as the last sample analyzed.

10.3.3.4.5.3 If a re-extract is required, the "Request for Repreparation/Reclean" book should be filled out and a photocopy of the appropriate page should be given to the Preparation Group leader or the Organics Section Head.

10.4 Continuing Calibration

Continuing Calibration Criteria is outlined in section 10.3.2

10.5 Preventive Maintenance

If performing any maintenance on any piece of equipment it must be documented in the *Instrument Maintenance Logbook* located in the laboratory specific to each instrument.

Daily

Injection port maintenance: Maintenance should be done when the daily CCAL starts to demonstrate degradation either by %D outliers or area responses <50% as compared to the ICAL areas. Several tune clocks may be injected before maintenance is needed. The type of samples analyzed will have an effect on how soon maintenance should be performed. Injection port maintenance should be done as needed. General maintenance includes replacing the single baffle liner packed lightly with glass wool, cutting about 2-4 inches off the head of the column, and replacing the septa. Refer to maintenance log for more specific information.

The Gerstel Injection port should be handled with care. The liners are quite thin. Do not force the Gerstel weldmen into place as the threads are soft metal and will cross thread. Always make sure the weldmen goes on straight. The Gerstel injection port does not require significant tightening of either the weldmen or column nut, tighten enough to seal but there is no need to crank down on it.

11. Data Evaluation, Calculations and Reporting

11.1 Qualitative Analysis

11.1.1 The qualitative identification of compounds determined by this method is based on retention time and on comparison of 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 defined as the two ions of greatest relative intensity, and are over 30% relative intensity. Compounds are identified when the following criteria are met.

11.1.2 The intensities of the characteristic ions of a compound must maximize in the same scan or within one scan of each other. A peak selected by the data system, based on the presence of target specific ions at a target specific retention time will be accepted as meeting these criteria.

11.1.3 The relative retention time of the sample component is within $\pm$ 0.06 RRT units of the RRT of the standard component.

11.1.4 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%.) The relative intensities are monitored daily. The relative intensities will be updated when they exceed established values from the reference spectrum.

11.1.5 Structural isomers that produce very similar mass spectra should be 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.

11.1.6 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. Selective ion monitoring eliminates this potential.

11.2 Quantitative Analysis

11.2.1 Response factors and % RSD to evaluate Initial Calibration acceptability.

Calculate RF by:

$$RF = \frac{area_{cmp}}{area_{is}} \times \frac{conc_{is}}{conc_{cmp}}$$

where:

area cmp = Area of the characteristic ion for the compound being measured.
area is = Area of the characteristic ion for the specific internal standard.
conc is = Concentration of the specific internal standard.
conc cmp = Concentration of the compound being measured.

Calculate % RSD by:

$$\%RSD = \frac{SD}{\overline{x}} \times 100 \qquad SD = \sqrt{\sum_{i=1}^{N} \frac{(x_i - \overline{x})^2}{N-1}}$$

where:

% RSD = percent relative standard deviation
x = average of RF's
SD = standard deviation
xi = analytical results of each level in the final reporting units
N = number of results (levels)

11.2.2 Calculate % Difference (%D) by:

$$\%D = \frac{\overline{RF}_i - RF_c}{\overline{RF}_i} \times 100$$

where:

RFi - Initial Calibration average RF
RFc = Continuing Calibration RF

11.2.3 Results of Water Analysis - calculation as performed in report form:

$$\text{Concentration (ug/L)} = \frac{(\text{Conc})\ (\text{Vf})\ (\text{DF})}{(\text{Vi})} \times 1000$$

11.2.4 Results of Soil/Sediment Analysis – calculation as performed in report form:

$$\text{Concentration (ug/Kg)} = \frac{(\text{Conc})\ (\text{Vf})\ (\text{DF})}{(\text{Vi})\ \%S} \times 1000$$

where:
Conc = Raw on-column concentration obtained from the quantitation report using Initial Calibration results.
Vf = Final volume of extract (mL)
Vi = Volume of sample extracted (mL), or weight of sample extracted in grams (g)
DF = Dilution factor, for manually prepared dilutions, not instrumental "dilutions".
%S = percent solids, as a decimal

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Section 9.0 outlines sample batch QC acceptance criteria. If non-compliant organic compound results are to be reported, the Organic Section Head and/or the Laboratory Director, and the Operations Manager must approve the reporting of these results. The laboratory Project Manager

shall be notified, and may chose to relay the non-compliance to the client, for approval, or other corrective action, such as re-sampling and re-analysis. The analyst, Data Reviewer, or Department Supervisor performing the secondary review initiates the project narrative, and the narrative must clearly document the non-compliance and provide a reason for acceptance of these results.

All results for the organic compounds of interest are reportable without qualification if extraction and analytical holding times are met, preservation requirements (including cooler temperatures) are met, all QC criteria defined in the table below are met, and matrix interference is not suspected during extraction or analysis of the samples. If any of the below QC parameters are not met, all associated samples must be evaluated for re-extraction and/or re-analysis.

QC Parameter	Acceptance Criteria
Method Blank	No analyte above the reporting limit The results are qualified with a "B" for any associated sample concentrations that are less than 10x the blank concentration for this analyte
Surrogate Recovery	15% - 110%
Laboratory Control Samples	40% - 140% and 30% RPD
Matrix Duplicate	30% RPD
Matrix Spike	40% - 140%
Matrix Spike Duplicate	40% - 140% and 30% RPD

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP 1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP 1732 Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ)
SOP 1739 Demonstration of Capability (DOC) Generation
SOP 1731 Manual Integration & Compound Rejection
SOP 1797 Hazardous Waste and Sample Disposal

SOP 1816 Reagent, Solvent and Standard Control

16. Attachments

None

Method 1633 Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids and Tissue Samples by LC-MS/MS

References: Method 1633 - Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS (2nd Draft - June 2022)

DOD QSM (US Department of Defense Quality Systems Manual for Environmental Laboratories, version 5.4, 20221)

1. Scope and Application

Matrices: Drinking water, Non-potable Water, Tissues, Biosolids and Soil Matrices

Definitions: Refer to Alpha Analytical Quality Manual.

1.1 Method 1633 is for use in the Clean Water Act (CWA) for the determination of the per- and polyfluoroalkyl substances (PFAS) in Table 1 in aqueous, solid (soil, biosolids, sediment) and tissue samples by liquid chromatography/mass spectrometry (LC-MS/MS).

1.2 The method calibrates and quantifies PFAS analytes using isotopically labeled standards. Where linear and branched isomers are present in the sample and either qualitative or quantitative standards containing branched and linear isomers are commercially available, the PFAS analyte is reported as a single analyte consisting of the sum of the linear and branched isomer concentrations

1.3 This is a liquid chromatography/tandem mass spectrometry (LC/MS/MS) method for the determination of selected perfluorinated alkyl substances (PFAS) in Non-Drinking Water, tissue soil and biosolid Matrices. Accuracy and precision data have been generated for the compounds listed in Table 1.

1.4 The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

1.5 This method is restricted to use by or under the supervision of analysts experienced in the operation of the LC/MS/MS and in the interpretation of LC/MS/MS data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

2.1 Environmental samples are prepared and extracted using method-specific procedures. Sample extracts are subjected to cleanup procedures designed to remove interferences. Analyses of the sample extracts are conducted by LC-MS/MS in the multiple reaction monitoring (MRM) mode. Sample concentrations are determined by isotope dilution or extracted internal standard quantification using isotopically labeled compounds added to the samples before extraction.

2.2 Aqueous samples are spiked with isotopically labeled standards, extracted using solid-phase extraction (SPE) cartridges and undergo cleanup using carbon before analysis.

2.3 Solid samples are spiked with isotopically labeled standards, extracted into basic methanol, and cleaned up by carbon and SPE cartridges before analysis

2.4 Tissue samples are spiked with isotopically labeled standards, extracted in potassium hydroxide and acetonitrile followed by basic methanol, and cleaned up by carbon and SPE cartridges before analysis.

2.5 A sample extract is injected into an LC equipped with a C18 column that is interfaced to an MS/MS). The analytes are separated and identified by comparing the acquired mass spectra and retention times to reference spectra and retention times for calibration standards acquired under identical LC/MS/MS conditions. The concentration of each analyte is determined by using the isotope dilution technique. Extracted Internal Standards (EIS) analytes are used to monitor the extraction efficiency of the method analytes.

2.6 Method Modifications from Reference

N/A

3. Reporting Limits

The reporting limit for PFAS's are listed in Table 8.

4. Interferences

4.1 PFAS standards, extracts and samples should not come in contact with any glass containers or pipettes as these analytes can potentially adsorb to glass surfaces. PFAS analyte and EIS standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in polypropylene containers.

4.2 Method interferences may be caused by contaminants in solvents, reagents (including reagent water), sample bottles and caps, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. The method analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) products, LC solvent lines, methanol, aluminum foil, SPE sample transfer lines, etc. All items such as these must be routinely demonstrated to be free from interferences (less than 1/2 the RL for each method analyte) under the conditions of the analysis by analyzing laboratory reagent blanks as described in Section 9.1. Subtracting blank values from sample results is not permitted.

4.3 Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature of the water. Humic and/or fulvic material can be co-extracted during SPE and high levels can cause enhancement and/or suppression in the electrospray ionization source or low recoveries on the SPE sorbent. Total organic carbon (TOC) is a good indicator of humic content of the sample.

4.4 SPE cartridges can be a source of interferences. The analysis of field and laboratory reagent blanks can provide important information regarding the presence or absence of such interferences. Brands and lots of SPE devices should be tested to ensure that contamination does not preclude analyte identification and quantitation.

5. Health and Safety

5.1 The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

5.2 All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.3 PFOA has been described as “likely to be carcinogenic to humans.” Pure standard materials and stock standard solutions of these method analytes should be handled with suitable protection to skin and eyes, and care should be taken not to breathe the vapors or ingest the materials.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection for Aqueous Samples

6.1.1 Samples must be collected in two (2) 500-mL or 250-mL high density polyethylene (HDPE) container with an unlined plastic screw cap. All sample containers must have linerless HDPE or polypropylene caps.

6.1.2 The sample handler must wash their hands before sampling and wear nitrile gloves while filling and sealing the sample bottles. PFAS contamination during sampling can occur from a number of common sources, such as food packaging and certain foods and beverages. Proper hand washing and wearing nitrile gloves will aid in minimizing this type of accidental contamination of the samples.

6.1.3 Open the tap and allow the system to flush until the water temperature has stabilized (approximately 3 to 5 min). Collect samples from the flowing system.

6.1.4 Fill sample bottles. Samples do not need to be collected headspace free.

6.1.5 After collecting the sample and cap the bottle. Keep the sample sealed from time of collection until extraction.

6.1.6 Maintain all aqueous samples protected from light at 0 - 6 ºC from the time of collection until shipped to the laboratory. Samples must be shipped as soon as practical with sufficient ice to maintain the sample temperature below 6 ºC during transport and be received by the laboratory within 48 hours of collection. The laboratory must confirm that the sample temperature is 0 - 6 ºC upon receipt. Once received by the laboratory, the samples must be stored at ≤ -20 ºC until sample preparation.

6.2 Sample Collection for Soil and Sediment samples.

6.2.1 Grab samples are collected in polypropylene containers. Sample containers and contact surfaces containing PTFE shall be avoided. Samples should fill no more than ¾ full.

6.2.2 Maintain solid samples protected from light (in HDPE containers) at 0 - 6 ºC from the time of collection until receipt at the laboratory. The laboratory must confirm that the sample temperature is 0 - 6 ºC upon receipt. Once received by the laboratory, the samples must be stored at ≤ -20 ºC until sample preparation.

6.3 Sample Collection for fish and other tissue samples

6.3.1 Once received by the laboratory, the samples must be maintained protected from light at ≤ -20 ºC until prepared. Store unused samples in HDPE containers or wrapped in aluminum foil at ≤ -20 ºC.

6.3.2 The nature of the tissues of interest may vary by project. Field sampling plans and protocols should explicitly state the samples to be collected and if any processing will be conducted in the field (e.g., filleting of whole fish or removal of organs). All field procedures must involve materials and equipment that have been shown to be free of PFAS.

6.4 Sample Preservation

Not applicable.

6.5 Sample Shipping

Samples must be chilled during shipment and must not exceed 0 – 6 °C during the first 48 hours after collection. Sample temperature must be confirmed to be at or below 0 – 6 °C when the samples are received at the laboratory. Samples stored in the lab must be held at or below 6 °C until extraction but should not be frozen.

NOTE: Samples that are significantly above 0 – 6 ° C, at the time of collection, may need to be iced or refrigerated for a period of time, in order to chill them prior to shipping. This will allow them to be shipped with sufficient ice to meet the above requirements.

6.6 Sample Handling

6.6.1 Aqueous samples (including leachates) should be analyzed as soon as possible; however, samples may be held in the laboratory for up to 90 days from collection, when stored at ≤ -20 ºC and protected from the light. When stored at 0 - 6 ºC and protected from the light, aqueous samples may be held for up to 28 days, with the caveat that issues were observed with certain perfluorooctane sulfonamide ethanols and perfluorooctane sulfonamidoacetic acids after 7 days. These issues are more likely to elevate the observed concentrations of other PFAS compounds via the transformation of these precursors if they are present in the sample.

6.6.2 Solid samples (soils and sediments) and tissue samples may be held for up to 90 days, if stored by the laboratory in the dark at either 0 - 6 ºC or ≤ -20 ºC, with the caveat that samples may need to be extracted as soon as possible if NFDHA is an important analyte.

6.6.3 Biosolids samples may be held for up to 90 days, if stored by the laboratory in the dark at 0 - 6 ºC or at -20 ºC. Because microbiological activity in biosolids samples at 0 - 6 ºC may lead to production of gases which may cause the sample to be expelled from the container when it is opened, as well as producing noxious odors, EPA recommends that samples be frozen if they need to be stored for more than a few days before extraction. Store sample extracts in the dark at less than 0 - 4 ºC until analyzed. If stored in the dark at less than 0 - 4 ºC, sample extracts may be stored for up to 90 days, with the caveat that issues were observed for some ether sulfonates after 28 days. These issues may elevate the observed concentrations of the ether sulfonates in the extract over time. Samples may need to be extracted as soon as possible if NFDHA is an important analyte.

7. Equipment and Supplies

7.1 SAMPLE CONTAINERS – 500-mL or 250-mL high density polyethylene (HDPE) bottles fitted with unlined screw caps. Sample bottles must be discarded after use.

7.2 SAMPLE JARS – 8-ounce wide mouth high density polyethylene (HDPE) bottles fitted with unlined screw caps. Sample bottles must be discarded after use.

7.3 POLYPROPYLENE BOTTLES – 4-mL narrow-mouth polypropylene bottles.

7.4 CENTRIFUGE TUBES – 50-mL conical polypropylene tubes with polypropylene screw caps for storing standard solutions and for collection of the extracts.

7.5 AUTOSAMPLER VIALS – Polypropylene 0.7-mL autosampler vials with polypropylene caps.

7.5.1 NOTE: Polypropylene vials and caps are necessary to prevent contamination of the sample from PTFE coated septa. However, polypropylene caps do not reseal, so evaporation occurs after injection. Thus, multiple injections from the same vial are not possible.

7.6 POLYPROPYLENE GRADUATED CYLINDERS – Suggested sizes include 25, 50, 100 and 1000-mL cylinders.

7.7 Auto Pipets – Suggested sizes include 5, 10, 25, 50, 100, 250, 500, 1000, 5000 and 10,000-µls.

7.8 PLASTIC PIPETS – Polypropylene or polyethylene disposable pipets.

7.9 Silanized glass wool (Sigma-Aldrich, Cat # 20411 or equivalent) – store in a clean glass jar and rinsed with methanol (2 times) prior to use.

7.10 Disposable syringe filter, 25-mm, 0.2-µm Nylon membrane, PALL/Acrodisc or equivalent

7.11 Variable volume pipettes with disposable HDPE or polypropylene tips (10 µL to 5 mL) used for preparation of calibration standards and spiked samples.

7.12 ANALYTICAL BALANCE – Capable of weighing to the nearest 0.0001 g.

7.13 ANALYTICAL BALANCE – Capable of weighing to the nearest 0.1 g.

7.14 SOLID PHASE EXTRACTION (SPE) APPARATUS FOR USING CARTRIDGES

7.14.1 SPE CARTRIDGES – (Waters Oasis WAX 150 mg, Cat # 186002493 or equivalent). The SPE sorbent must have a pKa above 8 so that it remains positively charged during the extraction.

7.14.1.1 Note: SPE cartridges with different bed volume (e.g., 500 mg) may be used; however, the laboratory must demonstrate that the bed volume does not negatively affect analyte absorption and elution, by performing the initial demonstration of capability analyses described in Section.

7.14.2 VACUUM EXTRACTION MANIFOLD – A manual vacuum manifold with large volume sampler for cartridge extractions, or an automatic/robotic sample preparation system designed for use with SPE cartridges, may be used if all QC requirements discussed in Section 9 are met. Extraction and/or elution steps may not be changed or omitted to accommodate the use of an automated system. Care must be taken with automated SPE systems to ensure the PTFE commonly used in these systems does not contribute to unacceptable analyte concentrations in the MB.

7.14.3 SAMPLE DELIVERY SYSTEM – Use of a polypropylene transfer tube system, which transfers the sample directly from the sample container to the SPE cartridge, is recommended, but not mandatory. Standard extraction manifolds come equipped with PTFE transfer tube systems. These can be replaced with 1/8” O.D. x 1/16” I.D. polypropylene or polyethylene tubing cut to an appropriate length to ensure no sample contamination from the sample transfer lines. Other types of non-PTFE tubing may be used provided it meets the MB and LCS QC requirements.

7.15 EXTRACT CONCENTRATION SYSTEM – Extracts are concentrated by evaporation with nitrogen using a water bath set no higher than 55 °C.

7.16 LABORATORY OR ASPIRATOR VACUUM SYSTEM – Sufficient capacity to maintain a vacuum of approximately 10 to 15 inches of mercury for extraction cartridges.

7.17 LIQUID CHROMATOGRAPHY (LC)/TANDEM MASS SPECTROMETER (MS/MS) WITH DATA SYSTEM

7.17.1 LC SYSTEM – Instrument capable of reproducibly injecting up to 10-µL aliquots and performing binary linear gradients at a constant flow rate near the flow rate used for development of this method (0.4 mL/min). The LC must be capable of pumping the water/methanol mobile phase without the use of a degasser which pulls vacuum on the mobile phase bottle (other types of degassers are acceptable). Degassers which pull vacuum on the mobile phase bottle will volatilize the ammonium acetate mobile phase causing the analyte peaks to shift to earlier retention times over the course of the analysis batch. The usage of a column heater is optional.

7.17.2 LC/TANDEM MASS SPECTROMETER – The LC/MS/MS must be capable of negative ion electrospray ionization (ESI) near the suggested LC flow rate of 0.4 mL/min. The system must be capable of performing MS/MS to produce unique product ions for the method analytes within specified retention time segments. A minimum of 10 scans across the chromatographic peak is required to ensure adequate precision.

7.17.3 DATA SYSTEM – An interfaced data system is required to acquire, store, reduce, and output mass spectral data. The computer software should have the capability of processing stored LC/MS/MS data by recognizing an LC peak within any given retention time window. The software must allow integration of the ion

abundance of any specific ion within specified time or scan number limits. The software must be able to calculate relative response factors, construct linear regressions or quadratic calibration curves, and calculate analyte concentrations.

7.17.4 INSTRUMENT COLUMNS

7.17.4.1 ANALYTICAL: C18 column, 1.7 µm, 50 x 2.1 mm (Waters Acquity UPLC® BEH or equivalent)

7.17.4.2 OPTIONAL GUARD COLUMN: (Phenomenex Kinetex® Evo C18 or equivalent)

8. Reagents and Standards

8.1 GASES, REAGENTS, AND SOLVENTS – Reagent grade or better chemicals must be used.

8.1.1 REAGENT WATER – Purified water which does not contain any measurable quantities of any method analytes or interfering compounds greater than 1/2 the RL for each method analyte of interest. Prior to daily use, at least 3 L of reagent water should be flushed from the purification system to rinse out any build-up of analytes in the system's tubing.

8.1.2 METHANOL (CH_3OH, CAS#: 67-56-1) – High purity, demonstrated to be free of analytes and interferences.

8.1.3 AMMONIUM ACETATE ($NH_4C_2H_3O_2$, CAS#: 631-61-8) – High purity, demonstrated to be free of analytes and interferences.

8.1.4 ACETIC ACID (H_3CCOOH, CAS#: 64-19-7) - High purity, demonstrated to be free of analytes and interferences.

8.1.5 1M AMMONIUM ACETATE/REAGENT WATER – High purity, demonstrated to be free of analytes and interferences.

8.1.6 2mM AMMONIUM ACETATE/METHANOL:WATER (5:95) – To prepare, mix 2 ml of 1M AMMONIUM ACETATE,1 ml ACETIC ACID and 50 ml METHANOL into l Liter of REAGENT WATER.

8.1.7 ACETONITRILE – UPLC grade or equivalent, store at room temperature

8.1.8 TOLUENE – HPLC grade or equivalent.

8.1.9 ACETONE – pesticide grade or equivalent

8.1.10 AMMONIUM ACETATE – (Caledon Ultra LC/MS grade or equivalent

8.1.11 AMMONIUM HYDROXIDE (NH_3, CAS#: 1336-21-6) – High purity, demonstrated to be free of analytes and interferences.

8.1.12 METHANOLIC AMMONIUM HYDROXIDE (0.3%) - add ammonium hydroxide (1 mL, 30%) to methanol (99 mL), store at room temperature, replace after 1 month

8.1.13 METHANOLIC AMMONIUM HYDROXIDE (1%) - add ammonium hydroxide (3.3 mL, 30%) to methanol (97 mL), store at room temperature, replace after 1 month

8.1.14 METHANOLIC AMMONIUM HYDROXIDE (2%) - add ammonium hydroxide (6.6 mL, 30%) to methanol (93.4 mL), store at room temperature, replace after 1 month

8.1.15 METHANOLIC POTASSIUM HYDROXIDE (0.05 M) – add 3.3 g of potassium hydroxide to 1 L of methanol, store at room temperature, replace after 3 months

8.1.16 METHANOL WITH 4% WATER, 1% AMMONIUM HYDROXIDE AND 0.625% ACETIC ACID - add ammonium hydroxide (3.3 mL, 30%), reagent water (1.7 mL) and acetic acid (0.625 mL) to methanol (92 mL), store at room temperature, replace after 1 month. This solution is used to prepare the instrument blank and calibration standards (Section 8.3.2).

8.1.17 FORMIC ACID – (greater than 96% purity or equivalent).

8.1.18 FORMIC ACID (aqueous, 0.1 M) - dissolve formic acid (4.6 g) in reagent water (1 L), store at room temperature, replace after 2 years

8.1.19 FORMIC ACID (aqueous, 0.3 M) - dissolve formic acid (13.8 g) in reagent water (1 L), store at room temperature, replace after 2 years

8.1.20 FORMIC ACID (aqueous, 5% v/v) - mix 5 mL formic acid with 95 mL reagent water, store at room temperature, replace after 2 years

8.1.21 FORMIC ACID (methanolic 1:1, 0.1 M formic acid/methanol) - mix equal volumes of methanol and 0.1 M formic acid, store at room temperature, replace after 2 years

8.1.22 FORMIC ACID (aqueous, 50% v/v) - mix 50 mL formic acid with 50 mL reagent water, store at room temperature, replace after 2 years

8.1.23 POTASSIUM HYDROXIDE – certified ACS or equivalent

8.1.24 CARBON - – EnviCarb® 1-M-USP or equivalent, verified by lot number before use, store at room temperature. Loose carbon allows for better adsorption of interferent organics. Note: The single-laboratory validation laboratory achieved better performance with loose carbon than carbon cartridges. Loose carbon will be used for the multi-laboratory validation to set statistically based method criteria.

8.1.25 NITROGEN – Used for the following purposes: Nitrogen aids in aerosol generation of the ESI liquid spray and is used as collision gas in some MS/MS instruments. The nitrogen used should meet or exceed instrument

manufacturer's specifications. In addition, Nitrogen is used to concentrate sample extracts (Ultra High Purity or equivalent).

8.1.26 ARGON – Used as collision gas in some MS/MS instruments. Argon should meet or exceed instrument manufacturer's specifications. Nitrogen gas may be used as the collision gas provided sufficient sensitivity (product ion formation) is achieved.

8.2 REFERENCE MATRICES - Matrices in which PFAS and interfering compounds are not detected by this method. These matrices are to be used to prepare the batch QC samples.

8.2.1 Reagent water - purified water, Type I

8.2.2 Solid reference matrix Ottawa Sand or equivalent

8.2.3 Tissue Reference matrix – Cod loin or other animal tissue demonstrated to be PFAS free

8.3 STANDARD SOLUTIONS – When a compound purity is assayed to be 96% or greater, the weight can be used without correction to calculate the concentration of the stock standard. PFAS analyte and IS standards commercially purchased in glass ampoules are acceptable; however, all subsequent transfers or dilutions performed by the analyst must be prepared and stored in polypropylene containers and are stored at ≤4 °C. Standards for sample fortification generally should be prepared in the smallest volume that can be accurately measured to minimize the addition of excess organic solvent to aqueous samples.

8.3.1 Stock standards and diluted stock standards are stored at ≤4 °C. Prepare a spiking solution, containing the method analytes listed in Table 1, in methanol from prime stocks. The solution is used to prepare the calibration standards and to spike the known reference QC samples that are analyzed with every batch. Quantitative standards containing a mixture of branched and linear isomers must be used for method analytes if they are commercially available. Currently, these include PFOS, PFHxS, NEtFOSAA, and NMeFOSAA.

8.3.2 Calibration standard solutions – A series of calibration solutions containing the target analytes and the Labeled extracted internal standards (EIS) and non-extracted internal standards (NIS) is used to establish the initial calibration of the analytical instrument. Table 4 represents the concentrations of the native, EIS and NIS analytes of the calibration curve. Calibration standard solutions are made using the solution described in section 8.1.16.

8.3.3 ISOTOPE DILUTION EXTRACTED INTERNAL STANDARD (EIS) – Isotopically labelled analogs of the target analytes to be used for the quantification of target analytes. EIS stock standard solutions are purchased in glass ampoules and are stored in accordance with the manufacturer's recommendations. The EIS stock solution to be used for the fortification of samples and QC in accordance with the isotope dilution procedure. Table 2 represents the EIS concentrations and nominal sample amounts added to each field sample and QC element.

8.3.4 ISOTOPE DILUTION NON-EXTRACTED INTERNAL STANDARDS (NIS) – Isotopically labelled analogs to be added post extraction for the measurement of EIS extraction efficiency and is added to the final volume of all extractions. Table 3 represents the EIS concentrations and nominal sample amounts added to each field sample and QC element.

9. Quality Control

9.1 Method Blank

9.1.1 A Method Blank (MB) is required with each extraction batch to confirm that potential background contaminants are not interfering with the identification or quantitation of method analytes. An aliquot of reagent water that is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents and standards. Prep and analyze a MB for every 20 samples. If the MB produces a peak within the retention time window of any analyte that would prevent the determination of that analyte, determine the source of contamination, and eliminate the interference before processing samples. Background contamination must be reduced to an acceptable level before proceeding. Background from method analytes or other contaminants that interfere with the measurement of method analytes must be below the RL. If the method analytes are detected in the MB at concentrations equal to or greater than this level, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch.

9.2 Laboratory Control Sample (LCS)

9.2.1 Low Level LCS or OPR (Ongoing Precision Recovery) sample is required with each extraction batch. A LLCS or OPR samples is a method blank spiked with known quantities of analytes. The fortified concentration of the LCS is spiked at 2X the LOQ. Default limits of 70-130% of the true value may be used for analytes until sufficient replicates have been analyzed to generate proper control limits. Calculate the percent recovery (%*R*) for each analyte using the equation:

9.2.2 An LCS or OPR (Ongoing Precision Recovery) sample is required with each extraction batch. A LCS or OPR samples is a method blank spiked with known quantities of analytes. The fortified concentration of the LCS is spiked at the midpoint of the calibration curve. Default limits of 70-130% of the true value may be used for analytes until sufficient replicates have been analyzed to generate proper control limits. Calculate the percent recovery (%*R*) for each analyte using the equation:

$$\%R = \frac{A \times 100}{B}$$

Where:

A = measured concentration in the fortified sample
B =fortification concentration.

9.1.1 Where applicable, in the absence of additional sample volume required to perform matrix specific QC, LCSD's are to be extracted and analyzed. The concentration and analyte recovery criteria for the LCSD must be the same as the batch LCS The RSD's must fall within ≤30% of the true value for medium and high-level replicates, and ≤50% for low level replicates. Calculate the relative percent difference (RPD) for duplicate MSs (MS and MSD) using the equation:

$$RPD = \frac{|LCS - LCSD|}{(LCS + LCSD) / 2} \times 100$$

9.1.2 If the LCS and or LCSD results do not meet these criteria for method analytes, then all data for the problem analyte(s) must be considered invalid for all samples in the extraction batch.

9.3 Non-extracted Internal Standard Area (NIS)

Each time an initial calibration is performed, use the data from all the initial calibration standards used to meet the linearity test in Section 10.3.3.3 to calculate the mean area response for each of the NIS compounds, using the equation below.

$$\text{Mean Area}_{NISi} = \sum AREA_{NISi} / n$$

where:

AreaNISi = Area counts for the ith NIS, where i ranges from 1 to 7, for the seven NIS compounds listed in Table 1
n = The number of ICAL standards (the default value is n = 6). If a different number of standards is used for the ICAL, for example, to increase the calibration range or by dropping a point at either end of the range to meet the linearity criterion, change 6 to match the actual number of standards used)
Record the mean areas for each NIS for use in evaluating results for sample analyses. There is no acceptance criterion associated with the mean NIS area data.

9.4 Extracted Internal Standards (EIS)

9.4.1 The EIS standard is fortified into all samples, CCVs, MBs, LCSs, MSs, MSDs, FD, and FRB prior to extraction. It is also added to the CAL standards. The EIS is a means of assessing method performance from extraction to final chromatographic measurement. Calculate the recovery (%R) for the EIS using the following equation:

$$\%R = (A / B) \times 100$$

Where:

A = calculated EIS concentration for the QC or Field Sample
B = fortified concentration of the EIS.

9.4.2 Default limits of 50-150% may be used for analytes until sufficient replicates have been analyzed to generate proper control limits. A low or high percent recovery for a sample, blank, or CCV does not require discarding the analytical data but it may indicate a potential problem with future analytical data. When EIS recovery from a sample, blank, or CCV are outside control limits, check 1) calculations to locate possible errors, 2) standard solutions for degradation, 3) contamination, and 4) instrument performance. For CCVs and QC elements spiked with all target analytes, if the recovery of the corresponding target analytes meet the acceptance criteria for the EIS in question, the data can be used but all potential

biases in the recovery of the EIS must be documented in the sample report. If the associated target analytes do not meet the acceptance criteria, the data must be reanalyzed.

9.5 Matrix Spike (MS/MSD)

9.5.1 Analysis of an MS is prepared one per preparation batch (if required).

9.5.2 Aliquots of field samples that have been fortified with a known concentration of target compounds, prior to sample preparation and extraction, and analyzed to measure the effect of matrix interferences. The use of MS/MSD samples is generally not required in isotope dilution methods because the labeled compounds added to every sample provide more performance data than spiking a single sample in each preparation batch. Aliquots of field samples

9.5.3 Analyte recoveries may exhibit matrix bias. For samples fortified at or above their native concentration, recoveries should range between 50-150%. If the accuracy of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the LCS, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.6 Laboratory Duplicate

9.6.1 FIELD DUPLICATE OR LABORATORY FORTIFIED SAMPLE MATRIX DUPLICATE (FD or MSD) – Within each extraction batch (not to exceed 20 Field Samples), a minimum of one FD or MSD must be analyzed. Duplicates check the precision associated with sample collection, preservation, storage, and laboratory procedures. If method analytes are not routinely observed in Field Samples, an MSD should be analyzed rather than an FD.

9.6.2 Calculate the relative percent difference (*RPD*) for duplicate measurements (*FD1* and *FD2*) using the equation:

$$RPD = \frac{|FD1 - FD2|}{(FD1 + FD2) / 2} \times 100$$

9.6.3 RPDs for FDs should be ≤30%. Greater variability may be observed when FDs have analyte concentrations that are within a factor of 2 of the RL. At these concentrations, FDs should have RPDs that are ≤50%. If the RPD of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the CCV, the recovery is judged to be matrix biased. The result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.6.4 If an MSD is analyzed instead of a FD, calculate the relative percent difference (RPD) for duplicate MSs (MS and MSD) using the equation:

$$RPD = \frac{|MS - MSD|}{(MS + MSD) / 2} \times 100$$

9.6.5 RPDs for duplicate MSs should be ≤30% for samples fortified at or above their native concentration. Greater variability may be observed when MSs are fortified at analyte concentrations that are within a factor of 2 of the RL. MSs fortified at these concentrations should have RPDs that are ≤50% for samples fortified at or above their native concentration. If the RPD of any analyte falls outside the designated range, and the laboratory performance for that analyte is shown to be in control in the LCSD where applicable, the result is judged to be matrix biased. If no LCSD is present, the associated MS and MSD are to be re-analyzed to determine if any analytical has occurred. If the resulting RPDs are still outside control limits, the result for that analyte in the unfortified sample is labeled suspect/matrix to inform the data user that the results are suspect due to matrix effects.

9.7 Bile Salt Interference Check

9.7.1 The laboratory must analyze a TDCA standard after the initial calibration, prior to the analysis of tissue samples, to check for interferences caused by bile salts. If an interference is present, the chromatographic conditions must be modified to eliminate the interference from TDCA (e.g., changing the retention time of TDCA such that it falls outside the

9.8 Initial Calibration Verification (ICV)

9.8.1 After each ICAL, analyze a QCS sample from a source different from the source of the CAL standards. If a second vendor is not available, then a different lot of the standard should be used. The QCS should be prepared and analyzed just like a CCV. Acceptance criteria for the QCS are identical to the CCVs; the calculated amount for each analyte must be ± 30% of the expected value. If measured analyte concentrations are not of acceptable accuracy, check the entire analytical procedure to locate and correct the problem.

9.9 Instrument Sensitivity Check (ISC)

9.9.1 At the start of each 12-hour shift, analyze a standard at the LOQ. The signal-to-noise ratio of the ISC standard must be greater than or equal to 3:1. If the requirements cannot be met, the problem must be corrected before analyses can proceed

9.10 Continuing Calibration Verification (CCV)

9.10.1 CCV Standards must be analyzed at the beginning of each analysis batch, after every 10 Field Samples, and at the end of the analysis batch.

9.10.2 The recovery of native and isotopically labeled compounds for the CVs must be within 70 - 130%

9.10.3

9.11 Method-specific Quality Control Samples

9.11.1 Instrument Blank – During the analysis of a batch of samples, a solvent blank is analyzed after samples containing high level of target compounds (e.g., calibration, CV) to monitor carryover from the previous injection. The injection blank consists of the solution in

Section 8.1.16 fortified with the EIS and NIS for quantitation purposes.

9.12 Example Method Sequence

- INSTRUMENT BLANK
- INSTRUMENT SENSITIVITY CHECK
- CALIBRATION VERIFICATION STANDARD
- QUALITATIVE IDENTIFICATION STANDARDS
- TDCA STANDARD (only if analyzing tissues)
- INSTRUMENT BLANK
- METHOD BLANK
- LOW-LEVEL LCS/OPR
- OPR/LCS
- SAMPLE (10 or fewer)
- CALIBRATION VERIFICATION STANDARD
- INSTRUMENT BLANK
- SAMPLE (10 or fewer)
- CALIBRATION VERIFICATION STANDARD
- INSTRUMENT BLANK

10. Procedure

10.1 Equipment Set-up

10.1.1 This procedure may be performed manually or in an automated mode using a robotic or automatic sample preparation device. If an automated system is used to prepare samples, follow the manufacturer's operating instructions, but all extraction and elution steps must be the same as in the manual procedure. Extraction and/or elution steps may not be changed or omitted to accommodate the use of an automated system. If an automated system is used, the MBs should be rotated among the ports to ensure that all the valves and tubing meet the MB requirements.

10.1.2 Some of the PFAS's adsorb to surfaces, including polypropylene. Therefore, the aqueous sample bottles must be rinsed with the elution solvent whether extractions are performed manually or by automation. The bottle rinse is passed through the cartridge to elute the method analytes and is then collected.

10.1.3 The SPE cartridges and sample bottles described in this section are designed as single use items and should be discarded after use. They may not be refurbished for reuse in subsequent analyses.

10.1.4 All SPE apparatus, including manifolds, tubing and sample ports must be thoroughly rinsed following each use with 1% methanolic ammonium hydroxide, followed by Methanol and then DI water. Additionally, sample manifold ports and transfer tubing should be inspected regularly for signs of wear and/or discoloration. When such observations are made, the associated components should be replaced.

10.1.5 Prior to the start of any extraction, sample site information must be evaluated for any potentially high level PFAS concentrations or sample matrix irregularities that may impact the extraction process. If such samples are identified, aqueous samples may be pre-screened via direct aqueous injection prior to analysis to estimate the potential PFAS concentrations present.

10.1.6 To perform a direct aqueous injection (DAI) screen, the sample should be inverted several times to try and evenly disperse any organic matter present. A 1 ml aliquot (or less depending on the matrix) is to be taken from the parent sample, volume adjusted to 1 ml with reagent water if less than 1ml, fortified with EIS and NIS spiking solutions to match the concentrations of an extracted sample (typically 5 µl per 1 ml DAI), and then analyzed under the same analytical conditions as field samples.

10.2 Sample Preparation of Aqueous Samples

10.2.1 Samples are preserved, collected, and stored as presented in Section 6.

10.2.2 Determine sample volume. Weigh all samples to the nearest 1g. If visible sediment is present, centrifuge and decant into a new HDPE bottle and record the weight of the new container.

NOTE: Some of the PFAS's adsorb to surfaces, thus the sample volume may not be transferred to a graduated cylinder for volume measurement.

10.2.3 The MB, LCS and FRB may be prepared by measuring reagent water with a polypropylene graduated cylinder or filling an HDPE sample bottle to near the top.

10.2.4 Check that the pH is 6.5 ± 0.5. If necessary, adjust pH with 50% formic acid or ammonium hydroxide and 3% aqueous ammonium hydroxide. The extract is now ready for solid-phase extraction (SPE) and cleanup.

10.2.5 Add 20 µL of the EIS to each sample and QC, cap and invert to mix.

10.2.6 If the sample is an LCS, LCSD, MS, or MSD, add the necessary amount of analyte PDS. Cap and invert each sample to mix.

10.3 Sample Prep and Extraction Protocol for Soils, Solids and Sediments.

10.3.1 Homogenize and weigh 5 grams of sample (measured to the nearest hundredth of a gram) into a 50 ml polypropylene centrifuge tube. For laboratory control blanks and spikes, 5 grams of clean sand is used.

10.3.1.1 For Biosolids and other complex matrices, a small aliquot may be required due to co-extracted matrix interferences.

10.3.1.2 For batch QC samples using 5 g of reference solid, add 2.5 g of reagent water. The addition of reagent water to the sand provides a matrix closer in composition to real-world samples.

10.3.2 Add 20 µL of the EIS to each sample and QC.

10.3.3 If the sample is an LCS, LCSD, MS, or MSD, add the necessary amount of analyte PDS. Cap and invert each sample to mix.

10.3.4 Vortex the samples to evenly disperse the spiking solutions and allow to equilibrate for 30 minutes.

10.3.5 To all samples, add 10 ml of 0.3% methanolic ammonium hydroxide, cap, vortex for 25 seconds.

10.3.6 Following mixing, shake each sample for 30 minutes on a shaker table.

10.3.7 Centrifuge each sample at 2800RPM for 10 minutes.

10.3.8 Remove the supernatant and transfer to a clean 50 ml polypropylene centrifuge tube.

10.3.9 Repeat steps 10.3.4 to 10.3.7, with 15 ml of 0.3% methanolic ammonium hydroxide, combining the supernatants.

10.3.10 Add 5ml of 0.3% methanolic ammonium hydroxide to the sample, vortex for 25 seconds and centrifuge each sample at 2800RPM for 10 minutes.

10.3.11 Remove the supernatant and transfer to the same 50 ml polypropylene centrifuge tube containing eluates from the previous cycles.

10.3.12 Add 10 mg of carbon to the combined extract, mix by occasional hand shaking for no more than five minutes and then centrifuge at 2800 rpm for 10 minutes. Immediately decant the extract into a 50 ml polypropylene centrifuge tube.

10.3.13 Dilute to approximately 35 mL with reagent water. Samples containing more than 50% water may yield extracts that are greater than 35 mL in volume; therefore, do not add water to these. Determine the water content in the sample as follows (percent moisture is determined from the % solids):

Water Content in Sample = (Sample Weight * Percent moisture) / 100

10.3.14 Concentrate each extract at approximately 55 ºC with a gentle N2 flow to a final volume that is based on the water content of the sample (see table below). Allow extracts to concentrate for 10 minutes, then mix (by vortex if the volume is < 20. Continue concentrating and mixing every 5 minutes until the extract has been reduced to the required volume as specified in the table below. If the extract volume appears to stop dropping, the concentration must be stopped and the volume at which it was stopped recorded.

Water Content in Sample	Concentrated Final Volume
< 5 grams	15 ml
5-8 grams	15-20 ml
8-9 grams	20-22.5 ml
9-10 grams	22.5-25 ml

10.3.15 Add 40 - 50 mL of reagent water to the extract and vortex. Check that the pH is 6.5 ±0.5 and adjust as necessary with 50% formic acid or 30% ammonium

hydroxide, or with 5% formic acid and 3% aqueous ammonium hydroxide. The extracts are ready for SPE and cleanup.

10.4 Sample Prep and Extraction Protocol for Tissues.

10.4.1 Homogenize and weigh 2 grams of sample (measured to the nearest hundredth of a gram) into a 50 ml polypropylene centrifuge tube. For laboratory control blanks and spikes, 2 grams of clean tissue is used.

10.4.2 Add 20 µL of the EIS PDS to each sample and QC.

10.4.3 If the sample is an LCS, LCSD, MS, or MSD, add the necessary amount of analyte PDS. Cap and invert each sample to mix.

10.4.4 Add 10 mL of 0.05M KOH in methanol to each sample. Vortex to disperse the tissue then place tubes on a mixing table to extract for at 16 hours. Centrifuge at 2800 rpm for 10 minutes and collect the supernatant in a 50-mL polypropylene centrifuge tube.

10.4.5 Add 10 mL of acetonitrile to remaining tissue in the 50-mL centrifuge tube, vortex to mix and disperse the tissue. Sonicate for 30 minutes. Centrifuge at 2800 rpm for 10 minutes and collect the supernatant, adding it to the 50-mL centrifuge tube containing the initial extract.

10.4.6 Add 5 mL of 0.05M KOH in methanol to the remaining sample in each centrifuge tube. Vortex to disperse the tissue and hand mix briefly. Centrifuge at 2800 rpm for 10 minutes and collect the supernatant, adding it to the 50-mL centrifuge tube containing the first two extracts.

10.4.7 Add 10 mg of carbon to the combined extract, mix by occasional hand shaking over a period of no more than five minutes and then centrifuge at 2800 rpm for 10 minutes. Immediately decant the extract into a 50-mL centrifuge tube.

10.4.8 Add 1 mL of reagent water to each tube and concentrate each extract at approximately 55 ºC with a gentle N2 flow to a final volume of 2.5 ml.

10.4.9 Add reagent water to each evaporation/concentrator tube to dilute the extracts to 50 mL. Check that the pH = 6.5 ± 0.5 and adjust as needed with 50% formic acid, or ammonium hydroxide or with 5% formic acid and 3% aqueous ammonium hydroxide. The extracts are ready for SPE and cleanup.

10.5 SPE Extract: All matrices

10.5.1 Pack clean silanized glass wool to half the height of the WAX SPE cartridge barrel.

10.5.2 Pre-condition the cartridges by washing them with 3 X 5 mL of 1% methanolic ammonium hydroxide, discarding the wash volumes.

10.5.3 Rinse the cartridge with 5 mL of 0.3M formic acid, allowing the cartridge to drain using gravity only, discarding the rinse volume. Do not allow the cartridge to go dry

10.5.4 Adjust the vacuum so that the approximate flow rate is ~5 mL/min and load the sample across the cartridge. Do not allow the cartridge to go dry before all the sample has passed through.

10.5.5 Once all the sample has passed across the cartridge, rinse the walls of the reservoir with 2 X 5 mL reagent water, loading the rinse across the cartridge.

10.5.6 Rinse the walls of the reservoir with 5 mL of 1:1 0.1M formic acid/methanol and pass the rinse through the cartridge using vacuum. Dry the cartridge by pulling air through for 15 seconds.

10.5.7 Rinse the inside of the sample bottle with 5 mL of 1% methanolic ammonium hydroxide. Use vacuum to pull the elution solvent through the cartridge and into the collection tubes. When the cartridge bed and glass wool are submerged, stop the cartridge flow by closing the valve, keeping the sorbent bed and wool submerged.

10.5.8 Let the wetted sorbent bed and wool soak for 1 minute.

10.5.9 Open the cartridge valve and collect the eluate into a 15 ml polypropylene collection tube.

10.5.10 Add 25 µL of concentrated acetic acid to each sample eluted in the collection tubes and vortex to mix.

10.5.11 Add 10 mg of carbon to each sample and batch QC extract, using a 10-mg scoop. Handshake occasionally for no more than 5 minutes. It is important to minimize the time the sample extract is in contact with the carbon. Immediately vortex (30 seconds) and centrifuge at 2800 rpm for 10 minutes.

10.5.12 Add NIS solution to a clean collection tube. Place a syringe filter (25-mm filter, 0.2-µm nylon membrane) on a 5-mL polypropylene syringe. Take the plunger out and carefully decant the sample supernatant into the syringe barrel. Replace the plunger and filter the entire extract into the new collection tube containing the NIS.

10.5.13 Vortex to mix and transfer a portion of the extract into a .7-mL polypropylene LC vial for LC-MS/MS analysis. Cap the collection tube containing the remaining extract and store at 4 °C

10.6 Sample Volume Determination

10.6.1 If using weight to determine volume, weigh the empty bottle to the nearest 1 g and determine the sample weight by subtraction of the empty bottle weight from the original sample weight. Assume a sample density of 1.0 g/mL. In either case, the sample volume will be used in the final calculations of the analyte concentration.

10.7 Initial Calibration - Demonstration and documentation of acceptable initial calibration is required before any samples are analyzed. After the initial calibration is successful, a CCV is required at the beginning and end of each period in which analyses are performed, and after every tenth Field Sample.

10.7.1 ESI-MS/MS TUNE

10.7.1.1 Calibrate the mass scale of the MS with the calibration compounds and procedures prescribed by the manufacturer.

10.7.1.2 Optimize the [M-H]- or [M-CO_2]- for each method analyte by infusing approximately 0.5-1.0 µg/mL of each analyte (prepared in the initial mobile phase conditions) directly into the MS at the chosen LC mobile phase flow rate (0.4 mL/min). This tune can be done on a mix of the method analytes. The MS parameters (voltages, temperatures, gas flows, etc.) are varied until optimal analyte responses are determined.

The method analytes may have different optima requiring some compromise between the optima.

The Mass spec conditions found in Table 7 show the Sciex Triple Quad 5500+ operation conditions used in this method.

10.7.1.3 Optimize the product ion for each analyte by infusing approximately 0.5-1.0 µg/mL of each analyte (prepared in the initial mobile phase conditions) directly into the MS at the chosen LC mobile phase flow rate (approximately 0.4 mL/min). This tune can be done on a mix of the method analytes. The MS/MS parameters (collision gas pressure, collision energy, etc.) are varied until optimal analyte responses are determined. Typically, the carboxylic acids have very similar MS/MS conditions, and the sulfonic acids have similar MS/MS conditions.

The conditions found on table 5 are representative of expected tune optimizations for each analyte. If conditions other the ones close to the values provided in table 5 are achieved, the process should be re-performed and/or instrument maintenance performed to resolve the problem.

10.7.2 Establish LC operating parameters that optimize resolution and peak shape. Modifying the standard or extract composition to more aqueous content to prevent poor shape is not permitted.

Table 6 represents the operation conditions of a Sciex Exion LC system when running this method.

10.7.3 Inject 2µl of a mid-level CAL standard under LC/MS conditions to obtain the retention times of each method analyte. Divide the chromatogram into retention time windows each of which contains one or more chromatographic peaks. During MS/MS analysis, fragment a small number of selected precursor ions ([M-H]-) for the analytes in each window and choose the most abundant product ion. For maximum sensitivity, small mass windows of ±0.5 daltons around the product ion mass were used for quantitation.

10.7.4 Inject a mid-level CAL standard under optimized LC/MS/MS conditions to ensure that each method analyte is observed in its MS/MS window and that there are at least 10 scans across the peak for optimum precision.

NOTE: PFHxS, PFOS, NMeFOSAA, and NEtFOSAA have multiple chromatographic peaks using the LC conditions in Table 7 due to chromatographic resolution of the linear and branched isomers of these compounds. Most PFAS's are produced by two different processes. One process gives rise to linear PFAS's only while the other process produces both linear and branched isomers. Thus, both branched and linear PFAS's can potentially be found in the environment. For the aforementioned compounds that give rise to more than one peak, all the chromatographic peaks observed in the standard must be integrated and the areas totaled. Chromatographic peaks in a sample must be integrated in the same way as the CAL standard.

10.7.5 Prepare a set of CAL standards as outlined in table 5. The lowest concentration CAL standard must be at or below the LOQ.

10.7.6 The LC/MS/MS system is calibrated using the isotope dilution technique. Target analytes are quantitated against their isotopically labeled analog (Extracted Internal Standard) where commercially available. If a labeled analog is not

commercially available, the extracted internal standard with the closest retention time and /or closest chemical similarity is to be used. Use the LC/MS/MS data system software to generate a linear regression or quadratic calibration curve for each of the analytes. This curve must always be forced through zero and may be concentration weighted, if necessary. Forcing zero allows for a better estimate of the background levels of method analytes. A minimum of 5 levels are required for a linear calibration model and a minimum of 6 levels are required for a quadratic calibration model.

10.7.7 CALIBRATION ACCEPTANCE CRITERIA – A linear fit is acceptable if the calculated RSD or RSE for each target analyte is ≤20%. If linear or Quadratic regressions are used, coefficient of determination (r^2) values must be greater than 0.99. When quantitated using the initial calibration curve, each calibration point at or above the LOQ for each analyte must calculate to be within 70-130% of its true value. The calculate value of each EIS analyte must be within 50-150% of its true value. If these criteria cannot be met, corrective action is taken to reanalyze the CAL standards, restrict the range of calibration.

10.7.8 Bile salts interference check - The laboratory must analyze a TDCA standard after the initial calibration, prior to the analysis of tissue samples, to check for interferences caused by bile salts. If an interference is present, the chromatographic conditions must be modified to eliminate the interference from TDCA (e.g., changing the retention time of TDCA such that it falls outside the retention window for PFOS by at least one minute), and the initial calibration repeated.

10.8 CONTINUING CALIBRATION CHECK (CCV) – Minimum daily calibration verification is as follows. Verify the initial calibration at the beginning and end of each group of analyses, and after every tenth sample during analyses. In this context, a “sample” is considered to be a Field Sample. MBs, CCVs, LCSs, MSs, FDs FRBs and MSDs are not counted as samples. The beginning CCV of each analysis batch must be at or below the RL in order to verify instrument sensitivity prior to any analyses. If standards have been prepared such that all low CAL points are not in the same CAL solution, it may be necessary to analyze two CAL standards to meet this requirement. Alternatively, the analyte concentrations in the analyte PDS may be customized to meet these criteria. Subsequent CCVs should alternate between a medium and Low concentration CAL standard.

10.8.1 Inject an aliquot of the appropriate concentration CAL standard and analyze with the same conditions used during the initial calibration.

10.8.2 Calculate the concentration of each analyte and EIS in the CCV. The calculated amount for each native and EIS analyte for medium level CCVs must be within ± 30% of the true. If these conditions do not exist, then all data for the problem analyte must be considered invalid, and remedial action should be taken which may require recalibration. Any Field or QC Samples that have been analyzed since the last acceptable calibration verification should be reanalyzed after adequate calibration has been restored, with the following exception. If the CCV fails because the calculated concentration is greater than 130% for a particular method analyte, and Field Sample extracts show no detection for that method analyte, non-detects may be reported without re-analysis.

10.8.3 REMEDIAL ACTION – Failure to meet CCV QC performance criteria may require remedial action. Major maintenance, such as cleaning the electrospray probe, atmospheric pressure ionization source, cleaning the mass analyzer, replacing the LC column, etc., requires recalibration and verification of sensitivity by analyzing a CCV at or below the LOQ.

10.9 EXTRACT ANALYSIS

10.9.1 The same operating conditions used for the initial calibration and summarized in Tables 6 and 7 are to be used.

10.9.2 Prior to analysis of sample extracts, the Instrument mass calibration verification must be performed using standards whose mass range brackets the masses of interest and performed in the negative ion mode. The mass calibration is verified if the calculated mass is within ± .2 daltons of the specified mass.

10.9.3 Establish an appropriate retention time window for each analyte. This should be based on measurements of actual retention time variation for each method analyte in CAL standard solutions analyzed on the LC over the course of time. A value of plus or minus three times the standard deviation of the retention time obtained for each method analyte while establishing the initial calibration can be used to calculate a suggested window size. However, the experience of the analyst should weigh heavily on the determination of the appropriate retention window size.

10.9.4 Calibrate the system by either the analysis of a calibration curve or by confirming the initial calibration is still valid by analyzing a CCV.

10.9.5 Begin analyzing Field Samples, including QC samples, at their appropriate frequency by injecting the same size aliquots under the same conditions used to analyze the CAL standards.

10.9.6 For concentrations at or above the method LOQ, the total (branched and linear isomer) quantification ion response to the total (branched and linear isomer) confirmation ion response ratio must fall within ± 50% of the ratio observed in the midpoint initial calibration standard.

10.9.7 At the conclusion of data acquisition, use the same software that was used in the calibration procedure to identify peaks of interest in predetermined retention time windows. Use the data system software to examine the ion abundances of the peaks in the chromatogram. Identify an analyte by comparison of its retention time with that of the corresponding method analyte peak in a reference standard.

10.9.8 The analyst must not extrapolate beyond the established calibration range. If an analyte peak area exceeds the range of the initial calibration curve, the sample should be re-extracted with a reduced sample volume in order to bring the out of range target analytes into the calibration range. If a smaller sample size would not be representative of the entire sample, the following options are recommended. Re-extract an additional aliquot of sufficient size to ensure that it is representative of the entire sample. Spike it with a higher concentration of internal standard. Prior to LC/MS analysis, dilute the sample so that it has a concentration of internal standard equivalent to that present in the calibration standard. Then, analyze the diluted extract.3

10.9.9 In instances where re-extraction is not an option, dilute a subsample of the sample extract with 0.1% acetic acid by a factor no greater than 10x adjust the amount of the NIS in the diluted extract, and analyze the diluted extract. If the

responses for each EIS in the diluted extract meet the S/N and retention time, and the EIS recoveries from the analysis of the diluted extract are greater than 5%, then the compounds associated with those EISs may be quantified using isotope dilution. Use the EIS recoveries from the original analysis to select the dilution factor, with the objective of keeping the EIS recoveries in the dilution above that 5% lower limit. If the adjusted EIS recoveries are below 5%, the dilution is assumed invalid. If the adjusted EIS recoveries are greater than 5%, adjust the compound concentrations, detection limits, and minimum levels to account for the dilution.

11. Data Evaluation, Calculations and Reporting

11.1 Complete chromatographic resolution is not necessary for accurate and precise measurements of analyte concentrations using MS/MS. In validating this method, concentrations were calculated by measuring the product ions listed in Table 9.

11.2 Calculate analyte concentrations using the multipoint calibration established in Section 10.9. Do not use daily calibration verification data to quantitate analytes in samples. Adjust final analyte concentrations to reflect the actual sample volume determined in Section 10.8

C_{ex} = (Area of target analyte * Concentration of Labeled analog) / (area of labeled analog * CF)

C_s = (C_{ex} / sample volume in ml) * 1000

C_{ex} = The concentration of the analyte in the extract
CF = calibration factor from calibration.

11.3 Prior to reporting the data, the chromatogram should be reviewed for any incorrect peak identification or poor integration.

11.4 PFHxS, PFOS, PFOA, NMeFOSAA, and NEtFOSAA have multiple chromatographic peaks using the LC conditions in Table 7 due to the linear and branch isomers of these compounds (Sect. 10.10.4.). The areas of all the linear and branched isomer peaks observed in the CAL standards for each of these analytes must be summed and the concentrations reported as a total for each of these analytes.

11.5 Calculations must utilize all available digits of precision, but final reported concentrations should be rounded to an appropriate number of significant figures (one digit of uncertainty), typically two, and not more than three significant figures.

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

12.1 Section 9.0 outlines sample batch QC acceptance criteria. If non-compliant organic compound results are to be reported, the Organic Section Head and/or the Laboratory Director, and the Operations Manager must approve the reporting of these results. The laboratory Project Manager shall be notified and may choose to relay the non-compliance to the client, for approval, or other corrective action, such as re-sampling and re-analysis. The analyst, Data Reviewer, or Department Supervisor performing the secondary review initiates the project narrative, and the narrative must clearly document the non-compliance and provide a reason for acceptance of these results.

12.2 All results for the organic compounds of interest are reportable without qualification if extraction and analytical holding times are met, preservation requirements (including cooler temperatures) are met, all QC criteria are met, and matrix interference is not suspected during extraction or analysis of the samples. If any of the below QC parameters are not met, all associated samples must be evaluated for re-extraction and/or re-analysis.

13. Method Performance

13.1 Detection Limit Study (DL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

13.1.1 The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP ID 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

13.2.1 Refer to Alpha SOP ID 1739 for further information regarding IDC/DOC Generation.

13.2.2 The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

14.1 Refer to Alpha's Chemical Hygiene Plan and Hazardous Waste Management and Disposal SOP for further pollution prevention and waste management information.

14.2 This method utilizes SPE to extract analytes from water. It requires the use of very small volumes of organic solvent and very small quantities of pure analytes, thereby minimizing the potential hazards to both the analyst and the environment as compared to the use of large volumes of organic solvents in conventional liquid-liquid extractions.

14.3 The analytical procedures described in this method generate relatively small amounts of waste since only small amounts of reagents and solvents are used. The matrices of concern are finished drinking water or source water. However, laboratory waste management practices must be conducted consistent with all applicable rules and regulations, and that laboratories protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Also, compliance is required with any sewage discharge permits and regulations, particularly the hazardous waste identification rules and land disposal restrictions.

15. Referenced Documents

Chemical Hygiene Plan – ID 2124

SOP ID 1732 Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ) SOP

SOP ID 1739 Demonstration of Capability (DOC) Generation SOP

SOP ID 1728 Hazardous Waste Management and Disposal SOP

16. Attachments

Table 1: Names, Abbreviations, and CAS Registry Numbers for Target PFAS, Extracted Internal Standards and Non-extracted Internal Standards

Parameter	Acronym	CAS
PER- and POLYFLUOROALKYLETHER CARBOXYLIC ACIDS (PFECAs)		
Tetrafluoro-2-(heptafluoropropoxy)propanoic acid	HFPO-DA	13252-13-6
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
PERFLUOROALKYLCARBOXILIC ACIDS (PFCAs)		

Perfluorobutanoic acid	PFBA	375-22-4
Perfluoropentanoic acid	PFPeA	2706-90-3
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorononanoic acid	PFNA	375-95-1
Perfluorodecanoic acid	PFDA	335-76-2
Perfluoroundecanoic acid	PFUnA	2058-94-8
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluoorotetradecanoic acid	PFTeDA	376-06-7
PERFLUOROALKYL SULFONIC ACIDS (PFASs)		
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorononanesulfonic acid	PFNS	68259-12-1

Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluorododecanesulfonic acid	PFDoS	79780-39-5
CHLORO-PERFLUOROALKYLSULFONATE		
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1
FLUOROTELOMER CARBOXYLIC ACIDS		
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3
Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4
PERFLUOROOCTANESULFONAMIDES		
Perfluorooctanesulfonamide	PFOSA	754-91-6
N-methylperfluoro-1-octanesulfonamide	NMeFOSA	31506-32-8
N-ethylperfluoro-1-octanesulfonamide	NEtFOSA	4151-50-2
PERFLUOROCTANE SULFONAMIDE ETHANOLS		
N-Methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2
TELOMER SULFONIC ACIDS		

1H,1H,2H,2H-perfluorohexanesulfonic acid (4:2)	4:2FTS	757124-72-4
1H,1H,2H,2H-perfluorooctanesulfonic acid (6:2)	6:2FTS	27619-97-2
1H,1H,2H,2H-perfluorodecanesulfonic acid (8:2)	8:2FTS	39108-34-4
PERFLUOROOCTANESULFONAMIDOACETIC ACIDS		
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6
PERFLUOROETHER AND POLYETHER CARBOXYLIC ACIDS		
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6

Table 2: Stock and Nominal Extracted Internal Standard Concentrations

Isotope Labeled Standard	Conc. of EIS Stock (ng/mL)	Nominal amount of EIS added to extracts (ng)
M4PFBA	2000	40
M5PFPeA	1000	20
M5PFHxA	500	10
M4PFHpA	500	10
M8PFOA	500	10
M9PFNA	250	5
M6PFDA	250	5
M7PFUdA	250	5
MPFDoA	250	5
M2PFTeDA	250	5
M3PFBS	466	9.32
M3PFHxS	474	9.48
M8PFOS	479	9.58
M2-4:2FTS	938	18.8

Isotope Labeled Standard	Conc. of EIS Stock (ng/mL)	Nominal amount of EIS added to extracts (ng)
M2-6:2FTS	951	19
M2-8:2FTS	960	19.2
M8FOSA	500	10
d3-N-MeFOSA	500	10
d5-N-EtFOSA	500	10
d3-N-MeFOSAA	1000	20
d5-N-EtFOSAA	1000	20
d7-N-MeFOSE	5000	100
d9-N-EtFOSE	5000	100
M3HFPO-DA	2000	40

Table 3: Stock and Nominal Non-Extracted Internal Standard Concentrations

Isotope Labeled Standard	Conc. of EIS Stock (ng/mL)	Nominal amount of EIS added to extracts (ng)
M3PFBA	1000	40
M2PFHxA	500	10
M4PFOA	500	10
M5PFNA	250	5
M2PFDA	250	5
18O2PFHxS	474	9.48
M4PFOS	479	9.58

Table 4: Initial Calibration levels and Concentrations

Analyte	Cal A	Cal B (LOQ)	CAL C	Cal D	Cal E (CCV)	Cal F	Cal G	Cal H	Cal I
PFBA	.4	.8	2	5	10	20	50	250	500
PFPeA	.2	.4	1	2.5	5	10	25	125	250
PFHxA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFHpA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFOA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFNA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFDA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFUnA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFDoA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFTrDA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFTA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
PFBS	0.089	0.177	0.444	1.11	2.22	4.44	11.1	55.4	111
PFPeS	0.094	0.188	0.471	1.18	2.35	4.71	11.8	58.8	118

PFHxS	0.091	0.183	0.457	1.14	2.29	4.57	11.4	57.1	114
PFHpS	0.095	0.191	0.477	1.19	2.38	4.77	11.9	59.6	119
PFOS	0.093	0.186	0.464	1.16	2.32	4.64	11.6	58	116
PFNS	0.096	0.192	0.481	1.20	2.41	4.81	12	60.1	120
PFDS	0.097	0.193	0.483	1.21	2.41	4.83	12.1	60.3	121
PFDOS	0.097	0.194	0.485	1.21	2.43	4.85	12.1	60.6	121.
4:2FTS	0.375	0.75	1.88	4.69	9.38	18.8	46.9	234	469
6:2FTS	0.38	0.76	1.9	4.75	9.5	19	47.5	238	475
8:2FTS	0.384	0.768	1.92	4.8	9.6	19.2	48	240	480
PFOSA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
NMeFOSA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
NEtFOSA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
NMeFOSAA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
NEtFOSAA	.1	.2	.5	1.25	2.5	5	12.5	62.5	125
NMeFOSE	1	2	5	12.5	25	50	125	625	1250
NEtFOSE	1	2	5	12.5	25	50	125	625	1250
HFPO-DA	.4	.8	2	5	10	20	50	250	500
ADONA	0.378	0.756	1.89	4.73	9.45	18.9	47.3	236	473
9Cl-PFONS	0.374	0.748	1.87	4.68	9.35	18.7	46.8	234	468
11Cl-PFOUdS	0.378	0.756	1.89	4.73	9.45	18.9	47.3	236	473
PFMPA	.2	.4	1	2.5	5	10	25	125	250
PFMBA	.2	.4	1	2.5	5	10	25	125	250
PFEESA	0.178	0.356	0.89	2.23	4.45	8.9	22.3	111	223
NFDHA	.2	.4	1	2.5	5	10	25	125	250
3:3FTCA	.5	1	2.5	6.25	12.5	25	62.5	312	624
5:3FTCA	2.5	5	12.5	31.3	62.5	125	312	1560	3120
7:3FTCA	2.5	5	12.5	31.3	62.5	125	312	1560	3125
M4PFBA	10	10	10	10	10	10	10	10	10
M5PFPeA	5	5	5	5	5	5	5	5	5
M5PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
M4PFHpA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
M8PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
M9PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
M6PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
M7PFUdA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
MPFDoA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25

M2PFTeDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
M3PFBS	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
M3PFHxS	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
M8PFOS	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
M2-4:2FTS	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69
M2-6:2FTS	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76
M2-8:2FTS	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
M8FOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d3-N-MeFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d5-N-EtFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d3-N-MeFOSAA	5	5	5	5	5	5	5	5	5
d5-N-EtFOSAA	5	5	5	5	5	5	5	5	5
d7-N-MeFOSE	25	25	25	25	25	25	25	25	25
d9-N-EtFOSE	25	25	25	25	25	25	25	25	25
M3HFPO-DA	10	10	10	10	10	10	10	10	10
M3PFBA	5	5	5	5	5	5	5	5	5
M2PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
M4PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
M5PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
M2PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
18O2PFHxS	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37
M4PFOS	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4

Table 5: Expected Mass Transitions and instrument conditions.

Q1	Q2	Analyte	DP Volts	CE Volts
213.032	169.022	PFBA	-50	-14
263.039	219.03	PFPeA	-55	-12
263.039	68.9	PFPeA_2	-55	-55
313.047	269.037	PFHxA	-45	-12
313.047	119	PFHxA_2	-45	-28
363.055	319.045	PFHpA	-60	-12
363.055	169.022	PFHpA_2	-60	-24
413.063	369.053	PFOA	-65	-14
413.063	169.022	PFOA_2	-65	-23
463.071	419.061	PFNA	-70	-14
463.071	219.03	PFNA_2	-70	-24

513.078	469.069	PFDA	-80	-16
513.078	219.03	PFDA_2	-80	-30
563.086	519.076	PFUnA	-85	-18
563.086	269.037	PFUnA_2	-85	-25
613.094	569.084	PFDoA	-85	-18
613.094	319.045	PFDoA_2	-85	-28
663.102	619.092	PFTrDA	-85	-20
663.102	169.022	PFTrDA_2	-85	-36
713.11	669.1	PFTA	-70	-22
713.11	169.022	PFTA_2	-70	-38
299.092	80.062	PFBS	-100	-65
299.092	99.061	PFBS_2	-100	-40
349.1	80.062	PFPeS	-100	-75
349.1	99.061	PFPeS_2	-100	-60
399.107	80.062	PFHxS	-120	-75
399.107	99.061	PFHxS_2	-120	-80
449.115	80.062	PFHpS	-140	-95
449.115	99.061	PFHpS_2	-140	-80
499.113	80.062	PFOS	-145	-108
499.113	99.061	PFOS_2	-145	-85
549.131	80.062	PFNS	-180	-100
549.131	99.061	PFNS_2	-180	-100
599.139	80.062	PFDS	-170	-110
599.138	99.061	PFDS_2	-170	-100
699.154	80.062	PFDoS	-160	-150
699.154	99.061	PFDoS_2	-160	-130
327.146	307.139	4:2FTS	-100	-28
327.146	81.07	4:2FTS_2	-100	-50
427.161	407.155	6:2FTS	-120	-33
427.161	81.07	6:2FTS_2	-120	-65
527.177	507.17	8:2FTS	-140	-39
527.177	81.07	8:2FTS_2	-140	-85
498.146	78.07	FOSA	-150	-90
498.146	478	FOSA_2	-150	-35
512.163	219.03	NMeFOSA	-130	-35
512.163	169.022	NMeFOSA_2	-130	-40
526.192	219.03	NEtFOSA	-140	-35
526.192	169.022	NEtFOSA_2	-140	-35
570.202	419.061	NMeFOSAA	-100	-28

570.202	483	NMeFOSAA_2	-100	-22
584.229	419.061	NEtFOSAA	-100	-28
584.229	526.192	NEtFOSAA_2	-100	-38
616.1	58.9	NMeFOSE	-90	-70
630	58.9	NEtFOSE	-80	-75
285.035	169.022	HFPO-DA	-60	-12
285.035	184.9	HFPO-DA_2	-60	-18
377.06	251.028	ADONA	-65	-18
377.06	84.8	ADONA_2	-65	-48
530.8	351.05	9Cl-PFONS	-130	-38
532.8	353	9Cl-PFONS_2	-130	-38
630.9	451.031	11Cl-PFOUdS	-145	-41
632.9	452.9	11Cl-PFOUdS_2	-145	-41
241.085	177.069	3:3FTCA	-60	-12
241.085	117	3:3FTCA_2	-60	-50
341.101	237.072	5:3FTCA	-70	-20
341.101	217	5:3FTCA_2	-70	-35
441.117	316.9	7:3FTCA	-85	-30
441.117	337.088	7:3FTCA_2	-85	-20
315.093	135.013	PFEESA	-100	-35
315.093	82.9	PFEESA_2	-100	-25
229.032	85.006	PFMPA	-40	-25
279.042	85.006	PFMBA	-45	-25
295.032	201	NFDHA	-30	-15
295.032	84.9	NFDHA_2	-30	-40
217.001	171.999	MPFBA	-50	-14
268.001	222.999	M5PFPeA	-55	-12
318.009	273.007	M5PFHxA	-45	-12
367.024	322.022	M4PFHpA	-60	-12
421.002	376	M8PFOA	-65	-14
472.002	427	M9PFNA	-70	-14
519.033	474.03	M6PFDA	-80	-16
570.033	525.031	M7-PFUdA	-85	-18
615.079	570.033	MPFDoA	-85	-18
715.094	670.092	M2PFTeDA	-70	-22
302.069	80.062	M3PFBS	-100	-65
402.084	80.062	M3PFHxS	-120	-74
507.062	80.062	M8PFOS	-145	-85
329.13	81.07	M2-4:2FTS	-100	-50

429.162	81.07	M2-6:2FTS	-120	-65
529.162	81.07	M2-8:2FTS	-140	-85
506.077	78.07	M8FOSA	-150	-90
515.183	219.03	d3-NMeFOSA	-130	-35
531.222	219.03	d5-NEtFOSA	-140	-35
573.22	419.061	d3-NMeFOSAA	-75	-28
589.259	419.061	d5-NEtFOSAA	-90	-28
623.2	58.9	d7-NMeFOSE	-100	-28
639.2	58.9	d9-NEtFOSE	-100	-28
287.02	169.022	M3HFPO-DA	-60	-12
216.009	171.999	M3PFBA	-50	-14
315.032	270.03	M2PFHxA	-45	-12
417.032	372.03	M4PFOA	-65	-14
468.032	423.03	M5PFNA	-70	-14
515.063	470.061	M2PFDA	-80	-16
403.107	84.062	18O2-PFHxS	-120	-74
503.093	80.062	M4PFOS	-145	-85

Table 6: LC Method Conditions

Time (min)	2 mM Ammonium Acetate (5:95 CH/H_2O)	100% Acetonitrile	Gradient Curve
Initial	100.0	0.0	0
.2	100.0	0.0	2
4	70	30	7
7	45	55	8
9	25	80	8
10	5	95	6
10.4	98	2	10
11.8	100	0	7
12	100	0	1
Waters Aquity UPLC ® BEHC_{18} 2.1 x 50 mm packed with 1.7 µm BEH C_{18} stationary phase Flow rate of 0.4 mL/min 2 µL injection			

Table 7: ESI-MS Method Conditions

ESI Conditions	
Polarity	Negative ion
Curtain Gas	30
Collision gas	9
Ion Spray Voltage	-4500
Desolvation gas temp.	500 ºC
Ion Source Gas 1	30
Ion Source Gas 2	50
Entrance Poitential	-10
Exic Cell Potential	-11

Table 8. Reporting limits by Matrix

Compound	Aqueous (ng/L)	Solid (ng/g)	Tissue (ng/g)
PFBA	6.4	0.8	2
PFPeA	3.2	0.4	1
PFHxA	1.6	0.2	0.5
PFHpA	1.6	0.2	0.5
PFOA	1.6	0.2	0.5
PFNA	1.6	0.2	0.5
PFDA	1.6	0.2	0.5
PFUnA	1.6	0.2	0.5
PFDoA	1.6	0.2	0.5
PFTrDA	1.6	0.2	0.5
PFTA	1.6	0.2	0.5
PFBS	1.6	0.2	0.5
PFPeS	1.6	0.2	0.5
PFHxS	1.6	0.2	0.5
PFHpS	1.6	0.2	0.5
PFOS	1.6	0.2	0.5
PFNS	1.6	0.2	0.5
PFDS	1.6	0.2	0.5
PFDoS	1.6	0.2	0.5
4:2FTS	6.4	0.8	2
6:2FTS	6.4	0.8	2
8:2FTS	6.4	0.8	2
FOSA	1.6	0.2	2
NMeFOSA	1.6	0.2	0.5

NEtFOSA	1.6	0.2	0.5
NMeFOSAA	1.6	0.2	0.5
NEtFOSAA	1.6	0.2	0.5
NMeFOSE	16	2	5
NEtFOSE	16	2	5
HFPO-DA	6.4	0.8	2
ADONA	6.4	0.8	2
9Cl-PFONS	6.4	0.8	2
11Cl-PFOUdS	6.4	0.8	2
3:3FTCA	8	1	2.5
5:3FTCA	40	5	12.5
7:3FTCA	40	5	12.5
PFEESA	3.2	0.4	1
PFMPA	3.2	0.4	1
PFMBA	3.2	0.4	1
NFDHA	3.2	0.4	1

Analysis of

Chlorinated Herbicides by GC Using Methylation Derivatization

Reference Methods: **EPA 8151A,** SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1997.

MA BWS-CAM Section VC, Quality Assurance and Quality Control Requirements and Performance Standards for SW-846 Method 8151A, for the Massachusetts Contingency Plan (MCP). Revision 1. July 1, 2010.

SW-846 Chlorinated Herbicides by 8151, State of Connecticut Department of Environmental Protection Reasonable Confidence Protocol **(RCP)**, Version 2.0, July 2006

1. Scope and Application

Matrices: Aqueous, soil and waste.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Specifically, Method 8151A may be used to determine the following compounds:

Parameter		CAS No.[a]
2,4-D	[1, 2, 3]	94-75-7
2,4-DB		94-82-6
2,4,5-TP (silvex)	[1, 2, 3]	93-72-1
2,4,5-T	[1, 2]	93-76-5
Dalapon		75-99-0
Dicamba		1918-00-9
Dichloroprop		120-36-5
Dinoseb		88-85-7
MCPA		94-74-6
MCPP		93-65-2

[a] Chemical Abstract Service Registry Number

[1] RCRA List

[2] APA List

[3] TCLP List

Method 8151A is a capillary gas chromatographic (GC) method for determining certain chlorinated acid herbicides and related compounds in aqueous, soil and waste matrices.

Because these compounds are produced and used in various forms (i.e., acid, salt, ester, etc.), Method 8151A describes a hydrolysis step than can be used to convert herbicide esters into the acid form prior to analysis. Herbicide esters generally have a half-life of less than one week in soil.

When Method 8151A is used to analyze unfamiliar samples, compound identifications should be supported by at least one additional qualitative technique. Section 10.1 provides gas

chromatograph/mass spectrometer (GC/MS) criteria appropriate for the qualitative confirmation of compound identifications.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the use of gas chromatography and skilled in the interpretation of gas chromatograms. Only experienced analysts should be allowed to work with diazomethane due to the potential hazards associated with its use (explosive, carcinogenic). Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

This SOP for Method 8151A details gas chromatographic conditions for the analysis of chlorinated acid herbicides in water, soil, and waste samples. The hydrolysis of esters is also described in SOP number 1964.

Water, soil, and waste samples are extracted with diethyl ether and then derivatized with diazomethane. The derivatives are determined by gas chromatography with an electron capture detector (GC/ECD). The results are reported as acid equivalents.

3. Reporting Limits

The sensitivity of Method 8151A depends on the level of interferences, in addition to instrumental limitations. Table 1 lists the estimated GC/ECD detection limits that can be obtained in aqueous and soil matrices in the absence of interferences. Detection limits for a typical waste sample should be greater.

4. Interferences

4.1 Refer to Method 8000 for instrumental interferences.

4.2 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing hardware that lead to discrete artifacts or elevated baselines in gas chromatograms. All these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis, by analyzing reagent blanks.

4.2.1 Glassware must be scrupulously cleaned. Clean each piece of glassware as soon as possible after use by rinsing it with the last solvent used in it. This should be followed by detergent washing with hot water and rinses with tap water, then with organic-free reagent water. Glassware should be solvent-rinsed with acetone and pesticide-quality hexane. After rinsing and drying, glassware should be sealed and stored in a clean environment to prevent any accumulation of dust or other contaminants. Store glassware inverted or capped with aluminum foil. Immediately prior to use, glassware should be rinsed with the next solvent to be used.

4.2.2 The use of high purity reagents and solvents helps to minimize interference problems.

4.3 Matrix interferences may be caused by contaminants that are coextracted from the sample. The extent of matrix interferences will vary considerably from waste to waste, depending upon the nature and diversity of the waste being sampled.

4.4 Organic acids, especially chlorinated acids, cause the most direct interference with the determination by methylation. Phenols, including chlorophenols, may also interfere with this procedure.

4.5 Alkaline hydrolysis and subsequent extraction of the basic solution removes many chlorinated hydrocarbons and phthalate esters that might otherwise interfere with the electron capture analysis. However, hydrolysis may result in the loss of Dinoseb and the formation of aldol condensation products if any residual Acetone remains from the extraction of solids.

4.6 The herbicides, being strong organic acids, react readily with alkaline substances and may be lost during analysis. Therefore, glassware must be acid-rinsed and then rinsed to constant pH with organic-free reagent water. Sodium Sulfate must be acidified.

4.7 Sample extracts must be dry prior to methylation otherwise poor recoveries will be obtained.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling supplies, samples, extracts, standards or solvents, and when washing glassware.

5.2 All extract concentration steps must be performed in extraction hoods. All solvent and extract transfers must also be handled in a hood.

5.3 All expired stock standards, working standards, and spent sample extracts must be placed into the waste bucket in the laboratory for future disposal by the Hazardous Waste Manager. The container must be properly labeled with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet or in the vented cabinets found under the hoods. All ether bottles are to be checked for peroxide immediately upon opening.

5.5 All waste solvents must be transferred to the satellite waste storage containers located in the extraction laboratory. Separate containers are provided for chlorinated and non-chlorinated solvents and must be used accordingly. Under no circumstances are solvents to be poured down the sink drains.

5.6 Inspect all glassware prior to use. Do not use any glassware that is chipped or cracked if it could present a safety hazard. Damaged glassware is put aside for repair; otherwise the piece is discarded. A number is etched onto each KD concentrator tube to keep track of calibration (Refer to SOP/08-04, KD Tube Calibration).

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Aqueous samples are collected in two one-liter amber glass containers. Soil samples are collected in 8oz. glass jars.

6.2 Sample Preservation

Both aqueous and soil/solid samples are stored in refrigerators to maintain a temperature of 2 – 6 °C.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Both aqueous and soil/solid samples and extracts are stored under refrigeration (2 – 6 ºC) and protected from light. Aqueous samples must be extracted within 7 days from the time of collection; soil samples, within 14 days from collection. Sample extracts must be analyzed within 40 days following extraction.

After the extraction is completed, the sample extract is stored in a stoppered KD tube before being transferred to a crimp-top or screw cap vial for analysis and long-term storage.

7. Equipment and Supplies

7.1 Gas Chromatograph, Agilent 7890 (or equivalent): An analytical system complete with gas chromatograph configured for split-splitless injection and all required accessories including syringes, analytical columns, gases, electron capture detectors (ECD), and data system.

7.2 GC Columns: Alpha utilizes dual-column analyses. The dual-column approach involves either a single injection that is split between two columns that are mounted in a single gas chromatograph, or dual injections of the split extract on a single GC equipped with two columns. Typical column pairs used are listed below. Other columns may be used as long as method performance criteria can be met.

Column Pair:

STX-CLP: Cat.: #11546 from Restek or equivalent, 30m, 0.32mm, 0.32 µm
STX-CLPII: Cat.: #11444 from Restek or equivalent, 30m, 0.32mm, 0.25µm

7.3 Guard Column: Cat. #10027 from Restek or equivalent; 5m, 0.32mm

7.4 Class “A” Volumetric Flasks: 10mL and 25mL (and other volumes), for standards preparation

7.5 Microsyringes: 10 µL – 1000 µL

7.6 Gooseneck splitless injecton liner, Cat #23303 from Restek or equivalent

7.7 Universal “Y” Press-tight tee split: Cat. #20406 from Restek or equivalent **/ Siltek MXT Connector:** Cat. #21388 from Restek or equivalent

8. Reagents and Standards

Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

NOTE: Store the standard solutions (stock, composite, calibration, internal, and surrogate) at 4±2 °C in Teflon(R)-sealed containers in the dark. When a large volume of standard is prepared, aliquots of that lot are stored in individual small vials.

All stock standard solutions must be replaced ***after one year or sooner*** if routine QC tests indicate a problem.

All other standard solutions must be replaced ***after six months or sooner*** if routine QC indicates a problem.

8.1 Reagent water: All references to water in this method refer to reagent water from Alpha's DI water treatment system.

8.2 n-Hexane: Pesticide grade or equivalent

8.3 Acetone: Pesticide grade or equivalent

8.4 Internal Standard Stock Solution: 4,4'-dibromooctafluorobiphenyl (DBOB) (AccuStandard, Cat # M-8151-IS) is used as the internal standard.

- **Working Internal Standard Solution**: To a 10mL volumetric flask, add 1mL of the 4,4'-dibromooctafluorobiphenyl (DBOB) (AccuStandard, Cat # M-8151-IS) and bring to volume with Acetone. Final concentration is 25µg/mL. 10µL of this solution is added to the 1mL sample and QC sample extracts as well as to all Calibration Standards to achieve a concentration of 0.25µg/mL for analysis.

8.5 Calibration Standards: Appropriate vendor derivatized standard(s) are volumetrically diluted with Hexane to obtain Initial Calibration Stock Standard which is used to prepare Initial Calibration Working Standards.

8.5.1 Initial Calibration Stock Standard: to a 10mL volumetric flask, add few mLs of Hexane:

- **1mL 2,4-Dichlorophenyl acetic acid (DCAA) methyl ester solution: (**100µg/mL in MTBE, Accustandard, Cat # M515-SS) and
- **1mL of Chlorinated Herbicides Methyl Derivatives** (100/10000µg/mL in MTBE, Accustandard, Cat # M-8151) Bring to volume using Hexane. Final concentration is 10µg/mL for all analytes except MCPP and MCPA at 1000µg/mL.

8.5.1.1 Initial Calibration Working Standards

8.5.1.1.1 Cal Level 1: To a 10mL volumetric flask, add 50µL of Initial Calibration Stock Standard. Bring to volume with Hexane. Final concentration is 0.05µg/mL for all analytes except MCPP and MCPA at 5.0µg/mL.

8.5.1.1.2 Cal Level 2: To a 10mL volumetric flask, add 100µL of Initial Calibration Stock Standard. Bring to volume with Hexane. Final concentration is 0.10µg/mL for all analytes except MCPP and MCPA at 10.0µg/mL.

8.5.1.1.3 Cal Level 3: To a 10mL volumetric flask, add 200µL of Initial Calibration Stock Standard. Bring to volume with Hexane. Final concentration is 0.20µg/mL for all analytes except MCPP and MCPA at 20.0µg/mL.

8.5.1.1.4 Cal Level 4: To a 10mL volumetric flask, add 500µL of Initial Calibration Stock Standard. Bring to volume with Hexane. Final concentration is 0.50µg/mL for all analytes except MCPP and MCPA at 50.0µg/mL.

8.5.1.1.5 Cal Level 5: To a 10mL volumetric flask, add 1.0mL of Initial Calibration Stock Standard. Bring to volume with Hexane. Final concentration is 1.0µg/mL for all analytes except MCPP and MCPA at 100µg/mL.

8.5.1.1.6 Cal Level 6: To a 10mL volumetric flask, add 2.0mL of Initial Calibration Stock Standard. Bring to volume with Hexane. Final concentration is 2.0µg/mL for all analytes except MCPP and MCPA at 200µg/mL.

8.6 Second Source Standard: (ICV) Appropriate vendor derivatized standard(s) are volumetrically diluted with Hexane to obtain Initial Calibration Verification Stock Standard which is used to prepare ICV Working Standard.

8.6.1 ICV Stock Standard: to a 10mL volumetric flask, add a few mLs of Acetone (to ensure mix of Methanol from the Herbicides Mixture):

- **1mL of Methylated Herbicides Mixture** (100/10000µg/mL in Methanol, Agilent, Cat # HBM-8151M) and
- **1mL of DCAA Methyl Ester Solution: 2,4-Dichlorophenyl acetic acid (DCAA) methyl ester solution –SURROGATE (**100µg/mL in Acetone, Agilent, Cat # PPS-166). Bring to volume using Hexane. Final concentration is 10µg/mL for all analytes except MCPP and MCPA at 1000µg/mL.

8.6.1.1 ICV Working Standard: To a 50mL volumetric flask, add 1mL ICV Stock Solution. Bring to volume with Hexane. Final concentration is 0.2µg/mL for all analytes except MCPP and MCPA at 20µg/mL.

8.6.2 ICV Standard (2,4-DB only): to a 50mL volumetric flask, add few mLs of Hexane and **2,4-DB methyl ester** (1000µg/mL in Hexane, Restek, Cat # 70931). Bring to final volume using Hexane. Final concentration is 0.2µg/mL.

8.7 Extraction Surrogate Standard: 2,4-Diclorophenylacetic Acid (DCAA) (1000µg/mL in Acetone, AccuStandard, M-8150B-SS-10X) The Surrogate standard is spiked into all samples and QC samples prior to extraction.

- To a 1000mL volumetric flask, add 10mL of ampulated surrogate solution. Bring to volume with Acetone. Final concentration is 10µg/mL.

8.8 LCS/MS Spiking Solutions: The LCS/MS spiking solutions are prepared volumetrically by diluting Underivatized Chlorinated Herbicides (100/10000µg/mL in Acetone, AccuStandard, Cat # M8151A.) in Acetone

- To a 200mL volumetric flask, add 20mL of ampulated LCS/MS solution. Bring to volume with Acetone. Final concentration is 10µg/mL for all analytes except MCPP and MCPA at 1000µg/mL.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

A matrix-specific extraction blank is performed with each extraction batch of 20 or fewer samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes at or above the reporting limit. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required, unless the associated samples are non-detect or concentration of the analyte in the samples is 10 times greater than the concentration of this analyte in the blank. The surrogate recoveries must also be within the acceptance criteria listed in Table 3. If surrogate acceptance criteria are exceeded, the extraction batch must be evaluated to determine if re-extraction or re-analysis is necessary. Actions associated with blank failures are listed in Table 4.

9.2 Laboratory Control Sample (LCS) / LCS Duplicate

A Laboratory Control Sample (LCS) and an LCS Duplicate (LCSD) is extracted with each analytical batch. The LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The LCS is spiked with all target analytes. The concentrations of the spiking solutions are listed in Table 2. The recovery and RPD acceptance criteria are listed in Table 3. If any recovery criteria are not met, the extract should be reanalyzed. If the criteria are still not met, the entire batch should be re-extracted, unless the recoveries are high and the associated samples are non-detect. If this is not possible, due to insufficient sample or holding time exceedance, the analyst must write up the failure on a narrative sheet for inclusion in the client report. Actions associated with LCS/LCSD failures are listed in Table 4.

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.2.7

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4

9.5 Matrix Spike (MS)/MS Duplicate

A matrix spike/matrix spike duplicate pair is extracted and analyzed for each batch of 20 or less samples only upon client request. MS and MSDs are field samples spiked with a known quantity of the target analyte(s). They are prepared by taking additional sample aliquots of the same weight or volume and adding the appropriate amounts of surrogate and spiking solutions. The spike compounds and levels are listed in Table 2. The recovery and RPD acceptance criteria are listed in Table 3. If the recovery criteria are not met, but are met in the LCS, the

failure may be attributed to sample matrix. Actions associated with MS/MSD failure are listed in Table 4.

9.6 Laboratory Duplicate (DUP)

A duplicate sample is extracted and analyzed upon Client request for each batch of 20 or less samples. Duplicates are laboratory selected replicate samples, prepared by taking an additional sample aliquot of the same weight or volume of a sample. The % RPD criteria are listed in Table 3. If the %RPD is not met, the failure may be attributed to sample matrix effects and must be noted on a narrative sheet for inclusion in the client report. Actions associated with duplicate failures are listed in Table 4.

For samples with a state of origin of New Jersey, a MS and MSD/DUP must be extracted for every twenty samples within a 24hr period.

9.7 Extraction Surrogates

All extracted samples and associated QC are spiked with surrogates at the levels listed in Table 2. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits for both columns listed in Table 3. If the surrogate limits are not met, the extract should be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

9.8 Method Sequence

Typical Initial Calibration (each level has to be identified with the standard lot number)

1. Instrument Prime
2. Blank
3. Std Level 1
4. Std Level 2
5. Std Level 3
6. Std Level 4
7. Std Level 5
8. Std Level 6
9. Initial Calibration Verification Standard (ICV)
10. Initial Calibration Verification Standard (ICV)

Typical Daily Sequence:

1. Instrument Prime
2. Blank
3. Herbicide Continuing Calibration Standard **(identified with the standard lot number**)
4. Extraction Blank
5. Laboratory Control Sample
6. Laboratory Control Sample Duplicate
7. Matrix Spike (Upon Client Request)
8. Duplicate/Matrix Spike Duplicate (Upon Client Request)
9. Samples (10 field samples)
10. Repeat 3 – 9 (as needed)

10. Procedure

10.1 Equipment Set-up

The dual-column / dual-detector approach involves the use of the columns listed in section 7.2. The columns are connected to an Y-split or similar or dual injection GC, and separate electron capture detectors. Alpha typical GC conditions are listed below but may be altered as long as method performance criteria are met.

Temperature 1:	80 °C	**Detector temperature:**	350 °C
Ramp 1:	15°C/minute	**Carrier gas:**	Hydrogen
Temperature 2:	200°C	**Carrier flow:**	2.5 mL/min
Ramp 2:	20°C/minute	**Carrier mode:**	Constant flow
Temperature 3:	280°C	**Makeup gas:**	Nitrogen
Hold Time:	3 minutes	**Total detector flow:**	55 mL/min
Injector Temperature:	250°C		
Injector Mode:	Split		
Injector Flow:	36.5 mL/min		
Septum Purge Flow:	24 mL/min		
Split Flow:	10 mL/min		
Split Ratio:	4:1		
Injection Volume	1 µL		

10.2 Initial Calibration

10.2.1 Prepare calibration standards using the procedures in Section 8.5 and Table 2. The calibration standards are aliquoted into autosampler vials and capped prior to loading onto the autosampler tray. The calibration standards are analyzed and the curve is calculated prior to sample analysis.

10.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in section 10.1. The same operating conditions are used for calibrations and sample analyses. Create the analytical sequence using the Agilent Chemstation data acquisition software. Record the calibration standard, unique lot number (PP#) and analyst's initials in the analytical sequence list.

10.2.3 A 1µL injection volume of each calibration standard is typically used. Other injection volumes may be employed, provided that the analyst can demonstrate adequate sensitivity for the compounds of interest. The same injection volume must be used for all standards and samples.

10.2.4 Column adsorption may be a problem when the GC has not been used for a day or more or after system maintenance. The GC column may be primed (or deactivated) by injecting a Herbicides standard mixture approximately 20 times more concentrated than the mid-concentration standard. Inject this standard mixture prior to beginning the initial calibration or calibration verification.

Alternately, the system may be primed by baking at the final analytical temperature for approximately 30 minutes.

Several analytes may be observed in the injection just following system priming. Always run an instrument blank after system priming.

10.2.5 Calibration Factors

Internal standard calibration techniques are employed in this method.

10.2.5.1 Internal Standard Procedure. In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Enviroquant data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

10.2.6 Initial Calibration Criteria

- If the **RSD for an analyte is < 20%,** then the response of the instrument for this compound is considered linear over the range and the mean calibration factor (Avg. RF) can be used to quantitate sample results.

- If the **RSD for any analyte is > 20%**, then linearity through the origin cannot be assumed. The mean response factor cannot be used for quantitation. An alternative calculation may be done by the use of **linear regression** or **quadratic regression** (minimum of six ICAL points are needed and regression must be weighted inversely proportional to concentration) as long as the **correlation coefficient is >0.990**. If both of these quantitation methods fail criteria for any compound in the initial calibration, then the system must be reevaluated and a new calibration curve must be analyzed. If quadratic regression is used for calibration, this must be noted in the laboratory narrative. The regression equation cannot be forced through the origin. The equation for linear regression may be found in Alpha's Quality Manual.

- **MCP requirement:** If linear or non-linear regression is used, RL must to be verified by recalculating concentrations in the lowest calibration standard using the final calibration curve. Recoveries must be **70-130%.**

- Minimum of five standards must be used for the linear regression and minimum of six for non-linear regression.

- Percent Relative Error (%RE): For linear and quadratic fit compounds, the %RE must be calculated for the standard at or near the midpoint and at the lowest level of the initial calibration. The %RE between the calculated and expected concentration of an analyte must be ≤ 30%, otherwise recalibration is necessary.

10.2.7 Initial Calibration Verification

An Initial Calibration Verification standards must be run immediately after each initial calibration, near the midpoint of the curve. The standards must be prepared using a second source that is different than the source used for the initial calibration. (Standards listed in Section 8.6). The **%D** has to be within **20%** (**15% for CT RCP**) when compared to the mean response factor from the initial calibration.

10.2.8 Retention Time Windows

- The retention time windows used for the identification of target analytes is ± 0.03 minutes. These criteria have been adopted from the EPA CLP Statement of Work (OLM04.2). It has been found that these limits work well, being wide enough to eliminate false-negatives while being tight enough to eliminate false-positives. Windows that are calculated using the procedure recommended in Method 8000 tend to be very narrow, creating the risk of false negative results.
- The windows listed above are used as guidance, however the experience of the analyst weighs heavily in the interpretation of the chromatograms. For example, it has been observed that certain oil matrices can cause the retention times to shift more dramatically. Additionally, if any positive results are questionable and at a sufficiently high concentration, GC/MS analysis is used for confirmation.

10.3 Sample Processing

10.3.1 The same GC operating conditions used for the initial calibration must be employed for sample analyses, including sample injection volume.

10.3.2 Tentative identification of an analyte occurs when a peak from a sample extract falls within the retention time window for the compound. Each tentative identification is confirmed using a second GC column of dissimilar stationary phase. In particularly difficult matrices, confirmation by GC/MS may be advisable.

10.3.3 The concentration reported for an identified target analyte in an extract is calculated using the Enviroquant data processing software. The Enviroquant methods have been configured to utilize the quantitation formulas found in Alpha's Quality Manual. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined. See the Manual Integration SOP for integration guidelines. Also refer to Section 11 for calculations.

10.3.3.1 If the responses exceed the calibration range of the system, dilute the extract and reanalyze.

10.3.4 The laboratory must report **HIGHER** of the two results unless obvious interference is present on one of the columns.

10.3.4.1 The **Relative Percent Difference (RPD)** should be 40 or lower. If the RPD exceeds 40, this will be denoted with a P flag. If the RPD exceedance is due to interference, the lower of the dual column values can be reported with I and P flags.

10.3.5 If compound identification or quantitation is precluded due to interference (e.g. broad, rounded peaks or ill-defined baselines are present) cleanup of the extract may be needed. If instrument problems are suspected, rerun the extract on another instrument to determine if the problem results from analytical hardware or

the sample matrix. Refer to the extraction SOPs for the procedures to be followed in sample cleanup.

10.3.6 GC/MS Confirmation

GC/MS confirmation may be used in conjunction with either single-column or dual-column analysis if the concentration is sufficient for detection by GC/MS.

10.4 Continuing Calibration

10.4.1 Verify calibration each **12-hours** shift by injecting Continuing Calibration standard prior to conducting any sample analyses. A calibration standard must also be injected at intervals of **not less than once every 10 filed samples.**

A bracketing CCV is not required with the use of internal standard calibration method with the exception of samples ran under CT RCP method.

10.4.2 The Response Factor (for internal standard compounds) for each analyte to be quantitated must not exceed a **± 20% difference (± 15% for MCP and CT RCP**) when compared to the initial calibration curve. The Enviroquant data processing software automatically calculates the %D for all analytes according to the formula in Alpha's Quality Manual.

If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

10.4.3 If routine maintenance does not return the instrument performance to meet the QC requirements based on the last initial calibration, then a new initial calibration must be performed. Due to the large number of analytes present, allowances may be made for a CF or RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples.

10.5 Internal Standard

The use of internal standard calibration does not require that all sample results be bracketed with CCV standard. However, when internal standard calibration is used, the retention times of internal standards and the area response of internal standards should be checked for each analysis.

10.5.1 **IS in CCAL** – The measured area of the internal standard must be no more than + 50% different from the average area calculated during initial calibration (-50 to 150%).

10.5.2 **IS in samples** - The measured area of the internal standard must be no more than -50% to +100% different from the area calculated from opening CCV (-50 to 200%)

Retention time shifts of more than 30 sec from the retention time of the most recent calibration standard are cause for concern and must be investigated.

10.6 Preventive Maintenance

- Routine preventive maintenance should be performed to maintain GC system performance. This includes periodic replacement of injector septa, replacement of injector liner(s), and replacement of injector seals. All maintenance is noted in individual Instrument Maintenance Logbooks.
- Other Maintenance: ECD detectors may become contaminated, requiring bake out at elevated temperatures, (no greater than 375℃) or repair by the manufacturer.

11. Data Evaluation, Calculations and Reporting

Herbicides are calculated as described in Section 11.1, 11.2, and reported in µg/L or µg/Kg units. After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. Two levels of review of the data in the LIMS system are preferred prior to release of data. These reviews include analyst review and review by the Department Supervisor or other trained analyst.

11.1 Aqueous Calculation

$$\mu g/L = \frac{(A_s)\,(C_{IS})\,(D)\,(V_f)}{(A_{IS})\,(\overline{RF})\,(V_s)\,(1000)}$$

Where:

A_s = Peak area of analyte
A_{IS} = Peak area of Internal Standard
C_{IS} = Concentration of IS (µg/L)
D = Dilution factor (D = 1 for no dilution)
V_f = Final extract volume (mL)
Vs = Initial volume extracted (mL)

$\overline{RF}$ = Mean response factor

11.2 Soil/Solid Calculation

$$\mu g/Kg = \frac{(A_s)\,(C_{IS})\,(D)\,(V_f)}{(A_{IS})\,(\overline{RF})\,(W_s)\,(1000)}$$

Where:

A_s = Peak area of analyte
A_{IS} = Peak area of Internal Standard
C_{IS} = Concentration of IS (µg/L)
D = Dilution factor (D = 1 for no dilution)
V_f = Final extract volume (mL)
Ws = Initial weight extracted (g)

$\overline{RF}$ = Mean response factor

11.2.1 Response Factor Calculation

$$RF = \frac{(A_s)\,(C_{IS})}{(A_{IS})\,(C_s)}$$

Where:

A_s = Peak area of analyte
A_{IS} = Peak area of Internal Standard
C_s = Concentration of analyte (µg/L)
C_{IS} = Concentration of IS (µg/L)

11.3 Molecular Weight Correction

In addition, conversion factors for the molecular weights have been listed for all analytes reported under EPA Method 8151.

The calibration is performed using the methyl ester compounds; therefore the calculation of the concentration includes a correction for the molecular weight of the methyl ester versus the acid herbicide.

Derivatized herbicides are used for the standard curve, and they are supplied as methyl esters as opposed to acid herbicide form which is used for the LCS. The difference between the acid form and the methyl ester is + 14 (i.e. In Derivatization, a -CH_3 group replaces the -H, (15-1 = 14)). The factors used for correction (listed in the Table below) vary for each herbicide and are applied to the standard concentration at each level of the calibration within the target processing software.

Example: 2,4-D

2,4-D MW = 221.04 2,4-D Methyl ester MW = 235.06

If you spike 10 ug of 2,4-D, and derivatized it, you end up with 10.634 ug of 2,4-D Methyl ester that you are measure, as you've stripped the -H and added a -CH3, increasing the molecular weight. The true value for the spike is 10 ug as the acid herbicide, and 10.634 ug as the methyl ester. So a spike of 10 ug of acid, would measure 10.634 ug of the methyl ester to get 100% recovery. The true value for the spike would be 10.634 as methyl ester, which you use to divide your measured value by.

If measuring recoveries, the value of the 10 ug of the methyl ester, would be 10 ug measured (as methyl ester)/10.634 ug spiked (as methyl ester) = 94.04%.

If, on the other hand you want to convert your final result using a correction factor, you would use the MW of the acid/MW of the ester (221.04/235.06 = 0.94).

Conversion Factors applied in EQ software:

Parameter	CAS No.[a]	MOL WT.	WT as methyl ester	Conversion Factor
2,4-D [1, 2, 3]	94-75-7	221.04	235.06	0.94
2,4-DB	94-82-6	326.18	340.18	0.96
2,4,5-TP (silvex) [1, 2, 3]	93-72-1	269.51	283.51	0.95
2,4,5-T [1, 2]	93-76-5	255.48	269.48	0.95
Dalapon	75-99-0	142.96	156.96	0.91
Dicamba	1918-00-9	221.04	235.04	0.94
Dichloroprop	120-36-5	235.06	249.06	0.94
Dinoseb	88-85-7	240.21	254.21	0.95
MCPA	94-74-6	200.62	214.62	0.93
MCPP	93-65-2	214.65	228.65	0.94

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Refer to Section 10 for specific corrective actions.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Qualtrax Document ID 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/08-12 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

- Chemical Hygiene Plan
- Qualtrax ID 1732 MDL/LOQ Generation
- Qualtrax ID 1739 IDC/DOC Generation
- Qualtrax ID 1728 Waste Management and Disposal SOP

16. Attachments

Table 1: REPORTING LIMITS

Table 2: STANDARD SOLUTIONS

Table 3: QC ACCEPTANCE CRITERIA

Table 4: QC FAILURE ACTION PLAN

TABLE 1

REPORTING LIMITS

Herbicides	RL (Aqueous)	RL (Soil)
2,4-D	1.0 ug/L	33 ug/kg
Dalapon	1.0 ug/L	33 ug/kg
2,4-DB	1.0 ug/L	33 ug/kg
Dicamba	1.0 ug/L	33 ug/kg
Dichloroprop	1.0 ug/L	33 ug/kg
Dinoseb	1.0 ug/L	33 ug/kg
MCPA	100.0 ug/L	3300 ug/kg
MCPP	100.0 ug/L	3300 ug/kg
Silvex (2,4,5-TP)	1.0 ug/L	33 ug/kg
2,4,5-T	1.0 ug/L	33 ug/kg

TABLE 2

STANDARD SOLUTIONS

Compound	Level 6	Level 5	Level 4	Level 3	Level 2	Level 1	Std. Spike Concentration *	Std. LCS Concentration *
	(µg/mL)	(µg/mL)	(µg/mL)	(µg/mL)	(µg/mL)	(µg/mL)	(µg/mL)	(µg/mL)
2,4-D	2.0	1.0	0.5	0.2	0.1	0.05	10	10
Dalapon	2.0	1.0	0.5	0.2	0.1	0.05	10	10
2,4-DB	2.0	1.0	0.5	0.2	0.1	0.05	10	10
Dicamba	2.0	1.0	0.5	0.2	0.1	0.05	10	10
Dichloroprop	2.0	1.0	0.5	0.2	0.1	0.05	10	10
Dinoseb	2.0	1.0	0.5	0.2	0.1	0.05	10	10
MCPA	200	100	50	20	10	5	1000	1000
MCPP	200	100	50	20	10	5	1000	1000
Silvex (2,4,5-TP)	2.0	1.0	0.5	0.2	0.1	0.05	10	10
2,4,5-T	2.0	1.0	0.5	0.2	0.1	0.05	10	10
DCAA (Surrogate)	2.0	1.0	0.5	0.2	0.1	0.05	10	10

***** Calculations are based on an initial aqueous sample volume of 1L**,** initial soil sample weight of 30g, and final extract volume of 10mL.

TABLE 3

QC ACCEPTANCE CRITERIA

	Aqueous/Soil	
Surrogate % Recovery	**Lower Control Limit**	**Upper Control Limit**
2,4-Diclorophenylacetic acid (DCAA)	30%	150%

	% Recovery		% RPD		MCP %RPD	
LCS/LCSD	**Lower Control Limit**	**Upper Control Limit**	**waters**	**soils**	**waters**	**soils**
2,4-D	40%	140%	≤ 50%	≤ 50%	≤ 20%	≤ 30%
dalapon						
2,4-DB						
dicamba						
dichloroprop						
dinoseb						
MCPA						
MCPP						
Silvex (2,4,5-TP)						
2,4,5-T						

	% Recovery		% RPD		MCP % RPD	
MS / MSD	**Lower Control Limit**	**Upper Control Limit**	**waters**	**soils**	**waters**	**soils**
2,4-D	30%	150%	≤ 30%	≤ 30%	≤ 20%	≤ 30%
dalapon						
2,4-DB						
dicamba						
dichloroprop						
dinoseb						
MCPA						
MCPP						
Silvex (2,4,5-TP)						
2,4,5-T						

TABLE 4

QC FAILURE ACTION PLAN

Blank Failures	Failure Situation	Action(s)
Surrogate Failure	1 of 2 high or low	Report as is
	Both high	Report as is
	Both low, samples are non-detect with passing surrogates	Report as is
	Both low, samples have hits and/or failing surrogates	Revial/rerun Re-extract if still failing
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Contamination	Below RL; sample(s) non-detect, below RL, or concentration 10 times or more above the blank	Report as is
	Below RL, sample(s) concentration above RL	See team leader/manager
	Above RL, sample(s) concentration 10 times or more above the blank	Report as is
	Above RL with non-detect sample(s)	Report as is
	Above RL, sample(s) concentration less than 10 times above the blank and volume available	Revial/rerun Re-extract if contamination still present
	Above RL, sample(s) concentration less than 10 times above the blank and no volume available	Revial/rerun B-flag affected data

LCS/LCSD Failures	Failure Situation	Action(s)
Surrogate Failure	1 of 2 high or low	Report as is
	Both high or low	Report as is
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Spike Failure	Spike compounds out high and sample(s) are non-detect with passing surrogates	Report as is
	Spike compounds out high and sample(s) have hits	Revial/rerun Re-extract if still high
	Spike compounds out low	Revial/rerun Re-extract if still low
	RPD failure	Report as is

MS/MSD/DUP Failures	Failure Situation	Action(s)
Surrogate Failure	(MS/MSD) 1 of 2 high or low	Report as is
	(MS/MSD) Both high or low	Report as is
	(DUP) 1 or more high, parent sample non-detect	Report as is
	(DUP) 1 of 2 low, parent sample matches	Report as is
	(DUP) 1 or more low, parent sample doesn't match	Revial/rerun Re-extract if still failing
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Spike Failure (MS/MSD only)	Compounds out high or low due to sample matrix or hits	Report as is
	Compounds out high or low due to extraction error	Revial/rerun Re-extract if still failing
	RDP failure	Report as is

Chromium, Hexavalent

References: **SM3500 Cr-B**, Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF. Standard Methods Online.

7196A, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update I, 1992.

3060A, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, 1996.

1. Scope and Application

Matrices: This method is applicable for the determination of hexavalent chromium in natural or treated water or in a soil or solid matrix.

Definitions: See Alpha Analytical Quality Manual Appendix A

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the Spectrophotometer and in the interpretation of Spectrophotometric data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

The hexavalent chromium concentration of U.S. drinking waters has been reported to vary between 3 and 40µg/L with a mean of 3.2µg/L. Chromium salts are used extensively in industrial processes and may enter a water supply through the discharge of wastes. Chromate compounds frequently are added to cooling water for corrosion control. Chromium may exist in water supplies in both the hexavalent and the trivalent state although the trivalent form rarely occurs in potable water.

2. Summary of Method

This procedure measures only hexavalent chromium (Cr^{6+}). The hexavalent chromium is determined colorimetrically by reaction with diphenylcarbazide in acid solution. A very sensitive red-violet color of unknown composition is produced, and its absorbance is measured photometrically at 540nm.

2.1 Method Modifications from Reference

The coloring reagent used for the standards in the calibration curve and for the samples is made by dissolving 1 gram of 1,5-diphenylcarbazine in 250mL of acetone, whereas the reference method 7196A dissolves 1 gram in 200mL of acetone.

Alpha uses a smaller sample volume for analysis; therefore reagent volumes are reduced accordingly.

Alpha doesn't perform Blank correction;

2.5 cm (not 1cm) absorption cell is used for water samples to increase sensitivity.

Soil samples with failed soluble or insoluble spikes will be analyzed for PH and ORP to check if sample has reducing condition. If reducing condition confirm then lab will not Reprep asnd reanalyze samples with failed insoluble and soluble spikes

3. Reporting Limits

The RDL reported is 0.01mg/L for 50mL of an aqueous sample. The RDL reported is 0.8mg/Kg for 2.5g of a soil/solid sample. The RDLs are not adjusted for % Moisture.

4. Interferences

4.1 Background Color

Turbidity and background sample color are removed by filtering the sample through a 0.45µm filter. In cases when filtration alone is not sufficient, background interference can be subtracted out by adding all reagents to the sample except diphenylcarbazide solution, measuring the background absorbance, and then subtracting this value from the colored sample absorbance value.

4.2 Other Metals

The reaction with diphenylcarbazide is nearly specific for chromium. Hexavalent molybdenum and mercury salts will react to form color with the reagent but the intensities are much lower than that for chromium at the specified pH. Concentrations as high as 200 mg/L of Mo or Hg can be tolerated. Vanadium interferes strongly but concentrations up to 10 times that of chromium will not cause trouble. Potential interference from permanganate is eliminated by prior reduction with azide. Iron in concentrations greater than 1mg/L may produce a yellow color but the ferric ion (Fe^{3+}) color is not strong and no difficulty is encountered normally if the absorbance is measured photometrically at the appropriate wavelength. Interfering amounts of molybdenum, vanadium, iron, and copper can be removed by extraction of the cupferrates of these metals into chloroform ($CHCl_3$). A procedure for this extraction is provided in the reference but do not use it unless necessary because residual cupferron and $CHCl_3$ in the aqueous solution complicate the later oxidation. Therefore, follow the extraction by additional treatment with acid fuming to decompose these compounds.

4.3 Reducing/oxidizing tendency of sample matrix

When analyzing a sample digest for total Cr(VI), it is appropriate to determine the reducing/oxidizing tendency of each sample matrix, if the matrix spike for that sample matrix has failed the quality control acceptance criteria for this method. Determination of the Reducing/oxidizing potential for failing matrix spike samples can be accomplished by characterization of each sample for additional parameters, such as pH (Method 9045) and Oxidation Reduction Potential (ORP) (ASTM 1498-93 –aqueous samples). Method 9045 (Section 7.2 of Method 9045) is referenced as the preparatory method for soil samples. The ORP and temperature probes are inserted directly into the soil slurry derived from the pH analysis. The displayed ORP value is allowed to equilibrate and the resulting measurement is recorded. Analysis of these parameters establishes the tendency of Cr(VI) to exist or not exist in the unspiked sample(s) and assists in the interpretation of QC data for matrix spike recoveries outside conventionally accepted criteria for total metals.

4.4 Soluble Cr(III) concentration

For waste materials or soils containing soluble Cr(III) concentrations greater than four times the laboratory Cr(VI) reporting limit, Cr(VI) results obtained using this method may be biased high due to method-induced oxidation. The addition of Mg^{2+} in a phosphate buffer to the alkaline extraction solution has been shown to suppress this oxidation. If an analytical method for Cr(VI) is used that can correct for possible method induced oxidation/reduction, then the Mg^{2+} addition is optional. The presence of soluble Cr(III) can be approximated by extracting the sample with deionized water.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound must be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available.Hexachrome is toxic and suspected carcinogen. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Samples are collected in plastic or glass containers with teflon-lined caps. Sample containers must not contain any stainless steel. Separate container has to be provided for MCP HexCr (see MCP addendum)

6.2 Sample Preservation

Samples are unpreserved and refrigerated at 4 ± 2 °C.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Aqueous samples must be analyzed within 24 hours of collection.

Soil and solid samples must be digested within 30 days of collection. The extracts must be analyzed within 168 hours (7 days) after extraction.

7. Equipment and Supplies

7.1 Spectrophotometer: Genesys 10 Vis or equivalent: for use at 540nm, with a light path of 1cm or longer.

7.2 100 ml digestion cups

7.3 pH Meter: Calibrated.

7.4 Volumetric flasks: 1000mL and 100mL.

7.5 Filtration apparatus.

7.6 0.45µm Membrane filters.

7.7 Hot block Model # SC151 with Stir Base Stirring device (part #SC160)

7.8 Balance.

7.9 Thermometers.

7.10 Volumetric pipets: various volumes.

7.11 50mL Centrifuge Tubes.

7.12 100mL Graduated cylinder

7.13 pH paper range 1-14.

7.14 Centrifuge

8. Reagents and Standards

8.1 1000ppm Stock Hexavalent Chromium Solution (for calibration and LCS): Commercial purchase. Expire upon manufacturer's expiration date. Use different lots for calibration and LCS.

8.2 1ppm Working Standard Hexavalent Chromium Solution (for calibration): Dilute 1.00mL stock chromium solution (Section 8.1) to 1000mL with DI. Store at room temperature. Expires three months from the date of preparation.

8.3 10ppm Working Standard Hexavalent Chromium Solution (for LCS/ICV): Dilute 1.00mL stock chromium solution (Section 8.1) to 100mL with DI. Store at room temperature. Expires six months from the date of preparation

8.4 Nitric acid, HNO_3, concentrated. Do not use if has a yellow tinge. Expires upon manufacturer's expiration date.

8.5 Nitric Acid, 50%: Into a 500mL volumetric flask, dilute 250mL of Concentrated Nitric Acid with 250mL of DI water. Expires six months from the date of preparation.

8.6 Sulfuric acid, H_2SO_4, concentrated.

8.7 Sulfuric acid, H_2SO_4, 10%: Dilute 50mL concentrated H2SO4 to 500mL with DI water. Expires six months from the date of preparation.

8.8 Diphenylcarbazide solution: Dissolve 1.0g 1,5-diphenylcarbazide (1,5-diphenylcarbohydrazide) in 250mL acetone. Store in a plastic bottle cover with aluminum foil or away from light. Discard when solution becomes discolored. Prepare fresh weekly.

8.9 Sodium carbonate: Na_2CO_3, anhydrous, analytical reagent grade. Store at 20 – 25°C in a tightly sealed container.

8.10 Sodium hydroxide: NaOH, analytical reagent grade. Store at 20 – 25°C in a tightly sealed container.

8.11 Magnesium Chloride: $MgCl_2$ (anhydrous), analytical reagent grade. 392.18mg $MgCl_2$ is equivalent to 100mg Mg^{2+}. Store at 20 – 25°C in a tightly sealed container. As an alternate, use 0.8366g $MgCl_2 \cdot 6\ H_2O$.

8.11.1 Magnesium Chloride solution: Dissolve 84g of $MgCl_2 \cdot 6\ H_2O$ in 100mL of DI. Store at 20 – 25°C in a tightly sealed container. Expires six months from the date of preparation.

8.12 Phosphate Buffer:

8.12.1 K_2HPO_4: Analytical reagent grade.

8.12.2 KH_2PO_4: Analytical reagent grade.

8.12.3 0.5M K_2HPO_4 / 0.5M KH_2PO_4 buffer: Dissolve 87.09g K_2HPO_4 and 68.04g KH_2PO_4 into 700mL of DI water. Transfer to a 1L volumetric flask and dilute to volume. (When prepared accordingly, the buffer solution has an approximate pH value of 7.)Record pH

in the reagent log book. Store at 20 – 25°C in a tightly sealed container. Expire one year from prep.

8.13 Lead Chromate: $PbCrO_4$, analytical reagent grade. Store under dry conditions at 20 – 25°C in a tightly sealed container. Expires upon manufacturer's expiration date.

8.13.1 Soil matrix insoluble spiking solution: Add 10 – 20mg $PbCrO_4$ (Section 8.12) to a separate aliquot of sample. This spike is used to evaluate the dissolution during the digestion process.

8.14 Digestion solution: Dissolve 20.0 ± 0.05g NaOH and 30.0 ± 0.05g Na_2CO_3 in deionized water in a one-liter volumetric flask and dilute to the mark. Store the solution in a tightly capped polyethylene bottle at 20 – 25 °C and prepare fresh monthly. The pH of the digestion solution must be checked before using. The pH must be 11.5 or greater; if not, discard.

8.15 Potassium Dichromate, $K_2Cr_2O_7$, spiking solution (1000mg/L Cr (VI)): Commercial purchase. Expire upon manufacturer's expiration date.

8.15.1 100mg/L Cr (VI): Add 10.0mL of the 1000mg/L $K_2Cr_2O_7$ spiking solution (Section 8.15) to a 100mL volumetric flask and dilute to volume with deionized water. Mix well.

8.15.2 5ppm: To a 100mL volumetric flask, add 5mL of 100ppm spiking solution (Section 8.15.1), bring to volume with DI.

8.15.3 Soil sample soluble spike: Add 1 ml of 1000mg/L Cr (VI) spiking solution (Section 8.15) to 2.5g of sample.

8.15.4 Post spike soil sample: Add 1 ml of 100mg/L Cr(VI) solution (section 8.15.1) to 25 ml extracted sample.

8.15.5 Aqueous sample spike: Add 1ml of 5 ppm (section 8.15.2) to 50 ml of sample**.**

8.16 ICV and CCV Standards: Commercially prepared solution of known hexavalent chromium concentration. A Certificate of Analysis is kept on file. This solution is diluted with DI to a concentration 0.2 ppm on each day of use

8.17 Acetone: Analytical reagent grade.

8.18 Ottawa Sand

8.19 SRM HexCr standard: ERA QC-Cat#921. Expires upon manufacturer's expiration date

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

One preparation blank is digested and analyzed per batch of 20 samples or less for method 3500. Method 7196: batch size is 10 samples or less. The concentration of the Blank must be less than the RDL, or one-tenth the regulatory limit or action level, whichever is greater, otherwise the entire batch must be redigested and reanalyzed.
Method Blanks consist of DI water for liquid samples or 2.5g of Ottawa sand for soil samples.

The ICB consists of DI water that has been colored and analyzed as per Section 10.3.4. Results must be less than the RDL, otherwise another ICB is colored and analyzed. It failure continues, a new calibration curve is generated (Section 10.1).

9.2 Laboratory Control Sample (LCS)

One LCS is prepared and analyzed per batch of 20 samples or less for method 3500. Method 7196: batch size is 10 samples or less.

The LCS for aqueous samples consists of the ICV (Section 10.2). LCS recovery for liquids must be within 85 – 115%, otherwise the entire sample batch must be reanalyzed.

For solids samples, a soluble LCS and insoluble LCS must be digested per batch of 20 samples or less (Refer to Section 10.3.3.1) LCS recovery for solids must be within 80 – 120%, otherwise the sample batch must be redigested and reanalyzed.

Note: SRM HexCr standard made by ERA is used for soil LCS: use 0.2-0.5 g, based on certified value. Expires upon manufacturer's expiration date.

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.2

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4

9.5 Matrix Spike

9.5.1 Aqueous samples

One sample per delivery group per batch of 20 samples (method 3500) or 10 samples (method 7196) or less is required to be spiked.

Example: If a batch consists of 6 liquid samples (3 wastewater from Client A and 3 wastewater from Client B), then one wastewater from Client A and one wastewater from Client B each require spiking.

The spike is prepared by adding 1mL of 5ppm aqueous spiking solution (Section 8.15.2) to 50mL of sample. Spike recovery must be within 85 – 115. If spike recovery is outside of the range, adjust sample pH to 8.5 then add 1 ml of 5 ppm spiking solution and reanalyze. If spike recovery still outside of the range, then dilute sample and retest both diluted sample and spiked diluted sample. Report sample results at the dilution for which the spike recovered at 85 – 115%.

Sample dilutions can be made with DI, up to 200X or up to the client's specified detection limits.

If interferences remain after dilutions, and spike recovery is still less than 85% for aqueous samples, refer to Section 10.3.5.

9.5.2 Soil / solid matrix samples

Two spikes per batch of 10 samples or less are required; one with a soluble spike and one with an insoluble spike (Section 10.3.3.1). The acceptance range for spike recovery is 75 – 125%. If recoveries are not within the specified limits, then samples will be analyzed for PH and ORP to confirm matrix interference. If samples have reducing condition then a re-digestion of the sample and matrix spikes will not be needed..

For NJ-HexCr packages: If recoveries are not within the specified limits, then the matrix spike(s) and the associated samples must be re-homogenized/re-digested/re-analyzed. If upon reanalysis, it is found that the recoveries are acceptable, then the data is submitted with the new spike results. If it is found that the recoveries are still unacceptable upon redigestion, then it is assumed that the sample matrix is suspect and the pH (SOP 2203) and ORP (SOP 2237) are measured at once for the sample that was spiked. (for NJ HexCr method). For MCP method, pH and ORP are measured within 24h of sample collection.

If prior knowledge of an interfering sample matrix is known, then matrix spike duplicates (MSD) are set for the soluble and insoluble matrix spikes, along with the pH and ORP analyses for the samples to be spiked. Failure of the MS/MSD will verify that the sample matrix interferes with the digestion and will not necessitate a re-digestion of the sample and matrix spikes.

SOP addendum must be checked for NJ HexCr and MCP HexCr methods for additional actions.

9.6 Laboratory Duplicate

Analyze one sample in duplicate per batch of 20 samples (method 3500) or 10 samples (method 7196) or less. The %RPD must be $\leq$ 20% for aqueous samples and $\leq$ 20% for solid samples, if both the original sample and the duplicate results are greater than or equal to four times the reporting limit. A control limit of ± the laboratory reporting limit is used when either the original sample result or the duplicate sample result is less than four times the laboratory reporting limit.

9.7 Method-specific Quality Control Samples

Not applicable.

9.8 Method Sequence

- Sample preparation (digestion and/or pH adjustment and filtration)
- Coloring procedure
- Analysis on Spectrophotometer
- Verification
- Calculation

10. Procedure

10.1 Equipment Set-up

10.1.1 A calibration curve is generated at a minimum of once per year, as follows:

10.1.1.1 **For Liquid**: Pipet the following volumes of the 1ppm working standard (Section 8.2) into separate 50mL volumetric flasks: 0.25 ml, 0.5 ml, 1 ml, 2.5 ml, 5 ml, 10 ml and 25 ml. Bring each to volume with DI to give the following concentrations respectively: 0.005ppm, 0.01ppm, 0.02 ppm, 0.05 ppm, 0.10ppm, 0.20ppm and 0.50ppm. Include a 50mL DI blank and proceed with subsequent treatment of the standards in the same manner as samples (Section 10.3.2).

10.1.1.2 **For Soil**: Prepare five 100 ml digestion cups, add 1 ml of Magnesium Chloride solution (8.11.1) into each cup, then pipet following volumes of the 10 ppm working standard (section 8.3) into separate digestion cups:0 ml, 0.1mL, 1.0mL, 5.0 ml and 10mL. To all digestion cups add 50 ml of digestion solution and 0.5 ml of phosphate buffer. Proceed to soil/solid digestion and extraction procedure(sections 10.3.3.2 to 10.3.3.7)

10.1.1.3 Develop color for standards and blank as in Section 10.3.4.

10.1.1.4 Construct a calibration curve by plotting the absorbance values against mg/L hexavalent chromium. An acceptable curve must have a calibration coefficient of $\geq$ 0.995. This calibration curve is valid for one year, unless failure of an ICV requires construction of a new calibration curve. For method 3500: analyze RL verification standard (at 0.01 mg/l) following calibration. % recovery must be within +/-30% from true value.

Note: see MCP-HexCr and NJ-HexCr addendum for frequency of calibrations for MCP and NJ sites.

10.2 Initial Calibration

A non-digested, colored ICV (Section 8.16) (from a different source than was used for the calibration standards) must be recovered between 85 – 115%. If these criteria are not met, then the ICV is re-analyzed. If failure repeats, then the ICV is re-made and re-analyzed. If failure continues, prepare a new calibration curve (Section 10.1). See Section 12 for corrective actions.

10.3 Equipment Operation and Sample Processing

10.3.1 Treatment of sample: If interfering amounts of molybdenum, vanadium, copper, or iron are present, then follow the removal procedures as stated in the reference method.

10.3.2 Aqueous Samples:

Samples containing sediment, floating or suspended matter, or turbidity are filtered through a 0.45µm membrane filter prior to pH adjustment. If background interferences persist, measure an absorbance reading before adding diphenylcarbazide reagent (Section 10.3.4) and correct the absorbance of the final colored solution by subtracting the absorbance measured previously.

Proceed to Section 10.3.4.

10.3.3 Solid / soil sample digestion and extraction procedure:

10.3.3.1 **Samples:** Thoroughly mix the sample and weigh 2.5g +/- 0.1g into a 100 ml digestion cup. Add 1 ml of $MgCl_2$ solution.

10.3.3.2 **Blank:** Weigh 2.5g Ottawa Sand into a 100ml digestion cup, add 1 ml of $MgCl_2$ solution.

10.3.3.3 **Insoluble LCS:** Add 0.2-0.5 g of SRM (ERA catalog # 921) and 1 ml of $MgCl_2$ solution.

10.3.3.4 **Soluble LCS:** Weigh 2.5g Ottawa Sand into a 100ml digestion cup, add 1 ml of $MgCl_2$ solution and 1.0mL 1000ppm $K_2Cr_2O_7$. (Section 8.15).

10.3.3.5 **Matrix Spike, insoluble:** Thoroughly mix the sample and weigh 2.5g into a 100 ml digestion cup. Add 1 ml of $MgCl_2$ solution and 0.01 – 0.02g $PbCrO_4$ (Section 8.13.1).

Matrix Spike, soluble: Thoroughly mix the sample and weigh 2.5g into a 100mL digestion cup. Add 1 ml of $MgCl_2$ solution and 1.0mL 1000ppm $K_2Cr_2O_7$. (Section 8.15).

To all samples and QC samples, add 50mL of digestion solution (8.14) and 0.5mL of phosphate buffer (Section 8.12.3).

10.3.3.6 Stir the sample on a stir plate (unheated) for at least 5 minutes.

10.3.3.7 Place samples on hot block with Stirring base; heat samples for 1 hour at 90 – 95 °C (after temperature reached 90°C)

10.3.3.8 While still stirring, allow to cool to room temperature. Transfer the contents of the digestion vessel to 50 ml centrifuge tube then centrifuge for 6 minutes .Pour centrifuged solution back to original cup. Save the solid centrifuged material from the matrix spikes for possible later analysis for assessing low Cr (VI) recoveries. Store the centrifuged solid at 4 ±2°C.

10.3.3.9 While constantly stirring, very slowly add 50% HNO_3 (Section 8.4) to the centrifuged liquid to carefully adjust the pH to 7.5 ± 0.5. If the pH drops below 7.0, discard the solution and re-digest.

10.3.3.10 Remove the stir-bar and rinse keeping rinsate in the cup, and transfer quantitatively to a 100mL volumetric flask, 100 ml graduated cylinder, or 100mL digestion cup. Bring to volume with DI.

10.3.3.11 Proceed with coloring and analysis as described in Section 10.3.4.

10.3.4 Color development and measurement:

Place 45mL of sample or standard solution into a 50mL centrifuge tube. Adjust to pH 2 ± 0.5 with 10% H_2SO_4 (Section 8.7). Record pH on excel format. Add 1mL Diphenylcarbazide solution (Section 8.8) and adjust to 50mL with DI water. Mix and let stand 5 – 10 minutes for full color development.

Set the spectrophotometer to zero at 540 nm, utilizing the colored reagent blank in a 1cm absorption cell for soil samples and 2.5 cm absorption call for waters. Next, transfer a suitable portion of each colored standard solution or sample to a 1cm absorption cell for soils and 2.5 cm absorption cell for waters. Measure and record each absorbance at 540nm. Determine mg/L chromium present by reference to the calibration curve (Section 10.1.1.3).

10.3.4.1 Dilute samples volumetrically with DI water if they are more concentrated than the highest standard in the calibration curve.

10.3.4.2 When necessary samples precipitate poured off for analysis.

10.3.5 Verification of Samples

10.3.5.1 For aqueous and soil samples, verification is required to ensure that neither a reducing condition nor a chemical interference is affecting color development. This is accomplished by analyzing a second 10mL aliquot of the pH adjusted filtrate of the soluble spike. 1mL of 100ppm $K_2Cr_2O_7$ solution (Section 8.15.1) is added to the filtrate and analyzed. To verify the absence of an interference, the spike recovery must be between 85% and 115%.

If the spike recovery is less than 85%, the presence of an interference or reducing condition is verified. Client Services must be notified and a narrative included on the final report that indicates "verification of this sample indicates the presence of a reducing condition or a chemical interference that could affect the results".

10.3.5.2 If addition of the spike extends the concentration beyond the calibration curve, the analysis solution must be diluted with a blank solution and the calculated results adjusted accordingly.

10.3.5.3 If the result of verification indicates a suppressive interference, the sample must be diluted and reanalyzed.

10.3.5.4 If the interference persists after sample dilution then an alternative method must be considered. See the Inorganics Supervisor for further instruction.

Aqueous samples with acidic extracts that yield recoveries of less than 85% are re-tested to determine if the low spike recovery is due to the presence of residual reducing agent. This determination is performed by first making an aliquot of the extract alkaline (pH 8.0-8.5) using 1N NaOH. The pH is recorded in the laboratory notebook. This aliquot is respiked and analyzed. If a spike recovery of 85-115% is obtained on the alkaline aliquot of an acidic extract that initially was found to contain less than 5 mg/L Cr(VI), one can conclude that the analytical method has been verified.

10.3.5.5 If the spike recovery is still below 85%, then the presence of reducing agent is confirmed. Client Services must be notified and a narrative included on the final report that indicates "verification of this sample indicates the presence of a reducing condition or a chemical interference that could affect the results".

10.4 Continuing Calibration

The calibration curve must be verified after every 10 samples or less, with a recovery of 85 – 115% of a non-digested, colored ICV/CCV standard (Section 8.16). If these criteria are not met, then the CCV is re-analyzed. If failure repeats, then the CCV is re-made and re-analyzed. If failure continues, prepare a new calibration curve (Section 10.1). See Section 12 for corrective actions.

10.5 Preventive Maintenance

The Spectrophotometer is calibrated on a semi-annual basis by an instrument service company. Records are kept on file.

11. Data Evaluation, Calculations and Reporting

For aqueous samples:

$$\text{mg } Cr^{+6}/L = \left[\frac{\text{absorbance} - \text{y-intercept}}{\text{slope}}\right] \times \text{dilution}$$

For solid samples:

$$\text{mg } Cr^{+6}/Kg = \left[\frac{\text{absorbance} - \text{y-intercept}}{\text{slope}}\right] \times \left[\frac{\text{dilution x 0.1L (final volume)}}{\text{weight (Kg) of sample}}\right]$$

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Holding time exceedence, improper preservation and observed sample headspace are noted on the nonconformance report form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form.

If the ICV or LCS recovery falls outside the designated acceptance range, the laboratory performance is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form. Immediate corrective action includes reanalyzing all affected samples by using any retained sample before the expiration of the holding time.

Failure of the LCS for method 3060A requires that the entire sample batch be re-digested and re-analyzed.

If the method blank for method 3060A is greater than the reporting limit, then the following action must be taken. Samples that are non-detect may be reported, and the method blank result is narrated on the final report. If the sample concentration is greater than 10X the concentration of the method blank, then the sample may be reported, and the method blank is narrated on the final report. If the sample(s) concentration are above the reporting limit, but are not greater than 10X the concentration of the method blank, then those samples must be re-digested and re-analyzed. In this case, it is not necessary to submit a narrative unless there is a problem with the hold time, or there is not enough sample to re-digest. The Client Services Department must be made aware of the situation, and if the data is released then the method blank non-conformance is narrated.

The ICV for the analysis must have a recovery of 85-115%. If the ICV fails, it must be re-made and re-analyzed. If the failure persists, then a new calibration curve is constructed.

The ICB for the analysis must be below the detection limit for the analysis. If the ICB fails this requirement, then fresh blank must be colored and analyzed, if this does not solve the problem then a new calibration curve must be constructed.

If the CCV or the CCB fail, pour out a fresh aliquot of CCV and CCB and re-color and re-analyze. If the CCV or the CCB does not pass, then construct a new calibration curve and re-analyze the samples that followed the last acceptable CCV/CCB.

A duplicate result that is outside of the controls limits for this method must be narrated. The sample must be examined to determine the cause of the poor duplication. If it is determined that the poor duplication was due to analyst technique, then the sample and its duplicate are re-digested and re-analyzed. Otherwise, narrate the non-conformance on the final report.

If the matrix spike (aqueous samples) falls outside of the acceptable range of the method, then the analyst must go to the verification (section 10.3.5) part of this method. Poor spike recoveries must be narrated on the final report. Upon Client authorization, hexachromes with poor spike recoveries can be analyzed for total chromium by ICP-AES (Method 6010). The sample must be processed according to the Total Chromium procedure employed and the digestion procedure necessary. Clients will be invoiced for the Total Chromium analysis. Solids and soils digested under 3060A that have failing matrix spike recoveries must be re-digested and re-analyzed to determine if the failure is do to poor technique or the sample matrix. If upon reanalysis, it is found that the recoveries are acceptable, then the data is submitted with the new spike results. If it is found that the recoveries are still unacceptable upon redigestion, then it is assumed that the sample matrix is suspect The pH and ORP results are evaluated against the Eh/pH Phase Diagram (Figure 1) for MCP or NJ HexCr, and the result (reducing or oxidizing) is included in a sample narrative explaining the poor spike recovery.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP/1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/1734,1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP/1732 MDL/LOD/LOQ Generation

SOP/1734, 1739 IDC/DOC Generation

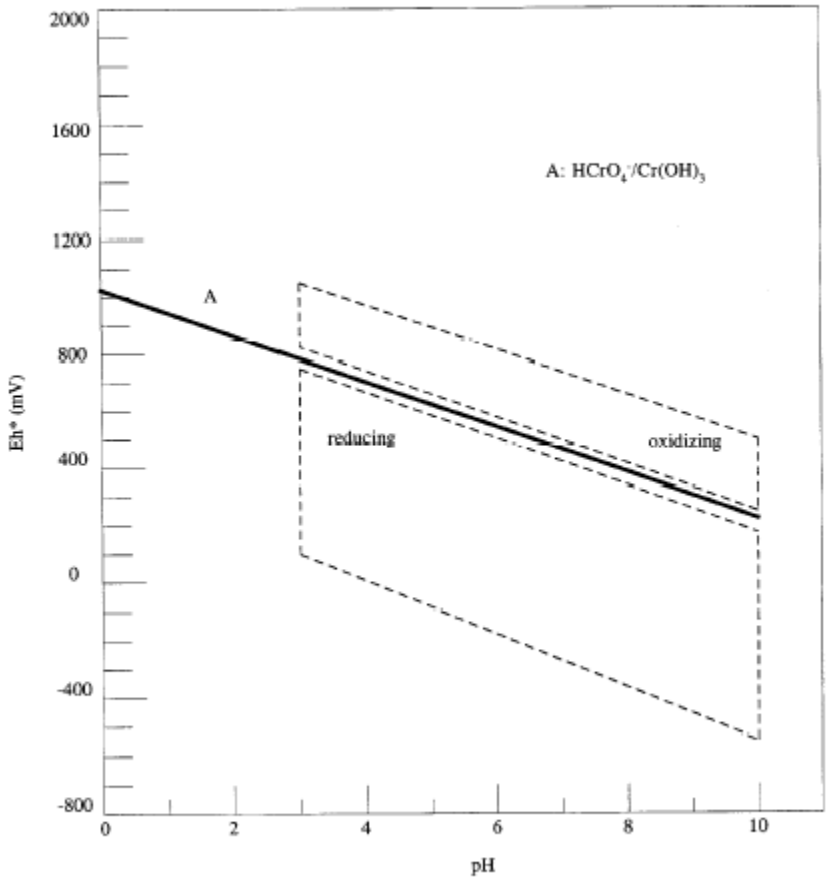
SOP/1728 Waste Management and Disposal SOP

16. Attachments

Figure 1: Eh/pH Phase Diagram

FIGURE 1
Eh/pH PHASE DIAGRAM

The dashed lines define Eh-pH boundaries commonly encountered in soils and sediments.



* Note the Eh values plotted on this diagram are corrected for the reference electrode voltage: 244 mV units must be added to the measured value when a separate calomel electrode is used, or 199 mV units must be added if a combination platinum electrode is used.

Mercury in Liquid Waste

(Automated Cold-Vapor Technique)

Reference Method No.: **EPA 7470A**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update II, September 1994.

1. Scope and Application

Matrices: Method 7470 is a cold-vapor atomic absorption procedure approved for determining the concentration of mercury in mobility-procedure extracts, aqueous wastes, and ground waters. (Method 7470 can also be used for analyzing certain solid and sludge-type wastes; however, Method 7471 is usually the method of choice for these waste types.) All samples must be subjected to an appropriate dissolution step prior to analysis.

Definitions: See Alpha Laboratories Quality Manual Appendix A.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the Mercury Analyzer and in the interpretation of Mercury data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

Prior to analysis, the liquid samples must be prepared according to the procedure discussed in this method.

Method 7470, a cold-vapor atomic absorption technique, is based on the absorption of radiation at 253.7-nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.

2.1 Method Modifications from Reference

2.1.1 A smaller sample sized is prepared, and therefore proportionately less reagent volumes are used.

2.1.2 The original method does not address the automated instrument procedure.

3. Reporting Limits

The typical reporting limit for Mercury is 0.0002mg/L. This satisfies Massachusetts, GW1 and GW 2 criteria. Connecticut mobility criteria for SPLP is 0.0004mg/L, Rhode Island is 0.002mg/L, and the Drinking Water reporting limit is 0.0002mg/L.

4. Interferences

Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of added inorganic mercury from reagent water.

Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/L had no effect on recovery of mercury from spiked samples.

Seawaters, brines, and industrial effluents high in chlorides require additional permanganate (as much as 25 mL) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253.7 nm. Care must therefore be taken to ensure that free chlorine is absent before the mercury is reduced and swept into the cell. This may be accomplished by using an excess of hydroxylamine sulfate reagent (25 mL). Both inorganic and organic mercury spikes have been quantitatively recovered from seawater by using this technique.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

Mercury compounds are highly toxic if swallowed, inhaled, or absorbed through the skin. Analysis is conducted under a laboratory exhaust hood. The analyst must wear chemical resistant gloves when handling concentrated mercury standards.

The acidification of samples containing reactive materials may result in the release of toxic gases, such as cyanides or sulfides. Therefore, the acidification of samples is to be conducted under a laboratory exhaust hood.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Samples are collected in either glass or plastic containers.

6.2 Sample Preservation

Samples are preserved with HNO_3 to a pH of <2.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Samples are stored under refrigeration at 4 ± 2°C and analyzed as soon as possible after collection. The samples have a 28-day holding time from the time of collection.

7. Equipment and Supplies

Instrumentation:

Perkin Elmer FIMS 100 Atomic absorption spectrophotometer: Use instrument settings recommended by the manufacturer. The PE FIMS is designed specifically for the measurement of mercury using the cold-vapor technique with BOC (background offset correction) performed by a survey scan prior to each sample introduction. PE S10 autosampler is coupled to the instrument.

Cetac M-6100 Atomic absorption spectrophotometer: Use instrument settings recommended by the manufacturer. This instrument employs a reference cell off-set correction and full automation through the CETAC software. A Cetac ASX-260 autosampler is coupled to the instrument.

Nippon Instrument model# RA-4300A analyzer with integrated 80 position autosampler:

The instrument adds a stannous chloride (II) solution to the sample post digestion, the divalent mercury ion (Hg2+) is reduced to zero-valent metallic mercury and turns into mercury gas by bubbling. Hg2++SnCl2 → Hg0 ↑
After removing the acid mist and water vapor generated by bubbling with an electronic cooling unit, the instrument measures the absorbance of mercury at 253.7 nm absorption wavelength. It measures the known mercury amount, creates a calibration curve, and then calculates the mercury amount from the absorbance.

7.1 Graduated cylinder: Rinse once with 50% HNO_3 and then rinse with reagent water prior to use.

7.2 Volumetric Flasks, Class A, various volumes: Rinse once with 50% HNO_3 and then rinse with reagent water prior to use.

7.3 Heating Block: Environmental Express HotBlock, 48 position capacity, able to maintain 95˚C +/-3.

7.4 50 mL Digestion Tubes: Polypropylene, graduated.

7.5 50 mL Digestion Tube Rack: 48 position, racklock

7.6 Pump tubing: Environmental Express, three stop and two in various IDs.

7.7 PTFE membranes: Whatman TE37 disks.

7.8 Dilution vials: 20mL capacity, used to prepare analytical dilutions.

7.9 Low Dust Laboratory Wipes

7.10 Compressed Air

7.11 Whatman 41 filter paper or equivalent

8. Reagents and Standards

8.1 Reagent Water: Reagent water is DI water shown to be interference free. All references to water in this method will refer to reagent water unless otherwise specified.

8.2 Sulfuric acid (H_2SO_4), concentrated: Reagent grade. Store at room temperature in an appropriately designated acid cabinet.

8.3 Hydrochloric acid, concentrated: Trace Metal grade. Store at room temperature in an appropriately designated acid cabinet.

8.4 Carrier, Hydrochloric Acid, 3%: This is the ***carrier*** for the Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl (Section 8.3). Bring to volume with reagent water. Store at room temperature, prepare daily as needed.

8.5 Reductant, Stannous Chloride in 3% HCl: This is the ***reductant*** for the Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl and 11g $SnCl_2 \cdot 2H_20$. Mix to dissolve the solid and bring to volume with reagent water. Store at room temperature, prepare daily as needed.

8.6 Nitric acid (HNO_3), concentrated: Trace metal grade of low mercury content. If a high reagent blank is obtained, it may be necessary to distill the nitric acid. Store at room temperature in an appropriately designated acid cabinet.

8.7 Sodium chloride-hydroxylamine hydrochloride solution: Dissolve 12 g of sodium chloride and 12 g of hydroxylamine hydrochloride in reagent water and dilute to 100mL. Store at room temperature. Expires one month from date of preparation.

8.8 Potassium permanganate, mercury-free, 5% solution (w/v): Dissolve 5 g of potassium permanganate in 100 mL of reagent water. Store at room temperature. Expires one month from date of preparation.

8.9 Potassium persulfate, 5% solution (w/v): Dissolve 5 g of potassium persulfate in 100 mL of reagent water. Store at room temperature. Expires one month from date of preparation.

8.10 Mercury Stock Standard, 1000ppm: Purchased from a commercial source with a certificate of analysis. Purchase three different sources. Store at room temperature. Expires upon manufacturer's specification.

8.11 Mercury Stock Calibration Standard, 10ppm: To a 100mL volumetric flask, add 5mL of concentrated HNO_3, 2.5mL of concentrated H_2SO_4 and 1000ppm Mercury Stock Standard (Section 8.10, use one source). Bring to volume with reagent water. Store at room temperature. Expires one month from date of preparation.

8.12 Mercury Working Calibration Standard / Matrix Spike Solution, 0.1ppm: To a 100mL volumetric flask, add 5mL of concentrated HNO_3, 2.5mL of concentrated H_2SO_4 and 1mL of 10ppm Mercury Stock Standard (Section 8.11). Bring to volume with reagent water. Store at room temperature. Make fresh daily.

8.13 Mercury Calibration Standards: All calibration standards are prepared daily.

8.13.1 0 ppm Calibration Standard: Add 10 mL of reagent water to a polypropylene digestion vessel. This aliquot may be used for the CCB. Another separate aliquot is prepared in the same manner for use as the ICB and diluent for sample dilutions.

8.13.2 **0.0002ppm Calibration Standard:** Add 10 mL of reagent water to a polypropylene digestion vessel. Pipet 0.05 mL of 0.1ppm Mercury Working Stock (Section 8.12) to the digestion vessel. Bring to a final volume of 25 mL.

8.13.3 **0.001ppm Calibration Standard:** Add 10 mL of reagent water to a polypropylene digestion vessel. Pipet 0.25 mL of 0.1ppm Mercury Working Stock (Section 8.12) to the digestion vessel. Bring to a final volume of 25 mL.

8.13.4 **0.002ppm Calibration Standard** Add 10 mL of reagent water to a polypropylene digestion vessel. Pipet 0.5 mL of 0.1ppm Mercury Working Stock (Section 8.12) to the digestion vessel. Bring to a final volume of 25 mL.

8.13.5 **0.005ppm Calibration Standard/Continuing Calibration Verification Standard:** Add 10 mL of reagent water to a polypropylene digestion vessel. Pipet 1.25 mL of 0.1ppm Mercury Working Stock (Section 8.12) to the digestion vessel. Bring to a final volume of 25 mL.

8.13.6 **0.010ppm Calibration Standard / Post Analytical Spike Solution:** Add 10 mL of reagent water to a polypropylene digestion vessel. Pipet 2.5 mL of 0.1ppm Mercury Working Stock (Section 8.12) to the digestion vessel. Bring to a final volume of 25 mL.

8.13.7 **0.020ppm Calibration Standard / Post Analytical Spike Solution:** Add 10 mL of reagent water to a polypropylene digestion vessel. Pipet 5.0 mL of 0.1ppm Mercury Working Stock (Section 8.12) to the digestion vessel. Bring to a final volume of 25 mL.

8.14 Mercury Stock LCS Standard, 10ppm: To a 100mL volumetric flask add 25mL of reagent water and 5mL of concentrated HNO_3 (Section 8.6). Add 1mL of 1000ppm Mercury Stock Standard (Section 8.10). Bring to volume with reagent water. Store at room temperature. Expires one month from date of preparation.

8.15 Mercury Working LCS Standard, 0.1ppm: To a 100mL volumetric flask add 25mL of reagent water and 5mL concentrated HNO_3 (Section 8.6). Add 1mL of 10ppm Stock LCS Standard (Section 8.14). Bring to volume with reagent water. Store at room temperature. Expires one week from date of preparation.

8.16 Mercury LCS Standard, 0.001ppm: Prepare daily with each batch of samples. To a 50mL digestion vessel add 10mL of reagent water Add 0.25 mL of 0.1ppm Working LCS Standard (Section 8.15). Bring to a final volume of 25mL and carry through entire digestion process as in Section 10.1.1.

8.17 Mercury Stock ICV Standard, 10ppm: To a 100mL volumetric flask add 25mL of reagent water and 5mL of concentrated HNO_3 (Section 8.6). Add 1mL of 1000ppm Mercury Stock Standard (Section 8.10-use alternate source than that used for both the calibration standards and the LCS Stock Standard). Bring to volume with reagent water. Store at room temperature. Expires one month from date of preparation.

8.18 Mercury Working ICV Standard, 0.3ppm: To a 100mL volumetric flask add 25mL of reagent water and 5mL of concentrated HNO_3 (Section 8.6). Add 3mL of 10ppm Stock ICV Standard (Section 8.5). Bring to volume with reagent water. Store at room temperature. Expires one week from date of preparation.

8.19 Mercury ICV Standard, 0.003ppm: Prepare daily with each batch of samples. To a 25mL digestion vessel add 10mL of reagent water. Add 0.25mL of 0.3ppm Working ICV Standard (Section 8.18). Bring to a 25mL final volume with reagent water and carry through entire digestion process as in Section 10.1.1..

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

The ICB, CCB, and Method Blank: A 25mL aliquot of 0ppm calibration standard brought through the preparation procedure as outlined in Section 10.1.1 . Blank results must be <RL. See Section 12.1 for corrective action. An ICB is analyzed after the initial calibration or re-calibration. The CCB is analyzed at every 10 sample injection interval. Method Blank is analyzed once per batch of samples; batch consists of 20 samples.

9.2 Laboratory Control Samples (LCS)

The LCS Standard consists of a 0.001ppm Mercury LCS Standard (Section 8.16). This standard is brought through the preparation procedure as outlined in Section 10.1.1. The LCS Standard must be recovered within ± 20% of the true value. See Section 12.3 for corrective action. The LCS Standard is analyzed once per batch of samples. A batch consists of 20 samples.

9.3 Initial Calibration verification (ICV)

The ICV Standard consists of a 25mL aliquot of 0.003ppm Mercury ICV Standard (Section 8.19). The ICV must be recovered within 10% of the true value. See Section 12.2 for corrective action.

9.4 Continuing Calibration Verification (CCV)

The CCV Standard consists of a 0.010ppm calibration standard (Section 8.13.3). The CCV must be recovered within 20% of the true value. See Section 12.2 for corrective action.

9.5 Matrix Spike

A matrix spike is analyzed once per batch of samples. A batch consists of 20 samples for monitoring wells, surface waters, influents and effluents. Prepare the matrix spike at 0.005ppm by adding 1.25mL of 0.1ppm Mercury Stock Standard (Section 8.3) to 25mL of the selected QC sample. The final concentration of the matrix spike is 0.005mg/L.

The matrix spike sample is brought through the preparation procedure as outlined in Section 10.1. A matrix spike is analyzed once per batch of samples. A batch consists of 20 samples for monitoring wells and surface waters. The recovery of the matrix spike must be between 75 – 125% (using the calculation in Section 11.2).

If the recovery of the matrix spike is out of range, a post-analytical spike is analyzed. Prepare the post analytical spike by adding 5mL of 0.010ppm Calibration Standard / Post Analytical Spike Solution (Section 8.1.6) and 5mL of the sample digestate to a 50mL centrifuge tube for a final concentration of 0.005mg/L. Analyze the post spike as outlined in Section 10.3.5.

Calculate the post spike concentration as follows:

Post Analytical Spike Sample Concentration (mg/L) =

[Sample Concentration (mg/L) x (0.5)] + 0.005mg/L

The percent recovery of the post-analytical spike must be between 75 – 125%. See Section 12.4 for corrective action.

9.6 Laboratory Duplicate

A sample is analyzed in duplicate once per batch of samples. A batch consists of 20 samples for monitoring wells and surface waters. The RPD between the sample and its duplicate must be 20% or less (using the calculation in Section 11.3), See Section 12.5 for corrective action.

9.7 Method-specific Quality Control Samples

Not applicable.

9.8 Method Sequence

- Calibration Blank
- 0.0002 ppm Calibration Standard
- 0.0005 ppm Calibration Standard
- 0.001 ppm Calibration Standard
- 0.002 ppm Calibration Standard
- 0.010 ppm Calibration Standard
- 0.020 ppm Calibration Standard
- ICV
- ICB
- Ten analytical samples
- CCV
- CCB
- Ten analytical samples
- CCV
- CCB
- Etc.

10. Procedure

10.1 Equipment Set-up

10.1.1 Preparation and Digestion

Samples, Standards and All Batch QC

Transfer 25mL of well-homogenized sample (or an aliquot of the sample diluted to 25mL with reagent water) or standards (Sections 8.13.1 through 8.13.7, 8.16 and 8.19) to a 50mL centrifuge tube.

Add 1.25mL of concentrated H_2SO_4 (Section 8.2), 0.625mL of concentrated HNO_3 (Section 8.6), Add 3.75mL of Potassium Permanganate Solution, shake and add additional portions of potassium permanganate solution (if necessary) to all samples and QC, until the purple color persists for at least 15 min. (Section 8.8). Add 2mL of Potassium Persulfate Solution (Section 8.9), and heat samples for 2 hours in a 95°C +/-3

heating block. Cool, and add 1.5mL of Sodium Chloride-Hydroxylamine hydrochloride solution (Section 8.7).
Filter the sample if needed to remove any sediment or particulate.

Analyze samples and the digested calibration standards (Sections 8.13.1 through 8.13.7) are used in Section 9.2 to generate a calibration curve.

10.2 Initial Calibration

Construct a calibration curve by plotting the absorbances of prepared standards (Section 10.1.1) versus micrograms of mercury. Determine the peak height of the unknown from the absorbance maxima on the spectrometer, and read the mercury value from the standard curve. (See Section 11.)

The curve correlation coefficient (cc) must be greater than or equal to 0.995 in order for the curve to be linear. If the correlation coefficient is less than 0.995, find and correct the problem. When the problem has been corrected, re-analyze either the previous standards or new standards. When the curve has generated an acceptable cc then the analysis can continue with the ICV/ICB.

10.3 Equipment Operation and Sample Processing

Sample and standard analysis:

10.3.1 Instrument Setup

10.3.1.1 Turn the instrument on. The autosampler will initialize itself.

10.3.1.2 Choose the instrument software from the desktop menu. The autosampler will initialize again.

FIMS 100 NOTE: The instrument must be turned on before the application is started. Otherwise, an error message will result.

10.3.1.3 Enter the appropriate fields for sample identification, and data storage.

10.3.1.4 Fill the carrier and reductant bottles.

10.3.1.4.1 The Carrier is 3% HCl (Section 8.6).

10.3.1.4.2 The Reductant is 1.1% $SnCl_2$ in 3% HCl (Section 8.5).

10.3.1.5 Allow the instrument to warm up while clearing samples. Samples that are cloudy or with particulate present after clearing must be filtered through Whatman 41 filter paper (Section 7.11) before analysis.

10.3.1.6 Place carrier uptake line and reductant uptake line.

10.3.1.7 Load carrier and reductant lines into pump magazines

10.3.1.8 Load the two waste lines into the pump magazines below the roller.

10.3.1.9 Lock the magazines into place.

FIMS100 only:

10.3.1.10 Remove the cap from the liquid/vapor separator and wipe dry with a Lab Wipe (Section 7.9). Compressed air (Section 7.10) through the vapor transfer line to dry it out.

10.3.1.11 Place a PTFE membrane (Section 7.7), rough side up, in the liquid/vapor separator; replace the cap and reattach the vapor transfer line to the sample absorption cell.

10.3.1.12 Adjust the gas flow by turning the black knob below the air flow meter to obtain a reading of just over 50.

10.3.2 Calibration and Sample Analysis

10.3.2.1 The instrument will now run the calibration standards; verify a CC of 0.995 or better before proceeding with the ICV and ICB. Ten analytical samples, a CCV and CCB, ten analytical samples, CCV, CCB, etc. The CCBs and CCVs must be recovered within the proper ranges (Sections 9.4 and 9.1.3) for analysis to continue.

10.3.2.2 If the sample result is beyond 90% of the concentration of the highest point on the calibration curve or LDR study used to establish the linear range, dilute the sample extract with a portion of one of the prepared blanks (ICB, CCB or PBS) to produce an analytical result that is within the range.

10.3.3 Instrument Shut Down

10.3.3.1 When analysis is complete place reagent uptake lines in a beaker of reagent water.

10.3.3.1.1 Continue to run the pumps for several minutes to flush reagents out of the lines.

10.3.3.1.2 Continue to run the pumps for several minutes to flush reagents out of the lines.

10.3.3.2 Pull the reagent uptake lines out of the reagent water beaker to allow the pump to draw air through the lines.

10.3.3.3 Unlock the top and bottom pump magazines and remove tubing from the magazines.

10.3.3.4 Exit from the software application.

10.3.3.4.1 Dump the samples and instrument waste in the Metals/WetChem waste drum located in the transfer room.

10.4 Continuing Calibration

Continuing calibration verification samples are analyzed after every 10 samples in the sample run, as outlined in Section 10.3.5.

10.5 Preventative Maintenance

Preventative maintenance is conducted per the manufacturer's instructions. All preventative maintenance is recorded in the Instrument Maintenance Logbook.

11. Data Evaluation, Calculations and Reporting

11.1 Calculate Mercury concentration

Calculate Mercury concentration from the daily calibration curve. The curve is generated utilizing a straight-line equation defined as:

$$A = k_1 + k_2C$$

Where:

A = Average peak height of the sample/standard integrations
C = Sample/Standard Concentration, µg/L
k_1 = y-intercept
k2 = slope

The instrument will plot peak height against concentration (µg/L). The result is generated in µg/L . This value is divided by 1000 to convert the units to mg/L. If the sample is diluted (DF), the result is multiplied by the DF to generate the final result.

Result, mg/L = (concentration, µg/L) x (1mg/1000µg) x (DF)

11.2 Matrix Spike Calculation

Calculate percent recovery for the Matrix Spike corrected for concentrations measured in the unfortified sample. Percent recovery is calculated using the following equation:

$$\% \text{ Recovery} = \frac{(Cm - C)}{s} \times 100$$

Where:

Cm = measured Mercury in the fortified sample
C = measured native mercury sample concentration
S = concentration equivalent of spike added to sample

11.3 Relative Percent Difference (RPD) Calculation

Calculate the Relative Percent Difference (RPD) for each Duplicate of the initial quantitated concentration (IC) and duplicate quantitated concentration (Dc) using the following formula:

$$RPD = \frac{|(IC - Dc)|}{\{(IC + Dc) / 2\}} \times 100$$

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

12.1 Method Blank Failure: When a prep blank mercury level constitutes 10% or more of analyte level determined for any sample in the batch, or is greater than 2.2x the MDL value (whichever is greater), the associated samples in the batch must be redigested (Section 10.1).

For method blanks that have concentrations greater than the RL, the data is rejected and the associated samples sent back for redigestion unless the associated sample concentrations are greater than 10x the blank concentration. In this case the blank is narrated and the results are reported without qualification.

12.2 ICV / CCV Failure: If the ICV %Recovery is outside of acceptance criteria, the ICV is reinjected. If the %Recovery is outside the acceptance criteria, the analysis is terminated until the problem is found and corrected. If the CCV %Recovery is outside of acceptance criteria, the CCV is reinjected. If the % Recovery is still outside the acceptance criteria, all samples analyzed since the last acceptable CCV must be reanalyzed following correction of the problem.

12.3 LCS Failure: If the LCS is not recovered within acceptance criteria, the LCS is reinjected. If the % Recovery is still outside the acceptance criteria, either recalibrate and rerun or the associated batch and another LCS must be redigested (Section 10.1).

12.4 Matrix Spike / Post Digestion Spike Failure: If the recovery of the matrix spike is outside of the acceptance criteria, a post digestion spike is performed (Section 9.54). If the post digestion spike is outside of 75 – 125%, a narrative must be included with the data. (Section 10.1).

12.5 Duplicate Failure: If the RPD between the sample and its duplicate is greater than 20%, visually evaluate the sample matrix. If the matrix appears problematic, the sample digestate may be diluted and reanalyzed, or a narrative included with the data to explain the matrix problem.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP 1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP/1732 DL/LOD/LOQ Generation

SOP/1739 IDC/DOC Generation

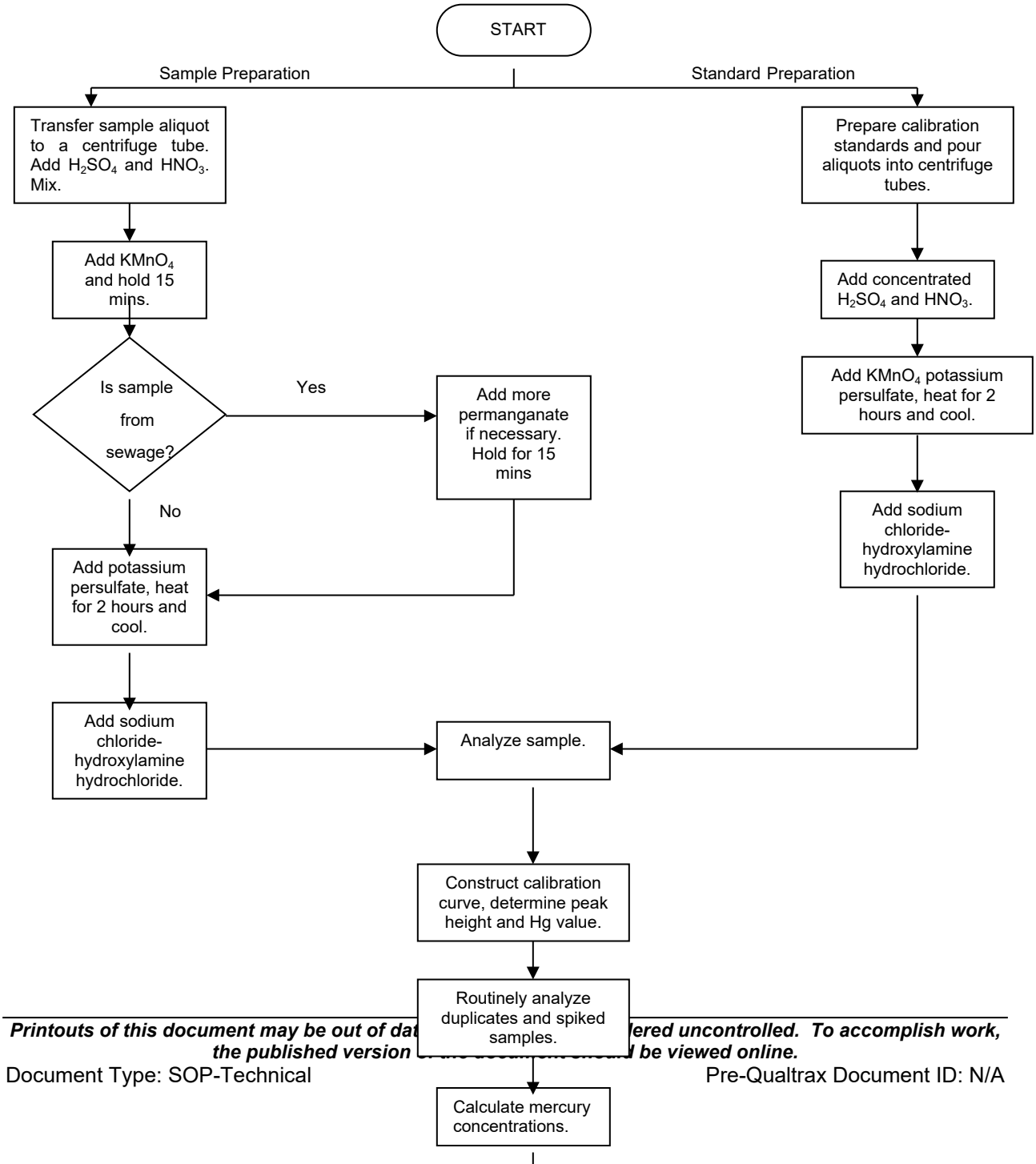
SOP/1797 Waste Management and Disposal SOP

16. Attachments

Figure 1: Method 7470A Flow Chart

Figure 1

Method 7470A Flow Chart



END

Mercury in Solid or Semisolid Waste
(Manual Cold-Vapor Technique)

Reference Method No.: **EPA 7471B**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, February 2007.

1. Scope and Application

Matrices: Method 7471 is approved for measuring total mercury (organic and inorganic) in soils, sediments, bottom deposits, and sludge-type materials. All samples must be subjected to an appropriate dissolution step prior to analysis. If this dissolution procedure is not sufficient to dissolve a specific matrix type or sample, then this method is not applicable for that matrix.

Definitions: Refer to Alpha Analytical Quality Manual.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the Mercury Analyzer and in the interpretation of Mercury data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability..

2. Summary of Method

Prior to analysis, the solid or semi-solid samples must be prepared according to the procedures discussed in this method.

Method 7471, a cold-vapor atomic absorption method, is based on the absorption of radiation at the 253.7-nm wavelength by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.

2.1 Method Modifications from Reference

Alpha analyzes only one 0.3g aliquot of sample. The original method does not address the automated instrument procedure. A reduced volume of sample is digested in disposable digestion tubes on a hot block digestor.

3. Reporting Limits

The reporting limit for this method is 0.08mg/Kg.

4. Interferences

Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/Kg of sulfide, as sodium sulfide, do not interfere with the recovery of added inorganic mercury in reagent water.

Copper has also been reported to interfere; however, copper concentrations as high as 10 mg/Kg had no effect on recovery of mercury from spiked samples.

Samples high in chlorides require additional permanganate (as much as 25 mL) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253 nm. Care must therefore be taken to ensure that free chlorine is absent before the mercury is reduced and swept into the cell. This may be accomplished by using an excess of hydroxylamine sulfate reagent (25 mL).

Certain volatile organic materials that absorb at this wavelength may also cause interference. A preliminary run without reagents should determine if this type of interference is present.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

Because mercury vapor is toxic, precaution must be taken to avoid its inhalation.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Samples may be collected in plastic or glass containers.

6.2 Sample Preservation

None.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Samples are stored under refrigeration at 4°C and analyzed as soon as possible after collection. The samples have a 28-day holding time from the time of collection.

7. Equipment and Supplies

7.1 Instrumentation:

Perkin Elmer FIMS 100 Atomic absorption spectrophotometer: Use instrument settings recommended by the manufacturer. The PE FIMS is designed specifically

for the measurement of mercury using the cold-vapor technique with BOC (background offset correction) performed by a survey scan prior to each sample introduction. PE S10 autosampler is coupled to the instrument.

Cetac M-6100 Atomic absorption spectrophotometer: Use instrument settings recommended by the manufacturer. This instrument employs a reference cell off-set correction and full automation through the CETAC software. A Cetac ASX-260 autosampler is coupled to the instrument.

Nippon Instrument model# RA-4300A analyzer with integrated 80 position autosampler:

The instrument adds a stannous chloride (II) solution to the sample post digestion, the divalent mercury ion (Hg2+) is reduced to zero-valent metallic mercury and turns into mercury gas by bubbling. $Hg2{+}{+}SnCl2 \rightarrow Hg0 \uparrow$

After removing the acid mist and water vapor generated by bubbling with an electronic cooling unit, the instrument measures the absorbance of mercury at 253.7 nm absorption wavelength. It measures the known mercury amount, creates a calibration curve, and then calculates the mercury amount from the absorbance.

7.2 Hot Block Digestor: Environmental Express, 54 position, capable of maintaining a temperature of 95°C +/-3°C.

7.3 Graduated cylinder. Rinse once with 50% Nitric Acid, then rinse with reagent water prior to use.

7.4 Volumetric Flasks, Class A, various volumes. Rinse once with 50% Nitric Acid, then rinse with reagent water prior to use.

7.5 Polypropylene Digestion Vessels: 50 mL volume, with plastic screw caps

7.6 Pump Tubing: Environmental Express, three stop and two stop tubing in various IDs.

7.7 PTFE membranes: Pall TF1000 disks

7.8 Dilution vials: 20mL capacity, used when making analytical dilutions.

7.9 Laboratory Wipes

7.10 Compressed Air

7.11 Whatman 41 or equivalent filter paper

7.12 Eppendorf pipets: Accurate means to make trace standards

8. Reagents and Standards

8.1 Reagent Water: Reagent water is DI water shown to be interference free. All references to water in this method refer to reagent water unless otherwise specified.

8.2 Aqua regia: Prepare immediately before use by carefully adding three volumes of concentrated HCl to one volume of concentrated HNO_3.

8.3 Concentrated Nitric Acid, (HNO_3): Trace grade. Store at room temperature in the appropriately marked acid cabinet.

8.4 Concentrated Hydrochloric Acid, (HCl): Trace grade. Store at room temperature in the appropriately marked acid cabinet.

8.5 Reductant, Stannous Chloride in 3% HCl: This is the ***reductant*** for the Instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl and 11g $SnCl_2 \cdot 2H_20$. Mix to dissolve the solid and bring to volume with reagent water. Store at room temperature, prepare as needed.

8.6 Carrier, Hydrochloric Acid, 3%: This is the ***carrier*** for the instrument. In a 1L volumetric flask, add 30mL concentrated trace grade HCl (Section 8.4). Bring to volume with reagent water. Store at room temperature, prepare as needed.

8.7 Potassium permanganate, mercury-free, 5% solution (w/v): Dissolve 5 g of potassium permanganate in 100 mL of reagent water. Store at room temperature.

8.8 Sodium chloride-hydroxylamine hydrochloride solution: Dissolve 12 g of sodium chloride and 12 g of hydroxylamine hydrochloride in reagent water and dilute to 100 mL. Store at room temperature.

8.9 Mercury stock solution, 1000ppm: This solution is purchased commercially prepared with a certificate of analysis. Three solutions are purchased, each from a different source. Store at room temperature. Expires according to manufacturer's specifications.

8.9.1 10ppm Mercury Stock Standard: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of 1000ppm Mercury Stock Solution (Section 8.9). Bring to volume with reagent water. Store at room temperature. Expires one month from date of preparation.

8.9.1.1 0.1ppm Mercury Working Stock / Matrix Spike Solution: To a 500mL volumetric flask, add 5mL of concentrated HNO_3 and 5 mL of 10ppm Mercury Stock Standard (Section 8.9.1). Bring to volume with reagent water. Store at room temperature. Expires one week from date of preparation.

8.9.2 10ppm Mercury ICV Stock Standard: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of Mercury Stock Solution (Section 8.9, from an alternate source than that used in Section 8.9.1). Bring to volume with reagent water. Store at room temperature. Expires one month from date of preparation.

8.9.2.1 0.3ppm Mercury ICV Working Stock: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 3.0mL of 10ppm Hg ICV Stock Standard (Section 8.9.2). Bring to volume with reagent water. Store at room temperature. Expires one week from date of preparation.

8.9.3 10ppm Mercury LCS Stock Standard: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of 1000ppm Mercury Stock Solution (Section 8.9, from an alternate source than that used in Sections 8.9.1 and 8.9.2). Bring to volume with reagent water. Store at room temperature. Expires one month from date of preparation.

8.9.3.1 0.1ppm Mercury LCS Working Stock: To a 100mL volumetric flask, add 5mL of concentrated HNO_3 and 1.0mL of 10ppm Mercury LCS Stock Standard (Section

8.9.3). Bring to volume with reagent water. Store at room temperature. Expires one week from date of preparation.

8.10 SRM: Purchased from ERA in 300-500g lots.

9. Quality Control and Data Assessment

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

The Method Blank consists of the 0ppm standard as prepared in Section 10.1.2.1.1. Analyze one Method Blank per analytical batch of twenty samples or less. The Method Blank must be less than the Reporting Limit (RL). See Section 12.1 for corrective action.

9.1.1 PBS

A preparation blank is analyzed once per batch of twenty samples or less. It is prepared in the same manner as the 0ppm standard (Section 10.1.2.1.1). The PBS must be recovered within ± 0.2 µg/L.

9.1.2 ICB

The ICB is analyzed after the ICV, and is prepared in the same manner as the 0ppm standard (Section 10.1.2.1.1). The ICB must be recovered within ± 0.2 µg/L.

9.1.3 CCB

The CCB is analyzed after the CCV. It is prepared in the same manner as the 0ppm standard (Section 10.1.2.1.1). The CCB must be recovered within ± 0.2 µg/L.

9.2 Laboratory Control Sample (LCS)

The LCS is analyzed once per each analytical batch of twenty samples or less. It is prepared in the same manner as in Section 10.1.2.3. The LCS must be recovered within 80 – 120% of the true value. See Section 12.3 for corrective action.

9.3 Initial Calibration Verification (ICV)

The ICV is analyzed after the calibration curve. It is prepared in the manner specified in Section 10.1.2.2. The ICV must be recovered within ± 10% of the true value. See Section 12.2 for corrective action.

9.4 Continuing Calibration Verification (CCV)

The CCV is analyzed after every ten analytical samples. It is prepared in the same manner as the 5.0ppb calibration standard (Section 10.1.2.1.5). The CCV must be recovered within 20% of the true value. See Section 12.2 for corrective action.

9.5 Matrix Spike

Analyze one matrix spike per twenty or less analytical samples. The recovery of the matrix spike must be between 80 – 120%. Calculate percent recovery using Section 11.2.

If the recovery of the matrix spike is out of range, a post-analytical spike is analyzed. Prepare the post analytical spike by adding 1.25mL of 0.020ppm Calibration Standard

(Section 10.1.2.1.6) and 1.25mL of the sample digestate to a 15mL centrifuge tube for a final concentration of 0.0105mg/L. Analyze the post spike as outlined in Section 10.3.

Calculate the post spike concentration as follows:

Post Analytical Spike Sample Concentration (mg/L) =

[Sample Concentration (mg/L) x (0.5)] + 0.010mg/L

The percent recovery of the post-analytical spike must be between 75 – 125%.

See Section 12.4 for corrective action.

9.6 Laboratory Duplicate

Analyze one sample in duplicate per twenty or less analytical samples. The RPD between the sample and its duplicate must be ≤ 20% (as calculated in Section 11.3). See Section 12.5 for corrective action.

9.7 Method-specific Quality Control Samples

None

9.8 Method Sequence

- Sample preparation
- Sample digestion
- Standards preparation:
  - Calibration standards
  - ICV standard
  - LCS standard
- Standards digestion
- Analysis of calibration standards
- Generation of calibration curve
- Analysis of samples and standards:
  - ICV
  - ICB
  - analytical samples
  - CCV
  - CCB
  - analytical samples
  - CCV
  - CCB
  - etc.

10. Procedure

10.1 Equipment Set-Up

10.1.1 Sample preparation: Weigh a 0.3-g portion of untreated and homogenized sample and place in the bottom of a polypropylene digestion vessel. Record the weight in the laboratory notebook. NOTE: When preparing the batch, include one sample duplicate aliquot to be prepared in the same manner.

Add 2.5 mL of reagent water and 2.5 mL of aqua regia (Section 8.2). Heat 2 min on a hot block at 95°C +/-3°C. Cool; then add 15 mL reagent water, and 7.5 mL potassium permanganate solution (Section 8.7) to the digestion vessel. Wait 15 minutes to be sure the potassium permanganate is not exhausted (purple color disappears), if it does add additional potassium permanganate to all samples and QC until stable. Mix thoroughly and place in the hot block for 30 min at 95°C +/-3°C. Cool and add 3 mL of sodium chloride-hydroxylamine hydrochloride (Section 8.8) to reduce the excess permanganate.

CAUTION: Perform this addition under a hood, as Cl_2 could be evolved.

Bring up to a final volume of 50 mL with reagent water. Continue as described under Section 10.3.1.

10.1.2 Standard preparation: Standard preparation is performed each time samples are digested.

10.1.2.1 Calibration Standards

10.1.2.1.1 0 ppb: Add 10mL of reagent water to a polypropylene digestion vessel. This aliquot may be used for the CCB. Another separate aliquot is prepared for use as the ICB and the diluent for any samples with concentration greater than 90% the highest calibration standard used to determine the linear range.

10.1.2.1.2 0.5ppb: Add 10 mL of reagent water to a polypropylene digestion vessel. Using a volumetric pipet, add 0.25 mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the digestion vesel.

10.1.2.1.3 1.0ppb: Add 10 mL of reagent water to a polypropylene digestion vessel.. Using a volumetric pipet, add 0.5 mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the digestion vessel.

10.1.2.1.4 2.0ppb: Add 10 mL of reagent water to a polypropylene digestion vessel.. Using a volumetric pipet, add 1.0mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the digestion vessel.

10.1.2.1.5 5.0ppb/CCV: Add 10 mL of reagent water to a polypropylene digestion vessel.. Using a volumetric pipet, add 2.5 mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the digestion vessel.

10.1.2.1.6 10ppb: Add 10 mL of reagent water to a polypropylene digestion vessel.Using a volumetric pipet, add 5.0 mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the digestion vessel.

10.1.2.1.7 20ppb: Add 10 mL of reagent water to a polypropylene digestion vessel.Using a volumetric pipet, add 10.0 mL of 0.1ppm Mercury Working Stock (Section 8.9.1.1) to the digestion vessel.

10.1.2.2 ICV Standard, 3.0ppb: This standard is used for calibration verification.

Add 10.0 mL of reagent water to a digestion vessel. Using a volumetric pipet, add 0.5 mL of 0.3ppm Mercury Working Stock (Section 8.9.2.1) to the digestion vessel. Digest the ICV Standard as in Section 10.1.3.

10.1.2.3 LCS Standard, 1.0ppb: This standard is prepared and analyzed with each analytical batch.

Add 5.0mL of reagent water to a digestion vessel. Add 0.15g of SRM (Section 8.10). Digest the LCS Standard as in Section 10.1.3.

10.1.2.4 Matrix Spike, 0.001mg/L: Weigh two aliquots of the sample designated to be the batch matrix spike.

Add 10.0 mL of the reagent water to the digestion vessel containing the weighed sample aliquot. Add a 5 mL aliquot of 0.1ppm Mercury LCS Working Stock (Section 8.9.3.1). Digest the MS as in Section 10.1.3.

10.1.3 Standard Digestion:

To each standard (Sections 10.1.2.1 through 10.1.2.3), add 2.5 mL of reagent water and 2.5 mL of aqua regia (Section 8.2) and heat 2 min on the hot block at 95°C +/- 3°C. Allow the standard to cool; add 15 mL reagent water and 7.5 mL of $KMnO_4$ solution (Section 8.7) to each bottle and return to the hot block for 30 min. Cool and add 3 mL of sodium chloride-hydroxylamine hydrochloride solution (Section 8.8) to reduce the excess permanganate. Bring up to final volume of 50 mL with reagent water, continue as described in Section 10.3.3.

Note: Alternate volumes of standards may be made base on need as long as they are made with the same proportions as describe above.

10.2 Initial Calibration

Construct a calibration curve by plotting the absorbances of prepared standards (Section 10.1.2) versus micrograms of mercury. (See Section 11.1.) Determine the peak height of the unknown from the absorbance maxima on the spectrometer, and read the mercury value from the standard curve.

The curve correlation coefficient (cc) must be greater than or equal to 0.995 in order for the curve to be linear. If the correlation coefficient is less than 0.995, find and correct the problem. When the problem has been corrected, re-analyze either the previous standards or new standards. When the curve has generated an acceptable cc, then the analysis can continue with the ICV/ICB.

Analyze an Initial Calibration Verification Standard (ICV) (Section 9.3), an Initial Calibration Blank sample (ICB) (Section 9.1.2) at the start of the analytical run. The results for the ICV must be within 10% of the true value. If results are outside this range, refer to Section 12.2 for corrective action.

10.3 Equipment Operation and Sample Processing

10.3.1 Instrument Setup

10.3.1.1 Turn the instrument on. The autosampler will initialize itself.

10.3.1.2 Choose the instrument software from the desktop menu. The autosampler will initialize again.

FIMS 100 NOTE: The instrument must be turned on before the application is started. Otherwise, an error message will result.

10.3.1.3 Enter the appropriate fields for sample identification, and data storage.

10.3.1.4 Fill the carrier and reductant bottles.

10.3.1.4.1 The Carrier is 3% HCl (Section 8.6).

10.3.1.4.2 The Reductant is 1.1% $SnCl_2$ in 3% HCl (Section 8.5).

10.3.1.5 Allow the instrument to warm up while clearing samples. Samples that are cloudy or with particulate present after clearing must be filtered through Whatman 41 filter paper (Section 7.11) before analysis.

10.3.1.6 Place carrier uptake line and reductant uptake line.

10.3.1.7 Load carrier and reductant lines into pump magazines

10.3.1.8 Load the two waste lines into the pump magazines below the roller.

10.3.1.9 Lock the magazines into place.

FIMS100 only:

10.3.1.10 Remove the cap from the liquid/vapor separator and wipe dry with a Lab Wipe (Section 7.9). Compressed air (Section 7.10) through the vapor transfer line to dry it out.

10.3.1.11 Place a PTFE membrane (Section 7.7), rough side up, in the liquid/vapor separator; replace the cap and reattach the vapor transfer line to the sample absorption cell.

10.3.1.12 Adjust the gas flow by turning the black knob below the air flow meter to obtain a reading of just over 50.

10.3.2 Calibration and Sample Analysis

10.3.2.1 The instrument will now run the calibration standards; verify a CC of 0.995 or better before proceeding with the ICV and ICB. Ten analytical samples, a CCV and CCB, ten analytical samples, CCV, CCB, etc. The CCBs and CCVs must be recovered within the proper ranges (Sections 9.4 and 9.1.3) for analysis to continue.

10.3.2.2 If the sample result is beyond 90% of the concentration of the highest point on the calibration curve or LDR study used to establish the linear range, dilute the sample extract with a portion of one of the prepared blanks (ICB, CCB or PBS) to produce an analytical result that is within the range.

10.3.3 Instrument Shut Down

10.3.3.1 When analysis is complete place reagent uptake lines in a beaker of DI water.

10.3.3.1.1 Continue to run the pumps for several minutes to flush reagents out of the lines.

10.3.3.1.2 Continue to run the pumps for several more minutes to flush the lines thoroughly with DI water.

10.3.3.2 Pull the reagent uptake lines out of the DI water beaker to allow the pump to draw air completely through the lines.

10.3.3.3 Unlock the top and bottom pump magazines and remove tubing from the magazines.

10.3.3.4 Exit from the software application.

Note: This procedure must be followed every time the instrument is shut down to prevent water or reagents from being draw back into the instrument which can cause severe damage.

10.3.3.4.1 Dump the samples and instrument waste in the Metals/WetChem waste drum located in the transfer room only after all data has been processed through final review and package generation.

10.4 Continuing Calibration

After every 10 samples, analyze a Continuing Calibration Verification Standard (CCV), and a Continuing Calibration Blank sample (CCB). Determine the concentrations from the calibration curve. The results for the CCV must be within 20% of the true value.

10.5 Preventive Maintenance

Preventative maintenance is conducted per the manufacturer's instructions. All preventative maintenance is recorded in the Instrument Maintenance Logbook.

11. Data Evaluation, Calculations and Reporting

11.1 Calculate Mercury Concentration From the Daily Calibration Curve

The curve is generated utilizing a straight-line equation defined as:

$$A = k_1 + k_2C$$

Where:

A = Average peak height of the sample/standard integrations
C = Sample/Standard Concentration, µg/L
k_1 = y-intercept
k2 = slope

The instrument will plot peak height against concentration (µg/L). The result is generated in µg/L. This value is divided by 1000 to convert the units to mg/L. The mg/L units are converted to mg/Kg by multiplying by L/Kg. A dilution factor (DF) is applied if necessary. The Result is then divided by the % Total Solids prior to release to the client.

$$\text{Result, mg/Kg} = (\text{concentration, µg/L}) \times (1\text{mg}/1000\mu\text{g}) \times (\text{DF}) \times (\text{L/Kg})$$

Where:

$$\text{L/Kg} = \frac{\text{Final volume of digestate, in L}}{\text{Weight of original sample, in Kg}}$$

11.2 Calculate Percent Recovery for the Matrix Spike corrected for concentrations measured in the unfortified sample. Percent recovery is calculated using the following equation:

$$\%\ \text{Recovery} = \frac{(Cm - C)}{s} \times 100$$

Where:

Cm = measured Mercury in the fortified sample
C = measured native mercury sample concentration
S = concentration equivalent of spike added to sample

11.3 Calculate the Relative Percent Difference (RPD) for each Duplicate of the initial quantitated concentration (IC) and duplicate quantitated concentration (Dc) using the following formula:

$$RPD = \frac{|(IC - Dc)|}{\{(IC + Dc) / 2\}} \times 100$$

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

12.1 Method Blank Failure

When a prep blank mercury concentration is ≥10% of the mercury concentration determined for any associated sample, or is greater than 2.2x the MDL value (whichever is greater), the entire batch associated with the prep blank must be redigested.

12.2 ICV / CCV Failure

If the ICV %Recovery is outside of acceptance criteria, analysis is terminated until the problem is found and corrected. If the CCV %Recovery is outside of acceptance criteria, all samples analyzed since the last acceptable CCV must be reanalyzed following correction of the problem.

12.3 LCS Failure

If the LCS is not recovered within acceptance criteria, the associated batch and another LCS must be redigested (Section 10.1).

12.4 Matrix Spike/Post Digestion Spike Failure

If the recovery of the matrix spike is outside of the acceptance criteria of 80 – 120%, a post digestion spike is performed (Section 9.5). If the post digestion spike is beyond 75 – 125%, the sample and its spike are redigested (Section 10.1).

12.5 Duplicate Failure

If the RPD between the sample and its duplicate is greater than 20%, visually evaluate the sample matrix. If the sample matrix appears clean, the sample and its duplicate are removed from the batch and redigested (Section 10.1). If the matrix appears problematic, the sample digestate may be diluted and reanalyzed, or a narrative included with the data to explain the matrix problem.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP 1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP/1732 DL/LOD/LOQ Generation

SOP/1739 IDC/DOC Generation

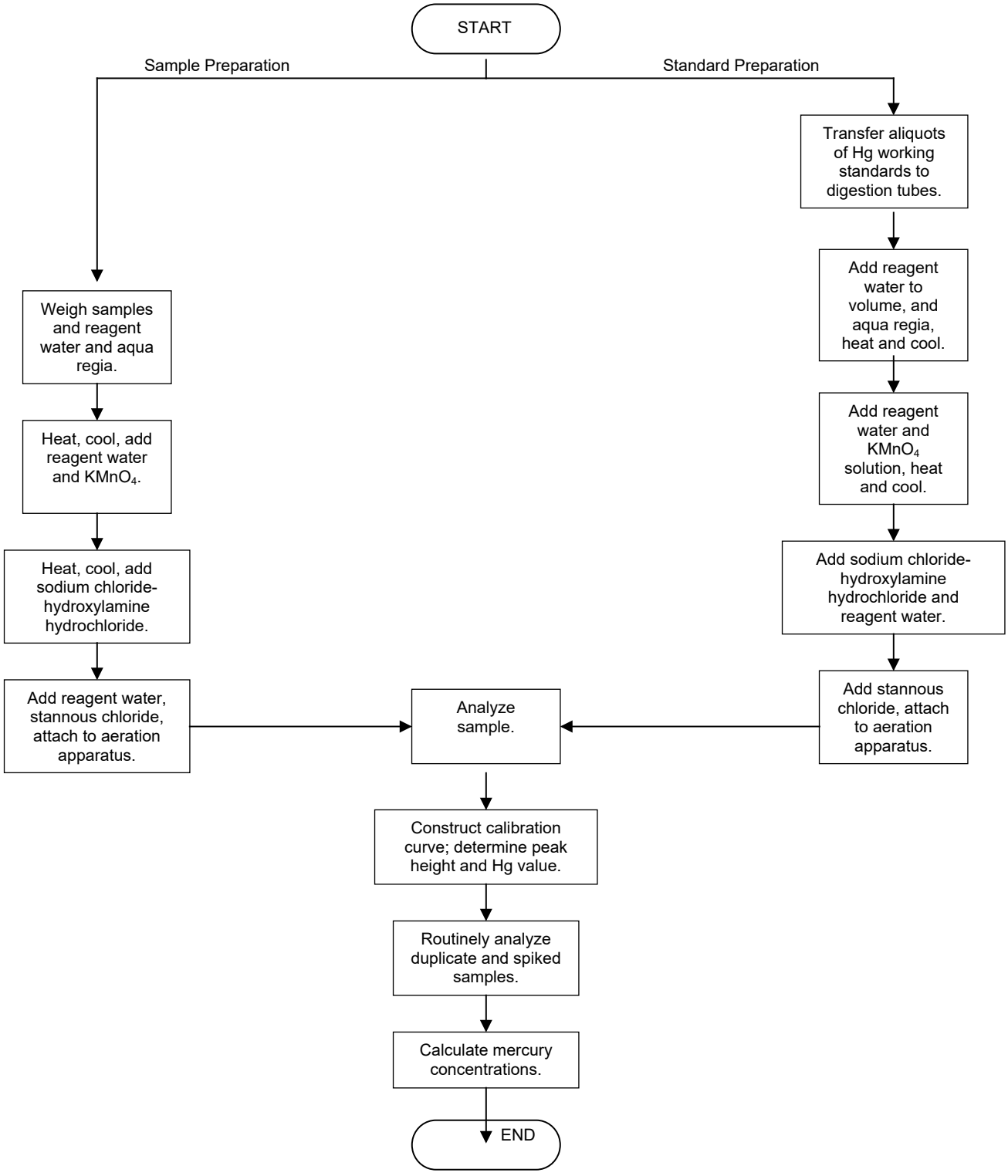
SOP/1797 Waste Management and Disposal SOP

16. Attachments

FIGURE 1: Flow Chart for Method 7471B

Figure 1

Method 7471B Flow Chart



Inductively Coupled Plasma - Atomic Emission Spectrometry

Reference Method No.: **Method 6010D** SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update V, July, 2014.

SM 2340B, Hardness by Calculation, Standard Methods for the Examination of Water and Wastewater, APHA-AWWA-WPCF, 21st Edition, 1997.

1. Scope and Application

Matrices: Digestates from all matrices.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Inductively coupled plasma-atomic emission spectrometry (ICP-AES) determines trace elements, including metals, in solution. The method is applicable to all of the elements listed in Table 1. All matrices, excluding filtered groundwater samples but including ground water, aqueous samples, TCLP and EP extracts, industrial and organic wastes, soils, sludge, sediments, and other solid wastes, require digestion prior to analysis. Groundwater samples that have been prefiltered and acidified will not need acid digestion unless chemical interferences are suspected. Samples which are not digested are matrix matched with the standards. Refer to Metals Preparation SOPs for the appropriate digestion procedures.

Table 1 lists the elements for which this method is applicable. Detection limits, sensitivity, and the optimum and linear concentration ranges of the elements can vary with the wavelength, spectrometer, matrix and operating conditions. Table 1 lists the recommended analytical wavelengths for the elements in clean aqueous matrices. Table 3 lists the Reported Detection Limits. The reported detection limit data may be used to estimate instrument and method performance for other sample matrices. Elements other than those listed in Table 1 may be analyzed by this method if performance at the concentration levels of interest (see Section 9) is demonstrated.

Users of the method should state the data quality objectives prior to analysis and must document and have on file the required initial demonstration performance data described in the following sections prior to using the method for analysis.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is made by one of the following laboratory personnel before performing the modification: Area Supervisor, Metals Manager, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer.

Use of this method is restricted to spectroscopists who are knowledgeable in the correction of spectral, chemical, and physical interferences described in this method. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

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2. Summary of Method

Prior to analysis, samples must be solubilized or digested using appropriate Sample Preparation Methods. When analyzing groundwater samples for dissolved constituents, acid digestion is not necessary if the samples are filtered and acid preserved prior to analysis.

This method describes multielemental determinations by ICP-AES using sequential or simultaneous optical systems and axial or radial viewing of the plasma. The instrument measures characteristic emission spectra by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the emission lines are monitored by photosensitive devices. Background correction is required for trace element determination. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background-intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. In one mode of analysis the position used must be as free as possible from spectral interference and must reflect the same change in background intensity as occurs at the analyte wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. The possibility of additional interferences named in Section 4.0 must also be recognized and appropriate corrections made; tests for their presence are described in Section 9.7. Alternatively, users may choose multivariate calibration methods. In this case, point selections for background correction are superfluous since whole spectral regions are processed.

This SOP includes the manual calculations for Total Hardness and Calcium Hardness, according to SM 2340B.

2.1 Method Modifications from Reference

None.

3. Reporting Limits

Refer to Table 3 for method Reporting Limits.

4. Interferences

4.1 Spectral

Spectral interferences are caused by background emission from continuous or recombination phenomena, stray light from the line emission of high concentration elements, overlap of a spectral line from another element, or unresolved overlap of molecular band spectra.

4.1.1 Background emission and stray light can usually be compensated for by subtracting the background emission determined by measurements adjacent to the analyte wavelength peak. Spectral scans of samples or single element solutions in the analyte regions may indicate when alternate wavelengths are desirable because of severe spectral interference. These scans will also show whether the most appropriate estimate of the background emission is provided by an interpolation from measurements on both sides of the wavelength peak or by measured emission on only one side. The locations selected for the measurement of background intensity will be determined by the complexity of the spectrum adjacent to the wavelength peak. The locations used for

routine measurement must be free of off-line spectral interference (interelement or molecular) or adequately corrected to reflect the same change in background intensity as occurs at the wavelength peak. For multivariate methods using whole spectral regions, background scans must be included in the correction algorithm. Off-line spectral interferences are handled by including spectra on interfering species in the algorithm.

4.1.2 To determine the appropriate location for off-line background correction, the user must scan the area on either side adjacent to the wavelength and record the apparent emission intensity from all other method analytes. This spectral information must be documented and kept on file. The location selected for background correction must be either free of off-line interelement spectral interference or a computer routine must be used for automatic correction on all determinations. If a wavelength other than the recommended wavelength is used, the analyst must determine and document both the overlapping and nearby spectral interference effects from all method analytes and common elements and provide for their automatic correction on all analyses. Tests to determine spectral interference must be done using analyte concentrations that will adequately describe the interference. Normally, 100 mg/L single element solutions are sufficient; however, for analytes such as iron that may be found at high concentration, a more appropriate test would be to use a concentration near the upper analytical range limit.

4.1.3 Spectral overlaps may be avoided by using an alternate wavelength or can be compensated by equations that correct for interelement contributions. Instruments that use equations for interelement correction require the interfering elements be analyzed at the same time as the element of interest. When operative and uncorrected, interferences will produce false positive determinations and be reported as analyte concentrations. More extensive information on interferant effects at various wavelengths and resolutions is available in reference wavelength tables and books. Users may apply interelement correction equations determined on their instruments with tested concentration ranges to compensate (off line or on line) for the effects of interfering elements. For multivariate methods using whole spectral regions, spectral interferences are handled by including spectra of the interfering elements in the algorithm. The interferences listed are only those that occur between method analytes. Only interferences of a direct overlap nature are listed. These overlaps were observed with a single instrument having a working resolution of 0.035 nm.

4.1.4 When using inter-element correction equations, the interference may be expressed as analyte concentration equivalents (i.e. false analyte concentrations) arising from 100 mg/L of the interference element. For example, assume that As is to be determined (at 193.696 nm) in a sample containing approximately 10 mg/L of Al. 100 mg/L of Al would yield a false signal for As equivalent to approximately 1.3 mg/L. Therefore, the presence of 10 mg/L of Al would result in a false signal for As equivalent to approximately 0.13 mg/L. The user is cautioned that each instrument may exhibit somewhat different levels of interference. The interference effects must be evaluated for each individual instrument since the intensities will vary.

Major known interferences are Fe, Al, Ca, Mg, V, Ni, Cu, and Cr. To minimize any of these interferences, every analyte is analyzed on each instrument at or near its linear range and corrected for these interferences. This is done on an annual basis, and data is kept on file.

4.1.5 Inter-element corrections will vary for the same emission line among instruments because of differences in resolution, as determined by the grating, the entrance and exit slit widths, and by the order of dispersion. Inter-element corrections will also vary depending upon the choice of background correction points. Selecting a background correction point where an interfering emission line may appear must be avoided when practical. Inter-element corrections that constitute a major portion of an emission signal may not yield accurate data. Users must not forget that some samples may contain uncommon elements that could contribute spectral interferences.

4.1.6 The interference effects must be evaluated for each individual instrument whether configured as a sequential or simultaneous instrument. For each instrument, intensities will vary not only with optical resolution but also with operating conditions (such as power, viewing height and argon flow rate). When using the recommended wavelengths, the analyst is required to determine and document for each wavelength the effect from referenced interferences as well as any other suspected interferences that may be specific to the instrument or matrix. The analyst is encouraged to utilize a computer routine for automatic correction on all analyses.

4.1.7 The primary wavelength for each analyte is based upon the instrument manufacturer's recommendations. An alternate wavelength is chosen if there is an indication of elevated background or overlap of another spectral wavelength. The wavelength for each analyte must be as free from interferences as possible.

4.1.8 If the correction routine is operating properly, the determined apparent analyte(s) concentration from analysis of each interference solution must fall within a specific concentration range around the calibration blank. The concentration range is calculated by multiplying the concentration of the interfering element by the value of the correction factor being tested and divided by 10. If after the subtraction of the calibration blank the apparent analyte concentration falls outside of this range in either a positive or negative direction, a change in the correction factor of more than 10% should be suspected. The cause of the change must be determined and corrected and the correction factor updated. The interference check solutions must be analyzed more than once to confirm a change has occurred. Adequate rinse time between solutions and before analysis of the calibration blank will assist in the confirmation.

4.1.9 When inter-element corrections are applied, their accuracy must be verified, daily, by analyzing the spectral interference check solution. The correction factor or multivariate correction matrices tested on a daily basis. All inter-element spectral correction factors or multivariate correction matrices are verified and updated when an instrumentation change, such as in the torch, nebulizer, injector, or plasma conditions occurs. The standard solution must be inspected to ensure that there is no contamination that may be perceived as a spectral interference.

4.1.10 When inter-element corrections are <u>not</u> used, verification of absence of interferences is required.

4.1.10.1 One method is to use a computer software routine for comparing the determinative data to limits, files for notifying the analyst when an interfering element is detected in the sample at a concentration that will produce either an apparent false positive concentration, (i.e., greater than) the analyte

instrument detection limit, or false negative analyte concentration, (i.e., less than the lower control limit of the calibration blank defined for a 99% confidence interval).

4.1.10.2 Another method is to analyze an Interference Check Solution(s) which contains similar concentrations of the major components of the samples (>10 mg/L) on a continuing basis to verify the absence of effects at the wavelengths selected. These data must be kept on file with the sample analysis data. If the check solution confirms an operative interference that is >20% of the analyte concentration, the analyte must be determined using (1) analytical and background correction wavelengths (or spectral regions) free of the interference, (2) by an alternative wavelength, or (3) by another documented test procedure.

4.2 Physical

Physical interferences are effects associated with the sample nebulization and transport processes. Changes in viscosity and surface tension can cause significant inaccuracies, especially in samples containing high dissolved solids or high acid concentrations. If physical interferences are present, they must be reduced by diluting the sample, using a peristaltic pump, use of an internal standard or by using a high solids nebulizer. Another problem that can occur with high dissolved solids is salt buildup at the tip of the nebulizer, affecting aerosol flow rate and causing instrumental drift. The problem can be controlled by wetting the argon prior to nebulization, using a tip washer, using a high solids nebulizer or diluting the sample. Also, it has been reported that better control of the argon flow rate, especially to the nebulizer, improves instrument performance: this may be accomplished with the use of mass flow controllers. The test described in Section 10.3.4.1 will help determine if a physical interference is present.

4.3 Chemical

Chemical interferences include molecular compound formation, ionization effects, and solute vaporization effects. Normally, these effects are not significant with the ICP technique, but if observed, can be minimized by careful selection of operating conditions (incident power, observation position, and so forth), by buffering of the sample, by matrix matching, and by standard addition procedures. Additionally, if filtered samples are found to have an organic or sulfur like odor they are processed by heating after the addition of the acids to matrix match. Chemical interferences are highly dependent on matrix type and the specific analyte element.

4.4 Memory

Memory interferences result when analytes in a previous sample contribute to the signals measured in a new sample. Memory effects can result from sample deposition on the uptake tubing to the nebulizer and from the build-up of sample material in the plasma torch and spray chamber. The site where these effects occur is dependent on the element and can be minimized by flushing the system with a rinse blank between samples. The possibility of memory interferences must be recognized within an analytical run and suitable rinse times must be used to reduce them. The rinse times necessary for a particular element must be estimated prior to analysis. This may be achieved by aspirating a standard containing elements at a concentration ten times the usual amount or at the top of the linear dynamic range. The aspiration time for this sample must be the same as a normal sample analysis period, followed by analysis of the rinse blank at designated intervals. The length of time required to reduce analyte signals to within a factor of two of the method detection limit must be noted. Until the required rinse time is established, this method suggests a rinse period of at least 60 seconds between samples and standards. If memory interference is suspected, the sample must be reanalyzed after a rinse period of sufficient length. Alternate rinse times may be established by the analyst based upon their DQOs.

4.5 Other Interferences

4.5.1 Users are advised that high salt concentrations can cause analyte signal suppressions and confuse interference tests. If the instrument does not display negative values, fortify the interference check solution with the elements of interest at 0.5 to 1 mg/L and measure the added standard concentration accordingly. Concentrations must be within 20% of the true spiked concentration or dilution of the samples will be necessary. In the absence of measurable analyte, overcorrection could go undetected if a negative value is reported as zero.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound must be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Samples are collected in plastic bottles.

6.2 Sample Preservation

If samples are for soluble metals analysis, filtration must take place prior to preservation with 1:1 HNO3 to a pH < 2. Soluble samples must be held at pH < 2 for at least 24 hours prior to digestion if not preserved at the time of filtration. Samples for total metals analysis are preserved with 1:1 HNO3 to a pH < 2. Samples must be pH <2 for at least 24 hours prior to digestion if not preserved at the time of collection.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Samples to be analyzed for soluble metals, that have not been filtered, must be filtered and preserved within 24 hours of sample collection.

Preserved samples have a hold time of 6 months, and are stored at ambient temperature.

7. Equipment and Supplies

7.1 Inductively coupled argon plasma emission spectrometer:

- **Thermo Scientific ICAP Duo 6500 (Trace7)**

7.1.1 Computer-controlled emission spectrometer with background correction.

7.1.2 Radio-frequency generator compliant with FCC regulations.

7.1.3 Optional mass flow controller for argon nebulizer gas supply.

7.1.4 Optional peristaltic pump.

7.1.5 Optional Autosampler.

7.1.6 Argon gas supply - high purity.

7.2 Volumetric flasks of suitable precision and accuracy.

7.3 Volumetric pipets of suitable precision and accuracy.

8. Standards and Reagents

Reagent semiconductor and/or trace grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination. If the purity of a reagent is in question, analyze for contamination. If the concentration of the contamination is less than the MDL then the reagent is acceptable.

8.1 Hydrochloric acid (conc), HCl. Stored at room temperature in acid resistant cabinet. Expiration date if defined by vendor.

8.2 Hydrochloric acid (1:1), HCl. Add 500 mL concentrated HCl to 400 mL DI water and dilute to 1 liter in an appropriately sized beaker. Stored at room temperature in polypropylene bottle, expiration date if defined by vendor..

8.3 Nitric acid (conc), HNO_3. Stored at room temperature in acid resistant cabinet. Expiration date if defined by vendor.

8.4 Nitric acid (1:1), HNO_3. Add 500 mL concentrated HNO_3 to 400 mL DI water and dilute to 1 liter in an appropriately sized beaker. Stored at room temperature in polypropylene bottle, expiration date if defined by vendor..

8.5 Reagent Water. All references to water in the method refer to reagent water unless otherwise specified. Reagent water will be interference free. Refer to Chapter One for a definition of reagent water.

8.6 Standard stock solutions may be purchased or prepared from ultra- high purity grade chemicals or metals (99.99% pure or greater). All stock standards are ordered through ISO and American Association for Lab Accreditation vendors. All standards are in aqueous solutions and are generally at concentrations of 1000ppm and 10,000ppm.

8.7 Mixed calibration standard solutions

Prepare mixed calibration standard solutions by combining appropriate volumes of the stock solutions in volumetric flasks. Add the appropriate types and volumes of acids so that the standards are matrix matched with the sample digestates. Care must be taken when preparing the mixed standards to ensure that the elements are compatible and stable together. Transfer the mixed standard solutions to HDPE or polypropylene bottles for storage. Fresh

mixed standards must be prepared, as needed, with the realization that concentration can change on aging as evidenced by failures in the ICV.

NOTE: If the addition of silver to the recommended acid combination results in an initial precipitation, add 15 mL of water and warm the flask until the solution clears. Cool and dilute to 100 mL with water. For this acid combination, the silver concentration must be limited to 2 mg/L. Silver under these conditions is stable in a tap-water matrix for 30 days. Higher concentrations of silver require additional HCl.
Additionally, sulfur standards are stand-alone single element standards and therefore are not to be combined in a mixed calibration standard solution.

8.8 Blanks

Three types of blanks are required for the analysis for samples. The calibration blank is used in establishing the analytical curve, and the method blank is used to identify possible contamination resulting from varying amounts of the acids used in the sample processing. The rinse blank is used to flush the system between all samples and standards.

8.8.1 The calibration blank is prepared by acidifying reagent water to the same concentrations of the acids found in the standards. Prepare a sufficient quantity to flush the system between standards and samples. The calibration blank will also be used for all initial (ICB) and continuing calibration blank (CCB) determinations (see Sections 10.2 and 10.4). Refer to Section 10.4.1.2 for acceptance criteria and/or corrective actions.

8.8.2 The method blank must contain all of the reagents in the same volumes as used in the processing of the samples. The method blank must be carried through the complete procedure and contain the same acid concentration in the final solution as the sample solution used for analysis. Refer to Section 9.1 for acceptance criteria and/or corrective actions.

8.8.3 The rinse blank consists of HNO_3 (1% or 2%) (v/v) in reagent water. Prepare a sufficient quantity to flush the system between standards and samples.

8.9 The Initial Calibration Verification Standard (ICV) and the Continuing Calibration Verification Standard (CCV)

These ICV is prepared by the analyst by combining compatible elements from a standard source different than that of the calibration standard at a concentration at or near the mid-point of the calibration curve. The CCV is prepared from the same source as the calibration standards and must be at a concentration near the mid-point of the calibration curve.

8.10 Low Level of Quantification, (LLOQ)

The LLOQ is initially verified by the analysis of at least 7 replicate samples, spiked at the LLOQ and processed through all preparation and analysis steps of the method at or below the lowest calibration point. The mean recovery and relative standard deviation of these samples provide an initial statement of precision and accuracy at the LLOQ. In most cases the mean recovery should be +/- 35% of the true value and RSD should be < 20%. In-house limits may be calculated when sufficient data points exist. Monitoring recovery of LLOQ over time is useful for assessing precision and bias.

Ongoing LLOQ verification, at a minimum, is on a quarterly basis to validate quantitation capability at low analyte concentration levels. This verification may be accomplished either with clean control material (e.g., reagent water, method blanks. Optimally, the LLOQ should be less than the desired regulatory action levels based on the stated project-specific requirements.

8.11 Spectral Interference Check Solution

These solutions are prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. Analysts are advised that high salt concentrations can cause analyte signal suppressions and confuse interference tests.

Single element interference checks - At a minimum, single element SIC checks must be performed for the following elements: Aluminum 500mg/L; Boron 50mg/L, Barium, 50mg/L, Calcium 500mg/L; Copper 50mg/L; Iron 200mg/L; Magnesium 500mg/L; Manganese 50mg/L; Molybdenum 20mg/L; Sodium 1000mg/L; Nickel 20mg/L; Selenium 20mg/L; Silicon 200mg/L; Tin 20mg/L; Vanadium 20mg/L; Zinc 20mg/L The absolute value of the concentration observed for any unspiked analyte in the single element SIC checks must be less than two times the analytes' LLOQ.

The concentration of the SIC checks are suggested, but become the highest concentration allowed in a sample analysis, and cannot be higher than the highest established linear range. Samples with concentrations of elements higher than the SIC check must be diluted until the concentration is less than the SIC check solution. Note that reanalysis of a diluted sample is required even if the high concentration element is not required to be reported for the specific sample, since the function of the SIC check is to evaluate spectral interferences on other elements. The single element SIC checks are performed when the instrument is setup and periodically (at least once every 6 months) thereafter.

Mixed element interference check - The mixed element SIC solution is analyzed at least once per day, immediately after the initial calibration. The concentration measured for any target analytes must be less than +/- the LLOQ. If this criterion is not met then sample analysis may not proceed until the problem is corrected, or alternatively the LLOQ may be raised to twice the concentration observed in the SIC solution. The only exceptions are those elements that have been demonstrated to be contaminants in the SIC solutions These may be present up to the concentration documented plus the LLOQ.

Mixed element SIC solution: Aluminum, 500mg/L; Calcium, 500mg/L; Iron, 200mg/L; Magnesium, 500mg/L

8.12 Ongoing Low Level of Quantification, (LLOQ)

Ongoing LLOQ verification, at a minimum, is on a quarterly basis to validate quantitation capability at low analyte concentration levels. This verification may be accomplished either with clean control material (e.g., reagent water, method blanks. Optimally, the LLOQ should be less than the desired regulatory action levels based on the stated project-specific requirements.

8.13 Internal Standard

The internal standard consists of a multi-element solution; each internal standard covers a range of the spectrum (low, middle, or high wavelengths) and the elements within that range.

5.0ug/mL Scandium

3.0ug/mL Yttrium

Note: The standard is used to monitor instrument fluctuations including but not limited to nebulization efficiency, plasma variations, environmental temperature changes, peristaltic pump pulsations, etc. Therefore, the solution used to start an analysis calibration cannot be added to or changed out during analysis without requiring subsequent full recalibration.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

Employ a minimum of one method blank per sample batch to determine if contamination or any memory effects are occurring. A method blank is a volume of reagent water carried through the same preparation process as a sample.

The method blank results must be less than ½ of the LLOQ for all analytes of concern. If the results of the method blank exceed the RDL for any analyte, perform re-analysis of a new aliquot of the method blank.

If the results continue to exceed the RDL, proceed as follows:

If all of the samples for the analyte are non-detected, and the method blank is at or above the RDL, no action is required.

If one or more associated samples for that analyte have positive results at or above the RDL, those samples must be considered to be out of control, and are re-digested and reanalyzed.

9.2 Laboratory Control Sample (LCS)

Analyze one LCSW/SRM per sample batch. A LCS/SRM sample is a spiked volume of reagent water that is brought through the entire preparation and analytical process. The LCSW must have a % Recovery of ± 20% within the actual value or within vendor control limits (95% confidence limits) for the solid SRM.

If the LCSW or SRM % Recovery is outside the acceptable limits as stated in Table 2, or outside any vendor control limits, the LCS is rerun once. If upon reanalysis the LCS is still out of control, the failed analytes are re-prepped and re-analyzed. Otherwise, a nonconformance report form is raised to document the exact problem and this form is then authorized by the QA/QC Director and/or the Laboratory Manager(s).

9.3 Initial Calibration Verification (ICV)

For all analytes and determinations, the laboratory must analyze an ICV (Section 8.9), and a calibration blank (ICB, Section 8.8.1), immediately following daily calibration. The results of the ICV are to agree within 10% of the expected value; if not, re-analyze once, if still failing terminate the analysis, correct the problem, and recalibrate the instrument.

9.4 Continuing Calibration Verification (CCV)

A calibration blank (CCB, Section 8.8.1) and a calibration verification standard (CCV, Section 8.9) must be analyzed after every tenth sample and at the end of the sample run. Analysis of the calibration verification (CCV) must verify that the instrument is within 10% of the calibration with the relative standard deviation < 5% from replicate (minimum of two) integrations.

Immediate corrective action for a failing CCV/CCB includes reanalyzing the failing standard. If the standard passes the second time then the analysis may be continued. The batch sheet is noted. If the standard fails again, instrument maintenance must be performed and the CCV/CCB standard is reanalyzed. If the standard passes, then all samples run after the last passing CCV/CCB pair must be re-analyzed.

If the standard fails after instrument maintenance, the instrument is recalibrated. A new ICV/ICB is performed, and all previous data after the last passing CCV/CCB is reanalyzed.

9.5 Matrix Spike

Analyze matrix spike samples at a frequency of one per matrix batch. The matrix spike is the same solution as used for the LCS (Table 4). A matrix spike sample is a sample brought through the entire sample preparation and analytical process.

9.5.1 The percent recovery is to be calculated as follows:

$$\% \text{ Recovery} = \frac{MS - S}{C} \times 100$$

where:

MS = Matrix Spike value
S = Sample value.
C = Concentration of the Spiking solution.

9.5.2 If the Matrix Spike falls outside of the limits as stated in Table 2, or outside any historical documentation for analytes of interest a post analytical spike is performed for the failed analytes. The same sample from which the MS/MSD aliquots were prepared should be spiked with a post digestion spike at a minimum level of 10 times and a maximum of 100 times the lower limit of quantitation. The acceptable % Recovery of the post analytical spike is 75-125%%. A nonconformance is noted in the LIMS and approved in secondary peer review and/or by the Metals Manager.

9.5.3 If the Post Spike fails the dilution test should be performed**.** If the analyte concentration is sufficiently high (minimally, a factor of 25 above the lower limit of quantitation after dilution), an analysis of a 1:5 dilution should agree within ± 20% of the original determination. If not, then a chemical or physical interference effect should be suspected.

9.6 Laboratory Duplicate

A duplicate sample is analyzed once per matrix batch. This sample is brought through the entire sample preparation and analytical process.

9.6.1 The relative percent difference between duplicate determinations is to be calculated as follows:

$$RPD = \frac{|D_1 - D_2|}{(|D_1 + D_2|)/2} \times 100$$

where:

RPD = relative percent difference.
D_1 = first sample value.
D_2 = second sample value (replicate).

9.6.2 If the Duplicate falls outside of the limits as stated in Table 2, or outside any historical documentation and the concentrations of the failing analytes are less than 5x the RL or a matrix interference is found a nonconformance is noted in the LIMS and approved in secondary peer review and/or by the Metals Manager.

9.7 Method-specific Quality Control Samples

9.7.1 Spectra Interference Check Standard

A mixed check solution is analyzed once daily (section 8.11). One solution (SIC) has only elevated concentrations of Fe, Al, Ca, Mg to ensure no interferences occur. The concentrations of the analytes of interest must have an absolute value of the LLOQ. This solution is analyzed at the beginning of the first analytical run of the day.

The high level interferences are not evaluated for recovery. If the SIC fails take corrective action which may include re-evaluation of the inter-element correction values (IECs) after running single element SIC. The instrument calibration routine must then be performed and confirmed by the ICV/ICB pair and the SIC re-analyzed before proceeding with analysis. Otherwise, the nonconformance issue is raised to the Department Supervisor and/or the QA Department.

9.7.2 Internal Standard

The internal standards are added prior to the nebulizer and corrects for intensity differences in the instrument response between the standard's and sample's matrix. They are monitored for any variation in response during the sample analyses and used to ratio the sample response to the internal standard response of the calibration blank. The ratio is applied to compensate for instrument conditions in the plasma or nebulization caused by the matrix. The internal standard is monitored for 50-150% recovery or laboratory generated control ranges difference from the calibration blank IS response to ensure the proper functioning of the internal standard introduction system and matrix interferences. If an injection falls outside of this acceptance range the sample or QC check is rerun once to check for an introduction error.

If a sample continues to fail it's to be run on successive increasing dilutions until the internal standards associated with the elements of interest are within range. If a QC check fails on the single rerun the analysis is stopped, the root cause investigated, corrected and the instrument re-calibrated/verified. The analysis begins again with all samples that were run after the last acceptable CCV/CCB pair.

9.7.3 LDR Check Solution: A multiple element or single element solution run at a point above the highest calibration standard under the same calibration used to quantify the associated sample data. The LDR check must be within +/-10% of the true value of each element of interest to be considered valid.

9.8 Method Sequence

- Calibration of instrument
- Initial Calibration Verification Standard
- Initial Calibration Blank
- Mixed SIC Solution
- Continuing Calibration Verification Standard
- Continuing Calibration Blank

- 10 samples
- Continuing Calibration Verification Standard
- Continuing Calibration Blank
- 10 Samples
- Continuing Calibration Verification Standard
- Continuing Calibration Blank

10. Procedure

10.1 Equipment Set-up

10.1.1 Sample Preparation

Preliminary treatment of most matrices is necessary because of the complexity and variability of sample matrices. Groundwater samples which have been prefiltered and acidified will not need acid digestion. Samples which are not digested must be matrix matched with the standards.

NOTE: Sample digestates intended for Silver analysis must be analyzed as soon as possible.

10.1.2 Instrument Set-Up

Set up the instrument with proper operating parameters established as detailed below. The instrument must be allowed to become thermally stable before beginning (usually requiring at least 30 minutes of operation prior to calibration).

Startup Procedures

For iCAP Duo 6500

- Turn on power to the chiller
- Click on ThermoSpec Icon; enter analyst initials in login screen
- Click on Plasma icon to start instrument
- Allow to warm up for 30 minutes
- Enter analytical workgroup number (obtained from LIMS) globally under the Instrument menu by selecting Tools, then Options, then Analyst.
- Click on the Sequence tab and enter the sequence by selecting New Autosampler Table, Add Sequence, Add # of spaces.
- Enter the sample locations and IDs
- Press Run Auto-Session button (►) in menu bar.

10.1.2.1 Specific wavelengths are listed in Table 1. Other wavelengths may be substituted if they can provide the needed sensitivity and are corrected for spectral interference. The instrument and operating conditions utilized for determination must be capable of providing data of acceptable quality to the program and data user.

Operating conditions for axial plasma will vary from 1100 – 1500 watts forward power, 15-19 Liters/min argon coolant flow, 0.5 – 0.7 L/min argon nebulizer flow, 140 – 200 rpm pump rate and a default 1 minute preflush time and 10 second measurement time is recommended for all simultaneous instruments.

10.1.2.2 The plasma operating conditions need to be optimized prior to use of the instrument. This routine is not required on a daily basis, but only when first setting up a new instrument or following a change in operating conditions. The following procedure is recommended or follow manufacturer's recommendations. The purpose of plasma optimization is to provide a maximum signal to background ratio for some of the least sensitive elements in the analytical array. The use of a mass flow controller to regulate the nebulizer gas flow or source optimization software greatly facilitates the procedure.

10.1.2.2.1 The Thermo ICP's typically use a Meinhard Nebulizer. The nebulizer flow for each instrument is 1.0 +/- 0.2 mL/min.

10.1.2.2.2 The 6500 Duo instruments automatically perform a wavelength check at start up without user interaction.

10.1.2.2.3 The instrument operating condition finally selected as being optimum must provide the lowest reliable instrument detection limits and method detection limits.

10.1.2.2.4 If either the instrument operating conditions, such as incident power or nebulizer gas flow rate are changed, or a new torch injector tube with a different orifice internal diameter is installed, the plasma and argon pressures must be reoptimized.

10.1.2.2.5 After completing the initial optimization of operating conditions, but before analyzing samples, the laboratory must establish and initially verify an interelement spectral interference correction routine to be used during sample analysis. A general description concerning spectral interference and the analytical requirements for background correction in particular are discussed in the section on interferences. Criteria for determining an interelement spectral interference is an apparent positive or negative concentration for the analyte that falls within ± ½ LLOQ. The upper control limit is the analyte instrument detection limit. Once established, the entire routine is periodically verified every six months. In between that time, IEC's are done on a need be basis per analyte. Only a portion of the correction routine must be verified more frequently or on a daily basis. Initial and periodic verification of the routine must be kept on file. Special cases where continual verification is required are described elsewhere.

10.1.2.3 Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be established for each individual analyte line on each particular instrument. All measurements must be within the instrument linear range where the correction equations are valid.

10.1.2.3.1 Method detection limits must be established for all wavelengths utilized for each type of matrix commonly analyzed. The matrix used for the MDL calculation must contain analytes of known concentrations within 3-5 times the anticipated detection limit.

10.1.2.3.2 Determination of limits using reagent water MDLs represent a best case situation and do not represent possible matrix effects of real world samples.

10.1.2.3.3 If additional confirmation is desired, reanalyze the seven replicate aliquots on two more non-consecutive days and again calculate the method detection limit values for each day. An average of the three values for each analyte may provide for a more appropriate estimate.

10.1.2.3.4 The upper limit of the linear dynamic range must be established for each wavelength utilized by determining the signal responses with 10% of the true value of each element from a concentration standard at the upper limit of the range run on the same calibration as required by the sample responses above the calibration range. The range which may be used for the analysis of samples must be no more than 90% of the resulting data. Determined analyte concentrations that are above the upper range limit must be diluted and reanalyzed. The analyst must also be aware that if an inter-element correction from an analyte above the linear range exists, a second analyte where the inter-element correction has been applied may be inaccurately reported.

NOTE: Many of the alkali and alkaline earth metals have non-linear response curves due to ionization and self-absorption effects. These curves may be used if the instrument allows; however the effective range must be checked and the second order curve fit must have a correlation coefficient of 0.995 or better. Third order fits are not acceptable. These curves are much more sensitive to changes in operating conditions than the linear lines and must be checked whenever there have been moderate equipment changes.

10.1.2.4 The analyst must (1) verify that the instrument configuration and operating conditions satisfy the analytical requirements and (2) maintain quality control data confirming instrument performance and analytical results.

10.2 Initial Calibration

Calibrate the instrument according to the instrument manufacturer's recommended procedures, using the typical mixed calibration standard solutions described in Section 8.7. Flush the system with the calibration blank (Section 8.8.1) between each standard or as the manufacturer recommends. (Use the average intensity of multiple exposures for both standardization and sample analysis to reduce random error.) The calibration curve consists of a calibration blank, RL standard and a high level standard. Calibration curve verification is accomplished through the analysis of the ICV, ICB and SIC standards.

10.3 Equipment Operation and Sample Processing

10.3.1 For all analytes and determinations, the laboratory must analyze an ICV (Section 8.9), and a calibration blank (ICB, Section 8.8.1), immediately following daily calibration.

A calibration blank (CCB, Section 8.8.1) and a calibration verification standard (CCV, Section 8.9) must be analyzed after every tenth sample and at the end of the sample run. Analysis of the calibration verification (CCV) must verify that the instrument is within 10% of the calibration with the relative standard deviation < 5% from replicate (minimum of three) integrations.

If the calibration cannot be verified within the specified limits, the sample analysis must be discontinued, the cause determined and the instrument recalibrated. All samples following the last acceptable ICV/ICB, or CCV/CCB must be reanalyzed. The analysis

data for the calibration blank, check standard, and ICV or CCV must be kept on file with the sample analysis data.

10.3.2 Rinse the system with the rinse blank solution (Section 8.8.3) before the analysis of each sample. The suggested default rinse time is one minute. Each ICP instrument may establish a reduction in this rinse time through a suitable demonstration.

10.3.3 Dilute and reanalyze samples that exceed the linear range or use a calibrated alternate, less sensitive line for which quality control data is already established.

10.3.4 If less than acceptable accuracy and precision data are generated a series of tests are performed prior to reporting concentration data for analyte elements. At a minimum, these tests should be performed with each batch of samples prepared/analyzed with corresponding unacceptable data quality results. These tests, as outlined in Sections 10.3.5 and 10.3.6, will ensure that neither positive nor negative interferences are operating on any of the analyte elements to distort the accuracy of the reported values.

10.3.5 **Post Digestion Spike Addition:** If the sample concentrations are insufficient to perform a dilution test a post digestion spike added to a portion of a prepared sample, or its dilution for the elements failing the matrix spike recoveries must be run, recovery limits equal to 75% to 125% of the known spike value. If the spike is not recovered within the specified limits If the post-digestion recovery fails to meet the acceptance criteria, the sample results must be reported as estimated values

10.3.6 **Dilution Test:** If the analyte concentration is sufficiently high (minimally, a factor of 25 above the lower limit of quantitation after dilution), an analysis of a 1:5 dilution must agree within ± 20% of the original determination. Elements that fail the dilution test are reported as estimated values.

10.3.7 **CAUTION:** If spectral overlap is suspected, use of computerized compensation, an alternate wavelength, or comparison with an alternate method is recommended.

10.4 Continuing Calibration

10.4.1 Check calibration with an ICV following the initial calibration (Section 8.9). Verify calibration with the Continuing Calibration Verification (CCV) Standard (Section 8.9) at the end of the initial calibration sequence (ICV, ICB), after every ten samples, and at the end of an analytical run. Use a calibration blank (Section 8.8.1) immediately following daily calibration, after every 10 samples and at the end of the analytical run.

10.4.1.1 The results of the ICV are to agree within 10% of the expected value, and CCVs are to agree within 10% of the expected value; if not, terminate the analysis, correct the problem, and recalibrate the instrument. Each may be rerun once to confirm or cure the initial failure.

10.4.1.2 The results of the calibration blank should be below ½ of LLOQ or RL (whichever is lower). If not, repeat the analysis and if the failure is repeated terminate the analysis, correct the problem, recalibrate, and reanalyze the previous 10 samples. If the blank is less than 1/10 the concentration of the action level of interest, and no sample is within ten percent of the action limit, analyses need not be rerun and recalibration need not be performed before continuation of the run.

10.4.2 Verify the inter-element and background correction factors at the beginning of each analytical run. Do this by analyzing the SIC (Section 8.10). Results must be less than +/- LLOQ for all non-spiked elements.

10.4.3 When low-level sensitivity is required, a check standard at the requested limit of quantitation is analyzed to confirm the reported detection limit (RDL). This is performed on a project-by-project basis.

10.5 Preventive Maintenance

Whenever instrument maintenance is performed, it is noted in the instrument's Maintenance Logbook.

10.5.1 Daily

Inspect the nebulizer pump tubing from the Autosampler to the Nebulizer. Replace if necessary.

10.5.2 Monthly or as needed

Remove the torch, "shot glass", nebulizer and spray chamber. Clean each with 10% Nitric Acid and rinse with tap water. Coat the inside of the spray chamber and shot glass with concentrated Sulfuric Acid and soak for one hour, then rinse well with DI water. Soak the torch and nebulizer in aqua regia overnight, then rinse with DI water.

10.5.3 Every 6 months

Preventive Maintenance is performed by the Vendor or in-house personnel as follows:

- check the cooling system
- flush/refill the chiller with distilled water and antibacterial conditioner
- clean the instrument to regain intensity
- clean/replace air filters.

11. Data Evaluation, Calculations and Reporting

11.1 If dilutions were performed, the appropriate factors must be applied to sample values. All results must be reported with up to three significant figures.

11.2 Soil samples

Soil samples are calculated as follows:

$$\mathbf{A} = \frac{\text{Sample weight (grams)}}{\text{Final Volume (mL)}}$$

$$\mathbf{B}\ (\text{concentration in mg/Kg}) = \frac{\text{Concentration of analyte (mg/L)}}{\mathbf{A}}$$

11.2.1 Dry weight correction

The LIMS calculates the dry weight correction, however it is calculated as follows:

$$\text{Final concentration in mg/Kg dry weight} = \frac{B}{\%\ \text{Solids}}$$

11.3 Liquid samples

Liquid samples are calculated as follows:

$$\text{Dilution Factor} = \frac{\text{Final Volume (mL)}}{\text{Sample Volume (mL)}}$$

Final concentration in mg/L = Concentration of analyte (mg/L) x Dilution Factor

11.4 Calculations for Hardness

The method for determining hardness is to compute it from the results of separate determinations of Calcium and Magnesium on aqueous samples.

11.4.1 Total Hardness

Total Hardness, mg equivalent $CaCO_3$/L = [2.497 (Ca, mg/L)] + [4.118 (Mg, mg/L)]

11.4.2 Calcium Hardness

Calcium Hardness, mg equivalent $CaCO_3$/L = [2.497 (Ca, mg/L)]

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Also refer to Section 9 for Quality Control and acceptance criteria.

If the SIC is outside of the recovery window, then the standard is reanalyzed. If the standard failure continues, the IECs for the element/elements in question are reviewed and recalculated if necessary.

Immediate corrective action for a failing CCV/CCB includes reanalyzing the failing standard. If the standard passes the second time then the analysis may be continued. The raw data is noted. If the standard fails again, the problem must be found and corrected and the instrument is recalibrated. The ICV/ICB standard is reanalyzed and all previous data that had failed back to the previous passing CCV/CCB is reanalyzed.

The reanalysis procedure outline above is also conducted for a failing LCS or Method Blank; they may be rerun alone on the new or any subsequent passing bracket. The LCS or Method Blank do not qualify a bracket of samples but the batch run itself.

If the Matrix Spike does not meet acceptance criteria, a dilution test is performed. If the levels of the native sample is inadequate (see section 10.3.6) The RPD must be within 20% of the true value of the native sample. If the dilution test fails or the concentrations in the native sample are inadequate, the post spike is analyzed and evaluated (section 10.3.5). If these criteria are met, then the Matrix Spike data is reported, with the post spike narrated on the final report. If the post spike fails the data is reported as estimated.

If sample Duplicates are outside of the acceptance criteria, the analyst examines the sample for homogeneity. If the sample is not homogenous, this is narrated on the final report. Clean, homogenous samples are reanalyzed and if still outside of the acceptance limits, redigested and reanalyzed.

Sample nonconformance regarding a Matrix Spike recovery or a duplicate %RSD is narrated on the final report along with the corrective action(s) taken.

The mixed element SIC solution is analyzed at least once per day, immediately after the initial calibration. The concentration measured for any target analytes must be less than +/- the LLOQ. If this criterion is not met then sample analysis may not proceed until the problem is corrected, instrument is recalibrated, verified with the ICV/ICB and the SIC is then re-analyzed. Alternatively, the LLOQ may be raised to twice the concentration observed in the SIC solution if approved by the Department Manger or QA Department and the level is below the regulatory action limit or project specific requirements. The only exceptions are those elements that have been demonstrated to be contaminants in the SIC solutions These may be present up to the concentration documented plus the LLOQ. If failure continues notify the Department Supervisor or Manager.

Silver is only slightly soluble in the presence of chloride unless there is a sufficient chloride concentration to form the soluble chloride complex. Therefore, low recoveries of silver may occur in samples, matrix spikes and even laboratory control samples.

Silver is flagged in our data software during analysis if the concentration of silver is >100ug/L. Liquid samples that exceed 100ug/L will be redigested at dilution. Soil and solid samples that exceed 500ug/L (approximately 20mg/kg) will be re-digested at a reduced weight of 0.625g to allow more silver to become soluble during digestion.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP/08-05 unless supersede within this SOP. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/08-12 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP #1732 MDL/LOD/LOQ Generation

SOP# 1739 IDC/DOC Generation

SOP# 1728 Waste Management and Disposal

16. Attachments

TABLE 1: Element Wavelengths

TABLE 2: Precision and Accuracy Acceptance Criteria

TABLE 3: Reporting Limits

TABLE 4: LCS and Matrix Spike Concentrations

TABLE 1
ELEMENT WAVELENGTHS

Element	6500 Duo wavelength (nm)
Pb	220.3
Se	196.0
Sb	206.8
As	189.0
Ba	455.4
Be	313.0
Cd	214.4
Co	228.6
Cu	324.7
Cr	267.7
Fe	259.9
Mn	257.6
Mo	202.0
Ni	231.6
Ag	328.0
Tl	190.8
V	292.4
Zn	206.2
Al	396.1
Ca	315.8
Mg	279.0
B	208.9
Si	212.9
Sn	189.9
Sr	421.5
Ti	334.9
Bi	223.0
Na	589.5
K	766.4
S	180.7
Li	

TABLE 2
PRECISION AND ACCURACY ACCEPTANCE CRITERIA

	% Recovery LCS		Aqueous % Recovery MS		Soil % Recovery SRM *		Duplicate	
Element	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**	**Aqueous %RPD**	**Soil %RPD**
Aluminum	80	120	75	125	29	171	20	20
Antimony	80	120	75	125	4	196	20	20
Arsenic	80	120	75	125	81	119	20	20
Barium	80	120	75	125	83	118	20	20
Beryllium	80	120	75	125	83	117	20	20
Boron	80	120	75	125	70	129	20	20
Cadmium	80	120	75	125	82	117	20	20
Calcium	80	120	75	125	83	117	20	20
Chromium	80	120	75	125	80	119	20	20
Cobalt	80	120	75	125	83	117	20	20
Copper	80	120	75	125	83	117	20	20
Iron	80	120	75	125	51	150	20	20
Lead	80	120	75	125	80	120	20	20
Lithium	80	120	75	125	80	120	20	20
Magnesium	80	120	75	125	74	126	20	20
Manganese	80	120	75	125	83	117	20	20
Molybdenum	80	120	75	125	81	119	20	20
Nickel	80	120	75	125	82	117	20	20
Potassium	80	120	75	125	74	126	20	20
Sulfur	80	120	75	125	NA	NA	20	20
Selenium	80	120	75	125	80	120	20	20
Silica (SiO_2)	80	120	75	125	NA	NA	20	20
Silver	80	120	75	125	66	134	20	20
Sodium	80	120	75	125	74	127	20	20
Strontium	80	120	75	125	80	120	20	20
Thallium	80	120	75	125	79	120	20	20
Tin	80	120	75	125	69	131	20	20
Titanium	80	120	75	125	82	118	20	20
Vanadium	80	120	75	125	79	121	20	20
Zinc	80	120	75	125	82	119	20	20

** Ranges of the SRM are presented as an example of a typical SRM; actual limits may vary by lot provided by the vendor.

TABLE 3
REPORTING LIMITS

Element	Aqueous (mg/L)	Soil (mg/Kg)
ALUMINUM	0.10	4.0
ANTIMONY	0.05	2.0
ARSENIC	0.005	0.40
BARIUM	0.01	0.40
BERYLLIUM	0.005	0.20
BORON	0.03	1.2
CADMIUM	0.005	0.40
CALCIUM	0.10	4.0
CHROMIUM	0.01	0.40
COBALT	0.02	0.80
COPPER	0.01	0.40
IRON	0.05	2.0
LEAD	0.01	2.0
LITHIUM	0.009	0.36
MAGNESIUM	0.10	4.0
MANGANESE	0.01	0.40
MOLYBDENUM	0.05	2.0
NICKEL	0.025	1.0
POTASSIUM	2.5	100
SULFUR	0.25	10
SELENIUM	0.01	0.80
SILICA	0.50	20
SILVER	0.007	0.40
SODIUM	2.0	80
STRONTIUM	0.01	2.0
THALLIUM	0.02	0.80
TIN	0.05	4.0
TITANIUM	0.01	0.40
VANADIUM	0.01	0.40
ZINC	0.05	2.0

TABLE 4
LCS and Matrix Spike

Analyte	Liquid Concentration (mg/L)	Soil Concentration * (MS spike only) (mg/Kg)
Antimony	0.5	160
Arsenic	0.12	160
Barium	2.00	160
Beryllium	0.05	80
Cadmium	0.051	80
Chromium	0.20	160
Copper	0.25	160
Lead	0.51	160
Nickel	0.50	160
Selenium	0.12	160
Silver	0.05	40
Thallium	0.12	160
Zinc	0.50	160
Iron	1.00	800
Manganese	0.50	160
Calcium	10.0	800
Magnesium	10.0	800
Potassium	10.0	800
Sodium	10.0	800
Silica	1.0	800
Aluminum	2.00	800
Cobalt	0.50	160
Vanadium	0.50	160
Boron	1.0	NA
Molybdenum	1.0	NA
Lithium	1.0	800
Titanium	1.0	NA

*MS spike of a solid based on 1.25g and a final volume of 50 mL.

Note: Solids LCS is an SRM with certified value provided by the vendor on a lot basis.

Organochlorine Pesticides
By Capillary Column Gas Chromatography

Reference Method No.: **Method 8081B**

References: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update IV, 2007.

Mass DEP CAM QC Requirements and Performance Standards for the Analysis of Chlorinated Pesticides by Gas Chromatography (GC), Revision 1, July 1, 2010.

SW-846 Pesticides by 8081, State of Connecticut Department of Environmental Protection Reasonable Confidence Protocol (RCP), Version 1.0, July 2005

1. Scope and Application

Method 8081B is used to determine the concentrations of various organochlorine pesticides in extracts from solid and liquid matrices. This SOP details the analysis for these compounds using fused-silica, open-tubular, capillary columns with electron capture detectors (ECD).

Matrices: Extracts from solid and liquid matrices.

Definitions: See Alpha Analytical Quality Manual

Regulatory Parameter List: The compounds listed below are determined by this method:

Parameter	CAS
Aldrin	309-00-2
Alpha-BHC	319-84-6
Beta-BHC	319-85-7
Gamma-BHC (Lindane)	58-89-9
Delta-BHC	319-86-8
Alpha-chlordane	5103-71-9
Gamma-chlordane	5103-74-2
4,4'-DDD	72-54-8
4,4'-DDE	72-55-9
4,4'-DDT	50-29-3
Dieldrin	60-57-1
Endosulfan I	959-98-8
Endosulfan II	33213-65-9
Endosulfan Sulfate	1031-07-8
Endrin	72-20-8
Endrin Aldehyde	7421-93-4
Endrin Ketone	53494-70-5
Heptachlor	76-44-8
Heptachlor Epoxide	1024-57-3
Methoxychlor	72-43-5
Toxaphene	8001-35-2
Chlordane	57-74-9
Alachlor [+]	15972-60-8
Hexachlorobenzene [++]	118-74-1

[+] CT-RCP only compound [++] MCP only compound

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Services Manager, Laboratory Director, or Quality Assurance Officer

This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph (GC) and in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (see section 13), analyzing a proficiency test sample and completing the record of training.

After initial demonstration, ongoing demonstration is based on acceptable laboratory performance of at least a quarterly laboratory control sample or acceptable performance from an annual proficiency test sample. A major modification to this procedure requires demonstration of performance. The identification of major method modification requiring performance demonstration is directed by the QA Officer and/or Laboratory Director on a case-by-case basis.

2. Summary of Method

A measured volume or weight of sample (for liquids, 500 mls or 1L, for solids, 15g to 30g) is extracted using the appropriate matrix-specific sample extraction technique.

Liquid samples are extracted at neutral pH with methylene chloride using Method 3510C (separatory funnel), or other appropriate technique.

Solid samples are extracted with methylene chloride: acetone (1:1) using Method 3540C (Soxhlet), Method 3546 (microwave extraction), or other appropriate technique.

Wipe samples are extracted with methylene chloride: acetone (1:1) using Method 3540C (Soxhlet) or other appropriate technique.

Oil samples are diluted with hexane following the procedure outlined in the extraction SOP.

After cleanup, the extract is analyzed by injecting a 1µL sample into a gas chromatograph equipped with narrow- or wide-bore fused silica capillary columns and electron capture (GC/ECD) detectors.

2.1 Method Modifications from Reference

None.

3. Reporting Limits

Table 1 lists our routine reporting limits.

4. Interferences

4.1 Only high purity gases are used in the GC system to eliminate this source of possible contamination. Both the hydrogen (carrier gas – 99.999%) and argon-methane (detector make-up gas) are certified by the gas supplier.

4.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 9.5 details the maintenance steps.

4.3 Glassware must be scrupulously cleaned. This procedure is detailed in the extraction SOPs. Store dry glassware in a clean environment.

4.4 All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free. All of these materials are routinely determined to be free of interferences by analysis of extraction blanks with every extraction batch performed.

4.5 Certain compounds (i.e. phthalates) can be extracted from the sample matrix and be detected by the ECD that could possibly result in false positive results or complicate the data interpretation. The use of the cleanup procedures detailed in the extraction SOPs minimize these possible interferences. Analyst experience is also crucial in making compound determinations.

4.6 Interferences co-extracted from the samples will vary considerably from waste to waste. While general cleanup techniques are referenced or provided as part of the method, unique samples may require additional cleanup approaches to achieve desired degrees of discrimination and quantitation.

4.7 Interferences by phthalate esters introduced during sample preparation can pose a major problem in pesticide determinations.

4.7.1 Common flexible plastics contain varying amounts of phthalate esters which are easily extracted or leached from such materials during laboratory operations.

4.7.2 Cross-contamination of clean glassware routinely occurs when plastics are handled during extraction steps, especially when solvent-wetted surfaces are handled.

4.7.3 Interferences from phthalate esters are minimized by avoiding contact with any plastic materials and checking all solvents and reagents for phthalate contamination.

4.8 The presence of elemental sulfur will result in broad peaks that interfere with the detection of early-eluting organochlorine pesticides. Sulfur contamination is often seen in sediment and some soil samples.

4.9 Other halogenated pesticides or industrial chemicals may interfere with the analysis of pesticides. Coeluting chlorophenols are eliminated by using Method 3620B (florisil).

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. The following analytes covered by this method have been tentatively classified as known or suspected human or mammalian carcinogens: 4,4'-DDT, 4,4'-DDD, and BHCs. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers must be handled in the vented bench area in the GC laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammables cabinet.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Aqueous samples are collected in either two 500 ml amber glass jars or two 1L amber glass jars with teflon-lined lids. Solid samples are collected in one 250 mL wide-mouth glass jar with a teflon-lined lid. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of 4 ± 2° C. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of 4 ± 2° C.

6.3 Sample Shipping

No special shipping requirements.

6.4 Sample Handling

Aqueous samples must be extracted within 7 days of sample collection, solid samples within 14 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

7. Equipment and Supplies

7.1 Gas Chromatograph, Hewlett Packard 6890 (or equivalent): An analytical system complete with gas chromatograph configured for split-splitless injection and all required accessories including syringes, analytical columns, gases, electron capture detectors (ECD), and data system.

7.1.1 Data System: A computer system is interfaced to the GC for collection of data. Data acquisition is performed using Agilent Technologies GC ChemStation (Rev. A.10.02 [1757]).

7.2 GC Columns: Alpha utilizes dual-column analyses. The dual-column approach involves either a single injection that is split between two columns that are mounted in a single gas chromatograph, or dual injections of the split extract on a single GC equipped with two columns. Typical column pairs used are listed below. Other columns may be used as long as method performance criteria can be met.

7.2.1 Column pair 1

30m x 0.32mm ID fused silica capillary column (RTX-clpesticide), 0.32µm film thickness.

30m x 0.32mm ID fused silica capillary column (RTX-clpesticideII) 0.25µm film thickness.

7.2.2 Column pair 2

30m x 0.32mm ID fused silica capillary column (STX-clpesticide), 0.32µm film thickness.

30m x 0.32mm ID fused silica capillary column (STX-clpesticideII) 0.25µm film thickness.

7.3 Volumetric Flasks: 10mL, 25mL, 50mL, 100mL, 200mL, and 2000mL, for the preparation of standards.

7.4 Microsyringes/Wiretrol syringes: 10 µL – 1000 µL

7.5 Disposable Borosilicate Pipets

7.6 Vials: 2 mL clear glass, crimp-top and screw-cap.

8. Reagents and Standards

Reagent grade or pesticide grade chemicals are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

NOTE: Store the standard solutions (stock, composite, calibration, internal, and surrogate) at 4 ± 2°C in Teflon(R)-sealed containers in the dark. When a lot of standards is prepared, aliquots of that lot are stored in individual small vials. All stock standard solutions must be replaced after one year or sooner if routine QC tests indicate a problem. All other standard solutions must be replaced after six months or sooner if routine QC indicates a problem.

8.1 n-Hexane: Pesticide quality or equivalent.

8.2 Acetone: Pesticide quality or equivalent.

8.3 Methylene chloride: Pesticide quality or equivalent.

8.4 Organic-free Reagent Water: All references to water in this method refer to organic-free reagent water from Alpha's RO water treatment system.

8.5 Stock Standard Solutions: All stock standard solutions are purchased from commercial vendors as ampulated certified solutions. When an ampulated stock solution is opened, it is transferred to a labeled amber screw-cap vial. The expiration date of the stock solution is either the vendor specified expiration date, or 1 year from the date the ampule was opened, whichever is sooner. Typical stock standard concentrations are listed in Table 2.

8.6 Calibration Standards: Calibration standards are prepared volumetrically by diluting the appropriate stock standard(s) with hexane. Calibration standards expire 6 months from the date of preparation, or on the earliest expiration date of any of the stock solutions used to prepare the calibration standard. Calibrations are performed at 10 concentration levels for individual pesticides, Chlordane and Toxaphene; concentrations for all levels are listed in Table 2. Below are suggested procedures for preparation of individual pesticides (Sec. 8.6.1), Chlordane (Sec. 8.6.2), and Toxaphene (Sec. 8.6.3) initial calibration standards.

8.6.1 Preparation of individual pesticides initial calibration standards;

(syringes needed: *100µL [A], 500µL [B], 1000µL [C]*)
(solvent: *Hexane)*
(glassware: *9x10mL, 2x25mL, 1x50mL, 2x100mL, volumetric flasks*)

ICAL (Initial Calibration) STOCK #1: *2000µg/L; 25mL*
50µL[A] of AccuStandard M-8081-SC (Pesticides mix; 1000µg/mL)
250µL[B] of AccuStandard CLP-032-R (TCMX, Deca; 200µg/mL)
500µL[B] of AccuStandard P-102S (Alachlor; 100µg/mL)
500µL[B] of AccuStandard APP-9-112 (Hexachlorobenzene; 100µg/mL)

ICAL STOCK #2 (=LEVEL 10)**:** *200µg/L; 25mL.*
2500µL[B] of STOCK #1
…..

LEVEL 1, 0.5 µg/L:	25µL[A] of ICAL STOCK #2, 10mL
LEVEL 2, 1.0 µg/L:	50µL[A] of ICAL STOCK #2, 10mL
LEVEL 3, 2.0 µg/L:	100µL[A] of ICAL STOCK #2, 10mL
LEVEL 4, 3.0 µg/L:	150µL[B] of ICAL STOCK #2, 10mL
LEVEL 5, 4.0 µg/L:	200µL[B] of ICAL STOCK #2, 10mL
LEVEL 6, 5.0 µg/L:	250µL[B] of ICAL STOCK #2, 10mL
LEVEL 7, 10 µg/L:	500µL[B] of ICAL STOCK #2, 10mL
LEVEL 8, 50 µg/L:	2500µL[C] of ICAL STOCK #2, 10mL
LEVEL 9, 100 µg/L:	5000µL[C] of ICAL STOCK #2, 10mL
LEVEL 10, 200 µg/L:	2500µL[C] of ICAL STOCK #1, 25mL
LEVEL 11, 400 µg/L:	2000µL[C] of ICAL STOCK #1, 10mL

ICV (Initial Calibration Verification) STOCK #1: *2000µg/L; 100mL*
1000µL[C] of Restek 579104 (Custom Pesticides Mix; 200µg/mL)

ICV STOCK #2: *1000µg/L; 50mL*
250µL[B] of Agilent ISM-320-1 (TCMX, Deca; 200µg/mL)
…..

ICV, 50 µg/L:	2500µL[C] of ICV STOCK #1 with 5000µL[C] of ICV STOCK #2, 100mL

8.6.2 Preparation of Chlordane initial calibration standards;

(syringes needed: *100µL [A], 500µL [B], 1000µL [C]*)
(solvent: *Hexane)*
(glassware: *11x10mL, 1x25mL, 1x50mL, volumetric flasks*)

ICAL STOCK #1: *50µg/mL (Chlordane);10mL*
100µL[A] of Agilent EPA-1086-1 (Chlordane Standard; 5000µg/mL)

ICAL STOCK #2 (=LEVEL 9)**:** *2000µg/L; 25mL.*
1000µL[C] of STOCK #1

LEVEL 1, 2µg/L:	10µL[A] of ICAL STOCK #2, 10mL
LEVEL 2, 5µg/L:	25µL[A] of ICAL STOCK #2, 10mL
LEVEL 3, 10µg/L:	50µL[A] of ICAL STOCK #2, 10mL
LEVEL 4, 20µg/L:	100µL[A] of ICAL STOCK #2, 10mL
LEVEL 5, 100µg/L:	500µL[B] of ICAL STOCK #2, 10mL
LEVEL 6, 250µg/L:	1250µL[B] of ICAL STOCK #2, 10mL
LEVEL 7, 500µg/L:	2500µL[C] of ICAL STOCK #2, 10mL
LEVEL 8, 1000µg/L:	5000µL[C] of ICAL STOCK #2, 10mL
LEVEL 9, 2000µg/L:	1000µL[C] of ICAL STOCK #1, 25mL
LEVEL 10, 5000µg/L:	1000µL[C] of ICAL STOCK #1, 10mL

ICV STOCK: *50µg/mL; 10mL*
500µL[B] of Restek 32021 (Chlordane Standard; 1000µg/mL)
…..
ICV, 1000µg/L: 1000µL[C] of ICV STOCK, 50mL

8.6.3 Preparation of Toxaphene initial calibration standards;

(syringes needed: *100µL [A], 500µL [B], 1000µL [C]*)
(solvent: *Hexane)*
(glassware: *11x10mL, 1x50mL, volumetric flasks*)

ICAL STOCK #1: *100µg/mL (Toxaphene);10mL*
1000µL[C] of Absolute Standards 20021 (Toxaphene; 1000µg/mL)

ICAL STOCK #2 (=LEVEL 8)**:** *2000µg/L; 10mL.*
200µL[A] of STOCK #1

LEVEL 1, 5 µg/L:	25µL[A] of ICAL STOCK #2, 10mL
LEVEL 2, 10 µg/L:	50µL[A] of ICAL STOCK #2, 10mL
LEVEL 3, 20 µg/L:	100µL[A] of ICAL STOCK #2, 10mL
LEVEL 4, 100 µg/L:	500µL[B] of ICAL STOCK #2, 10mL
LEVEL 5, 200 µg/L:	1000µL[C] of ICAL STOCK #2, 10mL
LEVEL 6, 500 µg/L:	50µL[A] of ICAL STOCK #1, 10mL
LEVEL 7, 1000 µg/L:	100µL[A] of ICAL STOCK #1, 10mL
LEVEL 8, 2000 µg/L:	200µL[B] of ICAL STOCK #1, 10mL
LEVEL 9, 5000 µg/L:	500µL[B] of ICAL STOCK #1, 10mL
LEVEL 10, 10000 µg/L:	1000µL[C] of ICAL STOCK #1, 10mL

ICV: *2000μg/L; 50mL*
1000μL[C] of Agilent PP-271-1 (Toxaphene Standard; 100μg/mL)

8.7 Internal Standard Solution: 1-Bromo-2-nitrobenzene is used as the internal standard and is added to all single-component calibration standards and sample extracts to achieve a concentration of 0.25 µg/mL. Standard solution expires 6 months after the date of preparation. Below are suggested procedures for preparation of PCB Internal Standard which is diluted to prepare Pesticides Internal Standard.

8.7.1 Preparation of Internal Standard solution:

(syringe needed: *1000μL [A]*)
(solvent: *Hexane)*
(glassware: *2x200mL, volumetric flasks*)

PCB INTERNAL STANDARD: *25μg/mL; 200mL*
1000μL[A] of Agilent PPS-351-1 (1-Bromo-2-nitrobenzene Standard; 5000μg/mL)

PESTICIDES INTERNAL STANDARD: *2.5μg/mL; 200mL*
20mL[A] of PCB INTERNAL STANDARD

8.8 Surrogate Standards: Tetrachloro-m-xylene and decachlorobiphenyl are used as surrogates. They are added to the calibration standards at the concentrations listed in Table 2, and are spiked into all samples and QC samples prior to extraction. The spiking solution is prepared in acetone at the concentrations listed in Table 2. Standard expires 6 months after the date of preparation. Below are suggested procedures for preparation of surrogate standard.

8.8.1 Preparation of surrogate standard:

(syringe needed: *1000μL [A]*)
(solvent: *Acetone)*
(glassware: *1x2000mL, volumetric flasks*)

SURROGATES: *2000μg/L; 2000mL*
20mL[A] of AccuStandard CLP-032-R (Deca. & TCMX; 0.2mg/mL)

8.9 LCS/MS Spiking Solutions: The LCS/MS spiking solutions are prepared volumetrically by diluting the appropriate stock standards in acetone. The spiking solution concentrations are listed in Table 2. Spiking solution expires 6 months after the date of preparation. Below are suggested procedures for preparation of individual pesticides, Chlordane, and Toxaphene spiking solutions.

8.9.1 Preparation of spiking solutions:

(syringes needed: *250μL [A], 1000μL [B]*)
(solvent: *Acetone)*
(glassware: *1x25mL, 1x50mL, 1x200mL, volumetric flasks*)

INDIVIDUAL PESTICIDES SPIKE: *2000μg/L; 200mL*
2000μL[B] of Restek 579104 (Custom Pesticides Mix; 200μg/mL)

CHLORDANE SPIKE: *25μg/mL; 50mL*
250μL[A] of Agilent EPA-1086-1 (Chlordane Standard; 5000μg/mL)

TOXAPHENE SPIKE: *25μg/mL; 25mL*
625μL[A] of Absolute Standards 20021 (Toxaphene; 1000μg/mL)

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes above the reporting limit. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required. Actions associated with blank failures are listed in Table 5.

9.2 Laboratory Control Sample (LCS)

A Laboratory Control Sample (LCS) is extracted with each analytical batch. The LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The LCS is spiked with the single component pesticide analytes. The concentration of the spiking solution is listed in Table 2. The recovery acceptance criteria are listed in Table 3. If any recovery criteria are not met, the extract should be reanalyzed. If the criteria are still not met, the entire batch should be re-extracted. If this is not possible, due to insufficient sample or holding time exceedance, the analyst must write up the failure on a narrative sheet for inclusion in the client report. Actions associated with LCS/LCSD failures are listed in Table 5.

9.2.1 LCS Duplicate (LCSD)

A Laboratory Control Sample Duplicate is extracted with each analytical batch. The LCSD consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The LCSD is spiked with the single component pesticide analytes. The concentration of the spiking solution is listed in Table 2. The recovery acceptance criteria is listed in Table 3. If Recovery limits are outside acceptance criteria, the non-conformance is narrated.

9.2.2 Connecticut RCP/MCP/NJ LCS Requirements

For CT- Reasonable Confidence Protocol (RCP) 8081B samples, Massachusetts Contingency Plan (MCP) samples, and samples with a state of origin of New Jersey, the LCS recovery criteria is 40 – 140%. MCP allows for up to 10% of reported spike compounds to fail in the LCS/LCSD and still report.

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.2.

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4

9.5 Matrix Spike

A matrix spike (MS)/matrix spike duplicate (MSD) is extracted and analyzed upon Client request for each batch of 20 or less samples. MS and MSDs are field samples spiked with a known quantity of the target analyte(s). They are prepared by taking additional sample aliquots of the same weight or volume and adding the appropriate amounts of surrogate and spiking solutions. The spike compounds and levels are listed in Table 2. The recovery acceptance criteria are 30-150%. If the recovery criteria are not met, but are met in the LCS, the failure may be attributed to sample matrix effects. Actions associated with MS/MSD failures are listed in Table 5.

9.6 Laboratory Duplicate (DUP)

A duplicate sample is extracted and analyzed upon Client request for each batch of 20 or less samples. Duplicates are laboratory selected replicate samples, prepared by taking an additional sample aliquot of the same weight or volume of a sample. The % RPD criteria are listed in Table 3. If the %RPD is not met, the failure may be attributed to sample matrix effects. Actions associated with duplicate failures are listed in Table 5.

For samples with a state of origin of New Jersey, a MS and MSD/DUP must be extracted for every twenty samples within a 24hr period.

9.7 Method-specific Quality Control Samples

9.7.1 Surrogates

All extracted samples and associated QC are spiked with surrogates at the levels listed in Table 2. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits listed in Table 3. If the surrogate limits are not met, the extract should be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples should be re-extracted to confirm that the failure was due to sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

9.8 Method Sequence

Initial calibration:

1. Instrument Blank (may be omitted to conserve tray space)
2. Degradation check standard
3. Std Level 1
4. Std Level 2
5. Std Level 3
6. Std Level 4
7. Std Level 5
8. Std Level 6
9. Std Level 7
10. Std Level 8
11. Std Level 9
12. Std Level 10
13. Std Level 11 (Individual Pesticides only)
14. Initial Calibration Verification Standard (ICV)
15. Repeat std Levels 1 –10 for other mixes until curve is complete.

    [**NOTE:** If multiple calibration mixtures are analyzed, it is acceptable to analyze appropriate ICVs after all calibration standards have been injected.]

Typical Daily sequence:

1. Degradation Check Standard
2. Pesticide Continuing Calibration Standard
3. Chlordane Continuing Calibration Standard
4. Toxaphene Continuing Calibration Standard
5. Extraction Blank
6. Laboratory Control Sample
7. Laboratory Control Sample Duplicate
8. Matrix Spike (Upon Client Request)
9. Duplicate/Matrix Spike Duplicate (Upon Client Request)
10. Samples (up to 20 may be analyzed)
11. Cal check
12. Repeat 1 – 10 (as needed)

10. Procedure

10.1 Equipment Set-up

10.1.1 Sample Extraction

Water samples are extracted at a neutral pH with methylene chloride using a separatory funnel (Method 3510C). See extraction SOP for details.

Solid samples are extracted with methylene chloride: acetone (1:1) using Soxhlet extraction (Method 3540C) or microwave extraction (Method 3546). See extraction SOP for details.

10.1.2 Extract Cleanup

Cleanup procedures may not be necessary for a relatively clean sample matrix, but most extracts from environmental and waste samples will require additional preparation before analysis. The specific cleanup procedure used will depend on the nature of the sample to be analyzed and the data quality objectives for the measurements. See extraction SOPs for details.

10.1.3 GC Conditions:

The dual-column / dual-detector approach involves the use of the columns listed in section 7.2. The columns are connected to an injection tee or dual injection GC, and separate electron capture detectors. Typical GC conditions for the HP 6890 instruments are listed below, but may be altered as long as method performance criteria are met.

Temperature 1:	120 °C
Time 1:	0 minute
Ramp 1:	45 °C/minute
Temperature 2	200 °C
Time 2:	0 minutes
Ramp 2:	15 ° C/minute
Temperature 3:	230 °C
Time 3:	0 minutes
Injector temperature:	250 °C
Ramp 3:	30 °C/minute
Final Temperature:	330 °C
Final Time:	2.0 minutes

Injector mode:	Pulsed Split
	4:1 split
Injector Flow:	20 mL/min split flow
Detector temperature:	350 °C
Carrier gas:	Hydrogen
Carrier flow:	28 mL/min
Carrier mode:	Constant flow
Makeup gas:	Nitrogen
Total detector flow:	60 mL/min
Injection volume:	1 µL

10.1.4 DDT and Endrin Breakdown

The breakdown of DDT and Endrin must be measured before samples are analyzed and at the beginning of each 12-hour shift. Injector maintenance must be completed if the breakdown in greater than 15% for either compound (See Section 10.5.1). Both analytical columns must pass DDT/Endrin breakdown criteria prior to sample analysis.

10.2 Initial Calibration

10.2.1 Prepare calibration standards using the procedures in Section 8.6 and the concentrations listed in Table 2. The calibration standards are aliquoted into autosampler vials and capped prior to loading onto the autosampler tray.

10.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in section 10.1.3. The same operating conditions are used for calibrations and sample analyses. Create the analytical sequence using the Turbochrom or Agilent Chemstation data acquisition software.

10.2.2.1 Record the calibration standard, unique lab identifier code (lot), the analytical sequence list.

10.2.3 A 1µL injection volume of each calibration standard is typically used. Other injection volumes may be employed, provided that the analyst can demonstrate adequate sensitivity for the compounds of interest. The same injection volume must be used for all standards and samples.

10.2.4 Because of the low concentration of pesticide standards injected on a GC/ECD, column adsorption may be a problem when the GC has not been used for a day or more or after system maintenance. The GC column may be primed (or deactivated) by injecting a pesticide standard mixture approximately 20 times more concentrated than the mid-concentration standard. Inject this standard mixture prior to beginning the initial calibration or calibration verification.

Alternately, the system may be primed by baking at the final analytical temperature for approximately 30 minutes.

Several analytes may be observed in the injection just following system priming. Always run an instrument blank after system priming.

10.2.5 Calibration Factors

Internal standard calibration techniques are employed in this method.

10.2.5.1 Internal Standard Procedure. In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Enviroquant data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

10.2.6 Initial Calibration Criteria

If the RSD for an analyte is $\leq$ 20%, then the response of the instrument for this compound is considered linear over the range and the mean calibration factor can be used to quantitate sample results.

If the RSD for any analyte is > 20%, then linearity through the origin cannot be assumed. The mean response factor cannot be used for quantitation. An alternative calculation may be done by the use of linearity as long as the correlation coefficient is $\geq$0.995. If both of these quantitation methods fail criteria for any compound in the initial calibration, then the system must be reevaluated and a new calibration curve must be analyzed.

If samples are to be analyzed per the Massachusetts Contingency Plan (MCP) Method, averaged, linear or non-linear regression may be used. When a linear calibration is used,

the required calibration coefficient needs to be > 0.99. In addition, when using linear or non-linear regression, the low standard must be processed against the curve and fall within 70-130% of the curve.

Percent Relative Error (%RE): For linear and quadratic fit compounds, the %RE must be calculated for the standard at or near the midpoint and at the lowest level of the initial calibration. The %RE between the calculated and expected concentration of an analyte must be ≤ 30%, otherwise recalibration is necessary.

10.2.7 Retention Time Windows

10.2.7.1 The retention time windows used for the identification of target analytes are calculated using the procedure recommended in Method 8000 and were found to be ± 0.015 minutes.

10.2.7.2 The windows listed above are used as guidance; however the experience of the analyst weighs heavily in the interpretation of the chromatograms. For example, it has been observed that certain oil matrices can cause the retention times to shift more dramatically. Additionally, if any positive results are questionable and at sufficiently high concentration, GC/MS analysis is used for confirmation.

10.2.8 Initial Calibration Verification

An initial calibration verification standard must be run immediately after each initial calibration, near the midpoint of the curve. This standard must be prepared using a second source that is different than the source used for the initial calibration. The %D for each analyte to be quantitated must not exceed a ± 20% difference when compared to the initial calibration curve.

10.2.8.1 CT-RCP requires that %D for each analyte to be quantitated must not exceed a ± 15% difference when compared to the initial calibration curve.

10.3 Equipment Operation and Sample Processing

10.3.1 The same GC operating conditions used for the initial calibration must be employed for sample analyses, including sample injection volume (Section 10.1.3).

10.3.2 Tentative identification of an analyte occurs when a peak from a sample extract falls within the retention time window for the compound. Each tentative identification is confirmed using a second GC column of dissimilar stationary phase. Confirmation is positive when the %RPD is ≤ 40% from the results of the two columns. In particularly difficult matrices, confirmation by GC/MS may be advisable (see Section 10.3.11).

10.3.3 The concentration reported for an identified target analyte in an extract is calculated using the Enviroquant data processing software. The Enviroquant methods have been configured to utilize the quantitation formulas found in Alpha's Quality Manual. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined. See the Manual Integration SOP for integration guidelines.

10.3.3.1 If the responses exceed the calibration range of the system, dilute the extract and reanalyze.

10.3.4 Each sample analysis must begin with an acceptable initial calibration, calibration verification standard(s) (each 12-hour analytical shift), or calibration standards

interspersed within the samples. The Internal Standard area of the samples must be within 50%-200% of the starting CCV. When a calibration verification standard fails to meet the QC criteria, all samples that were injected after the last standard that last met the QC criteria must be re-injected.

10.3.4.1 CT-RCP requires a closing calibration verification standard with a %D that is ± 15% for each of the target analytes.

10.3.5 Sample injections may continue for as long as the calibration verification standards and standards interspersed with the samples meet instrument QC requirements. The sequence ends when the set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded.

10.3.6 Use the calibration standards analyzed during the sequence to evaluate retention time stability. The retention time windows are established using the absolute retention time of each analyte in the mid-concentration standard during the initial calibration as the mid-point of the window. The widths of the windows are defined in Section 10.2.7.

10.3.7 Each subsequent injection of a standard during the 12-hour analytical shift (i.e., those standards injected every 20 samples, or more frequently) must be checked against the retention time windows. If any of these subsequent standards fall outside their absolute retention time windows, the GC system is out of control. Determine the cause of the problem and correct it. If the problem cannot be corrected, a new initial calibration must be performed.

10.3.8 Identification of mixtures (i.e. Chlordane and Toxaphene) is based on the characteristic 'fingerprint' retention time and shape of the indicator peak(s); and quantitation is based on the area under the characteristic peaks as compared to the area under the corresponding calibration peaks(s) of the same retention time and shape generated using internal calibration procedures.

10.3.9 If compound identification or quantitation is precluded due to interference (e.g., broad, rounded peaks or ill-defined baselines are present) cleanup of the extract may be needed. If instrument problems are suspected, rerun the extract on another instrument to determine if the problem results from analytical hardware or the sample matrix. Refer to the extraction SOPs for the procedures to be followed in sample cleanup.

10.3.10 For secondary column analysis, a second dissimilar column is utilized to confirm positive pesticide results. The laboratory must report the higher of the two results unless obvious interference is present on one of the columns. All required QA/QC parameters (e.g. calibrations, LCSs, etc.) must be met on the second column as well.

10.3.10.1 The **Relative Percent Difference (RPD)** should be 40 or lower. If the RPD exceeds 40, this will be denoted with a P flag. If the RPD exceedance is due to interference, the lower of the dual column values can be reported with I and P flags.

10.3.11 GC/MS Confirmation

GC/MS confirmation may be used in conjunction with either single-column or dual-column analysis if the concentration is sufficient for detection by GC/MS.

10.3.11.1 Full-scan GC/MS will normally require a concentration of approximately 10ng/µL in the final extract for each single-component compound.

10.3.11.2 The GC/MS must be calibrated for the specific target pesticides when it is used for quantitative analysis.

10.3.11.3 GC/MS may not be used for confirmation when concentrations are below the sensitivity of the instrument.

10.3.11.4 GC/MS confirmation should be accomplished by analyzing the same extract that is used for GC/ECD analysis.

10.3.11.5 The base/neutral/acid extract and the associated blank may be used for GC/MS confirmation if the surrogates and internal standards do not interfere and if it is demonstrated that the analyte is stable during acid/base partitioning. However, if the compounds are not detected in the base/neutral/acid extract, then GC/MS analysis of the pesticide extract should be performed.

10.3.11.6 A QC reference sample containing the compound should also be analyzed by GC/MS. The concentration of the QC reference sample must demonstrate that those pesticides identified by GC/ECD can be confirmed by GC/MS.

10.4 Continuing Calibration Verification

10.4.1 Verify calibration each 12-hour shift by injecting calibration verification standards (CCV) prior to conducting any sample analyses. A calibration standard must be injected at intervals of not less than once every twenty samples and at the end of the analysis sequence for CT-RCP samples.

10.4.1.1 The calibration factor (for external standard compounds) and response factor (for internal standard compounds) for each analyte to be quantitated must not exceed a ± 20% difference when compared to the initial calibration curve. The Enviroquant data processing software automatically calculates the %D for all analytes according to the formulae in Alpha's Quality Manual. The Internal Standard area of the CCV must be within 50%-150% of the Initial Calibration Internal Standard area.

CT-RCP samples require that the response factor (for internal standard compounds) for each analyte to be quantitated must not exceed a ± 15% difference when compared to the initial calibration curve.

10.4.1.2 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

10.4.1.3 If routine maintenance does not return the instrument performance to meet the QC requirements (Section 10) based on the last initial calibration, then a new initial calibration must be performed. Due to the large number of analytes present, allowances may be made for a CF or RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples. Any QC failures must be written up by the analyst on narrative sheets for inclusion with the sample data.

10.4.2 Compare the retention time of each analyte in the calibration standard with the absolute retention time windows described in section 10.2.7. The center of the absolute retention time window for each analyte is its retention time in the mid-concentration standard analyzed during the initial calibration. Each analyte in each standard must fall within its respective retention time window. If not, the gas chromatographic system must either be adjusted so that a second analysis of the standard does result in all analytes falling within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

10.5 Internal Standard

The use of internal standard calibration does not require that all sample results be bracketed with CCV standard. However, when internal standard calibration is used, the retention times of internal standards and the area response of internal standards should be checked for each analysis.

10.5.1 **IS in CCAL** – The measured area of the internal standard must be no more than ± 50% different from the average area calculated during initial calibration (-50 to 150%).

10.5.2 **IS in samples** - The measured area of the internal standard must be no more than -50% to +100% different from the area calculated from opening CCV (-50 to 200%)

Retention time shifts of more than 30 seconds from the retention time of the most recent calibration standard are cause for concern and must be investigated.

10.6 Preventive Maintenance

Routine preventive maintenance should be performed to maintain GC system performance. This includes periodic replacement of injector septa, replacement of injector liner(s), and replacement of injector seals.

10.6.1 Other Maintenance

Additional maintenance may be required if system performance degrades.

10.6.1.1 GC injector ports are of critical concern, especially in the analysis of DDT and Endrin.

10.6.1.1.1 Injectors that are contaminated or chemically active can cause the degradation (“breakdown”) of the analytes. Endrin and DDT breakdown to Endrin aldehyde, Endrin ketone, DDD, or DDE.

Check for degradation problems by injecting a standard containing only 4,4’-DDT and Endrin. Presence of 4,4’-DDE, 4,4’-DDD, Endrin ketone or Endrin indicates breakdown. If degradation of either DDT or Endrin exceeds 15%, take corrective action before proceeding with calibration.

When such breakdown is observed, replacement of the injector liner and seal may solve the problem. If not, clip approximately 3 – 6 inches from the injector end of the GC column. If the degradation does not improve, it may be necessary to replace the column(s).

Calculate percent breakdown as follows:

$$\%\ breakdown\ of\ DDT = \frac{sum\ of\ degradation\ peak\ areas\ (DDE + DDD)}{sum\ of\ all\ peak\ areas\ (DDT + DDE + DDD)} * 100$$

$$\%\ breakdown\ of\ Endrin = \frac{sum\ of\ degradation\ peak\ areas\ (Aldehyde + Ketone)}{sum\ of\ all\ peak\ areas\ (Endrin + Aldehyde + Ketone)} * 100$$

10.6.1.1.2 ECD detectors may also become contaminated, requiring bake out at elevated temperatures, or repair by the manufacturer.

11. Data Evaluation, Calculations and Reporting

11.1 Quantitation of Single Component Pesticides

The single component pesticide compounds are calculated as described in Section 10.3.3, and reported in µg/L or µg/Kg units. After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews should be done by two separate individuals.

11.1.1 Quantitation of Multiple-Component Analytes

Quantitation is based on use of 3-5 of the major peaks present for chlordane and 4-6 of the major peaks present for Toxaphene. Each of these peaks is individually calibrated with a 10 point calibration based on average response factors. The %RSD must meet the criteria of ≤20%. The 3 to 5 or 4 – 6 major peaks are calculated as described in Section 10.3.3. After individual calculation meets criteria, the average of the major 3-5 or 4 – 6 peaks is used to determine the final concentration.

11.1.1.1 Toxaphene

Toxaphene is quantitated by the internal standard method, using the 4 – 6 largest peaks found in the standard and averaging the resulting concentrations.

11.1.1.2 Chlordane

Chlordane is a mixture of at least 11 major components and 30 or more minor components. Trans- and cis-Chlordane (alpha and gamma, respectively), are the two major components of Chlordane. However, the exact percentage of each in the chlordane material is not completely defined, and is not consistent from batch to batch.

11.1.1.2.1 The GC pattern of a Chlordane residue may differ considerably from that of the chlordane standard. Depending on the sample substrate and its history, residues of Chlordane can consist of almost any combination of constituents from the Chlordane, plant and/or animal metabolites, and products of degradation caused by exposure to environmental factors such as water and sunlight.

11.1.1.2.2 Whenever possible, when Chlordane residue does not resemble Chlordane, the analyst should quantitate the peaks of alpha-Chlordane, gamma-Chlordane, Heptachlor, and trans-Nonachlor separately against the appropriate reference materials, and report the individual residues.

11.1.1.2.3 When the GC pattern of the residue resembles that of Chlordane, the analyst may quantitate Chlordane residues by comparing the total area of the Chlordane chromatogram using the 3-5 major peaks

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Holding time exceedance and/or improper preservation are noted on the nonconformance report form.

All non-conformances, sample preparatory extraction methods and clean-up methods must be addressed in a case narrative and included in the data report.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in Section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Qualtrax ID 1732. These studies performed by the laboratory are maintained on file for review

13.2 Demonstration of Capability Studies

Refer to Qualtrax ID 1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

Qualtrax ID 1732 MDL/LOQ Generation

Qualtrax ID1739 IDC/DOC Generation

Qualtrax ID 1728 Waste Management and Disposal SOP

16. Attachments

Table 1: REPORTING LIMITS

Table 2: STANDARD SOLUTIONS

Table 3: QC ACCEPTANCE CRITERIA

Table 4: MCP/CT/NJ SPECIFIC ACCEPTANCE CRITERIA

Table 5: QC FAILURE ACTION PLAN

TABLE 1

REPORTING LIMITS*

	RL (Aqueous)	RL (Soil)
Pesticides		
Alpha-BHC	0.02 µg/L	3.33 µg/Kg
Gamma-BHC (Lindane)	0.02 µg/L	2.67 µg/Kg
Heptachlor	0.02 µg/L	4 µg/Kg
Endosulfan I	0.02 µg/L	10 µg/Kg
Dieldrin	0.04 µg/L	5 µg/Kg
Endrin	0.04 µg/L	3.33 µg/Kg
4, 4'-DDD	0.04 µg/L	10 µg/Kg
4, 4'-DDT	0.04 µg/L	15 µg/Kg
Methoxychlor	0.2 µg/L	15 µg/Kg
Aldrin	0.02 µg/L	10 µg/Kg
Beta-BHC	0.02 µg/L	10 µg/Kg
Delta-BHC	0.02 µg/L	10 µg/Kg
Heptachlor Epoxide	0.02 µg/L	15 µg/Kg
trans-Chlordane	0.02 µg/L	10 µg/Kg
cis-Chlordane	0.02 µg/L	10 µg/Kg
4, 4'- DDE	0.04 µg/L	15 µg/Kg
Endosulfan II	0.04 µg/L	15 µg/Kg
Endrin Aldehyde	0.04 µg/L	10 µg/Kg
Endosulfan Sulfate	0.04 µg/L	3.33 µg/Kg
Endrin Ketone	0.04 µg/L	10 µg/Kg
Chlordane	0.2 µg/L	65 µg/Kg
Toxaphene	0.2 µg/L	150 µg/Kg
Alachlor +	0.1 µg/L	10 µg/Kg
Hexachlorobenzene ++	0.02ug/L	8 µg/Kg

*** RL:** Typical laboratory reporting limit. Actual RLs may be higher depending on sample matrix. RLs are not adjusted for % Moisture.

+ CT-RCP only compound.
++ MCP only compound.

TABLE 2

STANDARD SOLUTIONS

	Stock 1 solution (µg/mL)	Stock 2 solution (µg/mL)	Level 11 (µg/L)	Level 10 (µg/L)	Level 9 (µg/L)	Level 8 (µg/L)	Level 7 (µg/L)	Level 6 (µg/L)	Level 5 (µg/L)	Level 4 (µg/L)	Level 3 (µg/L)	Level 2 (µg/L)	Level 1 (µg/L)	Std. Spike Solution (µg/mL)	Std. LCS Solution (µg/mL)
Hexachlorobenzene	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Alpha-BHC	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Lindane	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Heptachlor	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Endosulfan I	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Dieldrin	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Endrin	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
4, 4'-DDD	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
4, 4'-DDT	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Methoxychlor	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Tetrachloro-m-Xylene *	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Decachloro-Biphenyl *	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Aldrin	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Beta-BHC	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Delta-BHC	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Heptachlor Epoxide	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Trans-Chlordane	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Cis-Chlordane	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
4, 4'- DDE	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Endosulfan II	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Endrin Aldehyde	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Endosulfan Sulfate	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Endrin Ketone	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Alachlor	2	0.1	400	200	100	50	10	5	4	3	2	1	0.5	2.0	2.0
Chlordane	50000	1000	10000	5000	2500	1000	500	250	100	20	10	5	2	25	25
Toxaphene	100000	2000	20000	10000	5000	2000	1000	500	200	100	20	10	5	25	25
Internal Standard															
1-Bromo-2-Nitrobenzene	5000	5000	25	25	25	25	25	25	25	25	25	25	25		

* - surrogates

TABLE 3

QC ACCEPTANCE CRITERIA**

	Aqueous		Soil	
Surrogate % Recovery*	**Lower Control Limit**	**Upper Control Limit**	**Lower Control Limit**	**Upper Control Limit**
2,4,5,6-Tetrachloro-m-xylene	30%	150%	30%	150%
Decachlorobiphenyl	30%	150%	30%	150%

*One surrogate on one column is allowed to be outside of the control limits and still be within criteria.

Compound	LCS % Recovery (Aqueous)		LCS % Recovery (Soil)		Duplicate and/or MSD %RPD	
	Lower Control Limit	**Upper Control Limit**	**Target Analyte Limits**	**Marginal Exceedance Limits**	**Aqueous RPD**	**Soil RPD**
Target Analytes LCS/LCSD	30%	150%	30%	150%	≤ 30%	≤ 50%
Target Analytes MS/MSD	30%	150%	30%	150%	≤ 30%	≤ 50%

TABLE 4

MCP/CT/NJ SPECIFIC QC ACCEPTANCE CRITERIA

Compound	LCS % Recovery (Aqueous)		LCS % Recovery (Soil)		Duplicate and/or MSD %RPD	
	Lower Control Limit	**Upper Control Limit**	**Target Analyte Limits**	**Marginal Exceedance Limits**	**Aqueous RPD**	**Soil RPD**
Target Analytes LCS/LCSD	40%	140%	40%	140%	≤ 20%	≤ 30%
Target Analytes MS/MSD	40%	140%	40%	140%	≤ 20%	≤ 30%

TABLE 5

QC FAILURE ACTION PLAN

Blank Failures	Failure Situation	Action(s)
Surrogate Failure	1 of 4 high or low	Report as is
	2 or more high	Report as is
	2 or more low, samples are non-detect with passing surrogates	Report as is
	2 or more low, samples have hits and/or failing surrogates	Revial/rerun Re-extract if still failing
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Contamination	Below RL; sample(s) non-detect, below RL, or concentration 10 times or more above the blank	Report as is
	Below RL, sample(s) concentration above RL	See team leader/manager
	Above RL, sample(s) concentration 10 times or more above the blank	Report as is
	Above RL with non-detect sample(s)	Report as is
	Above RL, sample(s) concentration less than 10 times above the blank and volume available	Revial/rerun Re-extract if contamination still present
	Above RL, sample(s) concentration less than 10 times above the blank and no volume available	Revial/rerun B-flag affected data

LCS/LCSD Failures	Failure Situation	Action(s)
Surrogate Failure	1 or more high or low	Report as is
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Spike Failure	Spike compounds out high and sample(s) are non-detect with passing surrogates	Report as is
	Spike compounds out high and sample(s) have hits	Revial/rerun Re-extract if still high
	Spike compounds out low	Revial/rerun Re-extract if still low
	RPD failure	Report as is

MS/MSD/DUP Failures	Failure Situation	Action(s)
Surrogate Failure	(MS/MSD) 1 or more high or low	Report as is
	(MS/MSD) 2 or more high or low	Report as is
	(DUP) 1 or more high, parent sample non-detect	Report as is
	(DUP) 1 or more low, parent sample matches	Report as is
	(DUP) 1 or more low, parent sample doesn't match	Revial/rerun Re-extract if still failing
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Spike Failure (MS/MSD only)	Compounds out high or low due to sample matrix or hits	Report as is
	Compounds out high or low due to extraction error	Revial/rerun Re-extract if still failing
	RDP failure	Report as is

PCBs

By Capillary Column Gas Chromatography

Reference Methods: Method 8082A SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update IV, 2007.

Quality Control Requirements and Performance Standards for Analysis of Polychlorinated Biphenyls (PCBs) by Gas Chromatography (GC) in Support of Response Action under the Massachusetts Contingency Plan (MCP), Revision No.1, July 1, 2010.

State of Connecticut, Department of Environmental Protection, RRCP, Version 2.0, July 2006.

1. Scope and Application

Method 8082A is used to determine the concentrations of Polychlorinated Biphenyls (PCBs) as Aroclors in extracts from solid, oil and liquid matrices. This SOP details the analysis for PCBs using fused-silica, open-tubular, capillary columns with electron capture detectors (ECD).

Matrices: Extracts from solid, oil and liquid matrices.

Definitions: See Alpha Laboratories Quality Manual Appendix A

Regulatory Parameter List: The standard compounds listed below are determined by this method.

Parameter	CAS#
Aroclor 1016	12674-11-2
Aroclor 1221	11104-28-2
Aroclor 1232	11141-16-5
Aroclor 1242	53469-21-9
Aroclor 1248	12672-29-6
Aroclor 1254	11097-69-1
Aroclor 1260	11096-82-5
* Aroclor 1262	37324-23-5
*Aroclor 1268	11100-14-4

*Note – not certified by NJ for the oil matrix

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Director, or Quality Assurance Officer.
This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph (GC) and in the interpretation of gas chromatograms. Each analyst must

demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (see section 13.2).

2. Summary of Method

A measured volume or weight of sample (volumes and weights can vary but approximately 1L or 140-272 mls (LVI – Low Volume Initiative) for liquids, 1g for oil and up to 15g for solids) is extracted using the appropriate matrix-specific sample extraction technique.

Liquid samples are extracted at neutral pH with methylene chloride using Method 3510C (separatory funnel), or other appropriate technique. See extraction SOP for details.

Solid samples are extracted with methylene chloride: acetone (1:1) using Method 3540C (Soxhlet), or other appropriate technique. Solid samples may also be extracted with hexane:acetone (1:1) using Method 3546 (microwave). See extraction SOP for details.

Wipe samples are extracted with methylene chloride: acetone (1:1) using Method 3540C (Soxhlet) or other appropriate technique. See extraction SOP for details.

Oil samples are diluted with hexane following the procedure outlined in the extraction SOP.

Sulfuric acid cleanup (Method 3665A), Copper cleanup (Method 3660B) and Silica Gel cleanup (Method 3630) are utilized for PCB extracts. See extraction SOP for details.

After cleanup, the extract is analyzed by injecting 1µL into a gas chromatograph equipped with narrow- or wide-bore fused silica capillary columns and electron capture (GC/ECD) detectors.

2.1 Method Modifications from Reference

Not applicable.

3. Reporting Limits

The reporting limits for this method as outlined is as follows:

- **Aqueous samples**: 0.25 ug/L / Aroclor (based on a 1L extraction or 140 ml LVI extraction)

- **Soil Samples**:
  - 33.3 ug/kg / Aroclor based on 15g extraction
  - 50.0 ug/kg / Aroclor based on 10g extraction
  - 100.0 ug/kg / Aroclor based on 5g extraction
  - 250.0 ug/kg / Aroclor based on 2g extraction

- **Oil Samples**: 5 mg/kg based on 1g extraction

- **Solid of Difficult Matrices** (i.e Caulking, Concrete, etc. are logged using the Alpha Low Level 8082 products): based on a 15g extraction
  - Aroclors 1016, 1221, 1232, 1242, 1254: 20 ug/kg
  - Aroclors 1248, 1260: 13.3 ug/kg
  - Aroclors 1262, 1268: 6.67 ug/kg

4. Interferences

4.1 Instrumental

4.1.1 Only high purity gases are used in the GC system to eliminate this source of possible contamination. Both the Hydrogen (carrier gas) and Nitrogen (detector make-up gas) are certified by the gas supplier.

4.1.2 Preventive instrument maintenance is performed routinely, and whenever highly contaminated extracts are analyzed that could result in chromatographic interferences or result in degradation of system performance. Section 10.6 describes the maintenance steps.

4.1.3 Glassware must be scrupulously cleaned. This procedure is detailed in the Organic Extraction Cleaning and Handling SOP/1953. Store dry glassware in a clean environment.

4.2 Parameters

4.2.1 All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free. All of these materials are routinely determined to be free of interferences by analysis of extraction blanks with every extraction batch performed.

4.2.2 Certain compounds (i.e. phthalates) can be extracted from the sample matrix and be detected by the ECD that could possibly result in false positive results or complicate the data interpretation. The use of the cleanup procedures detailed in the extraction SOP minimizes these possible interferences. Analyst experience is also crucial in making compound determinations.

4.2.3 Interferences co-extracted from the samples will vary considerably from waste to waste. While a general cleanup technique is referenced or provided as part of the method, unique samples may require additional cleanup approaches to achieve desired degrees of discrimination and quantitation.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound must be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. PCBs have been tentatively classified as known or suspected human or mammalian carcinogens. Additional references to laboratory safety are available in the Chemical Hygiene Plan.
All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers must be handled in the vented bench area in the GC laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab, for future disposal by the Hazardous Waste Manager. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing flammable solvents must be stored in the flammable's cabinet.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L or two 140 ml (LVI) amber glass jars with Teflon-lined lids. Solid samples are collected in one 250 mL wide-mouth glass jar with a Teflon-lined lid. Oil samples are collected in a glass jar with Teflon-lined lids. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of 4 ± 2° C. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of 4 ± 2° C. Preservation is not required for oil samples.

6.3 Sample Handling

TCLP/SPLP tumbled extracts, NJ DKQP and RCP CT aqueous samples must be extracted within 7 days of sample collection, solid and oil samples within 14 days of collection (NJ DKQP allows 365 days for solids if frozen). All other samples, both aqueous and solid, have a 365-day hold time. Once extracted, the samples must be analyzed within 40 days of the extraction date.

7. Equipment and Supplies

7.1 Gas Chromatograph, Agilent 6890, 7890: An analytical system completed with gas chromatograph configured for split-splitless injection and all required accessories including syringes, analytical columns, gases, electron capture detectors (ECD), and data system.

7.2 GC Columns: Alpha utilizes dual-column analyses. The dual-column approach involves a single injection that is split between two columns that are mounted in a single gas chromatograph. Typical column pair used is listed below. Other columns may be used as long as method performance criteria can be met.

Column pair:

RTX-CLP: Cat. #11141 from Restek or equivalent; 30m, 0.32mm, 0.32µm

RTX-CLPII Cat. #11324 from Restek or equivalent; 30m, 0.32mm, 0.25µm

7.3 Guard Column: Cat. #10027 from Restek or equivalent; 5m, 0.32mm

7.4 Class "A" Volumetric Flasks: 10mL and 25mL (and other volumes), for standards preparation

7.5 Microsyringes: 10 µL – 1000 µL

7.6 Gooseneck splitless injecton liner, Cat #20799-214.5 from Restek or equivalent

7.7 Universal "Y" Press-tight tee split: Cat. #20406 from Restek or equivalent / **Siltek MXT Connector:** Cat. #21388 from Restek or equivalent

8. Reagents and Standards

Reagent grade or pesticide grade chemicals are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.
NOTE: Store the standard solutions (stock, composite, calibration, internal, and surrogate) at 4 ± 2° C in Teflon(R)-sealed containers in the dark. When a Lot of standards is prepared, aliquots of that Lot are stored in individual small vials. All stock standard solutions must be replaced after one year or sooner if routine QC tests indicate a problem. All other standard solutions must be replaced after six months or sooner if routine QC indicates a problem.

8.1 n-Hexane: Pesticide quality or equivalent.

8.2 Acetone: Pesticide quality or equivalent.

8.3 Organic-free Reagent Water: All references to water in this method refer to organic-free reagent water from Alpha's RO water treatment system.

8.4 Stock Standard Solutions: All stock standard solutions are purchased from commercial vendors as ampullated certified solutions. When an ampullated stock solution is opened, it is transferred to a labeled amber screw-cap vial. The expiration date of the stock solution is either the vendor specified expiration date, or 1 year from the date the ampule was opened, whichever is sooner.

8.5 Calibration Standards: Calibration standards are prepared volumetrically by diluting the appropriate stock standard(s) with hexane. Calibration standards expire 6 months from the date of preparation, or on the earliest expiration date of any of the stock solutions used to prepare the calibration standard. Calibrations are performed at the 6 concentration levels listed in Table 1. The list of ampullated calibration standards are obtain from **Agilent**:

- Aroclor 1016, Cat. #PP-282, at 100ug/mL
- Aroclor 1260, Cat. #PP-361, at 100ug/mL
- Aroclor 1262, Cat. #PP-371, at 100ug/mL
- Aroclor 1268, Cat. #PP-382, at 100ug/mL
- Aroclor 1221, Cat. #PP-292, at 100ug/mL
- Aroclor 1232, Cat. #PP-302, at 100ug/mL
- Aroclor 1242, Cat. #PP-312, at 100ug/mL

- Aroclor 1248, Cat. #PP-342, at 100ug/mL
- Aroclor 1254, Cat. #PP-351, at 100ug/mL

8.5.1 Preparation of Initial Calibration Standards:

- **1660 L6**: (mix of Aroclors 1016 and 1260) is prepared by diluting
  - 2.5uL 1016 Standard (Agilent, Cat. #PP-282)
  - 2.5uL 1260 Standard (Agilent, Cat. #PP-361)
  - 1.6mL of PCB ICAL Surrogate Stock

  to 25ml of Hexane to achieve concentration of
  - 1016 and 1260 at 10ug/mL
  - TCMX at 0.64ug/mL and DCB at 1.28ug/mL.
- **For LVI**, this solution is diluted 10X more, achieving a concentration of
  - 1016 and 1260 at 1ug/mL
  - TCMX at 0.064ug/mL and DCB at 0.128ug/mL
- **2154 L6:** (mix of Aroclors 1221 and 1254) is prepared by diluting
  - 2.5uL 1221 Standard (Agilent, Cat. #PP-292)
  - 2.5uL 1254 Standard (Agilent, Cat. #PP-351)

  to 25ml of Hexane to achieve concentration of
  - 1221 and 1254 at 10ug/mL
- **For LVI**, this solution is diluted 10X more, achieving a concentration of
  - 1221 and 1254 at 1ug/mL
- **4268 L6** (mix of Aroclors 1242 and 1268), **3262 L6** (mix of Aroclors 1232 and 1262) and **1248 L6;** all are prepared from their respective Stock Standards according to the formula used for L6 of 2154.
- Levels 1-5 are prepared by serial dilutions of L6s and formula with volumes needed can be found in Table 2.

8.6 Second Source Standards: (ICV) Initial Calibration Verification standards are prepared volumetrically by diluting the appropriate stock standard(s) with hexane. Initial Calibration Verification standards expire 6 months from the date of preparation, or on the earliest expiration date of any of the stock solutions used to prepare the standard. The list of ampullated standards are obtain from **Accustandard**:

- Aroclor 1016, Cat. #C-216S-H-10X, at 1000ug/ml
- Aroclor 1260, Cat. #C-260S-H-10X, at 1000ug/ml
- Aroclor 1262, Cat. #C-262S-H-10X, at 1000ug/ml
- Aroclor 1268, Cat. #C-268S-H-10X, at 1000ug/ml
- Aroclor 1221, Cat. #C-221S-H-10X, at 1000ug/ml
- Aroclor 1232, Cat. #C-232S-H-10X, at 1000ug/ml
- Aroclor 1242, Cat. #C-242S-H-10X, at 1000ug/ml
- Aroclor 1248, Cat. #C-248S-H-10X, at 1000ug/ml
- Aroclor 1254, Cat. #C-254S-H-10X, at 1000ug/ml

8.6.1 Preparation of ICV Standards:

- **1660 ICV:** is prepared by diluting
  - 50uL 1016 Standard (AccuStandard, Cat. #C-216S-H-10X)
  - 50uL 1260 Standard (AccuStandard, Cat. #C-260S-H-10X)
  - 320uL of PCB CCAL Surrogate Stock

  to 20ml of Hexane to achieve concentration of
  - 1016 and 1260 at 2.5ug/mL
  - TCMX at 0.16ug/mL and DCB at 0.32ug/mL
- **For LVI**, this solution is diluted 10X more, achieving a concentration of
  - 1016 and 1260 at 0.25ug/mL
  - TCMX at 0.016ug/mL and DCB at 0.032ug/mL
- **2154, 4268, 3262 and 1248 ICVs** are prepared from their respective Stock Standards according to the formula used for 1660 ICV.

8.7 Internal Standard Solution: 1-Bromo-2-nitrobenzene (Ultra, Cat. #PPS-351) is used as the internal standard and is added to all single-component calibration standards and sample extracts to achieve a concentration of 0.25µg/mL. For LVI, this solution is diluted 10X more, achieving a concentration of 0.025µg/mL.

8.8 Surrogate Standards: Tetrachloro-m-xylene (TCMX) and Decachlorobiphenyl (DCB) are used as surrogates for Aroclor analysis. They are added to the calibration standards at the concentrations listed in Table 1, Continuing Calibration Standards and are spiked into all samples and QC samples prior to extraction.

- **ICAL Surrogates Stock:** is prepared by diluting of 500uL of Pesticides Surrogates Standard Spiking Solution (Ultra, Cat. #ISM-320-1) and 500uL of Decachlorobiphenyl (Accustandard, Cat. #CLP-032-R-01) to 20mL of Hexane to achieve concentration of TCMX at 5ug/mL and DCB at 10ug/mL. For LVI, this solution is diluted 10X more, achieving a concentration of 0.5ug/mL for TCMX and 0.1ug/mL for DCB.
- **CCAL Surrogates Stock:** is prepared by diluting of 1mL of TCMX&DCB (Accustandard, Cat. #CLP-032-R) and 1mL of Decachlorobiphenyl (Accustandard, Cat. #CLP-032-R-01) to 20mL of Hexane to achieve concentration of TCMX at 10ug/mL and DCB at 20ug/mL. For LVI, this solution is diluted 10X more, achieving a concentration of 1 ug/ml for TCMX and 2 ug/mL for DCB.
- **Extraction Surrogates Stock:** is prepared by diluting of 10mL of TCMX&DCB (Accustandard, Cat. #CLP-032-R) to 1000mL of Acetone to achieve concentration of TCMX and DCB at 2ug/mL. For LVI, this solution is diluted 10X more, achieving a concentration of 0.2 ug/mL for both TCMX and DCB.
- **PCB Caulking Surrogates Stock:** is prepared by diluting of 10mL of TCMX&DCB (Accustandard, Cat. #CLP-032-R) to 100mL of Acetone to achieve concentration of TCMX and DCB at 20ug/mL.
- **PCB Oil Surrogate Stock:** is prepared by diluting of 5mL of TCMX&DCB (Accustandard, Cat. #CLP-032-R) to 500mL of Hexane to achieve concentration of TCMX and DCB at 2.0ug/mL.

8.9 LCS/MS Spiking Solutions:

- **PCB Matrix Spike:** The LCS/MS spiking solution is prepared by diluting of 6.25mL of Arochlor 1016/1260 (Restek, Cat. #32039) to 500mL of Acetone to achieve

concentration of Arochlor 1016/1260 at 12.5ug/ml. For LVI, 1.25mL of the stock solution is diluted to 500mL of Acetone to achieve a concentration of Aroclor 1016/1260 at 2.5 ug/mL.

- **PCB Caulking Matrix Spike:** The LCS/MS spiking solution is prepared by diluting of 6.25mL of Arochlor 1016/1260 (Restek, Cat. #32039) to 50mL of Acetone to achieve concentration of Arochlor 1016/1260 at 125ug/mL.

- **PCB Oil Matrix Spike:** The LCS/MS spiking solution is prepared by diluting of 2.5mL of Arochlor 1016/1260 (Restek, Cat. #32039) to 200mL of Hexane to achieve concentration of Arochlor 1016/1260 at 12.5ug/mL.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

A Method Blank is an aliquot of a clean reference matrix (reagent water for water samples, Ottawa sand for soil/sediment samples, or PCB free transformer oil for oil samples) that is carried through the entire analytical procedure. Extraction blanks are performed with each extraction batch of 20 or less samples, according to the extraction SOPs. The extraction blank must not contain any of the reportable analytes above the reporting limit. If any reportable analytes are detected in the blank, the entire extraction batch is suspect and re-extraction of all associated samples is required, unless the associated samples are non-detect or concentration of the analyte in the samples is 10 times greater than the concentration of this analyte in the blank. The surrogate recoveries must also be within the acceptance criteria listed in Table 3. If surrogate acceptance criteria are exceeded, the extraction batch must be evaluated to determine if re-extraction or re-analysis is necessary. Actions associated with Method Blank failures are listed in Table 5.

9.2 Laboratory Control Sample (LCS)

A Laboratory Control Sample (LCS)/ Laboratory Control Sample Duplicate (LCSD) pair is extracted with each analytical batch. The LCS/LCSD consist of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. For Aroclor analysis, the LCS/LCSD are spiked with a mixture of Aroclor 1016 and 1260 (1660) at the levels listed in Table 4. The recovery acceptance criteria are listed in Table 3. If any recovery criteria are not met, the extract may be re-analyzed. If the criteria are still not met, the **entire batch is re-extracted**, unless the recoveries are high, and the associated samples are non-detect. If this is not possible, due to insufficient sample or holding time exceedances, the analyst must narrate the failure in the LIMS for inclusion in the client report. Actions associated with LCS/LCSD failures are listed in Table 5.

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.2.7.

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4.

9.5 Matrix Spike/ Matrix Spike Duplicate (MS/MSD)

Matrix Spike and Matrix Spike Duplicate are field samples spiked with known target analyte(s) at the levels listed in Table 4. Upon client request, a MS/MSD pair is extracted and analyzed with each batch of 20 or less samples. MS samples serve as a measure of extraction accuracy, by allowing the comparison of the found amount(s) of target analyte(s) with the spiked amount(s). An MS/MSD set also allows for the calculation of the extraction precision, by comparing the results of the two samples. The recovery acceptance criteria are listed in Table 3. If the recovery criteria are not met, but are met in the LCS, the failure may be attributed to sample matrix effects. Actions associated with MS/MSD failures are listed in Table 5.

For samples with a state of origin of New Jersey, a MS must be extracted for every twenty samples within a 24hr period.

9.6 Laboratory Duplicate (DUP)

Duplicates are laboratory selected replicate samples, prepared by taking an additional sample aliquot of a sample. Upon client request, a DUP is extracted and analyzed with batch of 20 or less samples. Duplicates serve as a measure of the extraction precision, by comparing the results of the sample and duplicate. The relative percent difference (RPD) acceptance criteria are listed in Table 3. If the RPD criteria are not met, the failure may be attributed to matrix effect. Actions associated with DUP failures are listed in Table 5.

For samples with a state of origin of New Jersey, a DUP must be extracted for every twenty samples within a 24hr period.

9.7 Surrogates

All extracted samples and associated QC are spiked with surrogates at the levels listed in Table 4. The laboratory must evaluate surrogate recovery data from individual samples and QC samples versus the surrogate control limits listed in Table 3. If the surrogate limits are not met, the extract may be reanalyzed to determine if the failure was due to an instrument problem. If the criteria are still not met, the affected samples must be re-extracted to confirm that the failure was due to sample matrix, unless the surrogate recovery is high, and the associated sample is non-detect. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

9.8 Method Sequence

Typical Initial calibration (each level to identified with the standard lot number)

1. Prime
2. Blank
3. Standard Level 1
4. Standard Level 2

5. Standard Level 3
6. Standard Level 4
7. Standard Level 5
8. Standard Level 6
9. Initial Calibration Verification Standard (ICV)

Repeat steps 3 – 9 as needed for each Aroclor necessary for calibration.

NOTE: If multiple calibration mixtures are analyzed, it is acceptable to analyze appropriate ICVs after all calibration standards have been injected.

Typical Daily Sequence

1. 1660 Continuing Calibration Standard **(identified with the standard lot number)**
2. Extraction Blank
3. Laboratory Control Sample
4. Matrix Spike / Matrix Spike Duplicate (if requested by Client)
5. Duplicate (if included with batch QC)
6. Samples up to 16
7. Repeat 1 – 6 as needed.

10. Procedure

10.1 Equipment Set-up

10.1.1 GC Conditions:

The dual-column / dual-detector approach involves the use of the columns listed in section 7.2. The columns are connected to an injection tee or dual injection GC, and separate electron capture detectors. Alpha typical GC conditions are listed below but may be altered as long as method performance criteria are met.

	OVEN TEMP PROGRAM
Temperature 1	150 ^{0}C
Time 1	0 min
Ramp 1	45^{0}C/minute
Temperature 2	230^{0}C
Time 2	0 min
Ramp 2	30^{0}C/minute
Temperature 3	330^{0}C
Time 3	1 min

	INSTRUMENT CONDITIONS
Injector temperature	250^{0}C
Injector mode	Split
Split Flow	60.1 mL/min
Total Flow	78.2 mL/min
Detector temperature	350^{0}C
Carrier gas	Hydrogen
Carrier flow	20mL/min
Carrier mode	Constant flow
Makeup gas	Nitrogen
Total detector flow	60mL/min
Injection Volume	1µL

10.2 Initial Calibration

10.2.1 Prepare calibration standards using the standards listed in Section 8.5 to achieve the concentrations from Table 1. Alternatively, a standard containing a mixture of Aroclor 1016 and Aroclor 1260 will include many of the peaks represented in the other five Aroclor mixtures. As a result, a multi-point initial calibration employing a mixture of Aroclors 1016 and 1260 (1660) at five concentrations should be sufficient to demonstrate the linearity of the detector response without the necessity of performing multi-point initial calibrations for each of the seven Aroclors. In addition, such a mixture can be used as a standard to demonstrate that a sample does not contain peaks that represent any one of the Aroclors. Single standards of each of the other seven Aroclors are required to aid the analyst in pattern recognition. Assuming that the Aroclor 1016/1260 standards have been used to demonstrate the linearity of the detector, these single standards of the remaining seven Aroclors also may be used to determine the calibration factor for each Aroclor when a linear calibration model through the origin is chosen. Prepare a standard for each of the other Aroclors. The concentrations should generally correspond to the mid-point of the linear range of the detector, but lower concentrations may be employed.

10.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in section 10.1.1. The same operating conditions are used for calibrations and sample analyses. Create the analytical sequence using the Agilent Chemstation data acquisition software. Record the calibration standard, unique lot number (PP#) and analyst's initials in the analytical sequence list.

10.2.3 A 1µL injection volume of each calibration standard is typically used. Other injection volumes may be employed, provided that the analyst can demonstrate adequate sensitivity for the compounds of interest. The same injection volume must be used for all standards and samples.

10.2.4 Column adsorption may be a problem when the GC has not been used for a day or more or after system maintenance. The GC column may be primed (or deactivated) by injecting a PCB standard mixture approximately 20 times more concentrated than the mid-concentration standard. Inject this standard mixture prior to beginning the initial calibration or calibration verification.

Alternately, the system may be primed by baking at the final analytical temperature for approximately 30 minutes.

Several analytes may be observed in the injection just following system priming. Always run an instrument blank after system priming.

10.2.5 **Calibration Factor:** Internal Standard Calibration techniques are employed in this method.

10.2.5.1 Internal Standard Procedure. In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Enviroquant data processing software. The calculations are performed automatically, using the formula listed in Alpha's Quality Manual.

Alternatively, standards of the other seven Aroclors are necessary for pattern recognition. When employing the traditional model of a linear calibration through the origin, these standards are also used to

determine a single-point calibration factor for each Aroclor, assuming that the Aroclor 1660 mixture has been used to describe the detector response.

The standards for these seven Aroclors should be analyzed before the analysis of any samples with hits above the RL. For example, an Aroclor 1254 standard should be analyzed before a sample with a hit of Aroclor 1254.

10.2.6 Initial Calibration Criteria

- If the **RSD for an analyte is < 20%**, then the response of the instrument for this compound is considered linear over the range and the mean calibration factor can be used to quantitate sample results.
- If the **RSD for any analyte is > 20%**, then linearity through the origin cannot be assumed. The mean response factor cannot be used for quantitation. An alternative calculation may be done by the use of **linear regression** or **quadratic regression** (minimum of six ICAL points are needed and regression must be weighted inversely proportional to concentration) as long as the correlation coefficient is **>0.990**. If both of these quantitation methods fail criteria for any compound in the initial calibration, then the system must be reevaluated, and a new calibration curve must be analyzed. If quadratic regression is used for calibration, this must be noted in the laboratory narrative.
- **MCP (Massachusetts Contingency Plan) requirement**: minimum of five unique peaks must be evaluated for Aroclors 1016 and 1260.
- **MCP requirement:** Minimum of five standards (or six if non-linear regression used) must be used.
- **Percent Relative Error (%RE)**: For linear and quadratic fit compounds, the %RE must be calculated for the standard at or near the midpoint and at the lowest level of the initial calibration. The %RE between the calculated and expected concentration of an analyte must be **≤ 30%**, otherwise recalibration is necessary.

10.2.7 Initial Calibration Verification

An initial calibration verification standard must be run immediately after each initial calibration, near the midpoint of the curve. The standard must be prepared using a second source that is different than the source used for the initial calibration. (Standards listed in Section 8.6). The **%D** has to be within **20%** (**15% for CT RCP**) when compared to the mean response factor from the initial calibration.

10.2.8 Retention Time Window

10.2.8.1 The retention time window used for the identification of target analytes is ± 0.07 minutes. These criteria have been adopted from the EPA CLP Statement of Work (OLM04.2). It has been found that these limits work well, being wide enough to eliminate false-negatives while being tight enough to eliminate false-positives. Windows that are calculated using the procedure recommended in Method 8000 tend to be very narrow, creating the risk of false negative results.

10.2.8.2 The windows listed above are used as guidance; however, the experience of the analyst weighs heavily in the interpretation of the chromatograms. For example, it has been observed that certain oil matrices can cause the retention times to shift more dramatically.

10.3 Sample Processing

The determination of PCB Aroclors is accomplished by comparing the sample chromatogram to that of the most similar Aroclor standard. The use of PCB overlays is extremely helpful, either by using hardcopies of chromatograms or by utilizing the Enviroquant software. A choice must be made as to which Aroclor is most similar and whether that standard is truly representative of the PCB in the sample. Both retention time and pattern are important when determining PCBs in a sample.

Samples that contained weathered PCB present special analytical challenges. Weathering could alter the Aroclor pattern to the extent that different peaks have to be selected for quantitation. Samples that contained more than one Aroclor present similar problems. For these samples, the Analyst may have to consider selecting the earlier eluting peaks for the lower boiling Aroclor and selecting the later eluting peaks for the higher boiling Aroclors to minimize overlapping peaks.

Minimum of 3 peaks must be chosen for each Aroclor. In these instances, the Analyst may need request the assistance of someone with more expertise in determining the presence of PCB Aroclor.

If compound identification or quantitation is precluded due to interference (e.g., broad, rounded peaks or ill-defined baselines are present) cleanup of the extract may be needed. If instrument problems are suspected, rerun the extract on another instrument to determine if the problem results from analytical hardware or the sample matrix. Refer to the extraction SOPs for the procedures to be followed in sample cleanup.

- The laboratory must report the ***HIGHER*** of the two results unless obvious interference is present on of the columns.
- The **Relative Percent Difference (RPD)** should be **≤ 40%.** If the RPD exceeds 40, this will be denoted with a P flag. If the RPD exceedance is due to interference, the lower of the dual column values can be reported with I and P flags.

10.4 Continuing Calibration

10.4.1 Verify calibration each **12-hours** shift by injecting calibration verification standards prior to conducting any sample analyses. A calibration standard must also be injected at intervals of not less than **once every twenty injections**.

A bracketing CCV is not required with the use of internal standard calibration (Method 8082A 11.6.8) with the exception of samples ran under CT RCP method.

For Aroclor analysis, the calibration verification standard should be a mixture of Aroclor 1016 and 1260 (1660). The calibration verification process does not require analysis of the other Aroclor standards used for pattern recognition

(Method 8082A 11.6.2). However, if the one-point calibration is used for the seven other Aroclor, a calibration standard must be analyzed before the sample for any hits.

10.4.2 The **Response Factor** (for internal standard compounds) for each analyte to be quantitated must not exceed a **± 20% difference** when compared to the initial calibration curve (**+ 15% for CT RCP**). The Enviroquant data processing software automatically calculates the **%D** for all analytes according to the formulae in Alpha's Quality Manual.

10.4.3 **A Retention Time shift >30 seconds** for the internal standard necessitates reanalysis of all affected samples.

10.5 Internal Standard

The use of internal standard calibration does not require that all sample results be bracketed with CCV standard. However, when internal standard calibration is used, the retention times of internal standards and the area response of internal standards should be checked for each analysis (10.4.3).

10.5.1 **IS in CCAL** – The measured area of the internal standard must be no more than ± 50% different from the average area calculated during initial calibration **(-50 to 150%).**

10.5.2 **IS in samples** - The measured area of the internal standard must be no more than -50% to +100% different from the area calculated from opening CCV **(-50 to 200%)**

Retention time shifts of more than 30 sec from the retention time of the most recent calibration standard are cause for concern and must be investigated.

10.6 Preventive Maintenance

10.6.1 **Preventive Maintenance:** Routine preventive maintenance is performed to maintain GC system performance. This includes periodic replacement of injector septa, replacement of injector liner(s), and replacement of injector seals.

10.6.2 **Other Maintenance:** ECD detectors may become contaminated, requiring bake out at elevated temperatures, (no greater than 375°C) or repair by the manufacturer.

11. Data Evaluation, Calculations and Reporting

11.1 Quantitation of Aroclors

Per Method 8082A, quantitation is based on the use of a minimum of 3 of the major peaks present in the analyte, although the use of 5 of the major peaks is recommended. Each of these peaks is individually calibrated with a **minimum of five calibration points** based on average response factors. The %RSD must meet the criteria of ≤20% for the ICAL. The five major peaks are calculated as described below. After individual calculation meets criteria, the average of the peaks selected for quantitation is used to determine the final concentration.

11.1.1 Aqueous samples

$$\text{Concentration } (\mu g/L) = \frac{C \times DF \times Vf \times 1000}{Vo}$$

where:
C = Extract concentration (µg/mL), **NOTE**: ng on column = ng/injection volume = ng/uL = ug/mL
DF = Dilution factor
Vf = Final extract volume (mL)
Vo = Sample volume (mL)

11.1.2 Soil/sediment samples

$$\text{Concentration } (\mu g/Kg, \text{ dry weight}) = \frac{C \times DF \times Vf \times 1000}{W \text{ (gm)}} \div \%S$$

where:
C = Extract concentration (µg/mL), **NOTE**: ng on column = ng/injection volume = ng/uL = ug/mL
DF = Dilution factor
Vf = Final extract volume (mL)
W = Weight of the sample extracted (10g for high, 30g for low)
%S = Percent solids, as a decimal value

11.1.3 Reporting Results

11.1.3.1 After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews must be done by two separate individuals.

11.1.3.2 Reporting Results for PCBs in Caulking Samples

If in the screen sample Aroclor concentration as calculated above is **≥20000ppm**, the Client is contacted by a Customer Service Representative and these results are sent to the LIMS and reported to the Client.

If the sample concentration as calculated above for any Aroclor is **<20000ppm**, the sample is sent for re-extraction by Method 3540C (Alpha SOP/1954).

11.1.3.3 Summation Rules

"TOTAL" concentrations are calculated for **ALL samples and Quality Control Samples** (i.e. LCS, MS, DUP, BLK).

TOTAL = sum of "reportable" Aroclors

Reportable- all Aroclors reported for associated project.

For dual-column analysis, Total is reported as part of column "A" data, unless all individuals are reported from "B" column. "Total" is calculated based on the associated "Report List". See Work Instruction #14335 for details.

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Holding time exceedance and/or improper preservation are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in Section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written into the LIMS by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP/1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP/1732 MDL/LOQ Generation

SOP/1739 IDC/DOC Generation

SOP/1728 Waste Management and Disposal SOP

16. Attachments

Table 1: STANDARD SOLUTIONS

Table 2: PCB ICAL PREPARATION

Table 3: QC ACCEPTANCE CRITERIA

Table 4: SPIKING LEVEL

Table 5: QC FAILURE ACTION PLAN

TABLE 1

STANDARD SOLUTIONS – Suggested Concentrations

STANDARD SOLUTIONS	Stock solution (ug/mL)	Level 1 (ug/mL)	Level 2 (ug/mL)	Level 3 (ug/mL)	Level 4 (ug/mL)	Level 5 (ug/mL)	Level 6 (ug/mL)
PCB							
Aroclor 1016/1260	100	0.1	0.5	1	2.5	5	10
Aroclors 1221, 1232, 1242, 1254, 1262, 1268	100	0.1	0.5	1	2.5	5	10
LVI		0.01	0.05	0.1	0.25	0.5	1
Internal Standard							
1-Bromo-2-Nitrobenzene	5000	0.25	0.25	0.25	0.25	0.25	0.25
LVI		0.025	0.025	0.025	0.025	0.025	0.025
Surrogates:							
Tetrachloro-m-xylene	2.0	0.0064	0.032	0.064	0.16	0.32	0.64
Decachlorobiphenyl	2.0	0.0126	0.064	0.128	0.32	0.64	1.28
LVI – 10X less							

LVI is spiked 10X lower

TABLE 2

PCB ICAL PREPARATION:

Aroclors: 1660, 2154, 4268, 3262, 1248				
Level	**Conc [ug/L]**	**Spike**	**Spike [uL]**	**Hexane [mL]**
6	10000	L6	1000	0
5	5000	L6	500	500
4	2500	L6	250	750
3	1000	L6	100	900
2	500	L6	50	950
1	100	L6	10	990

TABLE 3

QC ACCEPTANCE CRITERIA

Aqueous, Soils, Oils		
Surrogate % Recovery	**Lower Control Limit**	**Upper Control Limit**
2,4,5,6-Tetrachloro-m-xylene	30%	150%
Decachlorobiphenyl	30%	150%

	Aqueous, Soils % Recovery		**Duplicate and/or MSD**	
MS/MSD and LCS	**Lower Control Limit**	**Upper Control Limit**	**Aqueous RPD**	**Soil RPD**
Aroclor 1016, 1260	40%	140%	30%	50%

TABLE 4

SPIKING LEVEL

	LCS\MS\Surr Spiking Level			
	Spike Solution [ug/mL]	**Surr. Solution [ug/mL]**	**Spike Conc [ug/L]**	**Surr Conc [ug/L]**
LVI	0.2	0.2	250	200
Soil/Water	12.5	2	3125	500
Oil	12.5	2	1250	200
Caulking	125	20	3125	200

TABLE 5

QC FAILURE ACTION PLAN

Blank Failures	Failure Situation	Action(s)
Surrogate Failure	1 of 4 high or low	Report as is
	2 or more high	Report as is
	2 or more low, samples are non-detect with passing surrogates	Report as is
	2 or more low, samples have hits and/or failing surrogates	Revial/rerun Re-extract if still failing
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Contamination	Below RL; sample(s) non-detect, below RL, or concentration 10 times or more above the blank	Report as is
	Below RL, sample(s) concentration above RL	See team leader/manager
	Above RL, sample(s) concentration 10 times or more above the blank	Report as is
	Above RL with non-detect sample(s)	Report as is
	Above RL, sample(s) concentration less than 10 times above the blank and volume available	Revial/rerun Re-extract if contamination still present
	Above RL, sample(s) concentration less than 10 times above the blank and no volume available	Revial/rerun B-flag affected data

LCS/LCSD Failures	Failure Situation	Action(s)
Surrogate Failure	1 or more high or low	Report as is
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Spike Failure	Spike compounds out high and sample(s) are non-detect with passing surrogates	Report as is
	Spike compounds out high and sample(s) have hits	Revial/rerun Re-extract if still high
	Spike compounds out low	Revial/rerun Re-extract if still low
	RPD failure	Report as is

MS/MSD/DUP Failures	Failure Situation	Action(s)
Surrogate Failure	(MS/MSD) 1 or more high or low	Report as is
	(MS/MSD) 2 or more high or low	Report as is
	(DUP) 1 or more high, parent sample non-detect	Report as is
	(DUP) 1 or more low, parent sample matches	Report as is
	(DUP) 1 or more low, parent sample doesn't match	Revial/rerun Re-extract if still failing
IS Failure	IS not present (less than 10% recovery)	Add IS Rerun
	IS out high or low	Revial/rerun Re-extract if still failing
Spike Failure (MS/MSD only)	Compounds out high or low due to sample matrix or hits	Report as is
	Compounds out high or low due to extraction error	Revial/rerun Re-extract if still failing
	RDP failure	Report as is

Semivolatile Organic Compounds by Gas Chromatography/ Mass Spectrometry (GC/MS)

Reference Method No.: **EPA 8270 E**

Reference: SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update VI (Phase II), June, 2018.

1. Scope and Application

Matrices: This method is used to determine the concentration of semivolatile organic compounds in extracts prepared from many types of solid waste matrices, soils, and wastewater samples.

This method is used to quantitate most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted, without derivatization, as sharp peaks from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone.

Table 9 lists “difficult” compounds that may require special treatment when being determined by this method.

Approval of any method modifications is by one of the following laboratory personnel before performing the modification: Area Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of a gas chromatograph/mass spectrometer and in the interpretation of mass spectra. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability (Section 13.2).

2. Summary of Method

The samples are introduced into the GC/MS by injecting 1µL of the sample extract into a gas chromatograph (GC) with a narrow-bore fused-silica capillary column. The GC column is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) connected to the gas chromatograph.

Analytes eluted from the capillary column are introduced into the mass spectrometer via direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact spectra of standards run on the same GC/MS system. Quantitation is accomplished by comparing the response of quantitation ion relative to an internal standard using a calibration curve.

2.1 Method Modifications from Reference

None.

3. Reporting Limits

Table 6 lists our routine reporting limits.

4. Interferences

4.1 Only high purity helium is used in the GC system to eliminate this source of possible contamination. The helium (carrier gas) is certified by the gas supplier.

4.2 Preventive instrument maintenance is performed routinely. Section 10.5 details the maintenance steps.

4.3 Glassware must be scrupulously cleaned. This procedure is detailed in the Organic Extraction Glassware Cleaning & Handling SOP/1953.

4.4 Contaminated solvents or reagents are also possible sources of contamination. All solvents used are pesticide grade or equivalent, and reagents are purchased as certified contaminant free.

4.5 Contamination by carry-over can occur whenever high-concentration and low-concentration samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered (concentrations greater than 2x the highest concentration) and the next sample has reportable hits this sample should to be re-analyzed for confirmation based on analyst discretion.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound must be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material data handling sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, extracts, standards or solvents.

5.2 All solvent and extract transfers must be handled in the vented bench area in the GC/MS laboratory.

5.3 All stock standards, working standards, and vialed sample extracts must be placed into the waste bucket in the lab for future disposal by the Health and Safety Officer. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Flammable solvent bottles must be stored in the flammables cabinet.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Aqueous samples are collected in two 1L amber glass jars with teflon-lined lids. For LVI, aqueous samples are collected in two 275mL amber glass jars with teflon-lined lids. Solid samples are collected in 250mL wide-mouth glass jars with teflon-lined lids. All containers are purchased pre-cleaned and certified from commercial vendors.

6.2 Sample Preservation

Both aqueous and solid samples are then preserved by packing in coolers with ice or ice packs, to maintain a temperature of 4 ± 2ºC. Upon receipt at the laboratory, the samples are transferred into sample storage refrigerators to maintain at a temperature of 4 ± 2ºC.

6.3 Sample Handling

Aqueous samples must be extracted within 7 days of sample collection, solid samples within 14 days of collection. Once extracted, the samples must be analyzed within 40 days of the extraction date.

7. Equipment and Supplies

7.1 Gas Chromatograph/Mass Spectrometer System:

7.1.1 Gas Chromatograph, Hewlett Packard 6890 (or equivalent): An analytical system complete with a temperature-programmable gas chromatograph configured for split/splitless-injection and all required accessories, including syringes, analytical columns, and gases. The capillary column is directly coupled to the source.

7.1.2 Column: Rxi-5Sil MS30m x 0.32mm ID, 0.25µm film thickness or column of similar configuration.

7.1.3 Mass Spectrometer, Hewlett Packard 5973 (or equivalent): Scanning from 35 to 500 amu every 1 second or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer is capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets the criteria in Table 1 when 1 µL of the GC/MS tuning standard is injected through the GC (50ng of DFTPP).

7.1.4 Data System: A computer system is interfaced to the Mass Spectrometer. The system allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer software allows the analyst to search for any GC/MS data file for ions of specific mass and plot such ion abundances versus time or scan number. *HP ChemServer* software is used for data acquisition and *MSD Chemstation/Enviroquant version E.02.02* is used for data reduction.

7.2 Syringe: 10 µL.

7.3 Volumetric Flasks, Class A: Appropriate sizes with ground-glass stoppers.

7.4 Vials: Glass autosampler vials with polytetrafluoroethylene (PTFE)-lined crimp top caps.

8. Reagents and Standards

8.1 Stock Standard Solutions

Certified stock standard solutions, traceable to NIST, when available, are purchased from commercial vendors. They can be replaced with different standards as long as they contain all target analytes.

All stock standards, lot number, catalog number, expiration date, preparation date and initials are recorded in a logbook. Standards are stored in the refrigerator or freezer. Store away from any light source at 6 °C when not in use (−10 °C is recommended).

Stock standard expire 6 months from the date of preparation or on the earliest expiration date of any of the stock solution used to prepare it.

Please note that the following preparation instructions and stock standards are included for illustration purposes and may be modified as needed (ex. to accommodate standard availability or client requests), however final concentrations for the initial calibration levels shall always follow the example in 8.1.4.

Vendor	Standard	Catalog#	Concentration
Restek			
	8270 Mega Mix	31850	500-1000ug/mL
	Benzoic Acid Mix	31879	2000ug/mL
	Acid Surrogate Mix	31087	10000ug/mL
	B/N Surrogate Mix	31086	5000ug/mL
	Benzaldehyde Standard	33017	2000ug/mL
	Custom AP9 ICAL Standard	571813-FL	2000ug/mL
	Custom ADP Standard	572745-FL	2000ug/mL
	Benzidine Mix	31834	2000ug/mL
	SV Internal Standard Mix	31206	2000ug/mL
	1,4-Dioxane	30287	2000ug/mL
	Custom CLP 04.1 BNA Surrogate Mix	571320-FL	1000ug/mL
Absolute	Aromatic Amines Mix	99410	2000ug/ml
Ultra	Semi-Volatiles GC/MS Tuning Standard	GCM-150-1	1000ug/mL

8.1.1 ABN Stock Standard, 200ug/mL

Use 5mL of each of the following:
- Benzoic Acid Mix
- Benzidine Mix

and use 10mL of each of the following:
- 8270 Mega Mix
- Custom CLP 04.1 BNA Surrogate Mix

Bring up to 50mL volume with DCM.

8.1.2 AP9 Additional Compounds Stock Standard, 200ug/mL

Use 5mL of each of the following:
- Custom AP9 ICAL Standard
- Benzaldehyde Standard

Bring up to 50mL volume with DCM.

8.1.3 ADP Stock Standard, 200ug/ml

Use 5ml of:
- Custom ADP Standard

Bring up to 50mL volume with DCM.

8.1.4 Calibration Standard

A minimum of 5 calibration standards must be included for each analyte:

Calibration Curve Levels	
Level	Concentration ug/mL
1	1.0
2	2.0
3	3.0
4	5.0
5	10
6	20
7	50
8	100
9	150
10	200

LVI Calibration Curve Levels	
Level	Concentration ug/mL
1	0.2
2	0.4
3	1.0
4	2.0
5	3.0
6	5.0
7	10
8	15
9	35
10	50

*LVI- Low Volume Initiative

8.2 Internal Standard Solution

The internal standards are:

1,4-dichlorobenzene-d_4
naphthalene-d_8
acenaphthene-d_{10}
phenanthrene-d_{10}
chrysene-d_{12}
perylene-d_{12}

Each 500µL of standards, blank and sample extracts are spiked with 10µL of SV Internal Standard Mix, resulting in a concentration of 40ng/ µL.

For the LVI method, a 1:10 dilution is made of the Internal Standard Stock Solution. 500µL of standards, blank and sample extracts are spiked with 10µL of this preparation, resulting in a concentration of 4ng/ µL.

8.3 GC/MS Tuning Standard

The tuning standard is a methylene chloride solution containing 50ng/µL of decafluorotriphenylphosphine (DFTPP). The standard also contains 50ng/µL each of 4,4'DDT, pentachlorophenol, and benzidine to verify injection port inertness and GC column performance.

Prepare the GC/MS Tuning Standard with 25µL GCM-150 and 475µL Dichloromethane.

8.4 Surrogate Spiking Solution

8.4.1 Extraction Surrogate Preparation

In a 1000mL volumetric flask, add 5ml of 31086 and 31087. Bring up to volume with Acetone. The final concentration is 50µg/mL for the acid surrogates and 25µg/mL for the B/N surrogates.

8.4.2 LVI Extraction Surrogate Preparation

The LVI surrogate is a 10 fold dilution of the surrogate solution prepared in 8.4.1. For example, to make 200mL of LVI surrogate, add 20mL of 8.4.1 to a 200mL volumetric flask

and fill to volume with Acetone. The resulting surrogate concentration is 5µg/mL for the acid surrogates and 2.5µg/mL for the B/N surrogates.

8.5 Spike Solution (LCS, MS, MSD)

Spike Solution Preparation

ABN SPK1:
In a 500ml volumetric flask, add 20ml of 8270 Mega Mix #31850, 10ml of Benzoic Acid Mix #31879, 10ml Custom AP9 ICAL Standard #571813-FL and 10ml Benzaldehyde Standard #33017. Bring up to volume with Acetone. The final concentration is 40µg/ml.

Note: the LVI ABN SPK1 is prepared by making an 8 fold dilution of the 40µg/ml ABN SPK (in acetone), resulting in a 5µg/ml LVI ABN SPK1.

ABN SPK2:
In a 500ml volumetric flask, add 10ml Benzidine Mix #31834 and 10mL Custom ADP Standard #572945-FL. Bring up to volume with Acetone. The final concentration is 40µg/ml.

Note: the LVI ABN SPK2 is prepared by making an 8 fold dilution of the 40µg/ml ABN SPK (in acetone), resulting in a 5µg/ml LVI ABN SPK2.

8.6 Dichloromethane (DCM): Pesticide quality.

8.7 Acetone: Pesticide quality.

9. Quality Control

9.1 Blank(s)

Extraction blanks are performed with each extraction batch of 20 or less samples. The extraction blank must not contain any of the reportable analytes above the reporting limit. Corrective actions:

- No corrective action required if concentration of contaminant in sample is >10x concentration in blank or if contaminant not detected in sample

- If the blank have reportable hits and re-extraction could not be performed due to lack of additional sample volume, the sample results are reported and qualified with “B” flag for any associated samples that concentration is less than 10x the blank concentration

For NJ regulatory work the method blank must have all the target analytes less than RL except for Phthalates which must be less than 5x of the RL. Sample results are qualified with “B” flag for analytes observed in the blank greater than RL and the Phthalates observed in the blank greater than 5x RL

The surrogate recoveries must also be within the acceptance criteria listed in Table 2. If surrogate acceptance criteria are exceeded, the extraction batch must be evaluated to determine if re-extraction or re-analysis is necessary.

9.2 Laboratory Control Sample and Laboratory Control Sample Duplicate (LCS / LCSD)

A Laboratory Control Sample/Laboratory Control Sample Duplicate pair (LCS/LCSD) are extracted and analyzed with each analytical batch of 20 or fewer samples.

The LCS/LCSD acceptance criteria are based the performance standard control limits. These performance standards are based on commonly used state programs RCP,MCP etc. See table 3. Less than 10% of total compounds may be outside of control limits provided that recoveries are >10%. Note: this does not apply to difficult analytes listed in Table 9 which may be accepted at recoveries <10. If >10% of analytes are recovered above control limits, this is deemed acceptable as long as the analytes in question are not detected in associated samples.

If these criteria are not met, the entire batch is re-extracted. If re-extraction is not possible, due to insufficient sample or holding time exceedance, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

9.3 Initial Calibration Verification (ICV)

Refer to Section 10.2.7.

9.4 Continuing Calibration Verification (CCV)

Refer to Section 10.4.

9.5 Matrix Spike and Matrix Spike Duplicate (MS / MSD)

A matrix spike/matrix spike duplicate pair is extracted and analyzed for each batch of 20 or fewer samples per client request. The MS/MSD acceptance criteria are based on performance standards. See table 3 for individual control limits. If the recovery criteria are not met, but are met in the LCS/LCSD, this is noted on a narrative sheet for inclusion in the client report.

9.6 Laboratory Duplicate

Not applicable.

9.7 Method-specific Quality Control Samples

9.7.1 Surrogates

All extracted samples and associated QC are spiked with surrogates. The acceptable surrogate recovery limits are listed in Table 2.

Corrective action: Up to one surrogate can be out in each fraction (Acid and Base/Neutral) but not less than 10% recovery, before any corrective action is necessary. Otherwise, analysis must be repeated once to see if an analytical error has occurred. If the % recovery still exceeds the control limits the sample must be re-extracted and re-analyzed to confirm sample matrix. If matrix effect is confirmed, this must be noted on a narrative sheet for inclusion in the client report.

Re-extraction is not required if surrogate recoveries are high and target analytes are not detected in the sample.

9.7.2 Internal Standards

If the area for any of the internal standards in the samples changes by a factor of two (-50% to +100%) from that in the CCV, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

9.8 Method Sequence

In a 12-hour period, the typical analytical sequence is:

- Degradation Check
- DFTPP
- Continuing or Daily Standards (1 – 3)*
  (1) ABN 50 ppm
  (2) AP9 50 ppm
  (3) ADP 50 ppm
- Method/Instrument Blank
- Samples
- QC (as required)

***Additional Continuing standards may be run at the analyst's discretion or by client request.**

10. Procedure

10.1 Equipment Set-up

10.1.1 GC/MS Operating Conditions:

Typical GC/MS operating conditions are listed below, but may be altered as long as method performance criteria are met.

Mass range:	35 – 500 amu
Scan time:	3.15 second / scan
Initial temperature:	50°C, hold for 1.5 minutes
Temperature program:	28°C/minute to 250°C then 9°C/minute to 320°C
Final temperature:	320°C for 1.50 min
Injector temperature:	300°C
Transfer line temperature:	280°C
Source temperature:	230ºC
Injector:	split ratio 5:1; 11.7mL/min
Injection volume:	1µL
Carrier gas:	helium at 523 cm/second (2.0 mL/min) constant flow

GC/MS Operating Conditions for LVI method:

Mass range:	35 – 550 amu
Scan time:	3.15 second / scan
Initial temperature:	45°C, hold for 4 minutes
Temperature program:	25°C/minute to 250°C then 20°C/minute to 320°C
Final temperature:	320°C for 4.3 min
Injector temperature:	270°C
Transfer line temperature:	280°C
Source temperature:	320ºC
Injector:	split ratio 5:1; 8.57mL/min
Injection volume:	2µL
Carrier gas:	helium at 1.7148mL/min) constant flow

10.1.2 GC/MS Tune:

At the beginning of every 12 hour sequence, analyze DFTPP tuning solution (Section 8.3).

The resultant mass spectrum for DFTPP must meet the criteria given in Table 1 before sample analysis begins. The mass spectrum of DFTPP should be acquired in the following manner:

(1) Three scans (the peak apex scan, the scan immediately preceding the apex and the scan immediately following the apex) are acquired and averaged.
(2) Background subtraction is performed using a single scan of no more than 20 scans prior to the elution of DFTPP.

The GC/MS tuning standard is also used to assess GC column performance and injection port inertness. Degradation of DDT to DDE and DDD must not exceed 20%. Benzidine and pentachlorophenol must be present at their normal responses and no peak tailing must be visible.

The tailing factor for benzidine and pentachlorophenol must be calculated in every DFTPP run. (See Table 4)

If degradation is excessive and/or poor chromatography is noted, the system needs maintenance (see Section 10.5).

10.2 Initial Calibration

10.2.1 Prepare calibration standards for all target analytes at a minimum of five concentration levels as specified in Section 8.1.4.

10.2.2 Add 10µL of Internal Standard to each calibration standard directly into the autosampler vial containing 500µL of standard. Analyze each calibration standard under the conditions specified in Section 10.1.1.

10.2.3 Record the calibration standard, unique lab identifier code (lot), concentration, and analyst's initials in the analytical sequence list.

10.2.4 In each standard, calculate the response factor (RF) for each analyte, the average RF, and the relative standard deviation (RSD) of the RFs, using the Enviroquant data processing software. The calculations are performed automatically, using the formulae listed in Alpha's Quality Manual.

It is recommended that a minimum response factor for the most common target analytes, as noted in Table 8, 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 standard is critical in establishing and demonstrating the desired sensitivity.

10.2.5 Initial Calibration %RSD Criteria:

For all analytes, the RSD must be ≤ 20% for the mean response factor to be used for sample quantitation.

If the RSD for any target analyte exceeds 20%, the fit must be ≥0.99 quadratic or ≥ 0.995 linear fit for all target analytes. A minimum of 5 levels are required for a linear calibration model and a minimum of 6 levels are required for a quadratic calibration model. When calculating calibration using the linear regression model, a quantitation check must be performed on the lowest calibration point, or the point that corresponds to that compound's established reporting limit.
For RCP, the RSD must be ≤ 15% for the mean response factor to be used for sample quantitation

Percent Relative Error (%RE): For linear and quadratic fit compounds, the %RE must be calculated for the standard at or near the midpoint and at the lowest level of the initial calibration. The %RE between the calculated and expected concentration of an analyte must be ≤ 30%, otherwise recalibration is necessary.

10.2.6 Evaluation of Retention Times:

The relative retention time (RRT) of each target analyte in each calibration standard should agree within 0.06 RRT units.

10.2.7 Initial Calibration Verification (Second Source Verification)

10.2.7.1 The initial calibration (Section 10.2) for each compound of interest must be verified prior to sample analysis. This is accomplished by analyzing second source calibration standards at a concentration near the midpoint concentration for the calibrating range of the GC/MS.

10.2.7.2 Analyze the standards and calculate the % Difference for each analyte according to the formula in Alpha's Quality Manual.

If the % Difference for each analyte is ± 30%, then the calibration is assumed to be valid. If this criterion is not met, then corrective action must be taken prior to the analysis.

For RCP, if the % Difference for each analyte is ± 20%, then the calibration is assumed to be valid. If this criterion is not met, then corrective action must be taken prior to the analysis.

10.2.7.3 In cases where compounds fail (greater than 30% difference), they may still be reported as non-detects.

10.2.7.4 Once the calibration curve is accepted and prior to processing any samples, the analyst must demonstrate through the analysis of a Method Blank or Instrument Blank that equipment and reagents are free from contaminants and interferences. If a peak is found in the blank that would prevent the identification or bias the measurement of an analyte, the analyst should determine the source of the contaminant peak and eliminate it, if possible. Blank are generally considered to be acceptable if target analyte concentration are less than one half the LLOQ or are less than project specific requirements. Blanks may contain analyte concentrations are greater than acceptance limits if the associated samples in the batch are unaffected.

10.3 Equipment Operation and Sample Processing

10.3.1 GC/MS Analysis of Samples

10.3.1.1 Allow the sample extracts to warm to room temperature.

10.3.1.2 Transfer all of the sample extract to a 1.5mL vial. Remove 500µL of sample extract to another vial, and add 10µL of the internal standard solution (Section 8.2).

10.3.1.3 The autosampler is programmed to inject 1µL aliquot of the sample extract into the GC/MS system, using the same instrument conditions that were used for calibration. The injection volume of the sample must be the same as the volume used for the calibration standard.

10.3.1.4 If the response of any quantitation ion exceeds the initial calibration range of the GC/MS system, the sample extract must be diluted and reanalyzed.

10.3.2 Qualitative Identification

Perform first level data review. Obtain the primary m/z (Table 5) masses for each parameter of interest. The following criteria must be met to make qualitative identification:

- Compare the background subtracted mass spectra for the sample to the reference spectra. The characteristic masses of each parameter of interest must maximize in the same or within one scan of each other.
- The retention time must fall within ± 0.1 minutes of the retention time of the compound in the analytical standard. However, analyst experience must be used in making the qualitative identification.
- The relative peak height of the one characteristic mass must fall within 30% of the relative intensity of the mass in a reference mass spectrum. The reference spectrum is obtained from a standard analyzed on the GC/MS system.

Structural isomers that have very similar mass spectra are identified only if the resolution between authentic isomers in a standard mix is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

10.4 Continuing Calibration

10.4.1 The initial calibration (Section 10.2) for each compound of interest must be verified once every 12 hours prior to sample analysis. This is accomplished by analyzing calibration standards at a concentration near the midpoint concentration for the calibrating range of the GC/MS.

10.4.2 Analyze the standards and calculate the % Difference for each analyte according to the formula in Alpha's Quality Manual.

If the % Difference for each CCV analyte is $\leq$ 20%, then the calibration is assumed to be valid. If the criterion is not met for more than 20% of the compounds then corrective action must be taken.

Due to the large number of analytes present, allowances may be made for a RF that drifts out high, as long as there are no positive hits for that particular analyte in any of the associated samples.

10.4.3 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

10.4.4 If routine maintenance does not return the instrument performance to meet the QC requirements based on the last initial calibration, then a new initial calibration must be performed.

10.4.5 Internal Standard Retention Time

The retention times of the internal standards in the calibration verification standard is evaluated after data acquisition. If the retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard of the most recent initial calibration, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

10.4.6 Internal Standard Response

Refer to section 9.7.2

10.5 Preventive Maintenance

When poor sensitivity is observed, replacement of the injector liner and seal may solve the problem. If not, clip approximately 3 – 6 inches from the injector end of the GC column. If the sensitivity does not improve it may be necessary to replace the split line or the injector weldment assembly. If the problem persists, it may be necessary to replace the GC column.

Periodic cleaning (typically twice per year) of the mass spectrometer ion source is required. More frequent source cleaning may be needed, especially if dirty samples are analyzed.

11. Data Evaluation, Calculations and Reporting

When a parameter is identified, the quantitation of that parameter must be based on the integrated abundance of the quantitation characteristic m/z given in Table 5

Calculate the concentration in the sample using the average response factor (RF) from the initial calibration curve according to the formula in Alpha's Quality Manual.

After performing technical data review, validating that all QC criteria have been met and confirming all positive hits, the data report is sent electronically to the LIMS computer for generation of the client report. There are two levels of review of the data in the LIMS system prior to release of data. These reviews must be done by two separate individuals.

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Holding time exceedence and improper preservation are noted on the nonconformance report form.

Perform instrument maintenance as described throughout this SOP as needed when instrument calibration criteria are not met. Record all maintenance in the instrument logbook.

All batch and sample specific QC criteria outlined in Section 9 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample

volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Method Performance

13.1 Detection Limit Study (DL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP/1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

Alpha SOP/1732 DL/LOD/LOQ Generation

Alpha SOP/1739 IDC/DOC Generation

Alpha SOP/1729 Waste Management and Disposal SOP

16. Attachments

Table 1: DFTPP Key Ions and Ion Abundance Criteria

Table 2: Acceptable Surrogate Spike Recovery Limits

Table 3A: Acceptable Aqueous QC Limits

Table 3B: Acceptable Soil QC Limits

Table 4: Tailing Factor Calculation

Table 5: Characteristic Ions for Semivolatile Compounds

Table 6: Reported Detection Limits

Table 7: Semivolatile Internal Standards with Corresponding Target Compounds and Surrogates Assigned for Quantitation

Table 8: Recommended Minimum Response Factor Criteria

Table 9: Difficult analytes

TABLE 1

DFTPP KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
68	< 2% of mass 69
69	Present
70	< 2% of mass 69
197	< 2% of mass 198
198	Base peak or present
199	5-9% of mass 198
365	> 1% of Base Peak
441	Present but less than 24% mass 442
442	Base peak, or present
443	15-24% of mass 442

TABLE 2

ACCEPTABLE SURROGATE SPIKE RECOVERY LIMITS

Analytical Fraction	Surrogate Compound	Water	Soil/Sediment
BN-8270D	Nitrobenzene-d_5	23-120%	23-120%
BN-8270D	2-Fluorobiphenyl	15-120%	30-120%
BN-8270D	p-Terphenyl-d_{14}	41-149%	18-120%
Acid-8270D	Phenol-d_6	10-120%	10-120%
Acid-8270D	2-Fluorophenol	21-120%	25-120%
Acid-8270D	2,4,6-Tribromophenol	10-120%	10-136%

It is allowable for one surrogate from each fraction be outside acceptance criteria, provided a minimum recovery of 10% has been achieved.

TABLE 3A

ACCEPTABLE AQUEOUS QC LIMITS

	STANDARD TARGET COMPOUND LIST (Aqueous)		NEW JERSEY TARGET COMPOUND LIST (Aqueous)		CT TARGET COMPOUND LIST (Aqueous)	
Analyte	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**
1,2,4,5-Tetrachlorobenzene			70-130	20	40-140	20
1,2,4-Trichlorobenzene	39-98	30	70-130	20	40-140	20
1,2-Dichlorobenzene	40-140	30	70-130	20		
1,3-Dichlorobenzene	40-140	30	70-130	20		
1,3-Dinitrobenzene	15-130	30				
1,4-Dichlorobenzene	36-97	30	70-130	20		
1-Methylnaphthalene	41-103	30				
2,3,4,6-Tetrachlorophenol			70-130	20		
2,4,5-Trichlorophenol	30-130	30	70-130	20	30-130	20
2,4,6-Trichlorophenol	30-130	30	70-130	20	30-130	20
2,4-Dichlorophenol	30-130	30	70-130	20	30-130	20
2,4-Dimethylphenol	30-130	30	70-130	20	30-130	20
2,4- Dimethylaniline	40-140	30	70-130	20		
3,4- Dimethylaniline	40-140	30	70-130	20		
2,3- Dimethylaniline	40-140	30	70-130	20		
2,4,5-Dimethylaniline	40-140	30	70-130	20		
4-Chlorotoluidine	40-140	30	70-130	20		
2-Ethylaniline	40-140	30	70-130	20		
O-toluidine	40-140	30	70-130	20		
2-Napthylamine	40-140	30	70-130	20		
2,4-Dinitrophenol	20-130	30	20-130	20	30-130	20
2,4-Dinitrotoluene	24-96	30	70-130	20	40-140	20
2,6-Dinitrotoluene	40-140	30	70-130	20	40-140	20
2-Chloronaphthalene	40-140	30	70-130	20	40-140	20
2-Chlorophenol	27-123	30	70-130	20	30-130	20
2-Methylnaphthalene	40-140	30	70-130	20	40-140	20
2-Methylphenol	30-130	30	70-130	20	30-130	20
2-Nitroaniline	52-143	30	70-130	20	40-140	20
2-Nitrophenol	30-130	30	70-130	20	30-130	20
3,3'-Dichlorobenzidine	40-140	30	70-130	20	40-140	20
3,3'-Dimethylbenzidine			20-160	20		
3-Methylphenol/4-Methylphenol	30-130	30	20-160	20	30-130	20
3-Nitroaniline	25-145	30	70-130	20	40-140	20
4,6-Dinitro-o-cresol	20-164	30	70-130	20	30-130	20
4-Bromophenyl phenyl ether	40-140	30	70-130	20	40-140	20
4-Chloroaniline	40-140	30	20-160	20	40-140	20
4-Chlorophenyl phenyl ether	40-140	30	70-130	20	40-140	20
4-Nitroaniline	51-143	30	70-130	20	40-140	20
4-Nitrophenol	10-80	30	20-160	20	30-130	20
Acenaphthene	37-111	30	70-130	20	40-140	20
Acenaphthylene	45-123	30	70-130	20	40-140	20

	STANDARD TARGET COMPOUND LIST (Aqueous)		NEW JERSEY TARGET COMPOUND LIST (Aqueous)		CT TARGET COMPOUND LIST (Aqueous)	
Analyte	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**
Acetophenone	39-129	30	70-130	20		
Aniline	40-140	30	20-160	20	40-140	20
Anthracene	40-140	30	70-130	20	40-140	20
Atrazine			70-130	20		
Azobenzene	40-140	30	70-130	20		
Benzaldehyde			20-160	20		
Benzidine	10-75	30	20-160	20		
Benzo(a)anthracene	40-140	30	70-130	20	40-140	20
Benzo(a)pyrene	40-140	30	70-130	20	40-140	20
Benzo(b)fluoranthene	40-140	30	70-130	20	40-140	20
Benzo(ghi)perylene	40-140	30	70-130	20	40-140	20
Benzo(k)fluoranthene	40-140	30	70-130	20	40-140	20
Benzoic Acid	10-164	30	20-160	20		
Benzyl Alcohol	26-116	30	20-160	20		
Biphenyl	40-140	30	70-130	20		
Bis(2-chloroethoxy)methane	40-140	30	70-130	20	40-140	20
Bis(2-chloroethyl)ether	40-140	30	70-130	20	40-140	20
Bis(2-chloroisopropyl)ether	40-140	30	70-130	20	40-140	20
Bis(2-Ethylhexyl)phthalate	40-140	30	70-130	20	40-140	20
Butyl benzyl phthalate	40-140	30	70-130	20	40-140	20
Caprolactam			20-160	20		
Carbazole	55-144	30	70-130	20	40-140	20
Chrysene	40-140	30	70-130	20	40-140	20
Dibenzo(a,h)anthracene	40-140	30	70-130	20	40-140	20
Dibenzofuran	40-140	30	70-130	20	40-140	20
Diethyl phthalate	40-140	30	70-130	20	40-140	20
Dimethyl phthalate	40-140	30	70-130	20	40-140	20
Di-n-butylphthalate	40-140	30	70-130	20	40-140	20
Di-n-octylphthalate	40-140	30	70-130	20	40-140	20
Fluoranthene	40-140	30	70-130	20	40-140	20
Fluorene	40-140	30	70-130	20	40-140	20
Hexachlorobenzene	40-140	30	70-130	20	40-140	20
Hexachlorobutadiene	40-140	30	70-130	20	40-140	20
Hexachlorocyclopentadiene	40-140	30	20-160	20	40-140	20
Hexachloroethane	40-140	30	20-160	20	40-140	20
Indeno(1,2,3-cd)Pyrene	40-140	30	70-130	20	40-140	20
Isophorone	40-140	30	70-130	20	40-140	20
Naphthalene	40-140	30	70-130	20	40-140	20
Nitrobenzene	40-140	30	70-130	20	40-140	20
NitrosoDiPhenylAmine(NDPA)/ Diphenylamine (DPA)	40-140	30	70-130	20	40-140	20
n-Nitrosodimethylamine	22-74	30	20-160	20		
n-Nitrosodi-n-propylamine	29-132	30	70-130	20	40-140	20
P-Chloro-M-Cresol	23-97	30	70-130	20	30-130	20
Pentachlorophenol	9-103	30	20-160	20	30-130	20
Pentachloronitrobenzene					40-140	20

	STANDARD TARGET COMPOUND LIST (Aqueous)		NEW JERSEY TARGET COMPOUND LIST (Aqueous)		CT TARGET COMPOUND LIST (Aqueous)	
Analyte	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**
Phenanthrene	40-140	30	70-130	20	40-140	20
Phenol	12-110	30	20-160	20	30-130	20
Pyrene	26-127	30	70-130	20	40-140	20
Pyridine	10-66	30			40-140	20
2-Fluorophenol	*21-120*		*15-110*		*15-110*	
Phenol-d6	*10-120*		*15-110*		*15-110*	
Nitrobenzene-d5	*23-120*		*30-130*		*30-130*	
2-Fluorobiphenyl	*15-120*		*30-130*		*30-130*	
2,4,6-Tribromophenol	*10-120*		*15-110*		*15-110*	
4-Terphenyl-d14	*41-149*		*30-130*		*30-130*	

TABLE 3B

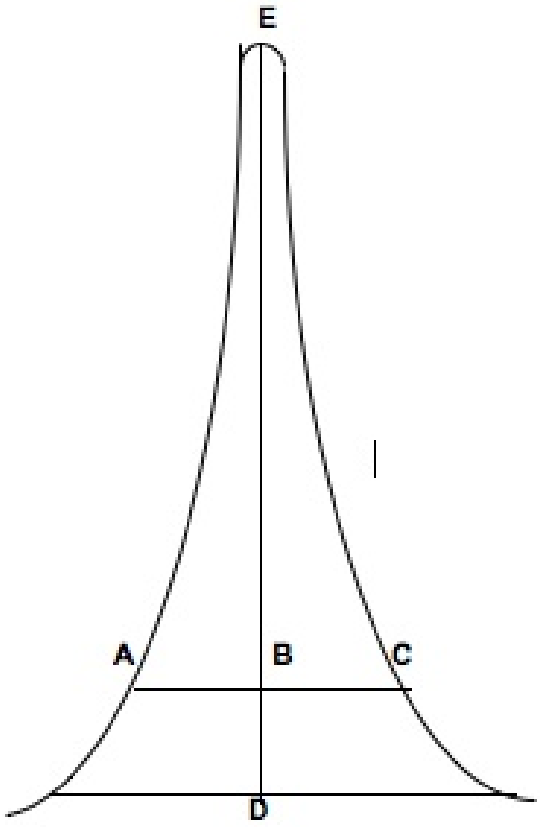
ACCEPTABLE SOIL QC LIMITS

	STANDARD TARGET COMPOUND LIST (Soil)		NEW JERSEY TARGET COMPOUND LIST (Soil)		CT TARGET COMPOUND LIST (Soil)	
Analyte	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**
1,2,4,5-Tetrachlorobenzene	40-117	50	70-130	30	40-140	30
1,2,4-Trichlorobenzene	38-107	50	70-130	30	40-140	30
1,2-Dichlorobenzene	40-140	50	70-130	30		
1,3-Dichlorobenzene	40-140	50	70-130	30		
1,3-Dinitrobenzene	40-140	50				
1,4-Dichlorobenzene	28-104	50	70-130	30		
1-Methylnaphthalene	26-130	50				
2,3,4,6-Tetrachlorophenol	40-140	50	70-130	30		
2,4,5-Trichlorophenol	30-130	50	70-130	30	30-130	30
2,4,6-Trichlorophenol	30-130	50	70-130	30	30-130	30
2,4-Dichlorophenol	30-130	50	70-130	30	30-130	30
2,4-Dimethylphenol	30-130	50	70-130	30	30-130	30
2,4-Dinitrophenol	4-130	50	20-160	30	30-130	30
2,4-Dinitrotoluene	28-89	50	70-130	30	40-140	30
2,6-Dinitrotoluene	40-140	50	70-130	30	40-140	30
2-Chloroaniline	30-130	50				
2-Chloronaphthalene	40-140	50	70-130	30	40-140	30
2-Chlorophenol	25-102	50	70-130	30	30-130	30
2-Methylnaphthalene	40-140	50	70-130	30	40-140	30
2-Methylphenol	30-130.	50	70-130	30	30-130	30
2-Nitroaniline	47-134	50	70-130	30	40-140	30
2-Nitrophenol	30-130	50	70-130	30	30-130	30
3,3'-Dichlorobenzidine	40-140	50	70-130	30	40-140	30
3,3'-Dimethylbenzidine	15-115	50				
3-Methylphenol/4-Methylphenol	30-130	50	20-160	30	30-130	30
3-Nitroaniline	26-129	50	70-130	30	40-140	30
4,6-Dinitro-o-cresol	10-130	50	70-130	30	30-130	30
4-Bromophenyl phenyl ether	40-140	50	70-130	30	40-140	30
4-Chloroaniline	40-140	50	20-160	30	40-140	30
4-Chlorophenyl phenyl ether	40-140	50	70-130	30	40-140	30
4-Nitroaniline	41-125	50	70-130	30	40-140	30
4-Nitrophenol	11-114	50	20-160	30	30-130	30
Acenaphthene	31-137	50	70-130	30	40-140	30

	STANDARD TARGET COMPOUND LIST (Soil)		NEW JERSEY TARGET COMPOUND LIST (Soil)		CT TARGET COMPOUND LIST (Soil)	
Analyte	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**
Acenaphthylene	40-140	50	70-130	30	40-140	30
Acetophenone	14-144	50	70-130	30	40-140	30
Aniline	40-140	50	20-160	30	40-140	30
Anthracene	40-140	50	70-130	30	40-140	30
Atrazine	40-140	50	70-130	30		
Azobenzene	40-140	50	70-130	30		
Benzaldehyde	40-140	50	20-160	30		
Benzidine	10-66	50	20-160	30		
Benzo(a)anthracene	40-140	50	70-130	30	40-140	30
Benzo(a)pyrene	40-140	50	70-130	30	40-140	30
Benzo(b)fluoranthene	40-140	50	70-130	30	40-140	30
Benzo(e)pyrene	40-140	50				
Benzo(ghi)perylene	40-140	50	70-130	30	40-140	30
Benzo(k)fluoranthene	40-140	50	70-130	30	40-140	30
Benzoic Acid	10-110	50	20-160	30		
Benzyl Alcohol	40-140	50	20-160	30		
Biphenyl	37-127	50	70-130	30		
Bis(2-chloroethoxy)methane	40-117	50	70-130	30	40-140	30
Bis(2-chloroethyl)ether	40-140	50	70-130	30	40-140	30
Bis(2-chloroisopropyl)ether	40-140	50	70-130	30	40-140	30
Bis(2-Ethylhexyl)phthalate	40-140	50	70-130	30	40-140	30
Butyl benzyl phthalate	40-140	50	70-130	30	40-140	30
Caprolactam	15-130	50	20-160	30		
Carbazole	54-128	50	70-130	30	40-140	30
Chrysene	40-140	50	70-130	30	40-140	30
Dibenzo(a,h)anthracene	40-140	50	70-130	30	40-140	30
Dibenzofuran	40-140	50	70-130	30	40-140	30
Diethyl phthalate	40-140	50	70-130	30	40-140	30
Dimethyl phthalate	40-140	50	70-130	30	40-140	30
Di-n-butylphthalate	40-140	50	70-130	30	40-140	30
Di-n-octylphthalate	40-140	50	70-130	30	40-140	30
Diphenamid	40-140	50				
Fluoranthene	40-140	50	70-130	30	40-140	30
Fluorene	40-140	50	70-130	30	40-140	30
Hexachlorobenzene	40-140	50	70-130	30	40-140	30
Hexachlorobutadiene	40-140	50	70-130	30	40-140	30
Hexachlorocyclopentadiene	40-140	50	20-160	30	40-140	30
Hexachloroethane	40-140	50	20-160	30	40-140	30
Indeno(1,2,3-cd)Pyrene	40-140	50	70-130	30	40-140	30
Isophorone	40-140	50	70-130	30	40-140	30

	STANDARD TARGET COMPOUND LIST (Soil)		NEW JERSEY TARGET COMPOUND LIST (Soil)		CT TARGET COMPOUND LIST (Soil)	
Analyte	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**	**Acceptance Criteria**	**Duplicate RPD**
Naphthalene	40-140	50	70-130	30	40-140	30
Nitrobenzene	40-140	50	70-130	30	40-140	30
NitrosoDiPhenylAmine(NDPA)/ Diphenylamine (DPA)	36-157	50	70-130	30	40-140	30
n-Nitrosodimethylamine	22-100	50	20-160	30		
n-Nitrosodi-n-propylamine	32-121	50	70-130	30	40-140	30
Parathion, ethyl	40-140	50	20-160	30		
P-Chloro-M-Cresol	26-103	50	70-130	30	30-130	30
Pentachloronitrobenzene	42-153	50			40-140	30
Pentachlorophenol	17-109	50	20-160	30	30-130	30
Phenanthrene	40-140	50	70-130	30	40-140	30
Phenol	26-90	50	20-160	30	30-130	30
Pyrene	35-142	50	70-130	30	40-140	30
Pyridine	10-93	50	20-160	30	40-140	30
Thionazin	40-140	50				
2-Fluorophenol	*25-120*		*30-130*		*30-130*	
Phenol-d6	*10-120*		*30-130*		*30-130*	
Nitrobenzene-d5	*23-120*		*30-130*		*30-130*	
2-Fluorobiphenyl	*30-120*		*30-130*		*30-130*	
2,4,6-Tribromophenol	*10-136*		*30-130*		*30-130*	
4-Terphenyl-d14	*18-120*		*30-130*		*30-130*	

TABLE 4 – Tailing Factor Calculation



Tailing Factor = $\frac{BC}{AB}$

Example calculation:

Peak Height = DE = 100mm
10% Peak Height = BD = 10mm
Peak Width at 10% Peak Height = AC = 23mm

AB = 11mm
BC = 12mm

Therefore: Tailing Factor = $\frac{12}{11}$ = 1.1

Tailing factor for benzidine < 2.0

Tailing factor for pentachlorophenol <2.0

TABLE 5

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
Acenaphthene	154	153, 152
Acenaphthylene	152	151, 153
Acetophenone	105	71, 51, 120
Aniline	93	66, 65
Anthracene	178	176, 179
Atrazine	200	202, 215
Azobenzene	77	182, 105
Benzaldehyde	105	77
Benzidine	184	92, 185
Benzo(a)anthracene	228	229, 226
Benzo(a)pyrene	252	253, 125
Benzo(b)fluoranthene	252	253, 125
Benzo(g,h,i)perylene	276	138, 277
Benzo(k)fluoranthene	252	253, 125
Benzoic acid	105	122, 77
Benzyl alcohol	79	77,108
Biphenyl	154	153,152
Bis (2-chloroethoxy) methane	93	95, 123
Bis (2-chloroethyl) ether	93	63, 95
Bis (2-chloroisopropyl) ether	45	77, 121
Bis (2-ethylhexyl) phthalate	149	167, 279
4-Bromophenyl phenyl ether	248	250, 141
Butyl Benzyl phthalate	149	91, 206
Caprolactam	55	85, 113
Carbazole	167	168, 166
4-Chloro-3-methylphenol	107	144, 142
2-Chloroaniline	127	129, 65
3-Chloroaniline	65	127, 129
4-Chloroaniline	65	127,129
2-Chloronaphthalene	162	127, 164
4-Chlorophenyl phenyl ether	204	206, 141
2-Chlorophenol	128	64,130
Chrysene	228	226, 229
Dibenzo(a,h)anthracene	278	139, 279
Dibenzofuran	168	139
1,2-Dichlorobenzene	146	148, 111

1,3-Dichlorobenzene	**146**	**148, 111**
1,4-Dichlorobenzene	**146**	**148, 111**
3,3'-Dichlorobenzidine	**252**	**254, 126**
2,4-Dichlorophenol	**162**	**164, 98**
Diethyl phthalate	**149**	**177, 150**

TABLE 5 (continued)

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
3,3-Dimethylbenzidine	**212**	**211, 213**
Dimethyl phthalate	**163**	**194, 164**
2,4-Dimethylphenol	**107**	**121,122**
Di-n-butyl phthalate	**149**	**150, 104**
Di-n-octyl phthalate	**149**	**167, 43**
4,6-Dinitro-2-methylphenol	**198**	**51, 105**
O-Toluidine	**106**	**107, 77**
2-Ethylaniline	**106**	**121, 77**
2,4-Dimethylaniline	**121**	**120, 106**
2,3-Dimethylaniline	**106**	**121, 120**
3,4- Dimethylaniline	**121**	**120,106**
2,4,5-Trimethylaniline	**120**	**135, 134**
4-Chlorotoluidine	**106**	**141, 140**
2-Napthylamine	**143**	**115, 116**
2,4-Dinitrophenol	**184**	**107,91**
2,4-Dinitrotoluene	**165**	**63, 89**
2,6-Dinitrotoluene	**165**	**63, 89**
Diphenamide	**167**	**72, 165**
1,4-Dioxane	**88**	**58,43**
Ethyl parathion	**109**	**97, 291**
Fluoranthene	**202**	**101, 203**
Fluorene	**166**	**165, 167**
Hexachlorobenzene	**284**	**142, 249**
Hexachlorobutadiene	**225**	**223, 227**
Hexachlorocyclopentadiene	**237**	**235, 272**
Hexachloroethane	**117**	**201, 199**
Indeno(1,2,3-cd)pyrene	**276**	**138, 227**
Isophorone	**82**	**95, 138**
1-Methylnaphthalene	**115**	**141, 142**
2-Methylnaphthalene	**142**	**141**
2-Methylphenol	**108**	**107,90**
3/4-Methylphenol	**108**	**107,90**

Naphthalene	**128**	**129, 127**
2-Nitroaniline	**65**	**92, 138**
3-Nitroaniline	**138**	**92,65**
4-Nitroaniline	**138**	**65, 108, 92, 80, 39**
Nitrobenzene	**77**	**123, 65**

TABLE 5 (continued)

CHARACTERISTIC IONS FOR SEMIVOLATILE COMPOUNDS

Compound	Primary Ion	Secondary Ion(s)
2-Nitrophenol	**139**	**109, 65**
4-Nitrophenol	**65**	**109, 139**
n-Nitrosodimethylamine	**74**	**42,44**
n-Nitrosodi-n-butylamine	**84**	**57, 41, 116, 158**
n-Nitrosodi-n-propylamine	**70**	**42, 101, 130**
n-Nitrosodiphenylamine/Diphenylamine	**169**	**168, 167**
Pentachlorobenzene	**250**	**252, 108, 248, 215, 254**
Pentachloronitrobenzene	**237**	**142, 214, 249, 295, 265**
Pentachlorophenol	**266**	**264, 268**
Phenanthrene	**178**	**179, 176**
Phenol	**94**	**65, 66**
Pyrene	**202**	**200, 203**
Pyridine	**79**	**52**
1,2,4,5-Tetrachlorobenzene	**216**	**214, 179, 108, 143, 218**
2,3,4,6-Tetrachlorophenol	**232**	**131, 230, 166, 234, 168**
m-Toluidine	**106**	**107, 79**
1,2,4-Trichlorobenzene	**180**	**182, 145**
2,4,5-Trichlorophenol	**196**	**200,198**
2,4,6-Trichlorophenol	**196**	**198, 200**
Acenaphthene-d_{10} (IS)	**164**	**162, 160**
Chrysene-d_{12} (IS)	**240**	**120, 236**
1,4-Dichlorobenzene-d_4 (IS)	**152**	**150, 115**
Naphthalene-d_8 (IS)	**136**	**68**
Perylene-d_{12} (IS)	**264**	**260, 265**
Phenanthrene-d_{10} (IS)	**188**	**94, 80**
2-Fluorobiphenyl (Surrogate)	**172**	**171**
2-Fluoroophenol (Surrogate)	**112**	**64**
Nitrobenzene-d_5 (Surrogate)	**82**	**128, 54**
Phenol-d_6 (Surrogate)	**99**	**42, 71**
Terphenyl-d_{14} (Surrogate)	**244**	**122, 212**
2,4,6-Tribromophenol (Surrogate)	**330**	**62,141**

TABLE 6

REPORTED DETECTION LIMITS FOR SEMIVOLATILE ORGANIC COMPOUNDS*

Analyte	RDL (µg/L)	RDL (µg/Kg)
Acenaphthene	2	133.34
Acenaphthylene	2	133.34
Acetophenone	5	333.34
Aniline	2	133.34
Anthracene	2	133.34
Atrazine	10	666.67
Azobenzene	2	500
Benzaldehyde	5	333.34
Benzidine	20	1333.34
Benzo(a)anthracene	2	133.34
Benzo(b)fluoranthene	2	133.34
Benzo(k)fluoranthene	2	133.34
Benzo(ghi)perylene	2	133.34
Benzo(a)pyrene	2	133.34
Benzoic acid	50.0	3333.34
Benzyl alcohol	2	133.34
Biphenyl	2	366.67
Bis(2-chloroethyl)ether	2	133.34
Bis(2-chloroisopropyl)ether	2	133.34
Bis(2-chloroethoxy)methane	5.0	333.34
Bis(2-ethylhexyl)phthalate	3	200
4-Bromophenyl phenyl ether	2	133.34
Butyl benzyl phthalate	5.0	333.34
Caprolactam	10	666.67
Carbazole	2	166.67
2-Chloroaniline	2	na
3-Chloroaniline	10	na
4-Chloroaniline	5	333.34
p-Chloro-m-cresol (4-chloro-3-cresol)	2	133.34
2-Chloronaphthalene	2	133.34
2-Chlorophenol	2	133.34
4-Chlorophenyl phenyl ether	2	133.34
Chrysene	2	133.34
m/p-Methylphenol (3/4-methylphenol)	5.0	333.34
o-Methylphenol (2-methylphenol)	5.0	333.34

Dibenzo(a,h)anthracene	2	133.34
Dibenzofuran	2	133.34
Di-n-butylphthalate	5.0	333.34
1,2-Dichlorobenzene	2	133.34

TABLE 6 (continued)

REPORTED DETECTION LIMITS FOR SEMIVOLATILE ORGANIC COMPOUNDS*

Analyte	RDL (µg/L)	RDL (µg/Kg)
1,3-Dichlorobenzene	2	133.34
1,3-Dinitrobenzene	2	N/A
1,4-Dichlorobenzene	2	133.34
3,3-Dichlorobenzidine	5	333.34
2,4-Dichlorophenol	5	333.34
O-Toluidine	2	N/A
2-Ethylaniline	2	N/A
2,4-Dimethylaniline	2	N/A
2,3-Dimethylaniline	2	N/A
3,4-Dimetylaniline	2	N/A
2,4,5-Trimethylaniline	2	N/A
4-Chlorotoluidine	2	N/A
2-Napthylamine	2	N/A
2,6-Dichlorophenol	10.0	666.67
Diethyl phthalate	5.0	333.34
3,3-Dimethylbenzidine	4	500
2,4-Dimethylphenol	5	333.34
Dimethyl phthalate	5.0	333.34
4,6-Dinitro-o-cresol	10	666.67
2,4-Dinitrophenol	20	1333.4
2,4-Dinitrotoluene	5.0	333.34
2,6-Dinitrotoluene	5.0	333.34
Di-n-octylphthalate	5.0	333.34
Diphenamide	5	N/A
1,4-Dioxane	5	166.67
Ethyl Parathion	N/A	166.67
Fluoranthene	2	133.34
Fluorene	2	133.34
Hexachlorobenzene	2	133.34
Hexachlorobutadiene	2	133.34
Hexachlorocyclopentadiene	20	1333.34
Hexachloroethane	2	133.34
Indeno(1,2,3-cd)pyrene	2	133.34
Isophorone	5.0	333.34

1-Methylnaphthalene	2	166.67
2-Methylnaphthalene	2	133.34
Naphthalene	2	133.34
2-Nitroaniline	5.0	333.34

TABLE 6 (continued)

REPORTED DETECTION LIMITS FOR SEMIVOLATILE ORGANIC COMPOUNDS*

Analyte	RDL (µg/L)	RDL (µg/Kg)
3-Nitroaniline	5.0	333.34
4-Nitroaniline	5.0	333.34
Nitrobenzene	2	133.34
2-Nitrophenol	10.0	666.67
4-Nitrophenol	10.0	666.67
Nitrosodi-n-butylamine	10.0	666.67
n-Nitrosodimethylamine	2	133.34
n-Nitrosodiphenylamine/Diphenylamine	2	133.34
Nitrosodipiperidine	20.0	2000
n-Nitrosodi-n-propylamine	5.0	333.34
Pentachlorobenzene	20.0	1333.34
Pentachloronitrobenzene	10.0	150
Pentachlorophenol	10.0	666.67
Phenanthrene	2	133.34
Phenol	5.0	333.34
Pyrene	2	133.34
Piridine	5	666.67
1,2,4,5-Tetrachlorobenzene	10	666.67
1,2,4-Trichlorobenzene	5.0	333.34
2,4,5-Trichlorophenol	5.0	333.34
2,4,6-Trichlorophenol	5.0	333.34
2,3,4,6-Tetrachlorophenol	5.0	166.66
m-Toluidine	5	300

*** Note**: Reporting Limits are based on standard 8270 reporting list. RLs may vary for other reporting lists.

Table 7
Semivolatile Internal Standards with Corresponding
Target Compounds and Surrogates Assigned for Quantitation

1,4-dichlorobenzene-d4	Naphthalene-d8	Acenaphthene-d10	Phenanthrene-d10	Chrysene-d12	Perylene-d12
O-Toluidine	2-Ethylaniline	2-Naphthylamine	3,3-Dimethylbenzidine	3,3'-Dichlorobenzidine	Benzo(g,h,i)perylene
1,2,4-Trichlorobenzene	2,4-Dimethylaniline	2,3,4,6-Tetrachlorophenol	Anthracene	Benzo(a)Anthracene	Dibenzo(a,h)anthracene
1,2-Dichlorobenzene	3,4-Dimethylaniline	2,3,5,6-Tetrachlorophenol	Benzidine	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene
1,3-Dichlorobenzene	2,3-Dimethylaniline	2,4,6-Tribromophenol, surr	Benzyl butyl phthalate	Benzo(b)fluoranthene	
1,4-Dichlorobenezne	2,4,5-Trimethylaniline	2,4-Dinitrophenol	Carbazole	Benzo(k)fluoranthene	
2,4-Dichlorophenol	4-Chlorotoludine	2,4-Dinitrotoluene	Di-n-Butylphthalate	Bis(2-ethylhexyl) phthalate	
2,4-Dimethylphenol	1,2,4,5-Tetrachlorobenzene	3-Nitroaniline	Diphenamid	Chrysene	
2-Chloroaniline	1,2-Dichlorobenzene	4,6-Dinitro-2-methylphenol	Fluoranthene	Di-n-octylphthalate	
2-Chlorophenol	1,3-Dichlorobenzene	4-Bromophenyl-phenyl ether	n-Octadecane		
2-Fluorophenol, surr	1,4-Diclorobenzene	4-Chlorophenyl-phenyl ether	Parathion		
2-Methylphenol	1-chloror-2-nitrobenzene	4-Nitroaniline	Phenanthrene		
2-Nitrophenol	1-Methylnapthalene	4-Nitrophenol	Pyrene		
3-Methylphenol / 4-Methylphenol	2,4,5-Trichlorphenol	Acenaphthene	Terphenyl-d14, surr		
Acetophenone	2,4,6-Trichlorophenol	Atrazine			
Aniline	2,6-Dichlorophenol	Azobenzene			
Benzaldehyde	2,6-Dinitrotoluene	Dibenzofuran			
Benzyl Alcohol	2-Chloronaphthalene	Dichloran			
Bis(2-chloroethoxy)methane	2-Fluorobiphenyl, surr	Diethyl phthalate			
Bis(2-chloroethyl)ether	2-Methylnaphthalene	Fluorene			

Table 7 (cont.)
Semivolatile Internal Standards with Corresponding
Target Compounds and Surrogates Assigned for Quantitation

1,4-dichlorobenzene-d4	Naphthalene-d8	Acenaphthene-d10	Phenanthrene-d10	Chrysene-d12	Perylene-d12
bis(2-Chloroisopropyl)ether	2-Nitroaniline	Hexachlorobenzene			
Hexachloroethane	3-Choloroaniline	NDPA/DPA			
Isophorone	4-Chloro-3-Methylphenol	Pentachloronitrobenzene			
m-Toluidine	4-Chloroaniline	Pentachlorophenol			
n-Decane	Acenaphthylene				
Nitrobenzene	a-Terpineol				
Nitrobenzene-d5, surr	Benzoic Acid				
N-Nitrosodimethylamine	Biphenyl				
N-Nitrosodi-n-propylamine	Caprolactam				
Phenol	Dimethyl Phthalate				
Phenol-d6, surr	Hexachlorobutadiene				
Pyridine 1,4-Dioxane	Hexachlorocyclopentadiene				
Phenol-d6, surr	Naphthalene				

Table 8

Recommended Minimum Response Factor Criteria from Initial and Continuing Calibration Verification Using the Suggested Ions in Table 5

Analyte	MRF
Benzaldehyde	0.010
Phenol	0.800
Bis(2-chloroethyl)ether	0.700
2-Chlorophenol	0.800
2-Methylphenol	0.700
2,2'-Oxybis-(1-chloropropane)	0.010
Acetophenone	0.010
4-Methylphenol	0.600
N-Nitroso-di-n-propylamine	0.500
Hexachloroethane	0.300
Nitrobenzene	0.200
Isophorone	0.400
2-Nitrophenol	0.100
2,4-Dimethylphenol	0.200
Bis(2-chloroethoxy)methane	0.300
2,4-Dichlorophenol	0.200
Naphthalene	0.700
4-Chloroaniline	0.010
Hexachlorobutadiene	0.010
Caprolactam	0.010
4-Chloro-3-methylphenol	0.200
2-Methylnaphthalene	0.400
Hexachlorocyclopentadiene	0.050
2,4,6-Trichlorophenol	0.200
2,4,5-Trichlorophenol	0.200
1,1'-Biphenyl	0.010
2-Chloronaphthalene	0.800
2-Nitroaniline	0.010
Dimethyl phthalate	0.010
2,6-Dinitrotoluene	0.200
Acenaphthylene	0.900
3-Nitroaniline	0.010
Acenaphthene	0.900
2,4-Dinitrophenol	0.010
4-Nitrophenol	0.010
Dibenzofuran	0.800
2,4-Dinitrotoluene	0.200
Diethyl phthalate	0.010
1,2,4,5-Tetrachlorobenzene	0.010

Table 8 (cont.)

Recommended Minimum Response Factor Criteria from Initial and Continuing Calibration Verification Using the Suggested Ions in Table 5

Analyte	MRF
4-Chlorophenyl-phenyl ether	0.400
Fluorene	0.900
4-Nitroaniline	0.010
4,6-Dinitro-2-methylphenol	0.010
4-Bromophenyl-phenyl ether	0.100
N-Nitrosodiphenylamine	0.010
Hexachlorobenzene	0.100
Atrazine	0.010
Pentachlorophenol	0.050
Phenanthrene	0.700
Anthracene	0.700
Carbazole	0.010
Di-n-butyl phthalate	0.010
Fluoranthene	0.600
Pyrene	0.600
Butyl benzyl phthalate	0.010
3,3'-Dichlorobenzidine	0.010
Benzo(a)anthracene	0.800
Chrysene	0.700
Bis-(2-ethylhexyl)phthalate	0.010
Di-n-octyl phthalate	0.010
Benzo(b)fluoranthene	0.700
Benzo(k)fluoranthene	0.700
Benzo(a)pyrene	0.700
Indeno(1,2,3-cd)pyrene	0.500
Dibenz(a,h)anthracene	0.400
Benzo(g,h,i)perylene	0.500
2,3,4,6-Tetrachlorophenol	0.010

Table 9
Difficult analytes

Aniline

Benzaldehyde
Benzidine
Benzoic acid
Benzyl alcohol

Caprolactam
4-Chloroaniline
4-chloro-3-methylphenol (p-chloro-m-cresol)

3,3-Dimethylbenzidine
1,4-Dioxane
Dimethylphthalate
2,4 Dinitrophenol
4,6-dinitro-2-methylphenol (4,6-dinitro-o-cresol)

Hexachlorocyclopentadiene
Hexachloroethane

2-Methylphenol
3-Methylphenol/4-Methylphenol

2-nitroaniline
3-nitroaniline
4-nitroaniline
4-Nitrophenol
Nitrosodiphenylamine and diphenylamine (NDPA/DPA)
n-Nitrosodimethylamine

Parathion
Pentachloronitrobenzene
Pentachlorophenol
Phenol
Pyridine

Total and Amenable Cyanide

Reference: **Method 9010C / 9012B,** SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Revision 2 and Revision 3 2004

SM 4500CN-CEG. Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF. Standard Methods Online.

Method 10-204-00-1-A, Lachat Instruments, 6645 West Mill Road, Milwaukee, WI 53218, 1994.

Method 9014 (Modified). SW-846, Test Methods for Evaluating Solid Waste: Physical / Chemical Methods, EPA SW-846, Update III, 1997

1. Scope and Application

Matrices: This method is applicable to waters, liquids, solids, soils and sludges

Definitions: Refer to Alpha Analytical Quality Manual.

The following SOP is a reflux-distillation procedure used to extract soluble cyanide salts and many insoluble cyanide complexes from wastes and leachates. It is based on the decomposition of nearly all cyanides by a reflux distillation procedure using a strong acid and a magnesium catalyst. Cyanide, in the form of hydrocyanic acid (HCN) is purged from the sample and captured into an alkaline scrubber solution. The concentration of cyanide in the scrubber solution is then determined by flow injection analysis on a Lachat Analyzer.

This method was designed to address the problem of “trace” analyses (<1000ppm). The method may also be used for “minor” (1000ppm – 10,000ppm) and “major” (>10,000ppm) analyses by adapting the appropriate sample dilution. However, the amount of sodium hydroxide in the standards and the sample analyzed must be the same.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the Lachat and in the interpretation of Lachat data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

The cyanide, as hydrocyanic acid (HCN), is released from samples containing cyanide by means of a reflux-distillation operation under acidic conditions and absorbed in a scrubber containing sodium hydroxide solution. The cyanide concentration in the absorbing solution is then determined colorimetrically by Lachat flow injection analysis.

2.1 Method Modifications from Reference

The sample size used is 50mL. The Midi distillation unit has demonstrated the ability to achieve the same RDL using 50mL instead of 500mL sample volume. Refer to EPA Method 335.4.

Modification for Method 9014: An automated determination of cyanide using the Lachat instrument is used instead of manual spectrophotometric determination.

Modification for amenable cyanide: Analysis is not prepped under amber light.

3. Reporting Limits

The Reported Limit for aqueous samples is 0.005mg/L; soil and solid samples is 1mg/Kg

4. Interferences

4.1 Interferences are eliminated or reduced by using the distillation procedure. However, chlorine and sulfide are interferences. Refer to Section 10.1.1.

4.2 High results may be obtained for samples that contain nitrate and/or nitrite. During the distillation, nitrate and nitrite will form nitrous acid, which will react with some organic compounds to form oximes. These compounds once formed will decompose under test conditions to generate HCN. The possibility of interference of nitrate and nitrite is eliminated by pretreatment with sulfamic acid just before distillation. Nitrate and nitrite are interferences when present at levels higher than 10mg/L and in conjunction with certain organic compounds.

4.3 Thiocyanate is reported to be an interference when present at very high levels. Levels of 10mg/L were not found to interfere.

4.4 Fatty acids, detergents, surfactants, and other compounds may cause foaming during the distillation when they are present in high concentrations. Add anti-foaming agent to the sample during the distillation procedure (Section 10.3.1).

4.5 Carbonates and aldehydes are possible interferences.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

The following chemicals have the potential to be highly toxic or hazardous. For detailed explanations consult the MSDS:

- Cyanide
- Sulfuric acid
- Pyridine
- Chloramine-T

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

Samples are collected in plastic or glass containers. All containers must be thoroughly cleaned and rinsed.

Oxidizing agents such as chlorine decompose most cyanides. Testing for chlorine must be done in the field prior to sample preservation.

6.2 Sample Preservation

Prior to preservation, samples must be tested for chlorine (Section 6.1).

Aqueous samples are preserved with 50% sodium hydroxide in the field to a pH $\geq$ 12 at the time of collection.

Samples and distillates are stored in the refrigerator at 4 ±2 °C.

6.3 Sample Shipping

No specific requirements.

6.4 Sample Handling

When properly preserved, cyanide samples are stored for up to 14 days prior to sample preparation steps.

Distillates must be analyzed within 14 days of distillation. Samples must be analyzed within 14 days of receipt.

Note: for MCP-TCN samples must be analyzed within 24h after distillation

7. Equipment and Supplies

7.1 Cyanide Midi Distillation Unit: Lab Crest, BGL or comparable midi distillation unit. With reaction vessels, collection vessels, cold fingers and impingers.

7.2 pH paper: Range 1-14

7.3 Lead Acetate Paper

7.4 Vacuum source

7.5 50mL centrifuge tubes: New, plastic, with caps.

7.6 KI starch paper: Residual Chlorine sensitivity

7.7 Class A volumetric flasks: 25, 50, 100, 500 and 1000mL

7.8 Graduated cylinders: 50mL glass or plastic

7.9 Eppendorf pipettor or pipets: 0.5, 1, 2, and 5mL

7.10 Lachat 8500 Flow Analyzer: Including Quick Chem software, autosampler, pump and accessories.

7.11 Balance: Capable of weighing to 0.0001gram

7.12 Beakers: 100mL

7.13 Chiller

7.14 Stir plate

7.15 Stir bars

7.16 Dilution vials

8. Reagents and Standards

Reagent grade chemicals are used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficient high purity to permit its use without lessening the accuracy of the determination.

8.1 Standards and Reagents for Distillation

8.1.1 Reagent Water: All references to water in this method refer to Deionized Water (DI) from Alpha's water treatment system.

8.1.2 Ascorbic Acid, $C_6H_8O_6$: Powder. Store at room temperature. Expires upon manufacturer's specified date.

8.1.3 Sodium hydroxide solution (1N), NaOH: In a 1L volumetric flask, dissolve 40g of NaOH. Bring to volume with DI water. Store at room temperature. Expires one month from date of preparation.

8.1.4 Sulfamic acid (0.4N), H_2NSO_3H: In a 1L volumetric flask, dissolve 40g H_2NSO_3H. Bring to volume with DI water. Store at room temperature. Expires 6 months from date of preparation.

8.1.5 Sulfuric acid (1:1), H_2SO_4: To a 1L volumetric flask, add 500mL DI water. Slowly and carefully add 500mL of concentrated H_2SO_4. Store at room temperature. Expires one month from date of preparation.

8.1.6 Magnesium chloride solution (2.5M), $MgCl_2 \cdot 6H_2O$: In a 1L volumetric flask, dissolve 510g of $MgCl_2 \cdot 6H_2O$. Bring to volume with DI water. Store at room temperature. Expires 6 months from date of preparation.

8.1.7 LCS, 1000ppm cyanide stock solution: Commercially available standard with a certificate of analysis and from a different source than the Lachat calibration standards. Purchased from Ricca, Catalog # 2543-32. Store refrigerated at 4 ± 2 °C. Expires upon manufacturer's specified date.

8.1.8 LCS 10ppm cyanide working solution: Pipet 1mL of 1000ppm cyanide stock solution (Section 8.1.7) into a 100mL volumetric flask. Add 10mL of 1N NaOH (Section 8.1.3). Bring to volume with DI water. Prepare each day of use.

8.1.8.1 This can also be made by taking 5mL of 10ppm (Section 8.1.8) up to 500mL with 0.1N NaOH. This would be distilled as a whole volume (50mL). Prepare daily.

8.1.9 1000ppm Stock Spiking Solution: 1000ppm cyanide standard available commercially with a certificate of analysis. This is from a different source than the LCS (8.1.7). Purchased from LabChem Inc., Catalog # LC13545. Store refrigerated at 4 ± 2 °C. Expires upon manufacturer's specified date.

8.1.10 10ppm Working Cyanide Spiking Solution: Pipet 1mL of the 1000ppm Stock Spiking Solution (Section 8.1.9) into a 100mL volumetric flask. Add 10mL 1N NaOH (Section 8.1.3). Bring to volume with DI water. Prepare fresh each day of use.**pH 4 Acetate Buffer solution:** In a 500mL volumetric flask, dissolve 410g of sodium acetate trihydrate. Bring to volume with DI water. Adjust to pH of 4.5 with acetic acid (Section 8.1.13). Store at room temperature. Expires 6 months from date of preparation.

8.1.11 Lead Carbonate Powder, [Pb (CO3)]

8.1.12 LCS 0.5 ppm Cyanide Working Solution: Pipet 5mL of the 10ppm Working Cyanide Spiking Solution (Section 8.1.10) into a 100mL volumetric flask . Add 1mL of 10N NaOH (Section 8.1.16). Bring to volume with DI water. Prepare each day of use.

8.1.13 Concentrated Acetic Acid: Store at room temperature. Expires upon manufacturer's specified date.

8.1.14 Ottawa Sand or Boiling chips

8.1.15 Sodium hydroxide solution (10N), NaOH: In a 1L volumetric flask, dissolve 400g of NaOH. Bring to volume with DI water. Store at room temperature. Expires 6 months from date of preparation.

8.1.16 Sodium hydroxide solution (0.1N), NaOH: In a 10L carboy mix 100mL of 10N NaOH. Bring to volume with DI water. Store at room temperature. Expires daily.

8.1.17 Total Cyanide SRM: ERA catalog # 541. Store in room temperature. Expires upon manufacturer's specified date.

8.1.18 Calcium Hypochlorite Solution: Dissolve 5g Ca(OCl)2 in 100mL Deionized water. Store in an amber colored bottle in the dark. Expires monthly.

8.2 Standards and Reagents for Lachat Analysis

8.2.1 Helium gas: To prevent bubble formation, degas all solutions except the standards with helium. Use He at 140kPa (20 lb/in^2) through a helium degassing tube (Lachat part number 50100). Bubble He vigorously through the solution for one minute.

8.2.2 Reagent 1. Carrier, 0.1N Sodium Hydroxide: In a 1L plastic container add 10mL of 10N NaOH (Section 8.1.16). Bring to 1L volume with DI. Store at room temperature. Prepare fresh bi-weekly.

8.2.3 Reagent 2. Acetate Buffer, 2.68M: In a 1L volumetric flask, dissolve 163g spdium acetate trihydrate (acetic acid, sodium salt trihydrate, $CH_3CO_2NA•H_2O$) in approximately 800mL of water. Add 40mL of acetic acid to solution. Dilute to the mark and invert to mix. Store at room temperature. Prepare fresh monthly.

8.2.4 Reagent 3. Chloramine-T: Dissolve 2.0g chloramine-T hydrate in 500mL DI. Prepare fresh daily.

8.2.5 Reagent 4. Pyridine-Barbituric Acid Reagent: Under a fume hood, place 15g barbituric acid in a 1L beaker and add 100mL water, rinsing down the sides of the beaker to wet the barbituric acid. Add 75mL pyridine (C_5H_5N) while stirring and mix

until the barbituric acid dissolves. Add the 15mL concentrated hydrochloric acid (12M HCl) and mix. Store at room temperature. Prepare fresh weekly.

8.2.6 **0.5ppm Calibration standard:** Pipet 5mL of the 10ppm working cyanide spiking solution (Section 8.1.10) into a 100mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use.

8.2.7 **0.2ppm Calibration standard:** Pipet 2mL of the 10ppm working cyanide spiking solution (Section 8.1.10) into a 100mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use.

8.2.8 **0.1ppm Calibration standard:** Pipet 1mL of the 10ppm working cyanide spiking solution (Section 8.1.10) into a 100mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use. This calibration standard is also used as the Continuing Calibration Verification sample.

8.2.9 **0.04ppm Calibration standard:** Pipet 5mL of the 0.2ppm calibration standard (Section 8.2.7) into a 25mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use.

8.2.10 **0.02ppm Calibration standard:** Pipet 1mL of the 0.5ppm calibration standard (Section 8.2.6) into a 25mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use.

8.2.11 **0.01ppm Calibration standard:** Pipet 10mL of the 0.02ppm calibration standard (Section 8.2.10) and 10mL of 0.1N NaOH into a container and mix. Prepare each day of use.

8.2.12 **0.004ppm Calibration standard:** Pipet 5mL of 0.04ppm calibration standard (Section 8.2.9) into a 50mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use.

8.2.13 **0.1ppm ICV standard:** Pipet 1mL of the 10ppm LCS cyanide working solution (8.1.8) into a 100mL volumetric flask. Bring to volume with 0.1N NaOH. Prepare each day of use.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank

A minimum of one method blank is distilled and analyzed per batch of 20 or less samples. The Method Blank is utilized to determine if contamination or any memory effects are occurring. (Section 10.3.1.1) The blank result must be less than the reporting limit of 0.005 mg/L for liquids and 1 mg/kg for soils. If the blank result is outside of acceptance criteria, it is injected another time. If failure continues, sample analysis is terminated and the source of the problem is found and corrected. All samples analyzed since the last acceptable blank analysis must be reanalyzed.

9.2 Laboratory Control Sample (LCS)

Distill and analyze two LCSs per batch of 20 samples. A Low LCS is analyzed at 0.1mg/L and a high LCS is analyzed at 0.2mg/L. (Section 10.3.1.2)

LCS measurements for Method SM 4500 CN-CE must be within ±10%. For Method 9010C/9012B, the LCS measurements must be within ± 15% for liquids and +/- 20% for soils.

Samples for Method 9010C/9012B: LCSDs are distilled and analyzed along with the LCSs, as described above. The RPD between LCS and LCSD must be ≤ 20% for liquids and <35% for soils.

For soil samples: LCS and LCSD recovery must be within vendor specified acceptance criteria (it will be different for different lots of SRM)

If any LCS fails acceptance criteria for either % Recovery or RPD, analysis is terminated and samples are redigested and analyzed

9.3 Initial Calibration Verification (ICV)

The Initial Calibration Verification Standard (ICV) (Section 8.2.13) is analyzed immediately following the calibration to verify the curve. If the measurements exceeds ±10% of 0.1ppm, the analysis is terminated and recalibration must occur. An acceptable result for the ICV must be obtained prior to any sample analysis.

9.4 Continuing Calibration Verification (CCV)

The Continuing Calibration Verification Standard (CCV) (Section 8.2.8) is analyzed after every 10 injections. The CCV measurements cannot exceed ±10% of the 0.1ppm. If the CCV is not within acceptance criteria, the standard is injected again. If failure continues, sample analysis is terminated and the source of the problem is found and corrected. All samples analyzed since the last acceptable calibration verification must be reanalyzed.

9.5 Matrix Spike

Distill and analyze one spike per batch of 20 samples. For Method 9010C/9012B distill and analyze one spike per batch of 10 samples.

For Method 9010C/9012B, the % Recovery must be within ±20% for liquids and ±35% for solids. For SM 4500CN-CE, the % Recovery must be within ±10%. (Section 10.3.1.4).

Samples for Method 9010C/9012B: A Matrix Spike Duplicate (MSD) is distilled and analyzed along with the MS, as described above. The RPD between MS and MCSD must be ≤ 20% for liquids and <35% for soils

9.6 Laboratory Duplicate

Analyze one duplicate sample for every 20 samples. A duplicate sample is a sample brought through the entire sample preparation and analytical process. (Section 10.3.1.5)

The RPD must be 20% or less for liquids and 35% or less for soils and solids. See Section 12 for Corrective Action if these criteria are not met.

9.7 Method-specific Quality Control Samples

None.

9.8 Method Sequence

The analytical sequence is:

- Screening of samples for chlorine and sulfide
- Prep of amenable cyanide, if needed
- Distillation:
    - Samples

- LCS Low
- LCS High
- Blank
- Matrix Spike
- Duplicate

- Analysis:
  - Calibration and Standardization of Lachat Instrument
  - CCV
  - CCB
  - ICV
  - ICB
  - 10 samples
  - CCV
  - CCB
  - 10 samples
  - CCV
  - CCB
  - Calculation of sample cyanide concentration

10. Procedure

10.1 Equipment Set-up

10.1.1 Screening for Chlorine and Sulfide Interference

10.1.1.1 Chlorine Interference

Oxidizing agents, such as chlorine, decompose most cyanides. Test by placing a drop of sample on a strip of potassium iodide (KI) - starch paper previously moistened with acetate buffer solution, pH 4. If positive indication is noted, then treat an aliquot of sample with Ascorbic Acid (Section 8.1.2). Repeat this test until the KI paper is negative. Immediately inform the Department Supervisor of this interference.

Manganese dioxide, nitrosyl chloride, etc., if present also may cause discoloration of the test paper

10.1.1.2 Sulfide Interference

Oxidized products of sulfide convert CN- to SCN- rapidly, especially at high pH. Test for S^{-2} by placing a drop of sample on lead acetate test paper previously moistened with acetic acid buffer solution, pH 4 (Section 8.1.11). Darkening of the paper indicates presence of S^{-2}. Add powdered lead carbonate [Pb (CO3)] in 1g increments to the whole sample volume. Re-test with acetate paper. Repeat test until a drop of treated sample no longer darkens the acidified lead acetate test paper. Record in the sample prep logbook the amount of lead carbonate added to the sample.

10.1.2 Amenable Cyanide Prep

10.1.2.1 Add 25mL, or 1g and 25mL of DI (8.1.1), to a 100mL beaker with a stir bar.

10.1.2.2 Add 1mL of 10ppm LCS cyanide working solution (8.1.8) to beaker.

10.1.2.3 Prep one sample in duplicate.

10.1.2.4 Add 1-2mL of calcium hypochlorite solution (8.1.18) to all samples and QC under the hood.

10.1.2.5 Check for the presence of chlorine by placing a drop of the sample on a KI-starch paper (7.6). It should turn blue if there is sufficient chlorine.

10.1.2.6 Check samples every 15 minutes for one hour for the presence of chlorine and add more calcium hypochlorite if needed.

10.1.2.7 After one hour of digesting, add ascorbic acid (8.1.2) until KI strip no longer turns blue.

10.1.2.8 Bring sample volume up to 50mL and distill following steps 10.3.1.6 thru 10.3.1.15.

10.2 Initial Calibration

10.2.1 Allow 15 minutes for heating unit to warm up to 60 °C.

10.2.2 Prepare a series of 7 calibration standards (Sections 8.2.6 – 8.2.12) and a 0.1N NaOH blank. Alternatively, calibration standards may be prepared by auto-diluting a 0.5ppm calibration standard (Section 8.2.6). Perform this function per the Lachat manufacturer's instructions for the Quick Chem 8500.

10.2.3 Set up manifold as shown in Table 1.

10.2.4 Input data system parameters as shown in Table 2.

10.2.5 Place standards and blank in the autosampler, per the manufacturer's instructions. Input the information required by the data system, such as concentration, replicates and QC scheme.

10.2.6 Inject the standards, per the manufacturer's instructions.

10.2.7 Prepare a standard curve by plotting instrument response against standard concentration values. A calibration curve is fitted to the calibration solution concentration/response data using the computer. The calibration coefficient of the curve must be greater than or equal to 0.995 before sample analysis can begin.

Calibration coefficient will be calculated using Lachat software. All calibration points are back calculated by Lachat software and should be within 10% from true concentration, except 2 lowest points of calibration curve. %recoveries for low range will be wider, but shouldn't exceed 100% and correlation coefficient will not be worse than 0.995.

10.3 Equipment Operation and Sample Processing

10.3.1 Distillation

10.3.1.1 Add 50mL of shaken liquid sample, or 1gram of a well-homogenized solid sample and 50mL of DI, to the 50mL reaction vessel.

10.3.1.2 For the Liquid High LCS, fill one 50mL reaction vessel with 50mL DI. For the soil High LCS, add 1g Ottawa Sand (Section 8.1.15) and 50mL of DI. After the system has been charged with air, add 1mL of 10ppm LCS cyanide working solution (8.1.8) to the closed system. (Final concentration equals 0.2mg/L.)

For the Liquid Low LCS, fill one 50mL reaction vessel with 50mL of DI. For a soil Low LCS, add 0.2-0.3 g (depending on actual SRM stock concentration) of SRM (sec 8.1.17) and 50mL of DI. Record exact SRM weight. For liquid samples: After

the system has been charged with air, add 0.5mL of 10ppm LCS cyanide working solution (Section 8.1.8) to the closed system. (Final concentration equals 0.1mg/L.) **Don't add liquid Cyanide Standard for soil samples!** Final LCS soil concentration will change based on SRM lot
Samples for Method 9010C/9012B: Prepare a LCS Duplicate along with the LCSs described above.

10.3.1.3 For the method blank for liquid samples, fill one 50mL reaction vessel with 50mL of DI. For the method blank for soil samples, fill a 50mL reaction vessel with 1g of Ottawa Sand (Section 8.1.15) and 50mL DI.

10.3.1.4 For the matrix spike, fill a 50mL reaction vessel with 50mL of sample that has been chosen to be spiked. For soil samples, use 1g of soil and add 50mL of DI water. After the system has been charged with air, add 1mL of 10ppm working cyanide spiking solution (8.1.10) to the closed system.

Samples for Method 9010C/9012B: Prepare a Matrix Spike Duplicate (MSD) in the same manner as the MS, as described above.

10.3.1.5 For the duplicate, fill a 50mL reaction vessel with a duplicate aliquot of 50mL, or 1g soil and 50mL DI water of a sample that has been chosen to be duplicated.

10.3.1.6 Into the receiver or scrubber tube add 5mL of a 1N NaOH solution and add 40mL of DI water.

10.3.1.7 Arrange tubes in the distillation unit noting in the logbook which sample is in which glassware. The glassware is numbered and consistently placed in the same position in the distillation unit.

10.3.1.8 Assemble the unit completely. Turn on the pump. There must be gas bubbling in each tube. Check to make sure all connections are tight and bubbles are flowing at an equal rate in each sample tube. If not, adjust flow rate with the knobs in front of each receiver tube and/or check lines to ensure they are not obstructed.

10.3.1.9 Add 5mL of 0.4N sulfamic acid (8.1.4) to each sample tube and rinse the closed 50mL reaction vessel with a squirt of DI. No residue is to be left of the vessel wall.

10.3.1.10 Add 5mL of 1:1 H_2SO_4 (8.1.5) to each sample tube and rinse the closed 50mL reaction vessel with a squirt of DI. No residue is to be left on the vessel wall. Turn on the heat. Samples are to come to a boil on all of the midi-still units.

10.3.1.11 After 2 minutes of heating, add 2mL of 2.5M $MgCl_2$ Solution (8.1.6) to each sample tube, followed by a rinse with DI. If foaming occurs, an additional 2mL of $MgCl_2$ Solution may be added. If foaming continues, stop the distillation for that sample and reduce the sample size by 2 – 5x (as determined by the severity of the foaming). Contact the Inorganics Supervisor for guidance.

10.3.1.12 Turn on the chiller.

10.3.1.13 Set the timer-dial on the distillation unit to "110".

10.3.1.14 After 110 minutes the unit will shut off; leave the chiller running for an additional 30 minutes while the tubes cool down.

10.3.1.15 Pour contents of the scrubber tube into a new, labeled, centrifuge tube (Section 7.5). Carefully rinse the scrubber tube with DI water and add rinseate to the centrifuge tube to bring to 50mL volume. Cap and refrigerate for later analysis by the Lachat Instrument.

10.3.2 Lachat Analysis

10.3.2.1 Following initial calibration and standardization, (Section 10.2 and 10.4), place the samples in the autosampler, per the manufacturer's instructions. Input the information required by the data system, such as concentration, replicates and QC scheme.

10.3.2.2 Inject the samples, per the manufacturer's instructions.

10.3.2.3 The data system calculates sample concentration using the regression equation. Results are mg/L for Aqueous samples and mg/Kg for soil and solid samples.

10.3.2.4 If sample concentrations are greater than the highest calibration standard, the distilled sample is diluted with 0.1N sodium hydroxide (NaOH) diluent (Section 8.2.2), and reanalyzed. When the automated diluter is used, 0.1N NaOH is also used. **Do not dilute distilled samples or standards with DI water.**

10.4 Continuing Calibration

10.4.1 After the calibration has been established, it must be verified by the analysis of an Initial Calibration Verification Standard (ICV) (Section 8.2.13). The ICV of 0.1ppm must be made from a different source than the calibration standards. If the measurements exceed ±10% of 0.1ppm, the analysis is terminated. See Section 9.3 for Corrective Actions.

10.4.2 A Blank and a Continuing Calibration Verification (CCV) sample (Section 8.2.8) are analyzed after every 10 injections. The CCV measurements cannot exceed ±10% of the CCV value of 0.1ppm and the blank result must be less than the reporting limit of 0.005 mg/L. See Section 9.4 for CCV Corrective Actions and Section 9.1 for Blank corrective actions.

10.5 Preventive Maintenance

Preventative maintenance is recorded in the instrument maintenance logbook and is performed on the Lachat instrument as follows:

Daily:

1) Clean the autosampler
2) Clean the surfaces on the auto-dilutor
3) Prime the dilutor with fresh DI water
4) Clean the pump surfaces
5) Clean the detector with DI and dry with Kim-Wipes
6) Clean the instrument surfaces with DI, wipe clean with a paper towel

Bi-weekly:

1) Clean the injection ports with DI. Take apart the injection valve and inspect it for corrosion. Make sure that the valve connectors are tight and the o-rings are not worn. If the O-rings look worn replace with new ones.

Monthly:

1) Using DI water, clean the unions and the tees that are associated with the manifold.
2) Delete Temporary files on the computer

Every 6 months:

1) Replace the o-rings in the injection valve.
2) Replace the o-rings in the manifold

3) Back up the files on the computer

11. Data Evaluation, Calculations and Reporting

11.1 The Lachat data system calculates sample concentration using the regression equation.

11.2 Report only those values that fall between the lowest and the highest calibration standards.

11.3 Report results in mg CN/L for liquids and in mg CN/kg for soils.

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

Holding time exceedance and improper preservation are noted on the nonconformance report form. The analyst narrates the nonconformance when the project is turned in for review. The narration must state what the nonconformance was and any corrective action taken.

Perform routine preventative maintenance according to Section 10.5. Record all maintenance in the instrument logbook. Notify the Department Manager if the instrument problems are not routine in nature. The Department Manager determines whether the problem can be corrected with in-house technical staff or if the instrument vendor should be contacted to schedule service. All service calls are documented in the Instrument logbook, and a copy of the service report is given to the Department Manager.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. If any part of batch quality control does not meet acceptance criteria, the Department Manager is notified. If enough sample remains and holding time has not expired, then the batch is redistilled and reanalyzed. If there is not sufficient sample remaining to allow redistillation, then that analysis is repeated and both sets of data are reported with the nonconformance narrated on the final report.

If either the ICV, ICB, Method Blank, LCS, LCSD, CCV, or CCB recovery falls outside the designated acceptance range, the laboratory performance is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate nonconformance action form.

Immediate corrective action for a failing CCV/CCB includes reanalyzing the failing standard. If the standard passes the second time then the analysis may be continued. The raw data is noted. If the standard fails again, the problem must be found and corrected. The CCV/CCB standard is remade and reanalyzed. If the standard passes, all samples analyzed since the previous passing standard are reanalyzed. The raw data is noted and all data associated with the failing standard must have one line drawn through the data, indicating it's unable.

If the standard fails after instrument maintenance, the instrument is recalibrated. A new ICV/ICB is performed, and all samples analyzed since the previous passing CCV/CCB are reanalyzed.

If following reanalysis of the LCS, it is found to still be outside acceptance criteria, the entire sample batch must be redistilled and reanalyzed. If the %RPD between the LCS/LCSD fails after reinjection, then the entire sample batch must be redistilled and reanalyzed.

If the Method Blank fails it is re-poured and reinjected. If failure continues, the associated sample data is evaluated as follows: Sample results below the detection limit may be reported with a narrative included. If samples have positive results, and the results are greater than 10x the concentration found in the method blank, the data may be reported with a narrative included. Any positive samples with results less than 10x the concentration found in the method blank must be redistilled and reanalyzed.

If the Matrix Spike recovery does not meet acceptance criteria, and the LCS recovery is acceptable, matrix interference may be assumed. The associated data may be reported with a narrative included.

If sample Duplicates are outside of the acceptance criteria, the analyst examines the sample for homogeneity. If the sample is not homogenous, this is narrated on the final report. Clean, homogenous samples are redistilled and reanalyzed within holding time.

Sample nonconformance regarding a Matrix Spike recovery or a duplicate %RSD is narrated on the final report along with the corrective action(s) taken.

13. Method Performance

13.1 Detection Limit Study (DL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP ID 1732. These studies performed by the laboratory are maintained on file for review.

The quarterly method reporting limit (MRL) verification requirement is satisfied by the quarterly LOQ analysis, as per SOP/1732.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP ID 1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Hazardous Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

2121 Chemical Hygiene Plan

1732 Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ) SOP

1739 Demonstration of Capability (DOC) Generation SOP

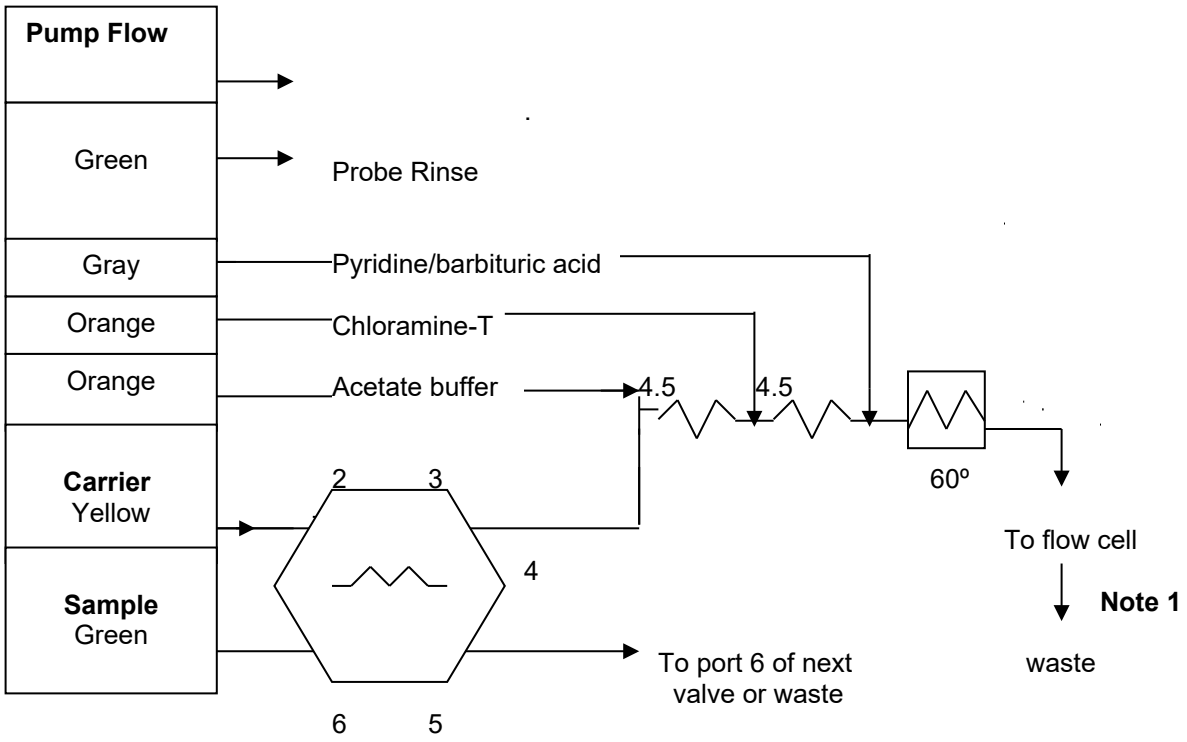
1728 Hazardous Waste Management and Disposal SOP

16. Attachments

TABLE 1: Cyanide Manifold Diagram

TABLE 2: Data System Parameters for QC 8500

TABLE 1
Cyanide Manifold Diagram



Sample Loop = 150cm x 0.8mm i.d. Interference Filter = 570nm
QC8000 Sample loop = 150cm x 0.8mm i.d.

CARRIER is 0.1 N sodium hydroxide solution.

All manifold tubing is 0.8mm (0.030 in) i.d. This is 5.2µL/cm.

4.5 is 70.0cm of tubing on a 4.5cm coil support

APPARATUS: An injection valve, flow cell, a 10mm path length flow cell, and a colorimetric detector module are required.

The box  shows 650cm of tubing wrapped around the heater block at the specified temperature.

Note 1: 2 meter back pressure loop, 0.52mm i.d.

TABLE 2
Data system Parameters for QC 8500

The timing values listed below are approximate and will need to be optimized using graphical events programming.

Sample Throughput: 65 samples/hour, 55 s/sample
Pump Speed: 35
Cycle Period: 55

Analyte Data:

Concentration Units: mg CN^-/L
Peak Base Width: 60.5 s
% Width Tolerance: 100
Threshold: none
Inject to Peak Start: 55 s
Chemistry: Direct

Calibration Data:

Levels	1	2	3	4	5	6	7	8
Concentration ug/50mL	25	10	5	2	1	0.5	0.2	0

Calibration Fit Type: 1st Order Polynomial
Calibration Rep. Handling: Replace
Weighting Method: 1/X
Concentration Scaling: None
Force Through Zero: No

Sampler Timing:

Min. Probe in Wash Period: 14 s
Probe in Sample Period: 13 s

Valve Timing:

Load Time: 0.0 s
Load Period: 9 s
Inject Period: 20 s

Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)

References: **Method 8260D**, SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update VI (Phase II), June 2018.

Method 5035A, SW-846, Closed System Purge & Trap and Extraction for Volatile Organics in Soil and Waste Samples. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Draft Revision I, July 2002.

Method 5030B, Purge & Trap for Aqueous Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update III, December 1996.

Method 5030C, Purge & Trap for Aqueous Samples. SW-846, Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, EPA SW-846, Update IV, May 2003.

1. Scope and Application

Matrices: Method 8260 is used to determine volatile organic compounds in a variety of solid waste matrices. This method is applicable to nearly all types of samples, 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.

Definitions: Refer to Alpha Analytical Quality Manual.

The compounds listed in Table 5 may be determined by this method.

There are various techniques by which these components may be introduced into the GC/MS system. Purge-and-trap, by Methods 5030C (aqueous samples) and 5035A (solid and waste oil samples), is the most commonly used technique for volatile organic analytes. However, other techniques are also appropriate and necessary for some analytes. One technique is direct injection of an aqueous sample (concentration permitting).

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Department Manager, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the gas chromatograph/mass spectrometers and in the interpretation of mass spectra and their use as a quantitative tool. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

2. Summary of Method

The volatile compounds are introduced into the gas chromatograph by the purge-and-trap method or by direct injection. The analytes are introduced to a narrow-bore capillary column for analysis. The Gas Chromatograph (GC) is temperature-programmed to separate the analytes, which are then detected with a mass spectrometer (MS) interfaced to the GC.

Analytes eluted from the capillary column are introduced into the mass spectrometer via a direct connection. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact (or electron impact-like) spectra of authentic standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard, comparing sample response to the calibration standards.

2.1 Method Modifications from Reference

None.

3. Reporting Limits

Table 1 lists our typical reporting limits.

4. Interferences

4.1 Impurities in the purge gas, organic compounds out-gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be free from contamination under the conditions of the analysis. Running laboratory reagent blanks as described in Section 9.1 and 10.3 demonstrates the system is free of contamination. The use of non-Teflon plastic tubing, non-Teflon thread sealants, or flow controllers with rubber components in the purge and trap system must be avoided.

4.2 Sample contamination occurs by diffusion of volatile organics (particularly fluorocarbons and methylene chloride) through the septum seal into the sample during shipment and storage. A trip blank or a field reagent blank prepared from reagent water and carried through the sampling and handling protocol serves as a check on such contamination.

4.2.1 Storage blanks shall be analyzed if contamination is suspect. If contamination is confirmed by positive detections in the sample storage blanks, all data from samples contained in the relative refrigerator or freezer shall be evaluated for possible contamination. If the samples contain suspected contamination, the Client Services department shall be notified in order to contact the necessary clients regarding the contamination. Samples shall be reanalyzed if so desired by the client. If suspected contamination is not confirmed by storage blanks, no further action shall be pursued concerning said blanks. It is recommended that further action be taken to determine the possible cause of suspected contamination.

4.3 Contamination by carry-over can occur whenever high level and low level samples are sequentially analyzed. Whenever a highly concentrated sample is being encountered, it should be followed by an analysis of reagent water (instrument blank) to check for potential contamination. If carry-over is suspected, then numerous instrument blanks may be required; additionally, all affected samples are rerun for confirmation. In case of severe contamination, preventive maintenance of the entire system may be required.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of safety data sheets (SDS) is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

The following method analytes have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, 1,4-dichlorobenzene, 1,2-dichloroethane, hexachlorobutadiene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, chloroform, 1,2-dibromoethane, tetrachloroethene, trichloroethene, and vinyl chloride. Pure standard materials and stock standard solutions of these compounds should be handled in a hood. A NIOSH/MESA approved toxic gas respirator should be worn when the analyst handles high concentrations of these toxic compounds.

5.1 Lab coats, safety glasses, and gloves must be worn when handling samples, standards, or solvents.

5.2 All stock solution standard preparation must be performed in the volatiles hood. Initial calibration, continuing calibration, laboratory control sample and client sample dilutions do not need to be performed in the hood.

5.3 All expired standards must be placed into the waste bucket in the lab for future disposal. The container must be labeled properly with hazard warning labels indicating the container contents.

5.4 Bottles containing Methanol must be stored in the flammables cabinet.

6. Sample Collection, Preservation, Storage, Shipping and Handling

6.1 Sample Collection and Preservation

6.1.1 Aqueous Samples

Grab samples are collected in standard 40mL glass screw-cap vials with Teflon lined silicon septa (VOA vial). Two or more VOA vials should be filled per sample location. EPA Method 8260 requires that samples be acidified to eliminate the possibility of biological degradation. Unless otherwise directed for project-specific reasons, all VOA vials are delivered to the client with approximately 2 – 4 drops of 1:1 HCl added to the vial, which is sufficient to adjust the pH of the sample to < 2. Prepared trip blanks are provided to the client to accompany field samples for QC purposes.

Fill the sample vial to the point of overflowing so that no headspace is contained within. Samples must be introduced into the vials gently to reduce agitation, which might drive off volatile compounds or cause loss of the HCl preservative.

Seal the bottle so that no air bubbles are in the VOA vial. If preservative has been added, shake vigorously for one minute. Invert the bottle and tap to check for air bubbles. Recollect the samples if any air bubbles are present.

Maintain the hermetic seal on the VOA vial until time of analysis.

6.1.2 Soil Samples

The recommended sampling method for soil samples is EPA 5035A. Method 5035A provides for two distinct sampling procedures, depending on the required reporting limits and suspected or known concentration levels of target analytes. These methods are referred to as the High Level and Low Level methods. Both are listed below but depending on the samples only one of the methods may be required. If concentration levels are unknown, it is recommended that samples be collected using both procedures.

The Lab will analyze the high level sample first, followed by the low level sample if the results from the high level analysis show that the sample is clean or contains analytes at low levels. The typical reporting levels of the two methods are listed in Table 1.

6.1.2.1 High Level Soil Samples

Collect sample in a standard 40mL glass screw-cap vial with Teflon lined silicon septa (VOA vial). The vial is provided containing 15mL of Purge and Trap Grade methanol and is labeled and weighed prior to addition of sample. Record the weight of the vial with methanol on the vial label. Prepared trip blanks are provided to the client to accompany field samples for QC purposes.

Approximately 15g of soil is added to the vial in the field, making sure that the sample is completely covered by the methanol.

Maintain the hermetic seal on the VOA vial until the time of analysis.

An additional sample of the soil must also be obtained (without methanol) to be used for the determination of soil moisture content to allow for the calculation of the dry weight results, and to calculate the methanol dilution effect. (See Sections 11.2.2.2 and 11.2.2.2.1)

6.1.2.2 Low Level Soil Samples

Collect sample in a standard 40mL glass screw-cap vials with Teflon lined silicon septa (VOA vial). Two samples should be taken per sample location. Vials are provided containing a magnetic stirring bar and 5 mL of either 200g/L sodium bisulfate solution or water, prepared by a certified vendor. These vials are labeled and weighed prior to addition of sample. Record the weight of the vial with the stirring bar and preservative on the vial label.

Approximately 5g of soil is added to the vial in the field, making sure that the sample is completely covered by the sodium bisulfate solution or water.

Maintain the hermetic seal on the VOA until the time of analysis.

6.2 Sample Handling and Storage

Document client specific sample handling, preservation and collection criteria in the project file. The laboratory Log-in staff documents sample temperature at the time of receipt.

Record deviations from this SOP or client specific criteria on the chain of custody form.

Record holding time exceedance, improper preservation and observed sample headspace on the nonconformance report form.

6.2.1 Aqueous Samples

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 1 and 4 °C. Sample receiving personnel must note on the sample delivery group form when samples received at the laboratory are not within the temperature criteria. If more than one vial is received for a sample, the vials are stored in separate refrigerators. Storing the vials apart provides a useful check if laboratory contamination of a sample is suspected. Samples must be analyzed within 14 days of collection. Unpreserved samples must be analyzed within 7 days of collection.

6.2.2 High Level Soil Samples

Ice or refrigerate all samples from the time of collection until analysis, maintaining the sample temperature between 2 and 6 °C. Sample receiving personnel note on the

nonconformance report form when samples received at the laboratory are not within the temperature criteria. Samples must be analyzed within 14 days of collection.

6.2.3 Low Level Soil Samples

Ice or refrigerate samples preserved with water or sodium bisulfate from the time of collection until analysis, maintaining the sample temperature between 2 and 6 °C. Samples preserved with water are to be immediately frozen after sampling. Sample receiving personnel note on the nonconformance report form when samples received at the laboratory are not within the temperature criteria. Samples must be analyzed within 14 days of collection.

6.3 Sample Shipping

Samples requiring shipment to the laboratory are shipped in ice-packed coolers via an overnight delivery service in accordance with applicable Department of Transportation regulations.

7. Equipment and Supplies

7.1 Purge and Trap System (For Aqueous samples): The purge-and-trap system consists of two separate pieces of equipment: a purging device (autosampler) (TekmarAtomxXYZ, EST Centurion or equivalents) coupled to the desorber (concentrator) (EST Encon or Encon EV, or equivalents).

7.1.1 Purge gas = Helium analytical grade (99.999%) or Nitrogen analytical grade (99.999%).

7.1.2 The purging device is configured with 25 mL sample purge tubes, and the purge gas is introduced at the bottom of the water column as finely divided bubbles.

7.1.3 The trap used in the desorber is typically a Supelco “K” trap. Different traps may be used if equivalent performance is demonstrated.

7.1.4 The desorber is capable of rapidly heating the trap to 260^{o}C. The trap is not heated above manufacturer’s specifications.

7.2. Purge and Trap System (For Low Level and High Level Soil Samples): The purge and trap system consists of two separate pieces of equipment: a purging device (autosampler) (Tekmar AtomxXYZ, EST Centurion or equivalents) coupled to the desorber (concentrator) (Tekmar Velocity or Atomx, or EST Encon or Encon EV, or equivalents).

7.2.1 Purge gas = Helium analytical grade (99.999%) Nitrogen analytical grade (99.999%).

7.2.2 The autosampler purging device is a closed system, designed to accept the 40mL VOA vials. The VOA vial, containing the soil sample, water (or sodium bisulfate), and stirring bar is placed into the autosampler tray. The instrument automatically adds reagent water, internal standards, and surrogates to the unopened VOA vial. The vial is heated to 40 °C, and the purge gas is introduced into the aqueous portion to purge the volatile components onto the trap.

7.2.3 The trap used in the desorber is typically a Supelco “K” trap. Different traps may be used if equivalent performance is demonstrated.The desorber is capable of rapidly heating the trap to 260 °C. The trap is not heated above manufacturer specifications.

7.3 Gas Chromatography/Mass Spectrometer/Data System:

7.3.1 Gas Chromatograph, Agilent 6890/7890 or equivalent: An analytical system complete with a temperature-programmable gas chromatograph with appropriate

interface for sample introduction device. The system includes all required accessories, including syringes, analytical columns, and gases. The capillary column is directly coupled to the source of the GC/MS system.

7.3.2 Typical Gas Chromatographic Columns:

7.3.2.1 Column 1: Restek 502.2, 40 meter, 0.18mm ID, 1.0um, or equivalent.

7.3.2.2 Column 2: Restek RTX-VMS, 30 meter, 0.25mm ID, 1.4um, or equivalent.

7.3.2.3 Column 3: Restek RTX-VMS, 20 meter, 0.18mm ID, 1.5um, or equivalent.

7.3.3 Mass Spectrometer, Agilent 5973/5975/5978 or equivalent: Capable of acquiring mass spectra from mass/charge (m/z) 35 to 270 at a rate fast enough to acquire at least five (but preferably 10 or more) mass spectra across each chromatographic peak of interest, 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 all of the criteria in Table 3, when 50ng of the GC/MS tuning standard (BFB) are injected through the GC. For all SIM analysis, the mass spectrometer must also be able to acquire data in a dual acquisition mode (SIM and full scan).

7.3.4 Data System: Hewlett-Packard EnviroQuant software is used for data acquisition and allows the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program.

EnviroQuant E.02.02 (or equivalent) is used for data processing and allows searching of any GC/MS data file for ions of a specified m/z, and plotting such ion abundances versus time or scan-number.

The most recent version of the EPA/NIST Mass Spectral Library is loaded onto the Target / EnviroQuant data system.

7.4 Wiretrol or Micro syringes: 10µL - 1,000µL.

7.5 Syringes: 5mL, 10mL, or 25mL, glass with Luerlock tip.

7.6 Balances: Top-loading, capable of weighing 0.01g.

7.7 Vials: 2mL, 4mL.

7.8 Disposable Pipets.

7.9 Volumetric Flasks: Class A, appropriate sizes, with ground-glass stoppers.

7.10 Eppendorf pipets.

7.11 Ottawa Sand: SiO_2

8. Reagents and Standards

Reagent grade organic chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all organic reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

Great care must be taken to maintain the integrity of all standard solutions. Standards in methanol are stored at –10ºC or less, in amber vials with PTFE-lined screw-caps.

8.1 Organic-free Reagent Water:

All references to water in this method refer to organic-free reagent water, which is tap water passed through activated carbon and air bubbled through.

8.2 Methanol:

Purge and Trap Grade or equivalent. Store in flammables cabinet.

8.3 Stock Solutions:

All stock standards are purchased from commercial vendors as certified ampule solutions. When an ampule of stock solution is opened, it is transferred to a labeled amber screw-cap vial with minimal headspace. The expiration date of the stock solution is either the vendor specified expiration date or 6 months from the date the ampule was opened, whichever is sooner. Typical stock standard concentrations are listed in Table 4.

8.4 Intermediate Standards: Intermediate standards are prepared volumetrically by diluting the appropriate stock standard(s) with methanol. Initial Calibration solutions expire 2 months from the date of preparation, or sooner if daily continuing calibration checks do not achieve the method acceptance criteria. If the Intermediate Standards are used as a second source to verify a valid Initial Calibration solution, there is no expiration date.

8.4.1 Internal Standard Solutions:

The internal standards are Fluorobenzene, Chlorobenzene-d_5, and 1,4-Dichlorobenzene-d_4. The intermediate IS solution is prepared by diluting the stock solution(s) with methanol to a concentration of 100 µg/mL. The appropriate amount of IS solution is added to the water or soil sample or QC sample to achieve a final concentration of 100 ng/sample or standard. Internal standard is added at the same concentration to all standards, samples, and QC samples.

8.4.2 Surrogate Standard Solutions:

The surrogate standards are Dibromofluoromethane, 1,2-Dichloroethane-d_4, Toluene-d_8, and 4-Bromofluorobenzene. The intermediate surrogate solution is prepared by diluting the stock solution(s) with methanol to a concentration of 100 µg/mL. The appropriate amount of surrogate solution is added to the water or soil sample or QC sample to achieve a final concentration of 100 ng/sample.

8.4.3 Target Compound Solutions:

The target analytes routinely reported by this method are listed in Table 1 and 4. The intermediate target compound solutions are prepared by diluting the stock solution(s) with methanol. This set of solutions, at concentrations of 200 µg/mL, is used for preparation of the calibration standards.

8.4.4 4-Bromofluorobenzene (BFB) Tune solution:

8.4.4.1 A solution containing BFB at a concentration of 50 µg/mL is prepared by volumetrically diluting the BFB stock solution. 1 µL of this solution is direct-injected or purged into the GC/MS system to verify system performance prior to any standard or sample analysis.

8.4.4.2 BFB may be analyzed in full scan mode while standards, samples, and QC are analyzed in SIM

8.5 Calibration Standards:

There are two types of calibration standards used for this method – initial calibration standards and calibration verification standards.

8.5.1 Initial Calibration Standards:

Initial calibration standards can be prepared at the levels listed in Table 4 (other/different levels are allowed). The Initial Calibration needs to have a minimum of 5 standards, 6 if a quadratic curve fit is used. Prepare these solutions in organic-free reagent water. The standards correspond to the range of concentrations found in typical samples and do not exceed the working range of the GC/MS system. Initial calibration should be mixed from fresh stock standards and dilution standards when generating an initial calibration curve.

8.5.2 Initial Calibration Verification Standard (ICV):

The initial calibration verification standard is at the same concentration as the level 3 for liquids and level 4 for soils initial calibration standard. This standard is prepared from source materials from a second manufacturer or from a manufacturer's batch prepared independently from the batch used for calibration. A second lot# from the same manufacturer may be adequate to meet this requirement. The standard must contain all calibrated target analytes that will be reported for the project, if readily available.

8.5.3 Continuing Calibration Verification Standard:

The continuing calibration verification standard, or calibration check standard, should be analyzed near the action level of the project. Since most projects are focused on achieving low reporting limits, the continuing calibration verification standard is at the same concentrations as the level 3 for liquids and level 4 for soils initial calibration standard. This standard is run at the beginning of each analytical sequence, following the BFB tune standard, to verify system performance.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method.

9.1 Blank(s)

9.1.1 Before processing any samples, the analyst must demonstrate through the analysis of a method blank (MB) or instrument blank that equipment and reagents are free from contaminants and interferences. The blank must contain the internal standards and surrogates and must be from the same source of water used for preparing the standards, QC samples and sample dilutions.

9.1.2 Analyze a matrix-specific blank, i.e. methanol samples need to have methanol in the blank; sodium bisulfate samples need to have a sodium bisulfate blank analyzed;

TCLP samples need a TCLP blank, after each ICAL and CCV, and prior to any sample analysis to demonstrate that interferences from the analytical system are under control.

9.1.3 Low level soil blanks must include 5g of Ottawa sand and be vortexed.

9.1.4 Blanks are considered to be acceptable if target analyte concentrations are less than one half the LOQ or are less than project-specific requirements. Blanks may contain analyte concentrations greater than acceptance limits if the associated samples in the batch are unaffected (i.e., target analytes are not present in samples or sample concentrations/responses are >10X the blank).

9.1.5 If an analyte of interest is found in a sample in the batch near a concentration detected in the blank, the presence and/or concentration of that analyte should be considered suspect and may require qualification. Reanalysis is not necessary if the analyte concentration falls well below the action or regulatory limit or if the analyte is deemed not important for the project.

9.1.6 The laboratory must not subtract the results of the MB (or any blank) from those of any associated samples.

9.2 Laboratory Control Sample (LCS)/ Laboratory Control Sample Duplicate (LCSD)

An LCS/LCSD pair is analyzed at the beginning of each analytical sequence. Since the LCS contains the same compounds at the same concentrations as the continuing calibration check standard, the same analysis is used to satisfy both QC elements. The LCS/LCSD acceptance criteria are based on in-house control limits, unless specified by project/regulation. Less than 10% of total compounds may be outside of control limits if recoveries are >10%. (Note: this does not apply to difficult analytes listed in Table 7 which may be accepted at recoveries <10.) If >10% of analytes are recovered above control limits, this is deemed acceptable as long as the analytes in question are not detected in associated samples. If these criteria are not met, the entire batch is re-extracted. If re-extraction is not possible, due to insufficient sample or holding time exceedance, the analyst must write up the failure on a narrative sheet for inclusion in the client report.

9.3 Initial Calibration Verification (ICV)

Refer to 12

9.4 Continuing Calibration Verification (CCV)

Refer to Section 11.2.

9.5 Matrix Spike/ Matrix Spike Duplicate

Upon Client Request or state mandate, a matrix spike/matrix spike duplicate pair may be analyzed with each batch of 20 or less samples. The MS/MSD are sample aliquots spiked with the target compounds at the same concentration as the continuing calibration standard for water analysis and level 6 for soils. The MS/MSD acceptance criteria are based on in-house control limits. If the MS/MSD does not meet the criteria, but the LCSD does, the failure may be attributed to sample matrix. Report the MS/MSD, including a narrative sheet for inclusion with the client report.

9.6 Laboratory Duplicate

Not applicable.

9.7 Method-specific Quality Control Samples

9.7.1 Internal Standards

Area counts of the internal standard peaks in all samples and QC samples must be between 50-200% of the areas of the internal standards in the QC check standard.

If any individual percent recovery falls outside the range, that parameter has failed the acceptance criteria. For calibration standards, CCVs, LCS/LCSD or blanks the internal standard must be within the range for data to be reported to the clients. For samples, matrix spikes and duplicates: if the data is not within the range, the sample is rerun to confirm that the failure is due to sample matrix. A nonconformance report form is completed to ensure client notification and reporting if matrix effect is confirmed.

9.7.2 Surrogates

Surrogates are added to each field sample and QC sample. The laboratory must evaluate surrogate recovery data from individual samples versus the surrogate control limits developed by the laboratory. The surrogate acceptance criteria are listed in Table 2. Since the SIM analysis is acquired in dual mode, the surrogates from the full scan are used to evaluate the entire sample (SIM and full scan).

9.8 Method Sequence

In a 12-hour period, the typical analytical sequence is as follows:

- BFB
- QC Check Standard/Laboratory Control Sample/LCSD
- Method Blank
- Samples
- MS/MSD (upon Client request, may be run any time after the Method Blank)

10. Procedure

10.1 Equipment Set-up

Typical instrument operating conditions are listed below. Alternate conditions are allowed if method performance criteria can be met.

10.1.1 GC Conditions:

Temperature 1:	35°C	Carrier gas:	Helium 99.999% or Nitrogen 99.999%
Hold Time 1:	4 minutes	Carrier mode:	Constant flow
Ramp 1:	6°C/minute	Carrier flow:	1 mL/minute
Temperature 2:	150°C		
Hold Time 2:	0 minutes		
Ramp 2:	8°C/minute		
Temperature 3:	220°C		
Final Time:	1 minute		

10.1.2 MS Conditions:

Mass range:	m/z of 35 – 270 amu
Scan time:	0.5 minutes/scan
Source temperature:	230°C or according to manufacturer's specifications.

10.1.3 Velocity Concentrator Purge and Trap Conditions:

Purge time:	11 minutes
Dry purge:	2 minutes
Desorb preheat:	250°C
Desorb temp:	255°C
Desorb time:	2 minutes
Bake temp:	290°C
Bake time:	10 minutes

10.1.4 Encon Concentrator Purge and Trap Conditions:

Purge time:	11 minutes
Dry purge:	1 minute
Desorb preheat:	245°C
Desorb temp:	255°C
Desorb time:	1 minute
Bake temp:	270°C
Bake time:	10 minutes

10.2 Initial Calibration

10.2.1 The initial calibration is performed at a minimum of five (5) concentration levels listed in Table 4, the low level either at or below the reporting limit. The calibration is performed using instrument conditions listed in 10.1.

BFB must be analyzed prior to analysis of the initial calibration standards and must pass the criteria listed in Table 3. The mass spectrum of BFB should be acquired in the following manner:

(1) Three scans (the peak apex scan, the scan immediately preceding the apex and the scan immediately following the apex) are acquired and averaged.
(2) Background subtraction is performed using a single scan of no more than 20 scans prior to the elution of BFB.

This is done automatically with the EnviroQuant software.

10.2.1.1 Low Level/High Level Soil Curve on Centurion: To prepare a calibration standard, add the appropriate volume of standard solution(s) to a 50mL volumetric flask using a micro syringe. Remove the needle quickly and mix by inverting the flask 3 times. Pour several mLs of the aqueous standard into the waste vessel, then gently fill a 5mL syringe with standard and transfer to a 40mL VOA vial containing a magnetic stir bar. Load the vial onto autosampler.

10.2.1.2 Aqueous/High Level Soil Curve on Solatek or Centurion: To prepare a calibration standard, add the appropriate volume of standard solution(s) to a 100mL volumetric flask using a micro syringe. Remove the needle quickly and mix by inverting the flask 3 times. Pour several mLs of the aqueous standard into the waste vessel, and then gently fill a 40mL VOA vial to the top. Load the vial onto the autosampler.

10.2.2 Establish the GC operating conditions by loading the appropriate GC method. Typical instrument conditions are listed in Section 10.1. The same operating conditions are used for calibration and sample analyses. Create the analytical sequence using the HP EnviroQuant data acquisition software.

Relative Response Factors: The internal standard calibration technique is used. In each calibration standard, calculate the relative response factor for each analyte and the relative standard deviation (RSD) of the response factors using the EnviroQuant data processing software. The response factors are calculated using the areas of the characteristic (quantitation) ion for each target analyte and internal standard. The calculations are performed automatically using the EnviroQuant software, using the formulae listed in Alpha's Quality Manual.

10.2.3 Initial Calibration Criteria: The following sections outline the method acceptance criteria for an initial calibration curve. All criteria must be met for the calibration to be deemed acceptable, and for sample analysis to proceed. For MCP and CT projects see the related project specific addenda for modifications.

10.2.3.1 Relative Standard Deviation Criteria: If the RSD for each target analyte is less than or equal to 20%, then the response for this compound is considered linear over the calibration range and the mean calibration factor can be used to quantitate sample results. If the 20% RSD criterion is not met for an analyte linear regression may be used if $\mathbf{r^2} \geq 0.990$, weighted linear with a weighting factor of 1/SD2 and r > 0.995, or quadratic fit if $\mathbf{r^2} \geq 0.990$. A minimum of five points are required for linear fit and six points is required for quadratic fit. The calibration must be repeated for any compounds that fail. If more than 10% of the compounds exceed the 20% RSD limit and do not achieve the minimum correlation coefficient for alternative curve fits, sample analysis cannot proceed.

10.2.3.1.1 Percent Relative Error (%RE): For linear and quadratic fit compounds the %RE relative error must be calculated for the standard at or near the midpoint of the initial calibration and at the lowest level. The %RE between the calculated and expected amounts of an analyte should be ≤ 30% for all standards, otherwise recalibration is necessary.

10.2.4 Evaluation of Retention Times: The relative retention times used for identification of target analytes are +/- 0.06 RRT (Relative Retention Time) units, based on the most recent standard run. It has been determined that these limits work well, being wide enough to eliminate false-negative results while being tight enough to eliminate false positive results. Due to the selectivity of the mass spectrometer, compound identification is more definitive than when using a less selective detector.

10.2.5 Initial Calibration Verification: After each calibration and before the analysis of samples, an ICV must be analyzed at or near the midpoint of the curve. The ICV must be prepared using a different source than the Initial Calibration and must contain all target analytes. The percent recoveries must be between 70% and 130% for target analytes

except for “difficult” analytes (Table 7), which must exhibit percent recoveries between 40% and 160%. Corrective action is required if greater than 10% of all analytes are outside the prescribed criteria.

10.2.5.1 The ICV used for the initial calibration can be used as the continuing calibration verification. See Section 10.4 for criteria.

10.2.6 Additional considerations for SIM analysis

10.2.6.1 SIM may be useful for applications requiring quantitation limits below the normal range of electron impact quadrupole mass spectrometry, and both are allowable options for this method. Using the primary m/z for quantitation and at least one secondary m/z (or product ion) for confirmation, set up the descriptor windows based on their retention times. The selected m/z values should include any mass defect noted in the target analyte mass spectra acquired on the instrument, usually less than 0.2 amu. The dwell time for each ion may be automatically calculated by the instrument software or may be calculated based on the peak widths of the analytes of interest, the number of spectra needed to be acquired across each peak, and the number of concurrent ions that need to be acquired in each segment. When fewer m/z values are monitored in each segment, the acquisition time for each m/z can be increased, thereby increasing the sensitivity of the system. The total cycle time for the MS should be short enough that at least five, but preferably ten or more, spectra are acquired per chromatographic peak.

10.2.6.2 When compounds are analyzed in SIM mode, the following best practices are recommended:

10.2.6.2.1 Monitor at least two ions for each target analyte and use the mid-point of the calibration curve to establish proper ion ratios for each compound. The ratios of primary and secondary ions are the only qualitative tools available in SIM runs (other than RT), which increases their importance in proper identification. When interferences are expected or observed in a given matrix, acquiring multiple secondary ions may aid in qualitative identification.

10.2.6.2.2 Verify that all monitored ions are correctly integrated in order to achieve proper ion ratios. Update the primary/secondary ion ratios and reference mass spectra after each ICAL using a mid-range ICAL standard.

10.3 Equipment Operation and Sample Processing

The same GC, MS, and Purge and Trap conditions used for the initial calibration must be employed for sample analysis. After verification of system performance by analysis of BFB, the continuing calibration standard and method blank, samples are analyzed and processed as described below.

10.3.1 All samples are initially screened using Tekmar 7000 Headspace Autosamplers.

10.3.2 Retrieve sample VOA vials from the sample refrigerator just prior to loading onto the purge and trap system.

10.3.3 Aqueous samples:
Load the VOA vial directly on the sampling rack. Dilutions may be prepared volumetrically and poured into VOA vials ensuring there is no headspace left in the vial. The autosampler will then sample 10mL from the VOA vial.

10.3.4 Low level soil samples:

Low level soil sample should be shaken briefly to ensure that the stir bar is loose, and will spin on the autosampler unit. Take the low level VOA vial and place directly into the rack of the autosampler unit. Surrogate and internal standards are added automatically by the autosampler prior to sample purging.

10.3.5 High level soil samples:

Shake or vortex the sample for 15 seconds, ensuring the methanol has completely penetrated the soil in the vial. Let sample settle prior to taking methanol aliquot.

10.3.5.1 Through liquid path

Load a maximum of 860µL or appropriate dilution of the methanol into a half-full VOA vial. Fill the VOA vial up to the top with water and cap with no headspace. Allow the auto-sampler to sample 10mL out of the VOA vial which would be equivalent to injecting 100µL of the methanol extract. Prepare dilutions accordingly.

10.3.5.2 Through soil path

Into a VOA vial with a stir bar added, load 4.9mL of water plus a maximum of 100 µL of methanol or appropriate dilution of methanol extract from a 5mL luerlock syringe. Cap the vial and load onto the auto-sampler.

10.3.6 Qualitative Analysis:

10.3.6.1 The qualitative identification of each compound is based on retention time and on comparison of the sample mass spectrum with the reference mass spectrum. The reference mass spectrum must be generated by the laboratory on the same GC/MS system. The characteristic ions from the reference mass spectrum are defined to be the three ions of greatest relative intensity, or any ions over 30% relative intensity if less than three such ions occur in the reference spectrum. Compounds are identified as present when the following criteria are met:

10.3.6.1.1 The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other. The EnviroQuant data system is configured to make this check.

10.3.6.1.2 The relative retention time (RRT) of the sample component is within ±0.06 RRT units of the RRT of the standard component.

10.3.6.1.3 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%.)

10.3.6.1.4 Structural isomers that produce very similar mass spectra should be 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 ≤ 50% of the average of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs (i.e., m and p-xylene).

10.3.6.1.5 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.

10.3.6.1.6 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.

10.3.6.2 For samples containing non-target analytes, a library search will be performed at client request. Compound identification will be classified as “tentative”, and the concentration will be reported as an estimate as no quantitative standards are run for these compounds.

10.3.6.2.1 Relative intensities of major ions in the reference spectrum (ions greater than 10% of the most abundant ion) are present in the sample spectrum.

10.3.6.2.2 The relative intensities of the major ions should agree within ±20%. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must be between 30 and 70%.)

10.3.6.2.3 Molecular ions present in the reference spectrum are present in the sample spectrum. If the molecular ion is not present, carefully review library matches in order to avoid misidentification.

10.3.6.2.4 Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of coeluting compounds.

10.3.6.2.5 Ions present in the reference spectrum but not in the sample spectrum are reviewed for possible subtraction from the sample spectrum because of background contamination or coeluting peaks.

10.3.6.2.6 Mass spectral library search algorithms typically assign a match factor to the peak identity based on comparison of an unknown mass spectrum to library spectra. For spectra meeting the above conditions, match factors greater than 0.85 (85%) may be considered confirming evidence. Where a known limitation in data collection is identified (e.g., the presence of an incompletely resolved spectral interference), a lower match factor may be considered confirmatory. For multiple library spectra with similar match factors (e.g., for hydrocarbons with low abundance molecular ions, or structural isomers), the tentative identification assigned to the unknown may be better represented as a more generic structure (e.g., unknown hydrocarbon, C4 benzene structural isomer).

10.3.7 Quantitative Analysis:

10.3.7.1 Quantitation of a target compound detected in a sample is performed automatically by the EnviroQuant data processing software, using the formulae found in Alpha’s Quality Manual. Either the average response factor or calibration curve will be used for sample quantitation, depending on how the particular analyte was processed in the initial calibration curve. If non-target

compounds are to be reported, the quantitation is performed automatically by the EnviroQuant software using the total area of the compound and the nearest internal standard, and assuming a relative response factor of 1.0.

10.4 Continuing Calibration

Calibration verification consists of three steps that are performed at the beginning of each 12-hour analytical shift. For MCP and CT projects see the related project specific addenda for modifications.

10.4.1 Prior to the analysis of samples or calibration standards, inject or purge 1 µL (50 ng) of the 4-Bromofluorobenzene standard (Section 8.4.4) into the GC/MS system. The resultant mass spectra for the BFB must meet the criteria given in Table 3 before sample analysis begins.

10.4.2 The initial calibration curve for each compound of interest must be verified once every 12 hours prior to sample analysis. This is accomplished by analyzing the continuing calibration check standard (Section 8.5.3).

10.4.3 A method blank must be analyzed prior to any samples, typically immediately following the continuing calibration check standard, to ensure that the analytical system is free of contaminants. The method blank must not contain any target analytes at or above the required compound reporting limits.

10.4.4 The percent difference or drift for each target analyte must be less than or equal to 20% (30% for all SIM compounds). If greater than 20% of target analytes exceed the %D criteria corrective action must be taken prior to the analysis of samples. If less than or equal to 20% of compounds exceed the criteria, corrective action is not required.

10.4.5 Internal Standard Retention Time:

The absolute retention times of the internal standards in the calibration verification standard are evaluated after data acquisition. If the absolute retention time for any internal standard changes by more than 30 seconds from that in the mid-point standard level of the most recent initial calibration sequence, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

10.4.6 Internal Standard Response:

If the area for any of the internal standards in the calibration verification standard changes by a factor of two (50% to 200%) from that in the mid-point standard level of the most recent initial calibration sequence, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate. When corrections are made, re-analysis of samples analyzed while the system was malfunctioning is required.

10.5 Preventive Maintenance

Routine preventive maintenance should be performed on the analytical system. This includes replacement of GC septa and periodic rinsing or replacement of purge and trap tubes and sparge needles. The trap should be replaced every six months or sooner if performance criteria

cannot be met. Periodic cleaning (typically twice per year) of the mass spectrometer ion source is required. More frequent source cleaning may be needed, especially if dirty samples are analyzed.

If system performance deteriorates, additional maintenance may be required. This includes replacement of injector ports and seals, clipping several inches off of the front end of the GC column, or in extreme cases the replacement of the GC column. Flushing or replacement of purge and trap lines may be necessary if they become contaminated or develop active sites.

Perform routine preventative maintenance as described throughout this SOP. Record all maintenance in the instrument logbook.

11. Data Evaluation, Calculations and Reporting

11.1 LIMS Data Corrections

Please note that the Laboratory Information Management System (LIMS) automatically adjusts soil sample results to account for the % Total Solids of the sample (as determined per Alpha SOP/07-38) and the methanol preservation dilution effect.

11.2 Data Calculations

11.2.1 Results of Aqueous Sample Analysis:

$$Concentration\ (ug/L) = \frac{(Conc.)\ (Vp)\ (DF)}{(Vs)}$$

where:

Conc. = On-column concentration obtained from the quantitation report.
Vp = Volume purged, 10 mL is standard
Vs = Volume of sample purged
DF = Dilution factor, for manually prepared dilutions, not instrumental "dilutions".

11.2.2 Results of Sediment/Soil, Sludge, and Waste Analysis:

All solids including soils, sediments, and sludges must be reported on a dry-weight basis.

11.2.2.1 Low-Level Samples:

$$Concentration\ (ug/Kg) = \frac{(Conc.)\ (Vp)\ (DF)}{(W)\ (\%S)}$$

11.2.2.2 High-Level Samples:

$$\text{Concentration (ug/Kg)} = \frac{\text{(Conc.) (Vp) (5000) (DF)}}{\text{(W) (Ve) (\%S)}}$$

where:

Conc. = On-column concentration obtained from the quantitation report.
DF = Dilution factor, for manually prepared dilutions, not instrumental "dilutions".
Ve = Extract volume, mL
Vp = Volume purged, 5 mL is standard
W = Aliquot of sample (wet), g
%S = Sample % solid
5000 = Constant representing the final volume of the methanol extraction.

11.2.2.2.1 High-Level Samples Corrected for Total Water/Solvent Mixture (V_t):

Samples that are extracted prior to analysis in a water miscible solvent such as methanol are diluted by the total volume of the water/solvent mixture. The total mixture volume can only be calculated based on the sample moisture present as determined by the % moisture calculation.

$$\text{\% moisture} = \frac{\text{g of sample – g of dry sample}}{\text{g of sample}} \times 100$$

$$V_t = \frac{\text{[mL of solvent + (\%moisture x g of sample)]}}{100} \times 1000\text{mL/mL}$$

The calculated V_t value is now added to the volume of methanol in the sample (typically 5000µL), and the corrected concentration is calculated using the equation below:

$$\text{Corrected concentration (mg/Kg)} = \frac{\text{(Conc.) } (V_t \text{ + methanol vol.) (Vp) (DF)}}{\text{(W) (Ve) (\%S)}}$$

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

All batch and sample specific QC criteria outlined in section 10 are evaluated by the analyst prior to approval of the data. When any QC criteria fail, the cause for the failure must be identified and corrected. This may include instrument recalibration followed by sample reanalysis, sample cleanup, or sample re-extraction. If it is determined that the failure is due to sample matrix effects, a project narrative report is written by the analyst for inclusion in the data report. If there is insufficient sample volume to perform the re-analysis for confirmation, this is also noted in the narrative and included in the client report.

13. Method Performance

13.1 Detection Limit Study (DL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the DL, LOD, and/or LOQ as outlined in Alpha SOP/1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP/1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP/1732 DL/LOD/LOQ Generation

SOP/1739 IDC/DOC Generation

SOP/1728 Waste Management and Disposal SOP

16. Attachments

Table 1: 8260 REPORTING LIMITS

Table 2: 8260 QC ACCEPTANCE CRITERIA

Table 3: BFB TUNING CRITERIA

Table 4: STANDARD SOLUTIONS and ICAL Levels

Table 5: 8260D Volatile Internal Standards with Corresponding Target Compounds and Surrogates Assigned for Quantitation

Table 6: 8260D Quantitation Ions

Table 7: Difficult Analytes

Table 8: ICAL Low Point re-quantitation ranges

Table 1

Standard Reported Detection Limits

US EPA METHOD 8260D and 5035A/8260D

Analyte	Recommended Minimum Response Factor	RDL (µg/L)	RDL(µg/KG)(1)	RDL (µg/KG) (2)
Acetone (3,4,5)	0.01	5.0	25	1250
Acrolein (5)		5.0	25	1250
Acrylonitrile (3,4)		5.0	4	200
Allyl Chloride (7)		N/A	5	250
Benzene (3,4,5)	0.2	0.5	0.5	25
Bromobenzene (3,4)		2.5	2	100
Bromochloromethane (3,4,5)	0.1	2.5	2	100
Bromodichloromethane (3,4,5)	0.300	0.5	0.5	25
Bromoform (3,4,5)	0.100	2.0	4	200
Bromomethane (3,4,5)	0.01	1.0	2	100
2-Butanone (3,4,5)	0.01	5.0	10	500
Butyl acetate (7)		N/A	5	50
n-Butylbenzene (3,4)		0.5	1	50
sec-Butylbenzene (3,4)		0.5	1	50
tert-Butylbenzene (3,4)		2.5	2	100
Carbon disulfide (3,4,5)	0.100	5.0	10	500
Carbon tetrachloride (3,4,5)	0.100	0.5	1	50
Chlorobenzene (3,4,5)	0.400	0.5	0.5	25
Chlorodifluoromethane (7)		N/A	5	250
Chloroethane (3,4,5)	0.01	1.0	2	100
2-Chloroethylvinyl ether (3)		10.0	20	1000
Chloroform (3,4,5)	0.300	0.75	1.5	75
Chloromethane (3,4,5)	0.01	2.5	4	200
o-Chlorotoluene (3,4)		2.5	2	100
Cyclohexane (5)	0.01	10	10	500
Cyclohexanone		10	20	1000
p-Chlorotoluene (3,4)		2.5	2	100
cis-Decahydronaphthalene (7)		N/A	5	250
trans-Decahydronaphthalene (7)		N/A	5	250
n-Decane (7)		N/A	5	250
Dibromochloromethane (3,4,5)	0.200	0.5	1	50
1,2-Dibromo-3-chloropropane (3,4,5)	0.01	2.5	3	150
1,2-Dibromoethane (3,4,5)	0.200	2.0	1	50
Dibromomethane (3,4)		5.0	2	100
1,2-Dichlorobenzene (3,4,5)	0.600	2.5	2	100
1,3-Dichlorobenzene (3,4,5)	0.500	2.5	2	100
1,4-Dichlorobenzene (3,4,5)	0.600	2.5	2	100
1,4-Dichlorobutane (3,4)		5.0	10	500
trans-1,4-Dichloro-2-butene (3,4)		2.5	5	250

Table 1 (continued)

Standard Reported Detection Limits

US EPA METHOD 8260D and 5035A/8260D

Analyte	Recommended Minimum Response Factor	RDL (µg/L)	RDL(µg/KG)(1)	RDL (µg/KG) (2)
Dichlorodifluoromethane (3,4,5)	0.01	5.0	10	500
1,1-Dichloroethane (3,4,5)	0.300	0.75	1	50
1,2-Dichloroethane (3,4,5)	0.07	0.5	1	50
1,1-Dichloroethene (3,4,5)	0.06	0.5	1	50
cis-1,2-Dichloroethene (3,4,5)	0.200	0.5	1	50
trans-1,2-Dichloroethene (3,4,5)	0.100	0.75	1.5	75
1,2-Dichloropropane (3,4,5)	0.200	1.75	1	50
1,3-Dichloropropane (3,4)		2.5	2	100
2,2-Dichloropropane (3,4)		2.5	2	100
1,1-Dichloropropene (3,4)		2.5	0.5	25
cis-1,3-Dichloropropene (3,4,5)	0.300	0.5	0.5	25
p-Diethylbenzene (4)		2.0	2	100
Diisopropyl Ether (6)		2.0	2	100
1,4-Dioxane (5) (non-SIM)		250.0	80	4000
trans-1,3-Dichloropropene (3,4,5)	0.300	0.5	1	50
Ethanol (7)		250.0	1000	50000
Ethyl acetate		10.0	10	500
Ethylbenzene (3,4,5)	0.400	0.5	1	50
Ethyl ether (3,4)		2.5	2	100
4-Ethyltoluene (4)		2.0	2	100
Ethyl methacrylate (3,4)		5.0	10	500
Ethyl-Tert-Butyl-Ether (6)		2.0	2	100
Freon-113 (5)	0.05	10.0	4	200
n-Heptane (7)		N/A	5	250
Hexachlorobutadiene (3,4)		0.5	4	200
Hexachloroethane (7)		N/A	5	250
Hexane		1.0	5	250
2-Hexanone (3,4,5)	0.01	5.0	10	500
Iodomethane		5.0	10	500
Isopropyl Alcohol (IPA)		100.0	100	5000
Isopropylbenzene (3,4,5)	0.400	0.5	1	50
p-Isopropyltoluene (3,4)		0.5	1	50
Limonene (7)		N/A	5	250
Methyl Acetate (5)	0.01	10.0	4	200
Methylene chloride (3,4,5)	0.01	3.0	5	250
Methyl Cyclohexane (5)	0.05	10.0	4	200
Methyl isothiocyanate (7)		N/A	5	250
Methyl Methacrylate		2.5	5	250
4-Methyl-2-pentanone (3,4,5)	0.03	5.0	10	500

Methyl-tert-butyl-ether (3,4,5)	0.100	1.0	2	100
Naphthalene (3,4)		2.5	4	200
Nitrobenzene (7)		N/A	5	250
2-Nitropropane (7)		N/A	5	250
n-Nonane (7)		N/A	5	250
n-Octane (7)		N/A	5	250
n-Butanol (5)		100.0	300	15000
n-Propylbenzene (3,4)		0.5	1	50
n-Propyl bromide		5.0	N/A	N/A
Pentachloroethane		2.0	N/A	N/A
Styrene (3,4,5)	0.200	1.0	1	50
Tert-Butyl Alcohol (5)		10.0	20	1000
Tertiary-Amyl Methyl Ether (6)		2.0	2	100
1,1,1,2-Tetrachloroethane (3,4)		0.5	0.5	25
1,2,4,5-Tetramethylbenzene (4)		2.0	2	100
1,1,2,2-Tetrachloroethane (3,4,5)	0.200	0.5	0.5	25
Tetrachloroethene (3,4,5)	0.100	0.5	0.5	25
Tetrahydrofuran (3)		5.0	4	200
Toluene (3,4,5)	0.300	0.75	1	50
1,2,3-Trichlorobenzene (3,4,5)	0.400	2.5	2	100
1,2,4-Trichlorobenzene (3,4,5)	0.400	2.5	2	100
1,3,5-Trichlorobenzene (6)		2.0	2	100
1,1,1-Trichloroethane (3,4,5)	0.05	0.5	0.5	25
1,1,2-Trichloroethane (3,4,5)	0.200	0.75	1	50
Trichloroethene (3,4,5)	0.200	0.5	0.5	25
Trichlorofluoromethane (3,4,5)	0.01	2.5	4	200
1,2,3-Trichloropropane (3,4)		5.0	10	500
1,2,4-Trimethylbenzene (3,4)		2.5	2	100
1,3,5-Trimethylbenzene (3,4)		2.5	2	100
n-Undecane (7)		N/A	5	250
Vinyl acetate (3,4)		5.0	10	500
Vinyl chloride (3,4,5)	0.01	1.0	1	50
m/p-Xylenes (3,4,5)	0.200	1.0	2	100
o-Xylene (3,4,5)	0.200	1.0	1	50
Isobutyl Alcohol		10.0	N/A	N/A
2-Butanol		25.0	N/A	N/A
4-penten-2-ol		100.0	N/A	N/A
2-methyl-2-butanol		25.0	N/A	N/A
4-methyl-2-pentanol		25.0	N/A	N/A
Chloropicrin		20.0	100	5000
Halothane		2.5	10	500
1,4-Dioxane (5) SIM		3.0	N/A	N/A
1,1,2,2-Tetrachloroethane SIM		0.1	N/A	N/A

(1) Detection Limits are for Low-level Aqueous preserved samples.

(2) Detection Limits are for High-level Methanol preserved samples.
(3) Analyte reported by standard 8260 reporting list.
(4) Analyte reported by New York TCL reporting list.
(5) Analyte reported by New Jersey TCL reporting list.
(6) Analyte reported for New Hampshire in addition to standard 8260 reporting list.
(7) Analyte only reported for New York TCL report upon client request.
(8) Note: Reporting Limits are based on standard 8260 reporting list, RL's may vary for NY and NJ reporting lists.

Table 2

QUALITY CONTROL ACCEPTANCE CRITERIA

Surrogate Spike Percent Recovery	Aqueous Limits		Soil Limits	
	Lower Control Limit	Upper Control Limit	Lower Control Limit	Upper Control Limit
1,2-Dichloroethane-d_4	70%	130%	70%	130%
4-Bromofluorobenzene	70%	130%	70%	130%
Toluene-d_8	70%	130%	70%	130%
Dibromofluoromethane	70%	130%	70%	130%

Table 3

BFB (4-BROMOFLUOROBENZENE) MASS INTENSITY CRITERIA

m/z	Required Intensity (relative abundance)
50	15 to 40% of m/z 95 (not required)
75	30 to 60% of m/z 95 (not required)
95	50 to 200% of m/z 174
96	5 to 9% of m/z 95
173	Less than 2% of m/z 174
174	50 to 200% of m/z 95
175	5 to 9% of m/z 174
176	95% to 105% of m/z 174
177	5 to 10% of m/z 176

Table 4

Stock Standard Concentrations and Suggested Calibration Concentration Levels

Soil	Stock (µg/mL)	Level 0 (ug/kg)	Level 1 (ug/kg)	Level 1.5 (ug/kg)	Level 2 (ug/kg)	Level 3 (ug/kg)	Level 4 (ug/kg)	Level 5 (ug/kg)	Level 6 (ug/kg)	Level 7 (ug/kg)	Level 8 (ug/kg)
Fluorobenzene	2500	20	20	20	20	20	20	20	20	20	20
Dichlorodifluoromethane	2000	0.5	1	2	4	20	40	60	100	200	300
Chlorodifluoromethane	2000	0.5	1	2	4	20	40	60	100	200	300
Chloromethane	2000	0.5	1	2	4	20	40	60	100	200	300
Vinyl chloride	2000	0.5	1	2	4	20	40	60	100	200	300
Bromomethane	2000	0.5	1	2	4	20	40	60	100	200	300
Chloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
Trichlorofluoromethane	2000	0.5	1	2	4	20	40	60	100	200	300
Ethyl ether	2000	0.5	1	2	4	20	40	60	100	200	300
Ethanol	2000	N/A	20	N/A	80	200	400	600	1000	3000	4000
1,1-Dichloroethene	2000	0.5	1	2	4	20	40	60	100	200	300
Carbon disulfide	2000	0.5	1	2	4	20	40	60	100	200	300
Freon-113	2000	0.5	1	2	4	20	40	60	100	200	300
Iodomethane	2000	0.5	1	2	4	20	40	60	100	200	300
Acrolein	2000	0.5	1	2	4	20	40	60	100	200	300
Allyl chloride	2000	0.5	1	2	4	20	40	60	100	200	300
Methylene chloride	2000	0.5	1	2	4	20	40	60	100	200	300
Isopropyl alcohol	2000	N/A	20	N/A	80	200	400	600	1000	3000	4000
Acetone	2000	0.5	1	2	4	20	40	60	100	200	300
trans-1,2-Dichloroethene	2000	0.5	1	2	4	20	40	60	100	200	300
Methyl acetate	2000	0.5	1	2	4	20	40	60	100	200	300
Hexane	2000	0.5	1	2	4	20	40	60	100	200	300
Methyl tert-butyl ether	2000	0.5	1	2	4	20	40	60	100	200	300
tert-Butyl alcohol	2000	2.5	5	10	20	100	200	300	500	1000	1500
Diisopropyl ether	2000	0.5	1	2	4	20	40	60	100	200	300
1,1-Dichloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
Halothane	2000	0.5	1	2	4	20	40	60	100	200	300
Acrylonitrile	2000	0.5	1	2	4	20	40	60	100	200	300
Ethyl tert-butyl ether	2000	0.5	1	2	4	20	40	60	100	200	300
Vinyl acetate	2000	0.5	1	2	4	20	40	60	100	200	300
cis-1,2-Dichloroethene	2000	0.5	1	2	4	20	40	60	100	200	300
2,2-Dichloropropane	2000	0.5	1	2	4	20	40	60	100	200	300
Bromochloromethane	2000	0.5	1	2	4	20	40	60	100	200	300
Cyclohexane	2000	0.5	1	2	4	20	40	60	100	200	300

Soil	Stock (µg/mL)	Level 0 (ug/kg)	Level 1 (ug/kg)	Level 1.5 (ug/kg)	Level 2 (ug/kg)	Level 3 (ug/kg)	Level 4 (ug/kg)	Level 5 (ug/kg)	Level 6 (ug/kg)	Level 7 (ug/kg)	Level 8 (ug/kg)
Chloroform	2000	0.5	1	2	4	20	40	60	100	200	300
Ethyl acetate	2000	0.5	1	2	4	20	40	60	100	200	300
Carbon tetrachloride	2000	0.5	1	2	4	20	40	60	100	200	300
Tetrahydrofuran	2000	0.5	1	2	4	20	40	60	100	200	300
Dibromofluoromethane	2500	20	20	20	20	20	20	20	20	20	20
1,1,1-Trichloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
2-Butanol	2000	N/A	20	N/A	80	200	400	600	1000	3000	4000
2-Butanone	2000	0.5	1	2	4	20	40	60	100	200	300
1,1-Dichloropropene	2000	0.5	1	2	4	20	40	60	100	200	300
Heptane	2000	0.5	1	2	4	20	40	60	100	200	300
Benzene	2000	0.5	1	2	4	20	40	60	100	200	300
tert-Amyl methyl ether	2000	0.5	1	2	4	20	40	60	100	200	300
1,2-Dichloroethane-d4	2500	20	20	20	20	20	20	20	20	20	20
1,2-Dichloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
Isobutyl alcohol	2000	N/A	20	N/A	80	200	400	600	1000	3000	4000
2-Methyl-2-butanol	2000	2.5	5	10	20	100	200	300	500	1000	1500
Methyl cyclohexane	2000	0.5	1	2	4	20	40	60	100	200	300
Trichloroethene	2000	0.5	1	2	4	20	40	60	100	200	300
n-Butanol	2000	N/A	20	N/A	80	200	400	600	1000	3000	4000
Dibromomethane	2000	0.5	1	2	4	20	40	60	100	200	300
1,2-Dichloropropane	2000	0.5	1	2	4	20	40	60	100	200	300
4-penten-2-ol	2000	2.5	5	10	20	100	200	300	500	1000	1500
2-Chloroethyl vinyl ether	2000	0.5	1	2	4	20	40	60	100	200	300
Bromodichloromethane	2000	0.5	1	2	4	20	40	60	100	200	300
Ethyl acrylate	2000	0.5	1	2	4	20	40	60	100	200	300
Methyl methacrylate	2000	0.5	1	2	4	20	40	60	100	200	300
1,4-Dioxane	2000	N/A	40	80	200	1000	2000	3000	5000	10000	15000
cis-1,3-Dichloropropene	2000	0.5	1	2	4	20	40	60	100	200	300
Chlorobenzene-d5	2500	20	20	20	20	20	20	20	20	20	20
Octane	2000	0.5	1	2	4	20	40	60	100	200	300
Toluene-d8	2500	20	20	20	20	20	20	20	20	20	20
Toluene	2000	0.5	1	2	4	20	40	60	100	200	300
4-Methyl-2-pentanone	2000	0.5	1	2	4	20	40	60	100	200	300
Tetrachloroethene	2000	0.5	1	2	4	20	40	60	100	200	300
2-Nitropropane	2000	0.5	1	2	4	20	40	60	100	200	300

Soil	Stock (µg/mL)	Level 0 (ug/kg)	Level 1 (ug/kg)	Level 1.5 (ug/kg)	Level 2 (ug/kg)	Level 3 (ug/kg)	Level 4 (ug/kg)	Level 5 (ug/kg)	Level 6 (ug/kg)	Level 7 (ug/kg)	Level 8 (ug/kg)
Chloropicrin	2000	N/A	50	N/A	100	200	300	400	500	600	700
trans-1,3-Dichloropropene	2000	0.5	1	2	4	20	40	60	100	200	300
Methyl isothiocyanate	2000	0.5	1	2	4	20	40	60	100	200	300
4-Methyl-2-pentanol	2000	N/A	20	N/A	80	200	400	600	1000	3000	4000
Ethyl methacrylate	2000	0.5	1	2	4	20	40	60	100	200	300
1,1,2-Trichloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
Chlorodibromomethane	2000	0.5	1	2	4	20	40	60	100	200	300
1,3-Dichloropropane	2000	0.5	1	2	4	20	40	60	100	200	300
1,2-Dibromoethane	2000	0.5	1	2	4	20	40	60	100	200	300
n-Butyl Acetate	2000	0.5	1	2	4	20	40	60	100	200	300
2-Hexanone	2000	0.5	1	2	4	20	40	60	100	200	300
Nonane	2000	0.5	1	2	4	20	40	60	100	200	300
Chlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Ethylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
1,1,1,2-Tetrachloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
p/m Xylene	2000	1	2	4	8	40	80	120	200	400	600
o Xylene	2000	1	2	4	8	40	80	120	200	400	600
Styrene	2000	1	2	4	8	40	80	120	200	400	600
1,4-Dichlorobenzene-d4	2500	20	20	20	20	20	20	20	20	20	20
Bromoform	2000	0.5	1	2	4	20	40	60	100	200	300
Butyl acrylate	2000	0.5	1	2	4	20	40	60	100	200	300
Isopropylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
4-Bromofluorobenzene	2500	20	20	20	20	20	20	20	20	20	20
Bromobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Decane	2000	0.5	1	2	4	20	40	60	100	200	300
n-Propylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
1,4-Dichlorobutane	2000	0.5	1	2	4	20	40	60	100	200	300
1,1,2,2-Tetrachloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
4-Ethyltoluene	2000	0.5	1	2	4	20	40	60	100	200	300
2-Chlorotoluene	2000	0.5	1	2	4	20	40	60	100	200	300
1,3,5-Trimethylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
1,2,3-Trichloropropane	2000	0.5	1	2	4	20	40	60	100	200	300
trans-1,4-Dichloro-2-butene	2000	0.5	1	2	4	20	40	60	100	200	300
4-Chlorotoluene	2000	0.5	1	2	4	20	40	60	100	200	300

Soil	Stock (µg/mL)	Level 0 (ug/kg)	Level 1 (ug/kg)	Level 1.5 (ug/kg)	Level 2 (ug/kg)	Level 3 (ug/kg)	Level 4 (ug/kg)	Level 5 (ug/kg)	Level 6 (ug/kg)	Level 7 (ug/kg)	Level 8 (ug/kg)
tert-Butylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Pentachloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
n-Butyl methacrylate	2000	0.5	1	2	4	20	40	60	100	200	300
1,2,4-Trimethylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Limonene	2000	0.5	1	2	4	20	40	60	100	200	300
sec-Butylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
p-Isopropyltoluene	2000	0.5	1	2	4	20	40	60	100	200	300
1,3-Dichlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
1,4-Dichlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
trans-Decahydronaphthalene	2000	0.5	1	2	4	20	40	60	100	200	300
Undecane	2000	0.5	1	2	4	20	40	60	100	200	300
p-Diethylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
n-Butylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Hexachloroethane	2000	0.5	1	2	4	20	40	60	100	200	300
1,2-Dichlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
cis-Decahydronaphthalene	2000	0.5	1	2	4	20	40	60	100	200	300
1,2,4,5-Tetramethylbenzene	2000	0.5	1	2	4	20	40	60	100	200	300
1,2-Dibromo-3-chloropropane	2000	0.5	1	2	4	20	40	60	100	200	300
1,3,5-Trichlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Nitrobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Hexachlorobutadiene	2000	0.5	1	2	4	20	40	60	100	200	300
1,2,4-Trichlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
Naphthalene	2000	0.5	1	2	4	20	40	60	100	200	300
1,2,3-Trichlorobenzene	2000	0.5	1	2	4	20	40	60	100	200	300
1,3-Dioxolane	2000	N/A	25	N/A	50	100	250	500	1000	1500	2000

Stock Standard Concentrations and Suggested Calibration Concentration Levels

Water	Stock (µg/mL)	Level 11 (ug/L)	Level 1 (ug/L)	Level 2 (ug/L)	Level 3 (ug/L)	Level 4 (ug/L)	Level 5 (ug/L)	Level 6 (ug/L)	Level 7 (ug/L)	Level 8 (ug/L)	Level 9 (ug/L)	Level 10 (ug/L)
							Optional		Optional		Optional	
Fluorobenzene	2500	10	10	10	10	10	10	10	10	10	10	10
Dichlorodifluoromethane	2000		0.5	2	10	30	50	80	100	120	160	200
Chloromethane	2000		0.5	2	10	30	50	80	100	120	160	200
Vinyl chloride	2000	0.19	0.5	2	10	30	50	80	100	120	160	200
Bromomethane	2000		0.5	2	10	30	50	80	100	120	160	200
Chloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
Trichlorofluoromethane	2000		0.5	2	10	30	50	80	100	120	160	200
Ethyl ether	2000		0.5	2	10	30	50	80	100	120	160	200
Ethanol	2000		0.5	2	10	30	50	80	100	120	160	200
1,1-Dichloroethene	2000		0.5	2	10	30	50	80	100	120	160	200
Carbon disulfide	2000		0.5	2	10	30	50	80	100	120	160	200
Freon-113	2000		0.5	2	10	30	50	80	100	120	160	200
Iodomethane	2000		0.5	2	10	30	50	80	100	120	160	200
Acrolein	2000		0.5	2	10	30	50	80	100	120	160	200
Methylene chloride	2000		0.5	2	10	30	50	80	100	120	160	200
Isopropyl alcohol	2000		2.5	10	50	150	250	400	500	600	800	1000
Acetone	2000		0.5	2	10	30	50	80	100	120	160	200
trans-1,2-Dichloroethene	2000		0.5	2	10	30	50	80	100	120	160	200
Methyl acetate	2000		0.5	2	10	30	50	80	100	120	160	200
Methyl tert-butyl ether	2000		0.5	2	10	30	50	80	100	120	160	200
tert-Butyl alcohol	2000		2.5	10	50	150	250	400	500	600	800	1000
Diisopropyl ether	2000		0.5	2	10	30	50	80	100	120	160	200
1,1-Dichloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
Halothane	2000		0.5	2	10	30	50	80	100	120	160	200
Acrylonitrile	2000		0.5	2	10	30	50	80	100	120	160	200
Ethyl tert-butyl ether	2000		0.5	2	10	30	50	80	100	120	160	200
Vinyl acetate	2000		0.5	2	10	30	50	80	100	120	160	200
cis-1,2-Dichloroethene	2000		0.5	2	10	30	50	80	100	120	160	200
2,2-Dichloropropane	2000		0.5	2	10	30	50	80	100	120	160	200
Bromochloromethane	2000		0.5	2	10	30	50	80	100	120	160	200
Cyclohexane	2000		0.5	2	10	30	50	80	100	120	160	200
Chloroform	2000		0.5	2	10	30	50	80	100	120	160	200
Ethyl acetate	2000		0.5	2	10	30	50	80	100	120	160	200

Water	Stock (µg/mL)	Level 11 (ug/L)	Level 1 (ug/L)	Level 2 (ug/L)	Level 3 (ug/L)	Level 4 (ug/L)	Level 5 (ug/L)	Level 6 (ug/L)	Level 7 (ug/L)	Level 8 (ug/L)	Level 9 (ug/L)	Level 10 (ug/L)
							Optional		Optional		Optional	
Carbon tetrachloride	2000	0.19	0.5	2	10	30	50	80	100	120	160	200
Tetrahydrofuran	2000		0.5	2	10	30	50	80	100	120	160	200
Dibromofluoromethane	2500	10	10	10	10	10	10	10	10	10	10	10
1,1,1-Trichloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
2-Butanol	2000		2.5	10	50	150	250	400	500	600	800	1000
2-Butanone	2000		0.5	2	10	30	50	80	100	120	160	200
1,1-Dichloropropene	2000		0.5	2	10	30	50	80	100	120	160	200
Benzene	2000	0.19	0.5	2	10	30	50	80	100	120	160	200
tert-Amyl methyl ether	2000		0.5	2	10	30	50	80	100	120	160	200
1,2-Dichloroethane-d4	2500	10	10	10	10	10	10	10	10	10	10	10
1,2-Dichloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
Isobutyl alcohol	2000		2.5	10	50	150	250	400	500	600	800	1000
2-Methyl-2-butanol	2000		2.5	10	50	150	250	400	500	600	800	1000
Methyl cyclohexane	2000		0.5	2	10	30	50	80	100	120	160	200
Trichloroethene	2000	0.19	0.5	2	10	30	50	80	100	120	160	200
n-Butanol	2000		2.5	10	50	150	250	400	500	600	800	1000
Dibromomethane	2000		0.5	2	10	30	50	80	100	120	160	200
1,2-Dichloropropane	2000		0.5	2	10	30	50	80	100	120	160	200
4-penten-2-ol	2000		2.5	10	50	150	250	400	500	600	800	1000
2-Chloroethyl vinyl ether	2000		0.5	2	10	30	50	80	100	120	160	200
Bromodichloromethane	2000		0.5	2	10	30	50	80	100	120	160	200
Ethyl acrylate	2000		0.25	1	5	15	25	40	50	60	80	100
Methyl methacrylate	2000		0.25	1	5	15	25	40	50	60	80	100
1,4-Dioxane	2000		100	400	500	600	1000	800	1000	1200	1600	2000
cis-1,3-Dichloropropene	2000		0.5	2	10	30	50	80	100	120	160	200
Chlorobenzene-d5	2500	10	10	10	10	10	10	10	10	10	10	10
Toluene-d8	2500	10	10	10	10	10	10	10	10	10	10	10
Toluene	2000		0.5	2	10	30	50	80	100	120	160	200
4-Methyl-2-pentanone	2000		0.5	2	10	30	50	80	100	120	160	200
Tetrachloroethene	2000		0.5	2	10	30	50	80	100	120	160	200
Chloropicrin	2000		30	50	80	120	200	160	400	200	320	400
trans-1,3-Dichloropropene	2000		0.5	2	10	30	50	80	100	120	160	200
4-Methyl-2-pentanol	2000		2.5	10	50	150	250	400	500	600	800	1000

Water	Stock (µg/mL)	Level 11 (ug/L)	Level 1 (ug/L)	Level 2 (ug/L)	Level 3 (ug/L)	Level 4 (ug/L)	Level 5 (ug/L)	Level 6 (ug/L)	Level 7 (ug/L)	Level 8 (ug/L)	Level 9 (ug/L)	Level 10 (ug/L)
							Optional		Optional		Optional	
Ethyl methacrylate	2000		0.5	2	10	30	50	80	100	120	160	200
1,1,2-Trichloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
Chlorodibromomethane	2000		0.5	2	10	30	50	80	100	120	160	200
1,3-Dichloropropane	2000		0.5	2	10	30	50	80	100	120	160	200
1,2-Dibromoethane	2000		0.5	2	10	30	50	80	100	120	160	200
2-Hexanone	2000		0.5	2	10	30	50	80	100	120	160	200
Chlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
Ethylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,1,1,2-Tetrachloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
p/m Xylene	2000		1	4	20	60	100	160	200	240	320	400
o Xylene	2000		1	4	20	60	100	160	200	240	320	400
Styrene	2000		1	4	20	60	100	160	200	240	320	400
1,4-Dichlorobenzene-d4	2500	10	10	10	10	10	10	10	10	10	10	10
Bromoform	2000		0.5	2	10	30	50	80	100	120	160	200
Butyl acrylate	2000		0.25	1	5	15	25	40	50	60	80	100
Isopropylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
4-Bromofluorobenzene	2500	10	10	10	10	10	10	10	10	10	10	10
Bromobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
n-Propylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,4-Dichlorobutane	2000		0.5	2	10	30	50	80	100	120	160	200
1,1,2,2-Tetrachloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
4-Ethyltoluene	2000		0.5	2	10	30	50	80	100	120	160	200
2-Chlorotoluene	2000		0.5	2	10	30	50	80	100	120	160	200
1,3,5-Trimethylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,2,3-Trichloropropane	2000		0.5	2	10	30	50	80	100	120	160	200
trans-1,4-Dichloro-2-butene	2000		0.5	2	10	30	50	80	100	120	160	200
4-Chlorotoluene	2000		0.5	2	10	30	50	80	100	120	160	200
tert-Butylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
Pentachloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
n-Butyl methacrylate	2000		0.25	1	5	15	25	40	50	60	80	100
1,2,4-Trimethylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
sec-Butylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200

Water	Stock (µg/mL)	Level 11 (ug/L)	Level 1 (ug/L)	Level 2 (ug/L)	Level 3 (ug/L)	Level 4 (ug/L)	Level 5 (ug/L)	Level 6 (ug/L)	Level 7 (ug/L)	Level 8 (ug/L)	Level 9 (ug/L)	Level 10 (ug/L)
							Optional		Optional		Optional	
p-Isopropyltoluene	2000		0.5	2	10	30	50	80	100	120	160	200
1,3-Dichlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,4-Dichlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
p-Diethylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
n-Butylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,2-Dichlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,2,4,5-Tetramethylbenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,2-Dibromo-3-chloropropane	2000		0.5	2	10	30	50	80	100	120	160	200
1,3,5-Trichlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
Hexachlorobutadiene	2000		0.5	2	10	30	50	80	100	120	160	200
1,2,4-Trichlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
Naphthalene	2000		0.5	2	10	30	50	80	100	120	160	200
1,2,3-Trichlorobenzene	2000		0.5	2	10	30	50	80	100	120	160	200
1,3-Dioxolane	2000		10	40	100	250	N/A	500	N/A	750	N/A	1000
Pentachloroethane	2000		0.5	2	10	30	50	80	100	120	160	200
1,4-Dioxane (SIM)	100		0.5	2	10	20	30	50	100	200	N/A	N/A
1,1,2,2-Tetrachloroethane (SIM)	100		0.05	0.1	0.2	0.5	1	2	5	10	N/A	N/A

- For Low Level Soil analysis, the calibration levels are the same in µg/Kg units.
- For High Level Soil analysis, the calibration levels are at 50x the levels listed due to sample preparation requirements.

Table 5

8260D Volatile Internal Standards with Corresponding Target Compounds and Surrogates Assigned for Quantitation

Fluorobenzene	Chlorobenzene-d5	1,4-Dichlorobenzene-d4
Dichlorodifluoromethane	Toluene-d8 (surr)	Isopropylbenzene
Chloromethane	Toluene	Bromoform
Vinyl Chloride	Ethyl Methacrylate	1,4-dichloro-2-butane
Bromomethane	Trans-1,3-dichloropropene	1,1,2,2,-tetrachloroethane
Chloroethane	1,1,2-trichloroethane	4-bromofluorobenzene (surr)
Trichlorofluoromethane	2-hexanone	1,2,3-trichloropropane
Ethyl Ether	1,3-dichloropropane	trans-1,4-dichloro-2-butene
Freon 113	Tetrachloroethene	n-propylbenzene
Acrolein	Chlorodibromomethane	Bromobenzene
Acetone	1,2-dibromoethane	4-ethyltoluene
Ethanol	Chlorobenzene	1,3,5-trimethybenzene
1,1,-dichloroethene	1,1,1,2-tetrachloroethane	2-chlorotoluene
Tert-Butyl Alcohol	Ethylbenzene	4-chorotoluene
Methyl Acetate	p/m xylene	tert-butylbenzene
Carbon Disulfide	o xylene	1,2,4-trimethylbenzene
Methylene Chloride	Styrene	sec-butylbenzene
Acrylonitrile	Octane	p-isopropyltoluene
Methyl Tert Butyl Ether	2-Nitropropane	1,3-dichlorobenzene
Halothane	Methyl isothiocyanate	1,4-dichlorobenzene
Trans-1,2-dichloroethene	n-Butyl acetate	n-butylbenzene
Diisopropyl Ether	Nonane	p-diethylbenzene
Vinyl Acetate		1,2-dichlorobenzene
1,1-dichloroethane		1,2,4,5-tetramethylbenzene
Ethyl-Tert-Butyl-Ether		1,2-dibromo-3-chloropropane
2-butanone		1,3,5-trichlorobenzene
2,2-dichloropropane		1,2,4-trichlorobenzene
Cis-1,2-dichloroethene		Hexachlorobutadiene
Chloroform		Naphthalene
Bromochloromethane		1,2,3-trichlorobenzene
Tetrahydrofuran		Cyclohexanone
Dibromofluoromethane (surr)		Nitrobenzene

1,1,1-trichloroethane		Pentachloroethane
Cyclohexane		Decane
1,1-dichloropropene		Limonene
carbon Tetrachloride		trans-Decahydronaphthalene
Tertiary-Amyl Methyl Ether		Undecane
1,2-dichloroethane-d4 (surr)		Hexachloroethane
1,2-dichloroethane		cis-Decahydronaphthalene
Benzene		
Trichloroethene		
Methyl cyclohexane		
1,2-Dichloropropane		
Bromodichloromethane		
1,4-Dioxane		
Dibromomethane		
2-Chloroethylvinyl Ether		
4-methyl-2-pentanone		
cis-1,3-Dichloropropene		
Iodomethane		
Methyl methacrylate		
n-Butanol		
Ethyl acetate		
Isopropyl alcohol (IPA)		
Hexane		
n-Propyl bromide		
Chlorodifluoromethane		
Allyl chloride		
Heptane		

Table 6

8260D Quantitation Ions

Analyte	Quantitation Ion	Analyte	Quantitation Ion
Dichlorodifluoromethane	85	Ethyl Methacrylate	69
Chloromethane	50	Trans-1,3-dichloropropene	75
Vinyl Chloride	62	1,1,2-trichloroethane	83
Bromomethane	94	2-hexanone	43
Chloroethane	64	1,3-dichloropropane	76
Trichlorofluoromethane	101	Tetrachloroethene	166
Ethyl Ether	74	Chlorodibromomethane	129
Freon 113	101	1,2-dibromoethane	107
Acrolein	56	Chlorobenzene	112
Acetone	43	1,1,1,2-tetrachloroethane	131
1,1,-dichloroethene	96	Ethylbenzene	91
Tert-Butyl Alcohol	59	p/m xylene	106
Methyl Acetate	43	o xylene	106
Carbon Disulfide	84	Styrene	104
Methylene Chloride	76	Isopropylbenzene	105
Acrylonitrile	53	Bromoform	173
Methyl Tert Butyl Ether	73	1,4-dichloro-2-butane	55
Halothane	117	1,1,2,2,-tetrachloroethane	83
Trans-1,2-dichloroethene	96	1,2,3-trichloropropane	75
Diisopropyl Ether	45	Trans-1,4-dichloro-2-butene	53
Vinyl Acetate	43	n-propylbenzene	91
1,1-dichloroethane	63	Bromobenzene	156
Ethyl-Tert-Butyl-Ether	59	4-ethyltoluene	105
2-butanone	43	1,3,5-trimethybenzene	105
2,2-dichloropropane	77	2-chlorotoluene	91
Cis-1,2-dichloroethene	96	4-chlorotoluene	91
Chloroform	83	tert-butylbenzene	119
Bromochloromethane	128	1,2,4-trimethylbenzene	105
Tetrahydrofuran	42	sec-butylbenzene	105
1,1,1-trichloroethane	97	p-isopropyltoluene	119
Cyclohexane	56	1,3-dichlorobenzene	146
1,1-dichloropropene	75	1,4-dichlorobenzene	146
Carbon Tetrachloride	117	n-butylbenzene	91
Tertiary-Amyl Methyl Ether	73	p-diethylbenzene	119
1,2-dichloroethane	62	1,2-dichlorobenzene	146
Benzene	78	1,2,4,5-Tetramethylbenzene	119
Trichloroethene	95	1,2-Dibromo-3-chloropropane	75
Methyl Cyclohexane	83	1,3,5-Trichlorobenzene	180
1,2-Dichloropropane	63	1,2,4-Trichlorobenzene	180
Bromodichloromethane	83	Hexachlorobutadiene	225
1,4-dioxane	88	Naphthalene	128
Dibromomethane	93	1,2,3-trichlorobenzene	180
2-Chloroethylvinyl Ether	63	Ethanol	45
4-methyl-2-pentanone	58	Cyclohexanone	55
Cis-1,3-dichloropropene	75	Ethyl acetate	43

Table 6

8260D Quantitation Ions (continued)

Analyte	Quantitation Ion	Analyte	Quantitation Ion
Toluene	92	Iodomethane	142
Methyl methacrylate	69	n-Butanol	56
Pentachloroethane	167	Isopropyl Alcohol (IPA)	45
Hexane	57	n-Propyl bromide	43
Chlorodifluoromethane	51	Iodomethane	142
Allyl chloride	76	Heptane	71
Octane	85	2-Nitropropane	41
Methyl isothiocyanate	73	n-Butyl Acetate	43
Nonane	57	Decane	57
Limonene	68	Undecane	57
trans-Decahydronaphthalene	138	cis-Decahydronaphthalene	138
Hexachloroethane	117	Nitrobenzene	77

Table 7

List of 8260 Difficult Analytes:

1,1,2,2-Tetrachloroethane
1,2-Dibromo-3-chloropropane (DBCP)
1,4-Dioxane
2-Butanone
2-chloroethylvinyl ether
2-Hexanone
2,2-dichloropropane
4-Methyl-2-pentanone
Acetone
Bromoform
Bromomethane
Carbon disulfide
Chloroethane
Chloromethane
cis-1,3-Dichloropropene
Dichlorodifluoromethane (Freon 12)
Ethanol
Iodomethane
Isobutyl Alcohol
Naphthalene
Nitrobenzene
n-butanol
Styrene
Tert-Butyl Alcohol
Trichlorofluoromethane (Freon 11)
Isopropyl Alcohol (IPA)

Table 8

ICAL Low Point re-quantitation ranges

Water	Level 11 (ug/L)	L11 (70% - 130%)	Level 1 (ug/L)	L1 (70% - 130%)	Level 2 (ug/L)	L2 (70% - 130%)	Level 3 (ug/L)	L3 (70% - 130%)
Dichlorodifluoromethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Chloromethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Vinyl chloride	0.19	0.133 - 0.247	0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Bromomethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Chloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Trichlorofluoromethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Ethyl ether			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Ethanol			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1-Dichloroethene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Carbon disulfide			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Freon-113			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Iodomethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Acrolein			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Methylene chloride			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Isopropyl alcohol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65

Water	Level 11 (ug/L)	L11 (70% - 130%)	Level 1 (ug/L)	L1 (70% - 130%)	Level 2 (ug/L)	L2 (70% - 130%)	Level 3 (ug/L)	L3 (70% - 130%)
Acetone			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
trans-1,2-Dichloroethene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Methyl acetate			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Methyl tert-butyl ether			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
tert-Butyl alcohol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
Diisopropyl ether			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1-Dichloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Halothane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Acrylonitrile			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Ethyl tert-butyl ether			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Vinyl acetate			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
cis-1,2-Dichloroethene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
2,2-Dichloropropane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Bromochloromethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Cyclohexane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Chloroform			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Ethyl acetate			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Carbon tetrachloride	0.19	0.133 - 0.247	0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Tetrahydrofuran			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1,1-Trichloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
2-Butanol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
2-Butanone			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1-Dichloropropene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Benzene	0.19	0.133 - 0.247	0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
tert-Amyl methyl ether			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2-Dichloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Isobutyl alcohol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
2-Methyl-2-butanol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
Methyl cyclohexane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Trichloroethene	0.19	0.133 - 0.247	0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
n-Butanol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
Dibromomethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2-Dichloropropane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
4-penten-2-ol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
2-Chloroethyl vinyl ether			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Bromodichloromethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Ethyl acrylate			0.25	0.175 - 0.325	1	0.7 - 1.3	5	3.5 - 6.5
Methyl methacrylate			0.25	0.175 - 0.325	1	0.7 - 1.3	5	3.5 - 6.5
1,4-Dioxane			100	70 - 130	400	280 - 520	500	350 - 650
cis-1,3-Dichloropropene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Toluene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
4-Methyl-2-pentanone			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Tetrachloroethene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0

Water	Level 11 (ug/L)	L11 (70% - 130%)	Level 1 (ug/L)	L1 (70% - 130%)	Level 2 (ug/L)	L2 (70% - 130%)	Level 3 (ug/L)	L3 (70% - 130%)
Chloropicrin			30	21 - 39	50	35 - 65	80	56 - 104
trans-1,3-Dichloropropene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
4-Methyl-2-pentanol			2.5	1.75 - 3.25	10	7 - 13.0	50	35 - 65
Ethyl methacrylate			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1,2-Trichloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Chlorodibromomethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,3-Dichloropropane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2-Dibromoethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
2-Hexanone			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Chlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Ethylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1,1,2-Tetrachloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
p/m Xylene			1	0.7 - 1.3	4	2.8 - 5.2	20	14 - 26
o Xylene			1	0.7 - 1.3	4	2.8 - 5.2	20	14 - 26
Styrene			1	0.7 - 1.3	4	2.8 - 5.2	20	14 - 26
Bromoform			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Butyl acrylate			0.25	0.175 - 0.325	1	0.7 - 1.3	5	3.5 - 6.5
Isopropylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Bromobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
n-Propylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,4-Dichlorobutane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1,2,2-Tetrachloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
4-Ethyltoluene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
2-Chlorotoluene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,3,5-Trimethylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2,3-Trichloropropane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
trans-1,4-Dichloro-2-butene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
4-Chlorotoluene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
tert-Butylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Pentachloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
n-Butyl methacrylate			0.25	0.175 - 0.325	1	0.7 - 1.3	5	3.5 - 6.5
1,2,4-Trimethylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
sec-Butylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
p-Isopropyltoluene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,3-Dichlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,4-Dichlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
p-Diethylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
n-Butylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2-Dichlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2,4,5-Tetramethylbenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2-Dibromo-3-chloropropane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,3,5-Trichlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
Hexachlorobutadiene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2,4-Trichlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0

Naphthalene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,2,3-Trichlorobenzene			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,3-Dioxolane			10	7 - 13.0	40	28 - 52	100	70 - 130
Pentachloroethane			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,4-Dioxane (SIM)			0.5	0.35 - 0.65	2	1.4 - 2.6	10	7 - 13.0
1,1,2,2-Tetrachloroethane (SIM)			0.05	0.035 - 0.065	0.1	0.07 - 0.13	0.2	0.14 - 0.26

ICAL Low Point re-quantitation ranges

Soil	Level 0 (ug/kg)	L0 (70% - 130%)	Level 1 (ug/kg)	L1 (70% - 130%)	Level 1.5 (ug/kg)	L1.5 (70% - 130%)	Level 2 (ug/kg)	L2 (70% - 130%)	Level 3 (ug/kg)	L3 (70% - 130%)
Dichlorodifluoromethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chlorodifluoromethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chloromethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Vinyl chloride	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Bromomethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Trichlorofluoromethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Ethyl ether	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Ethanol	N/A	N/A	20	14 - 26	N/A	N/A	80	56 -104	200	140 - 260
1,1-Dichloroethene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Carbon disulfide	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Freon-113	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Iodomethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Acrolein	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Allyl chloride	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Methylene chloride	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Isopropyl alcohol	N/A	N/A	20	14 - 26	N/A	N/A	80	56 -104	200	140 - 260
Acetone	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
trans-1,2-Dichloroethene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Methyl acetate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Hexane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26

Soil	Level 0 (ug/kg)	L0 (70% - 130%)	Level 1 (ug/kg)	L1 (70% - 130%)	Level 1.5 (ug/kg)	L1.5 (70% - 130%)	Level 2 (ug/kg)	L2 (70% - 130%)	Level 3 (ug/kg)	L3 (70% - 130%)
Methyl tert-butyl ether	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
tert-Butyl alcohol	2.5	1.75 - 3.25	5	3.5 - 6.5	10	7.0 - 13.	20	14 - 26	100	70 - 130
Diisopropyl ether	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,1-Dichloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Halothane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Acrylonitrile	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Ethyl tert-butyl ether	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Vinyl acetate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
cis-1,2-Dichloroethene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
2,2-Dichloropropane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Bromochloromethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Cyclohexane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chloroform	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Ethyl acetate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Carbon tetrachloride	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Tetrahydrofuran	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,1,1-Trichloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
2-Butanol	N/A	N/A	20	14 - 26	N/A	N/A	80	56 - 104	200	140 - 260
2-Butanone	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,1-Dichloropropene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Heptane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Benzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
tert-Amyl methyl ether	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2-Dichloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Isobutyl alcohol	N/A	N/A	20	14 - 26	N/A	N/A	80	56 - 104	200	140 - 260
2-Methyl-2-butanol	2.5	1.75 - 3.25	5	3.5 - 6.5	10	7	20	14 - 26	100	70 - 130
Methyl cyclohexane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26

Soil	Level 0 (ug/kg)	L0 (70% - 130%)	Level 1 (ug/kg)	L1 (70% - 130%)	Level 1.5 (ug/kg)	L1.5 (70% - 130%)	Level 2 (ug/kg)	L2 (70% - 130%)	Level 3 (ug/kg)	L3 (70% - 130%)
Trichloroethene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
n-Butanol	N/A	N/A	20	14 - 26	N/A	N/A	80	56 - 104	200	140 - 260
Dibromomethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2-Dichloropropane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
4-penten-2-ol	2.5	1.75 - 3.25	5	3.5 - 6.5	10	7	20	14 - 26	100	70 - 130
2-Chloroethyl vinyl ether	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Bromodichloromethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Ethyl acrylate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Methyl methacrylate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,4-Dioxane	N/A	N/A	40	28 - 52	80	56 – 104	200	140 - 260	1000	700 - 1300
cis-1,3-Dichloropropene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Octane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Toluene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
4-Methyl-2-pentanone	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Tetrachloroethene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
2-Nitropropane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chloropicrin	N/A	N/A	50	35 - 65	N/A	N/A	100	70 - 130	200	140 - 260
trans-1,3-Dichloropropene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Methyl isothiocyanate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
4-Methyl-2-pentanol	N/A	N/A	20	14 - 26	N/A	N/A	80	56 - 104	200	140 - 260
Ethyl methacrylate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,1,2-Trichloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chlorodibromomethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,3-Dichloropropane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2-Dibromoethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
n-Butyl Acetate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26

Soil	Level 0 (ug/kg)	L0 (70% - 130%)	Level 1 (ug/kg)	L1 (70% - 130%)	Level 1.5 (ug/kg)	L1.5 (70% - 130%)	Level 2 (ug/kg)	L2 (70% - 130%)	Level 3 (ug/kg)	L3 (70% - 130%)
2-Hexanone	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Nonane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Chlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Ethylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,1,1,2-Tetrachloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
p/m Xylene	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	8	5.6 - 10.4	40	28 - 52
o Xylene	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	8	5.6 - 10.4	40	28 - 52
Styrene	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	8	5.6 - 10.4	40	28 - 52
Bromoform	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Butyl acrylate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Isopropylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Bromobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Decane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
n-Propylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,4-Dichlorobutane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,1,2,2-Tetrachloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
4-Ethyltoluene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
2-Chlorotoluene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,3,5-Trimethylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2,3-Trichloropropane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
trans-1,4-Dichloro-2-butene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
4-Chlorotoluene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
tert-Butylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Pentachloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
n-Butyl methacrylate	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2,4-Trimethylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26

Soil	Level 0 (ug/kg)	L0 (70% - 130%)	Level 1 (ug/kg)	L1 (70% - 130%)	Level 1.5 (ug/kg)	L1.5 (70% - 130%)	Level 2 (ug/kg)	L2 (70% - 130%)	Level 3 (ug/kg)	L3 (70% - 130%)
Limonene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
sec-Butylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
p-Isopropyltoluene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,3-Dichlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,4-Dichlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
trans-Decahydronaphthalene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Undecane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
p-Diethylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
n-Butylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Hexachloroethane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2-Dichlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
cis-Decahydronaphthalene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2,4,5-Tetramethylbenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2-Dibromo-3-chloropropane	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,3,5-Trichlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Nitrobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Hexachlorobutadiene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2,4-Trichlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
Naphthalene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,2,3-Trichlorobenzene	0.5	0.35 - 0.65	1	0.7 - 1.3	2	1.4 - 2.6	4	2.8 - 5.2	20	14 - 26
1,3-Dioxolane	N/A	N/A	25	17.5 - 32.5	N/A	N/A	50	35 - 65	100	70 - 130

Determination of Volatile Organic Compounds in Air Using Specially-Prepared Canisters and Analyzed by GC/MS

References: **Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air - Second Edition.** U.S. Environmental Protection Agency. EPA/625/R-96/010b. Office of Research and Development National Risk Management Research Laboratory. Center for Environmental Research Information. Cincinnati, Ohio. January 1999.

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). U.S. Environmental Protection Agency. EPA/625/R-96/010b. Office of Research and Development National Risk Management Research Laboratory. Center for Environmental Research Information. Cincinnati, Ohio. January 1999.

1. Scope and Application

Matrices: Ambient Air, Soil Gas, Soil Vapor

Definitions: Refer to Section 16 and Alpha Analytical Quality Systems Manual

This SOP describes the procedure for the analysis of volatile organic compounds (VOCS) in ambient air. The whole air samples are collected in fused-silica lined (FSL) stainless steel canisters, or Tedlar® bags. The VOCs are subsequently separated by gas chromatography (GC) and measured by mass selective detector (MSD).

The organic compounds that are amenable to this method are listed in Table 9. Other compounds may also be amenable provided they meet the QA/QC requirements of the method.

The data report packages present the documentation of any method modification related to the samples tested. Depending upon the nature of the modification and the extent of intended use, the laboratory may be required to demonstrate that the modifications will produce equivalent results for the matrix. Approval of all method modifications is by one or more of the following laboratory personnel before performing the modification: Area Supervisor, Department Supervisor, Laboratory Director, or Quality Assurance Officer.

This method is restricted to use by or under the supervision of analysts experienced in the operation of the GC/MS and in the interpretation of GC/MS data. Each analyst must demonstrate the ability to generate acceptable results with this method by performing an initial demonstration of capability.

This SOP contains addendums for various state-specific requirements. The criteria in these addenda (Addendum C-F) must be adhered to for projects conducted under the state programs.

2. Summary of Method

Samples are collected in precleaned, evacuated FSL canisters or Tedlar® bags.

Samples are pre-concentrated using the Entech 7200 or 7200A Cryogenic Concentrator. A specified volume of sample is pulled using a vacuum pump through a mass flow controller. The sample is cryogenically concentrated to a volume of less than one mL on a Tenax® trap.

Following pre-concentration, the sample is refocused on the GC transfer line. This step further reduces the sample volume to less than one microliter for injection.

The sample is then injected into the GC, which is used to separate the compounds of interest. All compounds are detected using an MSD.

2.1 Method Modifications from Reference

Initial Calibration modifications: If a target analyte cannot meet the %RSD criteria for relative response factor calibration, then linear regression may be used. A minimum of five calibration points must be incorporated and a correlation coefficient of 0.995 or greater must be achieved. The calibration plot must be printed and approval by a supervisor must be obtained prior to calibration acceptance. If any compound is calibrated using linear regression then after the ICV and prior to any sample analysis, a low point standard must be analyzed to confirm there is no bias resulting from the linear regression calibration used. Recovery of the low point standard must be 60-140% using the linear regression curve.

Continuing calibration and laboratory controlled spike (LCS) modifications: The recoveries of all analytes must be within 70% to 130% of the true value. If more than 10% of the compounds fail these criteria, or if one compound has a recovery less than 50% or greater than 150% the LCS must be re-analyzed. If failure occurs a second time, the instrument must be re-calibrated. Recoveries greater than 150% may be acceptable, provided analytes are not detected in the samples.

Initial Calibration Verification modification: Two analytes are allowed to be greater than 30% RSD, but less than 40%.

Sample Duplicate modifications: Up to 10% of the target analyte detections may exceed acceptance criteria. If more variation occurs, the sample analysis must be repeated. If an analyte detected in one of the analysis at >5x the reporting limit, and not detected in the duplicate analysis, the analysis must be repeated. If an analyte is detected in one analysis at <5x the reporting limit and not detected in the duplicate analysis, the RPD is not calculable (NC) and the analysis does not have to be repeated. If an analyte is not detected in both the original and duplicate analysis, the RPD is NC.

Section 8.4.1.2 of the TO-15 method requires all canisters to be leak checked for a period of 24 hr via pressurization of the canister. The laboratory conducts the leak check by measuring the vacuum of the canister after a minimum of a 24 hr. period has elapsed, not by pressurizing the canister as per the method.

The % RSD for any analyte must be < 30%, as outlined in Section 10.2.2.7 of this SOP.

Humidified nitrogen is used in place of zero air due to the frequency of detection of VOCs in zero air, particularly at SIM detection limits.

There is no NIST-traceable second source standard currently available for the analytes listed in Table 1, Table 3B, and Table A-7.

3. Reporting Limits

Table 9 lists target analytes and Reported Detection Limit information.

4. Interferences

4.1 Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other sampling equipment (e.g., pump and flow controllers)

must be thoroughly cleaned to ensure that the filling apparatus will not contaminate samples.

4.2 System carryover can be a potential problem, particularly for the heavier molecular weight hydrocarbons. Carryover can occur after the analysis of standards or high-level samples. Measures that must be taken to remove this contamination can include the analysis of multiple blanks, lab air, and the purging of the autosampler with nitrogen.

4.3 High moisture content, methane levels and/or carbon dioxide levels may interfere with the chromatography and trapping of target analytes. Dilutions may be performed on these samples; however, the reporting limits will then be elevated.

5. Health and Safety

The toxicity or carcinogenicity of each reagent and standard used in this method is not fully established; however, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be reduced to the lowest possible level by whatever means available. A reference file of material safety data sheets is available to all personnel involved in the chemical analysis. Additional references to laboratory safety are available in the Chemical Hygiene Plan.

All personnel handling environmental samples known to contain or to have been in contact with municipal waste must follow safety practices for handling known disease causative agents.

All employees performing laboratory procedures must have read and understood the Alpha Analytical Chemical Hygiene Plan. All laboratory procedures must be performed in accordance with the provisions and policies of the manual. All accidents, injuries, spills, or unsafe conditions must be reported immediately to the laboratory manager, and such occurrences must be thoroughly documented.

The analyst must wear a lab coat, gloves, and safety glasses while preparing solutions or handling samples.

Preparation of liquid standards must be performed under a properly functioning fume hood. Preparation and venting of gaseous standards must also be performed under a properly functioning fume hood.

6. Sample Collection, Preservation, Shipping and Handling

6.1 Sample Collection

6.1.1 FSL canister samples can be collected as grab samples or as time-integrated samples. Time-integrated samples can be collected for a maximum of 12 hours using 2.7-liter canisters, or a maximum of 24 hours to 7 days using 6-liter canisters. One liter canisters are typically used for soil vapor sampling with a sampling flowrate of 100-200 ml/min.

6.1.1.1 Grab samples are collected by opening the canister valve and allowing the canister to fill to ambient pressure. This process takes approximately one minute.

6.1.1.2 Time-integrated samples require the use of a properly calibrated flow controller. The flow controller, if provided by Alpha, is calibrated prior to

sample collection and is documented in the Alpha ACS LIMs (Refer to Alpha SOP # 2190 for Canister and Flow Controller Preparation).

6.1.2 Tedlar® bag samples typically can be collected as grab or composite samples and may require a pumping system or evacuated box.

6.1.3 Upon receipt at the laboratory, all samples are assigned unique laboratory identification numbers, checked for possible discrepancies, etc. (See SOP # 1559.)

6.2 Sample Preservation

Canisters-None. Tedlar® bags-should be protected from light.

6.3 Sample Shipping

All samples must be accompanied by a chain of custody form, which documents the date, and time of sample collection.

6.4 Sample Handling

The pressure of all FSL canister samples is measured upon receipt at the laboratory and documented in the ACS LIMs (See Alpha SOP #2190). A pressure gauge is attached to the canister inlet, the canister valve is briefly opened and the pressure is recorded. The gauge apparatus used to measure ambient air samples must be separate from that used to measure soil vapor or other matrices known to have elevated levels of VOCs to avoid cross-contamination.

Samples with pressures greater than -15 inches Hg are considered acceptable for analysis.

Samples with less than -15 inches Hg should be pressurized to > -15 inches Hg in order for the concentrator system to accurately draw the correct volume, resulting in a dilution of the sample. For ambient air samples, the client must be notified prior to sample analysis since this dilution may cause reporting limits to be elevated above project action levels.

Any samples that undergo pressurization prior to analysis are documented in the instrument software. Refer to Section 10.3.3.6 for the calculation of dilution factors due to pressurization of samples.

Refer to SOP # 1559 for Sample Management information.

FSL canister and Tedlar® bag samples are stored in the Volatiles Laboratory until analysis has been completed. Tedlar® bag samples are stored in opaque containers.

The recommended holding time for the analysis of FSL canister samples for TO-15 is 30 days from date of collection. The recommended holding time for the analysis of Tedlar® bag samples for TO-15 is 48-72 hours from date of collection. Tedlar® bag samples requiring TO-15 analysis may be transferred into canisters upon receipt at the laboratory in order to extend the holding time of the sample to 30 days.

Samples designated by client to be held for subsequent analyses or are “on hold” are to be kept in a designated area in the laboratory. “Hold” samples are discarded upon client authorization or after holding time expiration date.

7. Equipment and Supplies

7.1 Microliter syringes: 10, 25,and 500 µL

7.2 Gas tight syringes: 1 mL, 5 mL, 25 mL, 50 mL, and 100 mL

7.3 FSL canisters: 1.0, 2.7, 6.0 and 15 Liter

7.4 Tedlar® bags: Various sizes. Alpha supplies 5-Liter sizes. All bags must have polypropylene fittings which are recommended for the analysis of Sulfides and Mercaptans (see App. A).

7.5 Stop watch

7.6 Sample Concentrator

7.6.1 The concentrator system consists of two separate pieces of equipment: (1) Entech Model 7016D VOC Autosampler, and (2) Entech Model 7200 or 7200A Cryogenic Concentrator using liquid nitrogen.

7.6.2 A vacuum pump (Vaccubrand Model ME2 or similar) delivers the sample from the autosampler to the cryogenic concentrator FSL-lined steel tubing.

7.7 Gas Chromatograph System

7.7.1 Gas chromatograph - Shimadzu 2010, 2030

7.7.2 Chromatographic column: Restek RTX-1; 60 meters, 0.25 mm or 0.32 mm ID, 1 micron film thickness

7.7.3 Transfer line from column to GC injection port: Hydroguard ™ 0.32 mm capillary tubing connected to column with Restek Vu-Union connector.

7.8 Mass Spectrometer System

7.8.1 Mass spectrometer - Shimadzu 2010, 2020

7.8.2 The mass spectrometer must be capable of scanning from 29 to 270 amu every 3 seconds or less, utilizing 70 volts (nominal) electron energy in the electron impact ionization mode and producing a mass spectrum that meets all the criteria in Table 5 when 50 ng of 4- bromofluorobenzene is injected. For SIM (selective ion monitoring) analysis, the system must be capable of simultaneous SIM/full scan acquisition.

7.8.3 Data System - Shimadzu GC/MS Solutions software for data acquisition and Agilent Enviroquant version E.02.00 for data processing.

7.9 Dilution Systems

7.9.1 Entech 4600A Dynamic Dilution System- for performing sample dilutions in canisters and Entech 4700 Precision Diluter preparing calibration standards in canisters. .

7.10 Primary flow measurement device: BIOS Cell Defender 510 or equivalent

8. Reagents and Standards

8.1 DI Water or Carbon-filtered tap water

8.2 High purity purge and trap grade methanol (Fisher part # A453-1 or equivalent) for MS source cleaning

8.3 Ultra high purity (UHP) helium for the GC/MS system

8.4 Ultra high purity (UHP) nitrogen for standard preparation

8.5 NIST certified TO-15 gas standards, purchased from Linde (formerly Spectra Gases). Standards are stored at room temperature and expire per vendor's expiration date, unless re-certified. Recertified standards are received with an updated certificate of analysis which includes a new expiration date.

8.6 Neat chemicals: Listed in Table 1, Table A-1, and Table 3B, ≥ 98% purity.

8.7 Liquid nitrogen: For the concentrator system and/or GC cooling

8.8 Primary Standards

8.8.1 Primary standard mixtures of TO-15 analytes are purchased certified gaseous standards already prepared as well as gaseous standards prepared in the laboratory by injecting neat chemicals into Tedlar® bags (See Table 1).

8.8.2 Table 1 indicates volumes of neat chemicals that are injected into 20 L of zero air or UHP nitrogen to obtain primary standard concentrations for all analytes.

8.8.3 Purchased primary standards are assigned a CSS # (commercially supplied standard) upon receipt for tracking purposes. Preparation of primary standards must be entered into the primary standard preparation logbook (Form No.: 117-11).

8.8.4 Standards are valid per the manufacturer's expiration date as noted.

8.9 Secondary Standards

8.9.1 Prepare secondary standards in canisters using the Entech 4700 Precision Diluter at a minimum of two concentration levels. Table 3A and 3B outlines the preparation steps for each secondary standard.

8.9.2 Prior to preparation of the standards, verify that an appropriate vacuum exists in the canister (>0.5 psia). Figure 3 demonstrates the standard preparation system. Primary standards prepared in Tedlar bags are injected into a canister (typically

15 L) using an injection tee with a septum or transferred from purchased and / or prepared cylinders via the precision diluter.

8.9.3 Attach the transfer lines from the primary standards to the dynamic diluter.

8.9.4 Prior to the injection of the gaseous standards, allow the dynamic diluter to equilibrate for a approximately 25 minutes by allowing each standard channel to flush for a minimum of 5 min. Be sure the vent line is attached to the outlet.

8.9.5 After equilibrating the system, attach the canister to the outlet of the diluter. Flush line with nitrogen for 20 sec prior to attaching canister. Load in the appropriate configuration and standard preparation method (TO15 ICAL, DIAZ, or TO15 LCS) into the precision dilution software for the corresponding target concentration (TO15 ICAL 100 ppbV, TO15 ICAL 10 ppbV).

Equation 1: Flow rate calculation:

$$T_f = V_{std} / F_{std}$$

Where:

T_f = standard transfer time, minutes
V_{std} = standard volume, mL
F_{std} = standard flowrate, mL/min

8.9.6 Inject the appropriate amount of Tedlar bag primary standard and/or the low vapor pressure compounds listed in Table 3B into the injection port tee. This injection must be done while the canister is below atmospheric pressure.

8.9.7 When all the primary standards have been added to the canister, the canister will be pressurized to the programmed final pressure using the precision diluter.

NOTE: Standard canisters prepared for analysis using the autosampler must have a maximum pressure of 30 psia to ensure proper and consistent sampling by the instrument.

8.9.8 Label the canister accordingly and record the standard preparation in the secondary standard (SS) preparation logbook (Form No.: 12925).

8.9.9 The ICV/LCS standard is prepared in the same manner, using primary standards of differing lot #s, at a concentration of 10 ppbV

Secondary standards are valid for 6 months.

8.10 Internal Standard and BFB Tuning Standard/Surrogate Standard

An internal standard (Bromochloromethane, 1,4-Difluorobenzene, and Chlorobenzene-D5) and tuning/surrogate standard containing Toluene-D8, 1,2-Dichloroethane-D4, and Bromofluorobenzene (BFB) are prepared as two separate gas standards at 25 ppbV (2

year expiration date). The internal standards and BFB / surrogates are loaded onto the sample trap prior to the calibration standard(s), sample, or QC sample(s) via a mass flow controller. The concentration of the internal standard and BFB / surrogates added is based upon the nominal concentration of sample that is analyzed. If the nominal volume of sample is 250 mL, then 100 mL of the 25 ppbV internal standard mix will yield a true value of 10 ppbV for the internal standards and BFB. Using equation 7, the ug/m^3 equivalent of BFB injected 179 ug/m^3 or 179 ng/L (MW of BFB = 175). Thus, the total ng injected is:

Total ng = 179 ng/L x 0.100 L = 17.9 ng

8.11 Instrument Calibration Standards

Calibration standards are prepared by injecting different volumes of the secondary standards into the concentrator/GC/MS system. The low standard will be used to establish the reporting limit for sample analyses. These are described in more detail in Section 10.

9. Quality Control

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. Quality control limits may also be found in the Laboratory Information Management System(LIMs)

At a minimum, for each day of analysis, a Continuing Calibration standard, Laboratory Method Blank, Laboratory Control Spike and Laboratory Duplicate must be analyzed. Laboratory Control Spike Duplicate (LCSD) will be analyzed only upon client request.

9.1 Laboratory Method Blank(s)

A FSL canister pressurized to 30 psia with humidified nitrogen is utilized as the Laboratory Method Blank. This method blank must be free of target analyte contamination at or above the reporting limit. If it is not, the system must be evaluated for possible sources of contamination. Once the source is determined and eliminated, the Blank must be reanalyzed.

A Laboratory Method Blank must be run after samples suspected of being highly contaminated to determine if sample carryover has occurred. If samples have been analyzed using an autosampler, data must be evaluated for potential carryover and re-analyses conducted, as appropriate.

9.2 Laboratory Control Sample (LCS) / Laboratory Control Spike Duplicate (LCSD)

NOTE: A Laboratory Control Spike Duplicate is only performed when specified by the project requirements and/or upon Client request.

Laboratory Control Spike - A Laboratory Control Spike (LCS) is prepared by spiking an evacuated FSL canister with a different primary standard solution than that used for the calibration or a purchased gaseous standard with the components of interest may be used. If the recovery is not within acceptance criteria, the LCS may be analyzed a second time. If the LCS failure continues, the instrument must be recalibrated. Refer to Section 12 for appropriate corrective actions to be taken. QC limits are subject to change for any particular analyte, if deemed necessary after review of QC control limits.

9.3 Initial Calibration Verification (ICV)

A mid-range calibration standard must be analyzed after the initial calibration and prior to sample analysis, and must be a different source than that used for the initial calibration. See section 10.4.1 for additional criteria. Otherwise, sample analysis may proceed.

9.4 Continuing Calibration Verification (CCV)

A mid-range calibration standard must be analyzed prior to sample analysis. This standard is of a different source than that used for the LCS/LCSD pair, typically the same source as the initial calibration standards. See section 10.4. or additional criteria. If repeated failure of the CCV occurs, the instrument must be recalibrated. Otherwise, sample analysis may proceed. The LCS may also be utilized as the continuing calibration unless otherwise defined in an addendum.

9.5 Matrix Spike

Not applicable.

9.6 Laboratory Duplicate

Laboratory Duplicate is a replicate analysis of a sample. The RPD of duplicate analyses must not exceed 25. Up to 10% of the target analyte detections may exceed acceptance criteria. The criteria does not need to be applied to concentrations less than 5X the reporting limit. If more variation occurs, the sample analysis must be repeated. If an analyte is detected in one analysis at >5x the reporting limit and not detected in the duplicate analysis, the analysis must be repeated. If an analyte is detected in one analysis at <5x the reporting limit and not detected in the duplicate analysis, the RPD is not calculable (NC) and the analysis does not have to be repeated. If an analyte is not detected in both the original and duplicate analyses, the RPD is NC. Equation 9 is used to calculate the RPD.
The sample chosen for duplicate analysis should not be a trip blank, field blank, or equipment blank. The sample chosen for duplicate analysis must be rotated among clients and/or sites. If possible, field duplicates should not be chosen for duplicate analysis, nor should outside air samples if indoor air samples are also included in the analytical batch. Refer to Appendices D - F for agency –specific criteria on laboratory duplicate criteria.

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Equation 9: RPD Calculation

$$RPD = ABS(C_s - C_d) / [(C_s + C_d)/2]*100$$

where:

RPD = relative percent difference
C_s = concentration in original sample analysis
C_d = concentration in duplicate sample analysis

9.7 Method-specific Quality Control Samples

9.7.1 BFB Tune - A successful BFB spectrum must meet the criteria in Table 5 prior to sample analysis. If a successful BFB spectrum is not obtained, the MS must be retuned and the BFB spectrum re-evaluated prior to analyzing samples.

9.7.2 Internal Standards - The internal standard area counts of each sample, blank, and Laboratory Control Sample are evaluated against the corresponding

continuing calibration standard. The internal standard area counts must be within 60-140% of the continuing calibration standard area counts. If the retention times of the internal standards must be within +/- 0.33 min. If the internal standards fall outside this range, the sample, blank, or Laboratory Control Sample must be reanalyzed. In addition, area counts for internal standards for continuing calibration must be within 60-140% recovery of initial calibration. Refer to Sect. 12 for contingencies on samples exhibiting internal standard recovery failures.

9.7.3 TIC Internal Standards - Internal standards used for the quantitation of TICs must be evaluated by comparing the total ion area counts of the internal standards in the samples to the total ion area counts of the internal standards in the blanks. The internal standard area counts must be within 50-200% of the blank area counts. If the internal standards fall outside this range, a different internal standard or an estimated internal standard total ion area must be used to quantitate the TIC. This estimate can be done by using the total ion area from a blank or a clean sample within the analytical batch.

9.8 Method Sequence

- BFB Tune Check
- Calibration Standards (initial) or Continuing Calibration
- Laboratory Control Sample (may be used as the ICV or CCV)
- Laboratory Control Sample Duplicate (if needed)
- Laboratory Method Blank
- Samples
- Laboratory Duplicate

Injections may be made until 24 hours after the injection used to check the BFB tune.

All analytical sequences must be recorded in the instrument software and documented in the instrument logbook (Form 117-09).

10. Procedure

10.1 Equipment Set-up

10.1.1 Canister Cleaning and Certification

Refer to Alpha SOP #2190 for canister and flow controller preparation.

10.1.2 Sample Preparation and Concentration

Ensure the integrity of the canister sample as described in Section 6.4. General description of procedure: A 3-stage concentration technique called Cold-Trap Dehydration is used to analyze VOC's in air. The air sample is first concentrated to about a 0.5cc volume by drawing an aliquot of sample simultaneously through a cold trap (no packing material) and then through a Tenax trap. The cold trap is then heated to 10 °C and is held there while slowly passing helium through it to transfer these compounds to the Tenax trap, leaving most of the moisture in the cold trap. Sweeping the VOC's from the first to the second trap with only 20cc of helium results in a transfer of less than 0.5 µL of water (40 mL @ 100% RH @ 10 °C) which can be easily handled by benchtop mass spectrometers. The 20 cc transfer volume also serves to flush the CO_2 through the Tenax trap. After transfer to the second trap, the VOC's are back-flushed while heating to be further focused on an open-tubular focusing trap (cryofocuser) for rapid injection onto the analytical column. Internal standard is added directly to the first stage cryogenic trap prior to the sample by a mass flow controller (MFC). MFC controlled introduction is advantageous over loop injection as it remains consistent with the mechanism used to measure the sample volume.

Connect the canisters or Tedlar® bag(s) to the Entech 7016D Autosampler. For FSL canisters: Align the tubing from one of the 16 positions to the canister inlet position. Push the inlet line into the orifice of the canister and hold in place while tightening the fitting finger tight. Turn the stainless steel nut ¼ turn more with a wrench. The canister valves must be closed at this point. For Tedlar® bags: Connect the valve of the Tedlar® bag with the autosampler line using an adapter fitting.

For canister samples, leak check all inlet connections using the leak check procedure included with the Entech software. The software will indicate if there is a change in vacuum over a period of 30 sec. The vacuum must not increase more than 2 psia. Analysis cannot begin until the leak check has passed for each canister being tested and/or the source of the leak has been determined..

Open the canister or bag valves.

Set up the sequence of the Entech system to withdraw 250 mL from each sample. If high concentrations are expected, lower volumes can be used (minimum of 25 mL).. Samples suspected to contain elevated concentrations (i.e. soil vapor, sub-slab, landfill gas) should be pre-screened prior to analysis to obtain more precise dilution information. If screening results indicate elevated concentrations of non-target analytes, the sample should be diluted such that the peak height of the non-target analyte is approximately 10X greater than the peak height of the first internal standard. Recommended concentrator operating parameters are provided in Table 6.

10.2 Initial Calibration

10.2.1 GC Conditions (Shimadzu 2010, 2030)

Oven program: 25° C, hold for 5.0 minutes, then:

Ramp 1: 100° C at 8.0° C / min.; hold for 0.0 min

Ramp 2: 220° C at 25° C / min.; hold for 4.0 min

Gas Flows

Helium carrier gas flow program: 2.0 mL/min for entire run (23.18 min)

Sample Injection

Injection mode:	split
Injection port temperature:	250^0 C
Inlet pressure:	27.3 psi
Total flow:	39.3 mL/min
Split ratio:	17.3
Split flow:	34.6 mL/min
Gas saver flow:	OFF

10.2.2 MS Conditions

Temperature of MSD transfer line: 250^0 C

Temperature of MS Quad: 150^0 C

Temperature of MS Source: 230^0 C

Solvent Delay: 3.0 minutes

Scanning Parameters: 29-270 amu until 10 min, scan rate = 5.52 scans/sec; then 35-270 amu, scan rate = 3.1 scans/sec. Threshold = 150. Sampling rate = 2. EM offset-variable to achieve response of 200K area counts (+/- 25K) for the internal standard bromochloromethane.

10.2.3 Daily GC/MS Performance Check

10.2.3.1 The first analysis of the day is typically a tune evaluation. The GC/MS system is checked to confirm that acceptable performance criteria for bromofluorobenzene (BFB), which is in surrogate mixture, are achieved. These criteria must be met prior to analyzing further standards, blanks and samples.

10.2.3.2 A maximum injection of 50 ng must successfully meet the BFB spectrum criteria in Table 5.

10.2.3.3 If the spectrum of BFB does not meet the above stated criteria, the analysis must be repeated. If the spectrum of BFB still does not meet these criteria, the GC/MS instrument must be re-tuned.

10.2.3.4 The Daily GC/MS Performance Check must be analyzed every 24 hours or less.

10.2.4 Initial Calibration

10.2.4.1 Analyze a minimum of five different levels by analyzing various volumes of the secondary standards prepared in Table 3 (Table A-3 for sulfide/mercaptan analysis). The lowest standard will be at or below the

reporting limit. If the response is not linear at the lowest level for the higher molecular weight compounds, this point must not be included in the calibration curve for these compounds. As a result, the analysis of more than five levels may be required in order to ensure a minimum of five calibration points for each analyte.

Table 4 lists the calibration standard levels and the volumes of the secondary standards needed to achieve these levels.

10.2.4.2 The true value of each of these calibration points is determined by applying a dilution factor that is based on the volume of sample extracted from the canister for each calibration point. Assuming that a volume of 250 mL will be the maximum volume extracted from the samples; this will be the "1X" volume. A dilution factor can be calculated using Equation 2.

Equation 2: Calculation of Instrument Dilution Factor

$$\mathbf{DF = V_{1X} / V_{actual}}$$

where:

DF = dilution factor
V_{1X} = maximum volume sampled, mL
V_{actual} = actual volume sampled for samples and standards

10.2.4.3 Analyze each calibration standard according to the procedures specified in Section 10. The true value of each calibration point is determined by dividing the concentration of the canister by the dilution factor determined using Equation 2.

10.2.4.4 Tabulate the area response of the characteristic ions against the amount for each analyte and internal standard and calculate relative response factors (RRF) for each compound using Equation 3. Perform this calculation for each calibration standard.

Equation 3: Relative Response Factor for Individual Target Analytes

$$\mathbf{RRF = [(A_{EC}) * (C_i)] / [(A_{EI}) * (C_c)]}$$

where:

RRF = relative response factor
A_{EC} = area count of the extracted ion for the analyte of interest
C_i= amount of internal standard (ppbV)
A_{EI} = area count of the extracted ion for the associated internal standard

C_c = amount of analyte of interest (ppbV)

Table 7 lists all TO-15 analytes, internal standards and the associated quantitation ion.

Table 8 lists the internal standards and the associated TO-15 analytes.

10.2.4.5 Calculate the average response factor for each of the target analytes by the following equation (AVG_x = SUM(RFs) / total # of RFs).

10.2.4.6 Calculate the percent relative standard deviation (%RSD) of the response factors over the secondary range of the curve for each of the target analytes using Equation 4.

Equation 4: Percent Relative Standard Deviation

$$\%RSD = [(SD_n - 1) / (AVG_x)] * 100]$$

where:

%RSD = percent relative standard deviation
SD_n -1 = standard deviation (n-1 degrees of freedom)
AVG_x = average response factor from the initial calibration curve

This task can also be accomplished using the quantitation software provided by the instrument manufacturer.

10.2.4.7 If the %RSD is <30 for each analyte, linearity can be assumed for the associated target analyte and sample analysis may proceed.

If the %RSD is >30 for any analyte, the integrations must be evaluated and the calculations verified. If a %RSD <30 cannot be achieved, it is acceptable for two (2) of the analytes to be above 30%, but below 40% RSD (applies to analytes flagged with a “C” on the Enviroquant initial calibration summary table).

Alpha may use the following modified acceptance criteria only for projects that have documentation and approval within the QAPP by the quality assurance project planners, and also for analytes not listed in EPA Method TO-15:

10.2.4.8 If the %RSD is >30 for any analyte, the integrations must be evaluated and the calculations verified. If a %RSD <30 cannot be achieved, it is acceptable for 10% of the total analytes to be above 30%, but below 50% RSD. Before acceptance of such a Calibration Curve, it must be confirmed with the approval of the Section Supervisor and/or the Project Manager that these analytes are typically and historically "trouble" analytes or "poor performers" (typically compounds listed in Table 3B), and that all Client and Project Data Quality Objectives (DQOs) will still be met when analyzing samples using this calibration. Refer to Appendices D - F for agency –specific criteria regarding initial calibration acceptance criteria.

Calibration points may be removed from the calibration curve to meet the 30% RSD criteria, so long as five consecutive points remain in the calibration curve, and the following procedure is followed:

- Remove high level calibration points
- Remove low-level calibration points; reporting limits will need to be elevated, however.

10.2.4.9 If calibration points in the mid-level range need to be removed due to a sequence error or instrument malfunction, the entire calibration level must be removed from the calibration curve. If the %RSD >30, a calibration curve is generated using the EnviroQuant quantitation software.

Correlation Coefficient calculation is performed by the Enviroquant software as follows;

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\, n\Sigma x^2 - (\Sigma x)^2 \,][\, n\Sigma y^2 - (\Sigma y)^2 \,]}}$$

Where:

r = Correlation Coefficient

n = number of standards measured

x = true concentration of the standard

y = observed concentration of the standard

The correlation coefficient (linear) for the calibration curve must be greater than 0.995. If these criteria cannot be met, prepare a new set of calibration standards and recalibrate the instrument. NOTE: Quadratic calibration in any form is not acceptable.

Authorization from the department supervisor is required prior to using linear regression calibration. Linear regression is only allowed if certain criteria listed below are met:

- The minimum number of points for a linear regression curve is five points.
- The curve must be plotted and printed and turned in with the raw data.
- A calibration standard must be analyzed at the low point of the curve. Recovery of the low point standard must be 60-140% using the linear regression curve.

  The recovery of the compound for the continuing calibration / LCS must be within 70-130%.

10.2.4.10 The reference spectra for all target analytes are reviewed for both assignments and purity for all instruments. In addition, this process of reviewing all spectra continues whenever a new calibration is completed.

Reference spectra should be updated with each initial calibration performed with the midpoint standard of the calibration.

10.2.4.11 Internal Standard Criteria for Initial Calibration Levels and ICV.

The mean response for each internal standard compound is calculated over the initial calibration range. The area response at each calibration level must be within 60-140% of the midpoint area response over the initial calibration range for each internal standard. If recovery is outside the range, re-analyze calibration level. This criteria must be met prior to sample analysis.

All of these criteria must be met prior to sample analysis.

10.3 Equipment Operation and Sample Processing

10.3.1 GC/MS ANALYSIS

10.3.1.1 The Entech 7200 or 7200A Concentrator is programmed to the specific analytical conditions listed in Table 6 (Entech method Alpha_TO15.CTD) and the GC/MS parameters are set to those listed in Sections 10.3.1 and 10.3.2. (Enviroquant method TO15-SFS.M (SIM and full scan) or TO15_FS_35C.M (full scan only, for sulfide & mercaptan analysis in App. A)).

10.3.1.2 The BFB spectrum is evaluated by analyzing a Laboratory Method Blank and adding 100 mL of the BFB/surrogate mix.

10.3.1.3 A continuing calibration and/or a laboratory control spike is analyzed. See sect. 9.2 for acceptable criteria, and refer to Appendices D - F for agency – specific criteria on continuing calibration and laboratory control spike criteria.

10.3.1.4 A Laboratory Method Blank is analyzed. The Laboratory Method Blank consists of the analysis of 250 mL from a canister of humidified nitrogen. The method blank must be free of target analyte contamination at or above the reporting limit.

10.3.1.5 A 250-mL aliquot of sample is preconcentrated on the Entech 7200 or 7200A concentrator and injected onto the GC column. For soil vapor samples, or other samples that may contain elevated levels, the aliquot amount must be determined using the results from a pre-screening analysis. Sample concentrations are determined using the following equation:

$$ppbV = [(A_{EC}) * (C_i)] / [(A_{EI}) * (RRF)]$$

10.3.1.6 Instrument Dilutions and Sub-Atmospheric Sample dilutions

10.3.1.6.1 For dilutions, smaller sample volumes (<250 mL) are analyzed. The smallest volume that can be analyzed with accuracy using the Entech concentrator is 10 mL. The dilution factor is accounted for by entering the volume analyzed in the sample calculation discussed in Section 10.2.2.2 (Equation 2).

10.3.1.6.2 Samples that arrive at the laboratory with pressures below -15 inches Hg should be pressurized with nitrogen to greater than -15 inches Hg, as discussed in Section 6.4. This pressurization results in a dilution factor. The dilution factor is calculated using Equation 6, and the canister dilution spreadsheet (Form No.: 117-05). Attach a green tag to the canister with the pressurization information (initial pressure and final pressure) recorded on the tag.

Equation 6: Dilution Factor for Pressurization of Subatmospheric Samples: Three Steps

Step 1: Calculate the volume in the canister prior to pressurization (Assume a 2.7-liter canister is used).

$$\mathbf{V_{ci} = 2.7 * P_I / 14.696}$$

Step 2: Calculate the volume in the canister after pressurization.

$$\mathbf{V_{cf} = 2.7 * P_F / 14.696}$$

Step 3: Calculate the dilution factor.

$$\mathbf{DF = V_{cf} / V_{ci}}$$

where:

V_{ci}= volume of air in canister prior to pressurization, L

P_I = pressure reading of canister prior to pressurization (psia)

V_{cf} = volume of air in canister after pressurization, L

P_F = pressure reading of canister after pressurization (psia)

DF = dilution factor

14.696 = atmospheric pressure (psia)

10.3.1.6.3 If samples require larger dilutions than pressurization and instrument dilutions, a syringe dilution into an additional canister or Tedlar bag (typically used only for App. A analytes) with a known volume of nitrogen is required.

10.3.1.6.4 Fit a VCO® adapter with a septa to the pressurized sample canister. With a gastight syringe remove appropriate sample size for dilution. Allow sample to flow through syringe for 1 – 2 seconds to flush syringe prior to volumizing. Inject the sample aliquot into a Tedlar bag. If using an evacuated canister, connect the canister to an injection port tee (see Figure 3) attached to the dynamic diluter. Inject the aliquot of sample while a steady stream of Nitrogen is flowing into the dilution canister. Pressurize this canister to 30 psia. Attach a green tag to the canister with dilution information recorded on the tag. Use the dilution calculation worksheet (Form No.: 117-05) to calculate resulting dilutions.

10.3.2 Qualitative Identifications

10.3.2.1 An analyst competent in the interpretation of mass spectra must identify the target analytes by comparison of the sample mass spectrum to the mass spectrum of the standard. Two criteria must be satisfied to verify the identification: (1) elution of the component in the sample at the same GC relative retention time (RRT) as the component in the standard, and (2) agreement of the sample component and standard component mass spectra.

10.3.2.2 For establishing correspondence of the GC RRT, the RRT of the component in the sample must compare within ± 0.06 RRT units of the RRT of the component in the standard. If co-elution of interfering components prohibits accurate assignment of the sample component RRT from the total ion chromatogram, the RRT must be assigned using extracted ion current profiles for the ion unique to the component of interest.

10.3.2.3 For comparison of the standard and sample component mass spectra, mass spectra of standards obtained on the GC/MS under the same instrument conditions are required. Reference spectra should be updated for each initial calibration performed, using the mid-level standard. Once obtained, these standard spectra may be used for identification and reference purposes.

10.3.2.4 The requirements for qualitative verification by comparison of mass spectra are as follows:

- All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum.
- The relative intensities of ions specified must agree within ± 20% between the standard and sample spectra.
- Ions greater than 10% in the sample spectrum must be considered and accounted for by the analyst making the comparison.

Table 7 lists the primary and secondary ions for all analytes.

10.3.2.5 Manual integrations: for peaks that are observed to be not integrated correctly by the quantitation software, manual integrations must be performed. Please refer to the manual integration SOP for further instruction on how to properly perform and document manual integrations (Alpha SOP # 1731).

10.3.2.6 **Tentatively identified compounds (TICs)-**A library search may be performed for non-target sample components for the purpose of tentative identification, as requested by the client. Mass spectra are compared to the National Institute of Standards and Technology Mass Spectral Library (2002 version), and a qualitative match is determined by the analyst. Computer generated library search routines must not use normalization routines that would misrepresent the library or unknown spectra when

compared to each other. Refer to Appendices D - F for agency –specific criteria on TIC reporting.

10.3.2.7 Guidelines for making tentative identification:

- Relative intensities of major ions in the reference spectrum (ions greater than 20% of the most abundant ion) must be present in the sample spectrum.
- The relative intensities of the major ions must agree within ± 30%.
- Molecular ions present in the reference spectrum must be present in the sample spectrum.
- Ions present in the sample spectrum but not in the reference spectrum must be reviewed for possible background contamination or presence of coeluting compounds.
- If, in the technical judgment of the mass spectral interpretation specialist, no valid tentative identification can be made, the compound will be reported as "Unknown". The mass spectral interpretation specialist should give additional classification of the unknown compound, if possible (i.e., unknown aromatic, unknown hydrocarbon, unknown acid, unknown chlorinated compound)..

10.4 Continuing Calibration

10.4.1 Calibration Verification

10.4.1.1 The initial calibration must be verified through the analysis of an Initial Calibration Verification (ICV) sample. (The ICV may also be used to satisfy LCS requirements.) This analysis must be performed every time an initial calibration is performed.

10.4.1.2 The ICV must be prepared using a purchased gaseous standard (from a different lot # or separate vendor) with the components of interest in an evacuated FSL canister. Follow the standard preparation procedure for the calibration standards outlined in Section 8.0. The standard must be prepared at or below the midpoint of the calibration curve.

See section 10.4.2.6 for acceptable criteria and Section 12 for corrective actions.

10.4.2 Continuing Calibration

10.4.2.1 A continuing calibration check must be performed daily prior to sample analysis. The continuing calibration standard must be one of the initial calibration levels.

10.4.2.2 Analyze a calibration standard that is at the midpoint of the calibration curve.

10.4.2.3 The LCS standard may be utilized as the continuing calibration check, provided that all target analytes of interest are present in the LCS standard.. Refer to Appendices D - F for agency –specific criteria on LCS criteria.

10.4.2.4 Evaluate continuing calibration for internal standard recoveries. Recoveries must be between 60-140%. If not, the CCV will be re-analyzed.

10.4.2.5 Calculate the percent difference (%D) of the continuing calibration response factor from the initial calibration average response factor using Equation 5.

Equation 5: Percent Difference

$$\% D = [(C_{found})-(C_{true}) / (C_{true})] * 100$$

where:

%D = percent difference

C_{found} = amount of the analyte detected in the standard (ppbV)
C_{true} = true amount of the analyte in the standard (ppbV)

This task can also be accomplished using the quantitation software provided by the instrument manufacturer.

10.4.2.6 Acceptance Criteria

The acceptance criteria is less than 30% RSD for any analyte, with an allowance of two analytes to be greater than 30%, but less than 40%.

Alpha may use the following modified acceptance criteria only for projects that have documentation and approval within the QAPP by the quality assurance project planners, and also for analytes not listed in EPA Method TO-15:

If the %RSD is <30 for each analyte, linearity can be assumed for the associated target analyte and sample analysis may proceed.

10.4.2.7 If the %RSD is >30 for any analyte, the integrations must be evaluated and the calculations verified. If a %RSD <30 cannot be achieved, it is acceptable for 10% of the total analytes to be above 30%, but below 50% RSD. Before acceptance of such a Calibration Curve, it must be confirmed with the approval of the Section Supervisor and/or the Project Manager that these analytes are typically and historically "trouble" analytes or "poor performers" (typically compounds listed in Table 3B), and that all Client and Project Data Quality Objectives (DQOs) will still be met when

analyzing samples using this calibration. . Refer to Appendices D - F for agency –specific criteria on initial calibration acceptance criteria.

10.4.2.8 Refer to Sect. 12 for additional procedures regarding continuing calibration acceptance criteria and corrective actions if criteria are not met.

10.5 Preventive Maintenance

Mass flow controllers should be checked annually for flowrate accuracy using a BIOS cell or other primary flow measurement device.

Ion source cleaning – typically prior to initial calibration.

Electron Multiplier (EM)-changed when the voltage setting required to achieve adequate response approaches 1900.

Rough pump oil changed annually.

Transfer lines, concentrator traps, and the GC guard column should be changed semi-annually, or when system repeatedly fails initial calibration.

11. Data Evaluation, Calculations and Reporting

11.1 Calculations

11.1.1 Individual Target Analytes: The average response factor from the initial calibration is used to calculate the amount of analyte detected in the sample analyses. Standards are prepared on a ppbV basis, so if no dilution is performed, values can be reported from the quantitation report without any calculations. Dilution factors are calculated using Equation 2. Equation 7 shows the conversion of ppbV to µg/m^3 .

Equation 7: Conversion of ppbV to µg/m^3

µg/m^3 = (ppbV) * MW / 24.45

where:

24.45 = molar gas constant (g/g-mole)
MW = molecular weight of the compound of interest (Table 1 and 2 lists the molecular weights of the target analytes)

11.1.2 TICS: An estimated amount for the TIC is calculated using the total area of the TIC, the total area of the internal standard assigned by the quantitation software, and a response factor of 1.000 (Equation 8). If the internal standard assigned by the quantitation software exhibits significant interference from other analytes, the next closest eluting internal standard will be utilized. Refer to Appendices D – F for agency-specific criteria on reporting TICS.

Equation 8: Calculation of TIC Results in ppbV

$ppbV = [(A_T) * (C_{IS})] / [(A_{IS-T}) * (1.000)]$

where:

A_T = total ion area of the TIC to be measured

C_{IS} = amount of the internal standard

A_{IS-T} = total ion area of the closest eluting internal standard

The integration of target analytes and internal standards must be performed from valley to valley.

11.1.3 Percent Recovery

$$\% \text{ Recovery} = \frac{C_x}{C_t} \text{ X } 100$$

where:
C_x = measured concentration of compound
C_t = true concentration of compound

11.2 Data Package

11.2.1 Canister Cleaning Information

A copy of the data for the batch certification analysis associated with the FSL canisters must be on file. The raw data must include a sample chromatogram, quantitation report, and spectra of all positive results.

11.2.2 BFB Tune Checks

Tune checks must be included for all days of analysis, including initial calibration. Raw data must include the chromatogram, mass spectra, and summary of relative abundances of the BFB ions.

11.2.3 Calibration Data

- Initial calibration summary (including average response factors, %RSDs, and copies of calibration curves, if appropriate) for target analytes and all calibration chromatograms must be on file.
- Continuing calibration summaries (including %Ds) for individual analytes.
- Chromatograms and quantitation reports associated with all standards used, in the initial and continuing calibrations.

11.2.4 QA/QC

- Internal standard responses and % recoveries vs. the continuing calibration.
- Quantitation report and chromatogram for laboratory control spike (and laboratory control spike duplicate, if requested).

- Quantitation reports, chromatograms, and spectra of positive results for all blanks.
- Copy of the instrument runlog.

11.2.5 Sample Data

- Quantitation reports, chromatograms, spectra of positive results, negative proofs, and pre- and post-manual integrations for all LCSs, samples, and duplicates.
- A copy of the canister dilution worksheet, Form No.: 117-05 (if any canister pressurizations or canister dilutions are performed).

12. Contingencies for Handling Out-of-Control Data or Unacceptable Data

The laboratory must maintain records to document the quality of data that is generated. Ongoing data quality checks are compared with established performance criteria to determine if the results of analyses meet the performance characteristics of the method. When results indicate atypical method performance, a calibration verification standard is used to confirm the measurements were performed in an in-control mode of operation.

Holding time exceedence and/or container damage is noted on the Sample Delivery Group form.

Perform routine preventative maintenance following manufacturer's specification. Record all maintenance in the instrument logbook.

Review of standards, blanks and standard response for acceptable performance occurs for each batch of samples. Record any trends or unusual performance on a nonconformance action form. The method blank must be free of target analyte contamination at or above the reporting limit. If it is not, the system must be evaluated for possible sources of contamination. Once the source is determined and eliminated, the method blank must be reanalyzed.

If the ICV, CCV, LCS or LCSD recovery of any parameter falls outside the designated acceptance range, the laboratory performance for that parameter is judged to be out of control, and the problem must be immediately identified and corrected. The analytical result for that parameter in the unspiked samples is suspect and is only reported for regulatory compliance purposes with the appropriate Narratives. Immediate corrective action includes reanalyzing all affected samples (provided sufficient volume of sample remains) by using any retained sample before the expiration of the holding time. If sufficient volume is not available, Alpha will narrate accordingly. Analytes that fail ICV, CCV and LCS criteria due to elevated recoveries may be reported, provided there are no detections in the associated samples.

Samples exhibiting internal standard recovery failures must be re-analyzed at the same dilution level if instrument malfunction is suspected to be the cause, or at a lesser dilution if sample matrix or concentration levels of target and/or non-target analytes are suspected of being the cause. If recovery failures are observed upon re-analysis, narrate bias accordingly (negative if high recovery, positive if low recovery).

When applicable criteria is not met (ICV, CCV, LCS, IS), Alpha will narrate bias which will be included in the opening narrative of the report.

13. Method Performance

13.1 Method Detection Limit Study (MDL) / Limit of Detection Study (LOD) / Limit of Quantitation (LOQ)

The laboratory follows the procedure to determine the MDL, LOD, and/or LOQ as outlined in Alpha SOP # 1732. These studies performed by the laboratory are maintained on file for review.

13.2 Demonstration of Capability Studies

Refer to Alpha SOP # 1739 for further information regarding IDC/DOC Generation.

13.2.1 Initial (IDC)

The analyst must make an initial, one-time, demonstration of the ability to generate acceptable accuracy and precision with this method, prior to the processing of any samples.

13.2.2 Continuing (DOC)

The analyst must make a continuing, annual, demonstration of the ability to generate acceptable accuracy and precision with this method.

14. Pollution Prevention and Waste Management

Refer to Alpha's Chemical Hygiene Plan and Waste Management and Disposal SOP for further pollution prevention and waste management information.

15. Referenced Documents

Chemical Hygiene Plan

SOP # 1732 MDL/LOD/LOQ Generation

SOP # 1739 IDC/DOC Generation

SOP # 1797 Hazardous Waste & Sample Disposal

SOP # 1731 Manual Integration

Form 117-05: Canister Dilution Worksheet Template

Form 117-09: Instrument Run Log

Form 117-11: Primary Standard Preparation Log

Form 12925: Secondary Standard Preparation Log

16. Attachments

Table 1 TO-15 Tedlar® Bag Stock Standard Preparation for LCS

Table 2A TO-14 Primary Mix #1 & TO-15 Mix #2 Stock Standard Cylinder

Table 2B TO-15 Custom Mix #3 Stock Standard Cylinder

Table 2C TO-15 Custom Mix #4 Stock Standard Cylinder

Table 2D TO-15 Custom Mix #5 Stock Standard Cylinder

Table 3A Summary of Working Standard Preparation

Table 3B Preparation of Calibration Standards for Low Vapor Pressure Compounds

Table 4 Calibration Standard Levels

Table 5 BFB Key Ions and Abundance Criteria

Table 6 Entech 7200 or 7200A /7016D Operating Parameters

Table 7 Quantitation and Secondary Ions for TO-15 Analytes and Internal Standards

Table 8 Internal Standards and the Associated Target Analytes

Table 9A TO-15 Target Analytes and Reporting Limits-Standard List

Table 9B TO-15 Target Analytes and Reporting Limits-Additional Analytes

Appendix A Cold Trap Dehydration technique (CTD) for Analysis of Sulifides and Mercaptans

Appendix B Data Acquisition Parameters and Analysis Modifications for Conducting SIM Analysis

Appendix C Modifications to Data Review and Case Narrative to Comply with MADEP MCP-TO-15 Method

Appendix E Modifications to Data Review and Case Narrative to Comply with 2014 NJDEP Technical Guidance for EPA Method TO-15

Appendix F Modifications to Data Review and Case Narrative to Comply with Ohio EPA Voluntary Action Program (VAP) Requirements for EPA Method TO-15

DEFINITIONS

Absolute canister pressure - Pg + Pa, where Pg = gauge pressure in the canister (psig) and Pa = barometric pressure.

Absolute pressure - Pressure measured with reference to absolute zero pressure (as opposed to atmospheric pressure), usually expressed as kPA, mm Hg, or psia (pounds per square inch absolute).

Cryogen - The refrigerant used to obtain very low temperatures in the cryogenic trap of the analytical system. A typical cryogen is liquid nitrogen (bp = -196^{0}C).

Gauge pressure - Pressure measured above atmospheric pressure (as opposed to absolute pressure). Zero gauge is equal to ambient atmospheric (barometric) pressure. Units = psig (pounds per square inch gauge).

ppmV – parts per million on a volume basis.

ppbV – parts per billion on a volume basis

psia – pounds per square inch absolute

Relative retention time (RRT)– retention time (RT) ratio of the target analyte and the internal standard used to quantitate (RT target / RT internal standard).

Table 1

TO-15 Tedlar® Bag Stock Standard Preparation- LCS/ICV Standard

ICV / LCS Standard				
COMPOUND (liquids)	**MOL WGT**	**Density ug/uL**	**uL injected***	**FINAL ppmV**
Acetone	58.1	791	12.0	200
Isopropyl alcohol	60.1	785	4.8	76.7

All neat chemicals are injected into a Tedlar® bag containing 20 Liters of zero air or UHP nitrogen.

See Table A-1 & Table A-4 for sulfide/mercaptan stock standard preparation

Table 2A

TO-15 Purchased Primary Standard Mix

TO-14 Primary Standard Mix #1

COMPOUND	MOL WGT	Conc. ppmV	COMPOUND	MOL WGT	Conc. ppmV
dichlorodifluoromethane	120.92	1.0	cis-1,3-dichloropropene	110.97	1.0
chloromethane	50.49	1.0	trans-1,3-dichloropropene	110.97	1.0
Freon-114	170.92	1.0	1,1,2-trichloroethane	133.41	1.0
vinyl chloride	62.5	1.0	toluene	92.14	1.0
bromomethane	94.94	1.0	1,2-dibromoethane	187.87	1.0
chloroethane	64.52	1.0	tetrachloroethene	165.83	1.0
trichlorofluoromethane	137.37	1.0	chlorobenzene	112.56	1.0
1,1-dichloroethene	96.94	1.0	ethylbenzene	106.17	1.0
methylene chloride	84.93	1.0	m-xylene	106.17	1.0
Freon-113	187.38	1.0	p-xylene	106.17	1.0
trans-1,2-dichloroethene	98.96	1.0	styrene	104.15	1.0
1,1-dichloroethane	98.96	1.0	1,1,2,2-tetrachloroethane	167.85	1.0
cis-1,2-dichloroethene	96.94	1.0	o-xylene	106.17	1.0
chloroform	119.38	1.0	1,3,5-trimethylbenzene	120.2	1.0
1,2-dichloroethane	98.96	1.0	1,2,4-trimethylbenzene	120.2	1.0
1,1,1-trichloroethane	133.41	1.0	1,3-dichlorobenzene	147.0	1.0
benzene	78.11	1.0	1,4-dichlorobenzene	147.0	1.0
carbon tetrachloride	153.82	1.0	1,2-dichlorobenzene	147.0	1.0
1,2-dichloropropane	113	1.0	1,2,4-trichlorobenzene	181.45	1.0
trichloroethene	131.38	1.0	hexachlorobutadiene	260.76	1.0

TO-15 Primary Standard Mix #2

COMPOUND	MOL WGT	Conc. ppmV
Propylene	42.08	1.0
1,3-butadiene	54.09	1.0
Vinyl bromide	106.96	1.0
Acetone	58.08	1.0
Isopropyl alcohol	60.1	1.0
Carbon disulfide	76.14	1.0
3-chloropropene	76.53	1.0
Trans-1,2-dichloroethene	96.94	1.0
Methyl-tert butyl ether	88.15	1.0
Vinyl acetate	86.09	1.0
2-butanone (MEK)	72.11	1.0
Hexane	86.18	1.0
Ethyl acetate	88.11	1.0
Tetrahydrofuran	72.11	1.0
Cyclohexane	84.16	1.0
Bromodichloromethane	163.83	1.0
1,4-dioxane	88.11	1.0
2,2,4-trimethylpentane	114.23	1.0
Heptane	100.21	1.0
4-methyl-2-pentanone (MIBK)	100.16	1.0
2-hexanone	100.16	1.0
Dibromochloromethane	208.29	1.0
Bromoform	252.75	1.0
Benzyl chloride	126.59	1.0
4-ethyl toluene	120.2	1.0

Table 2B

TO-15 Purchased Custom Mix #3

TO-15 Custom Standard Mix					
COMPOUND	**MOL WGT**	**Conc. ppmV**	**COMPOUND**	**MOL WGT**	**Conc. ppmV**
Propane	44.10	1.0	n-Octane	114.23	1.0
Chlorodifluoromethane	86.47	1.0	1,1,1,2-Tetrachloroethane	167.85	1.0
Methanol	32.04	5.0	1,2,3-Trichloropropane	147.43	1.0
n-Butane	58.12	1.0	Nonane	128.26	1.0
Dichlorofluoromethane	102.92	1.0	Isopropylbenzene	120.19	1.0
Ethanol	46.07	5.0	Bromobenzene	157.01	1.0
Acetonitrile	41.05	1.0	2-Chlorotoluene	126.58	1.0
Acrolein	56.10	1.0	n-Propylbenzene	120.19	1.0
n-Pentane	72.20	1.0	4-Chlorotoluene	126.58	1.0
Acrylonitrile	53.10	1.0	tert-Butylbenzene	134.20	1.0
Ethyl Ether	74.12	1.0	n-Decane	142.28	1.0
tert-Butyl Alcohol	74.12	1.0	sec-Butylbenzene	134.20	1.0
2,2-Dichloropropane	112.99	1.0	p-Isopropyltoluene	134.22	1.0
Di-Isopropyl Ether	102.17	1.0	n-Butylbenzene	134.20	1.0
Tert-Butyl Ethyl Ether	102.20	1.0	1,2-Dibromo-3-chloropropane	236.33	1.0
1,1-Dichloropropene	110.97	1.0	n-Undecane	156.31	1.0
Tert Amyl Methyl Ether	102.17	1.0	Naphthalene	128.17	1.0
Dibromomethane	173.83	1.0	n-Dodecane	170.33	1.0
1,3-Dichloropropane	112.99	1.0	1,2,3-Trichlorobenzene	181.45	1.0
n-Butyl Acetate	116.16	1.0			

All mixes currently purchased fromPraxair (formerly Linde and Spectra Gases)

Table 2C

TO-15 / PIANO Custom Mix #4

COMPOUND (liquids)	Boiling Pt, deg C	Molecular Weight	Density ug/uL	uL injected*	FINAL ppmV
1,1-difluoroethane (gas)	-24.7	66.05	NA	10 mL	5.0
1-ethyl-1-methylcyclopentane	121.55	112.21	785.4	11.9	1.0
Indan	177	118.18	965.0	10.2	1.0
Indene	182	116.16	996.0	9.7	1.0
1,2,3-trimethylbenzene	176	120.19	890.0	11.2	1.0
Acetaldehyde	20.2	44.05	785	23.3	5.0
Acetone	56.1	58.08	784.5	24.6	4.0
isopropyl alcohol	82.6	60.1	786	9.5	1.5
methyl methacrylate	101	100.1	940	8.8	1.0

Table 2D

TO-15 / PIANO Custom Mix #5

COMPOUND (liquids)	Boiling Pt, deg C	Molecular Weight	Density ug/uL	uL injected*	FINAL ppmV
Thiophene	83	84.14	1060	6.6	1.0
2-Ethylthiophene	133	112.19	990	9.4	1.0
2-methyllthiophene	114	98.17	1016	8.0	1.0
3-Methylthiophene	113	98.17	1017	8.0	1.0

* both mixes #4 and #5 prepared in 29.5 L high pressure cylinders, pressurized to 995 psia with UHP nitrogen. Total volume of standard is 1997 L. Two year expiration date.

Table 3A

Summary of Secondary Standards Preparation

Primary Standard	Primary Standard Conc. ppmV	Volume of Primary Standard Injected into canister	Primary Standard Transfer Method	Final Volume canister (L)	Final Concentration ppbV **
Secondary standards prepared using precision dilution system (Entech 4700)					
TO-15 Mixes #1 - #5	1.0	3000 mL	Pressure differential	30	100
TO-15 Mixes #1 - #5	1.0	300 mL	Pressure differential	51	10 ***
Secondary standards prepared via serial dilution					
100 ppbV ICAL mix	1.0	300 mL	Syringe Injection	30	1.0
100 ppbV ICAL mix	0.1 *	30 mL	Syringe Injection	30	0.1

All standards prepared using humidified nitrogen.

* This calibration standard is used for TO-15 SIM analysis only (see Appendix B).

** The following analytes have concentrations that are greater than the listed concentration

Methanol, acetylaldehyde, and ethanol – 5 times greater

m&p-xylene- 2 times greater

Isopropyl alcohol-2.5 times greater

*** 10 ppbV standards that are prepared at a pressure of 50 psia are split out into additional empty 15L canisters to reduce the pressure in the standard and allow for additional canisters to be prepared for continuing calibration usage.

Table 3B

Preparation of Calibration Standards for Low Vapor Pressure Compounds

COMPOUND (solids)	Vapor Pressure* (P), atm	Molecular Weight	Volume (V) extracted, mL	Gas Constant (R) (L atm/gm mol K)	T, °K	n**	Final Volume, L	mg	ug/m³	ppbV
1-methylnaphthalene	7.11E-05	142.20	7.1	0.082057	298.1	2.44E-08	51	0.00347	115.7	10
1-methylnaphthalene	7.11E-05	142.00	42	0.082057	298.1	1.22E-07	30	0.0173255	577.5	100
2-methylnaphthalene	8.96E-05	142.00	5.8	0.082057	298.1	2.491E-08	51	0.0035373	117.9	10.2
2-methylnaphthalene	8.96E-05	142.00	34	0.082057	298.1	1.246E-07	30	0.0176867	589.6	101.6
benzothiophene	7.70E-05	134.20	6.5	0.082057	291.5	2.446E-08	51	0.0032824	109.4	10.0
benzothiophene	7.70E-05	134.20	38	0.082057	291.5	1.223E-07	30	0.016412	547.1	100

Approximately 5.0 g of solid material was allowed to stand in a 250 mL jar w/ septa cap for 30 min prior to removal of vapor phase aliquot. The aliquot was then spiked directly into secondary standard.

All vapor pressure values from Lange's Handbook of Chemistry & Physics

Table 4

Calibration Standard Levels

Calibration Level	Amount (ppbV)	Volume / Secondary Standard
1	0.20	50 mL of 1.0 ppbV sec. standard
2	0.50	125 mL of 1.0 ppbV sec. standard
3	1.0	250 mL of 1.0 ppbV sec. standard
4	5.0	125 mL of 10 ppbV sec. standard
5	10	250 mL of 10 ppbV sec. standard
6	20	50 mL of 100 ppbV sec. standard
7	50	125 mL of 100 ppbV sec. standard
8	100	250 mL of 100 ppbV sec. standard

Table 5

BFB Key Ions and Abundance Criteria

Mass	Ion Abundance Criteria
50	8.0-40.0 percent of the base peak
75	30.0-66.0 percent of the base peak
95	Base peak, 100 percent relative abundance
96	5.0-9.0 percent of the base peak
173	Less than 2.0% of mass 174
174	50.0 to 120.0% of mass 95
175	4.0-9.0 percent of mass 174
176	Greater than 93.0 percent but less than 101.0 percent of mass 174
177	5.0-9.0 percent of mass 176

Table 6

ENTECH 7016D/ 7200 or 7200A Operating Parameters

Module 1 (Cold Trap)	
Parameter	**Setting**
Trapping Temperature	-40° C
Internal standard / surrogate volume	100 mL
Internal standard / surrogate flow rate	100 mL / min
Nominal Sample volume (may vary depending on sample concentrations)	250 mL
Sample flow rate, mL / min	100 mL / min
Preheat Temperature	10° C
Desorb Temperature	10° C
Bake Temperature	220° C
Bake Time	10 min
Module 1 to Module 2 transfer volume / rate	20 cc @ 5.0 cc/min
Module 2 (Tenax trap)	
Parameter	**Setting**
Trapping Temperature	-65° C to -75° C
Desorb Temperature	220° C
Bake Temperature	220° C
Module 2 to Module 3 desorb time	3.5 min
Module 3 (Cryofocusser)	
Parameter	**Setting**
Cryofocusing Temperature	-130° C to -190° C
Desorb Temperature	Approx. 90° C
Module 3 to GC desorb time	3.0-3.5 min
Bake temperature / event	Approx. 90° C / event 3
Delay time	13-17 min

Table 7
Quantitation and Secondary Ions for TO-15 Analytes and Internal Standards

Compound	Quant. Ion	Sec. Ion(s)	Compound	Quant. Ion	Sec. Ion(s)	Compound	Quant. Ion	Sec. Ion(s)
bromochloromethane	49	130	1,4-difluorobenzene	114	63	bromoform	173	171, 175
chlorodifluoromethane	51	67	n-hexane	57	43, 86	styrene	104	103, 78
propylene	41	39, 42	diisopropyl ether	87	45, 59	1,1,2,2-tetrachloroethane	83	85
propane	29	43,39	ethyl acetate	61	43, 70	o-xylene	91	106
dichlorodifluoromethane	85	87	2,2-dichloropropane	77	41, 97	1,2,3-trichloropropane	75	39, 110
chloromethane	50	52	tetrahydrofuran	42	71, 72	nonane	43	57, 128
Freon-114	85	87, 135	tert-butyl ethyl ether	59	87, 57	bromofluorobenzene	95	75, 174
methanol	31	32,29	1,2-dichloroethane-D4	65	67, 102	isopropylbenzene	105	120
vinyl chloride	62	64,	1,1,1-trichloroethane	97	61, 119	bromobenzene	77	156
1,3-butadiene	54	39	1,1-dichloropropene	75	39,110	2-chlorotoluene	126	91
butane	43	41,58	benzene	78	52	n-propylbenzene	120	91
bromomethane	94	96	carbon tetrachloride	117	119, 82	4-chlorotoluene	91	126
chloroethane	64	66	cyclohexane	56	84, 41	4-ethyl toluene	105	91, 120
dichlorofluoromethane	67	69, 47	tert-amyl methyl ether	73	43, 87	1,3,5-trimethylbenzene	105	91, 120
ethanol	31	45	dibromomethane	93	95, 174	tert-butlybenzene	119	134
acetonitrile	41	40	1,2-dichloropropane	63	39, 62	1,2,4-trimethylbenzene	105	91, 120
vinyl bromide	106	108	bromodichloromethane	83	85, 129	decane	57	43, 142
acrolein	56	55,29	trichloroethene	130	132, 97	benzyl chloride	91	126
acetone	43	58	1,4-dioxane	88	58	1,3-dichlorobenzene	146	75, 111
trichlorofluoromethane	101	103	2,2,4-trimethylpentane	57	41, 99	1,4-dichlorobenzene	146	75, 111
isopropyl alcohol	45	59	n-heptane	43	57, 100	sec-butylbenzene	105	134
acrylonitrile	53	52,51	cis-1,3-dichloropropene	75	39, 77	p-isopropyltoluene	119	134
pentane	43	57,72	4-methyl-2-pentanone	43	58, 100	1,2-dichlorobenzene	146	75, 111
ethyl ether	31	59,45	methyl methacrylate	41	69, 100	n-butylbenzene	91	134
1,1-dichloroethene	61	96, 63	trans-1,3-dichloropropene	75	39, 77	1,2-dibromo-3-chloropropane	75	39, 157
Tertiary butyl Alcohol	59	41, 43	1,1,2-trichloroethane	97	61, 83	undecane	57	43, 71, 156
methylene chloride	49	84	Thiophene	84	45, 58	dodecane	57	43
3-chloropropene	41	39, 76	chlorobenzene-D5	54	82, 117	1,2,4-trichlorobenzene	180	109, 145
carbon disulfide	76	44	toluene	91	92	naphthalene	128	102
Freon 113	101	85, 151	toluene-D8	98	100	1,2,3-trichlorobenzene	180	109, 145
trans-1,2-dichloroethene	61	96, 98	1,3-dichloropropane	76	41,49	hexachlorobutadiene	225	118, 260
1,1-dichloroethane	63	65	2-hexanone	43	58, 100	2-methylthiophene	97	45, 98
MTBE	73	57, 43	dibromochloromethane	129	127, 131	3-methylthiophene	97	45, 98
vinyl acetate	43	86	1,2-dibromoethane	107	109	2-ethylthiophene	97	45, 112
2-butanone	43	72	butyl acetate	73	43, 56	1,2,3-trimethylbenzene	105	120
cis-1,2-dichloroethene	61	96, 98	octane	85	43, 57, 114	indan	117	91, 118
chloroform	83	85, 47	tetrachloroethene	166	94, 131	indene	115	89, 116
1,2-dichloroethane	62	49, 63, 64	1,1,1,2-tetrachloroethane	131	95, 133	1,2,4,5-tetramethylbenzene	119	91, 134
acetaldehyde	29	43, 44	chlorobenzene	112	77, 114	benzothiophene	134	63, 89
			ethylbenzene	91	106	2-methylnaphthalene	142	115, 141
			m+p-xylene	91	106	1-methylnaphthalene	142	115, 141

Table 8

Internal Standards and the Associated Target Analytes

bromochloromethane		1,4-difluorobenzene	chlorobenzene-D5	
chlorodifluoromethane	trans-1,2-dichloroethene	hexane	toluene	decane
propylene	1,1-dichloroethane	diisopropyl ether	toluene-D8	benzyl chloride
propane	MTBE	tert-butyl ethyl ether	1,3-dichloropropane	1,3-dichlorobenzene
dichlorodifluoromethane	vinyl acetate	1,2-dichloroethane-D4	2-hexanone	1,4-dichlorobenzene
chloromethane	2-butanone	1,1,1-trichloroethane	dibromochloromethane	sec-butylbenzene
Freon-114	cis-1,2-dichloroethene	1,1-dichloropropene	1,2-dibromoethane	p-isopropyltoluene
methanol	chloroform	benzene	butyl acetate	1,2-dichlorobenzene
vinyl chloride	1,2-dichloroethane	carbon tetrachloride	Octane	n-butylbenzene
1,3-butadiene	trans-1,2-dichloroethene	cyclohexane	tetrachloroethene	1,2-dibromo-3-chloropropane
butane	1,1-dichloroethane	tert-amyl methyl ether	1,1,1,2-tetrachloroethane	undecane
bromomethane	acetaldehyde	dibromomethane	Chlorobenzene	dodecane
chloroethane	ethyl acetate	1,2-dichloropropane	Ethylbenzene	1,2,4-trichlorobenzene
dichlorofluoromethane	2,2-dichloropropane	bromodichloromethane	m+p-xylene	naphthalene
ethanol	tetrahydrofuran	trichloroethene	Bromoform	1,2,3-trichlorobenzene
acetonitrile		1,4-dioxane	Styrene	hexachlorobutadiene
vinyl bromide		2,2,4-trimethylpentane	1,1,2,2-tetrachloroethane	2-methylthiophene
acrolein		heptane	o-xylene	3-methylthiophene
acetone		cis-1,3-dichloropropene	1,2,3-trichloropropane	2-ethylthiophene
trichlorofluoromethane		4-methyl-2-pentanone	Nonane	1,2,3-trimethylbenzene
isopropyl alcohol		methyl methacrylate	bromofluorobenzene	indan
acrylonitrile		trans-1,3-dichloropropene	isopropylbenzene	indene
pentane		1,1,2-trichloroethane	bromobenzene	1,2,4,5-tetramethylbenzene
ethyl ether		thiophene	2-chlorotoluene	benzothiophene
1,1-dichloroethene			n-propylbenzene	2-methylnaphthalene
Tertiary butyl Alcohol			4-chlorotoluene	1-methylnaphthalene
methylene chloride			4-ethyl toluene	
3-chloropropene			1,3,5-trimethylbenzene	
carbon disulfide			tert-butlybenzene	
Freon 113			1,2,4-trimethylbenzene	

Table 9A

TO-15 Target Analytes and Reporting Limits
Standard List

COMPOUND	CAS #	Standard Reporting Limit, ppbV	Standard Reporting Limit, ug/m^3
1,1,1-trichloroethane	71-55-6	0.2	1.09
1,1,2,2-tetrachloroethane	79-34-5	0.2	1.37
1,1,2-trichloroethane	79-00-5	0.2	1.09
1,1-dichloroethane	75-34-3	0.2	0.81
1,1-dichloroethene	75-35-5	0.2	0.79
1,2,4-trichlorobenzene	120-82-1	0.2	1.48
1,2,4-trimethylbenzene	95-63-6	0.2	0.98
1,2-dibromoethane	106-93-4	0.2	1.54
1,2-dichlorobenzene	95-50-1	0.2	1.2
1,2-dichloroethane	107-06-2	0.2	0.81
1,2-dichloropropane	78-87-5	0.2	0.92
1,3,5-trimethylbenzene	108-67-8	0.2	0.98
1,3-butadiene	106-99-0	0.2	0.44
1,3-dichlorobenzene	541-73-1	0.2	1.2
1,4-dichlorobenzene	106-46-7	0.2	1.2
1,4-dioxane	123-91-1	0.2	0.72
2,2,4-trimethylpentane	540-84-1	0.2	0.93
2-butanone	78-93-3	0.5	1.48
2-hexanone	591-78-6	0.2	0.82
3-chloropropene	107-05-1	0.2	0.63
4-Ethyltoluene	622-96-8	0.2	0.98
Acetone	67-64-1	1.0	2.38
benzene	71-43-2	0.2	0.64
Benzyl Chloride	100-44-7	0.2	1.03
bromodichloromethane	75-27-4	0.2	1.34
bromoform	75-25-2	0.2	2.07
bromomethane	74-83-9	0.2	0.78
carbon disulfide	75-15-0	0.2	0.62
carbon tetrachloride	56-23-5	0.2	1.26
chlorobenzene	108-90-7	0.2	0.92
chloroethane	75-00-3	0.2	0.53
chloroform	67-66-3	0.2	0.98

COMPOUND	CAS #	Standard Reporting Limit, ppbV	Standard Reporting Limit, ug/m^3
chloromethane	74-87-3	0.2	0.41
cis-1,2-dichloroethene	156-59-2	0.2	0.79
cis-1,3-dichloropropene	10061-01-5	0.2	0.91
cyclohexane	110-82-7	0.2	0.69
dibromochloromethane	124-48-1	0.2	1.7
dichlorodifluoromethane	75-71-8	0.2	0.99
ethanol	64-17-5	2.5	4.71
ethyl acetate	141-78-6	0.5	1.8
ethylbenzene	100-41-4	0.2	0.87
Freon-113	76-13-1	0.2	1.53
Freon-114	76-14-2	0.2	1.4
hexachlorobutadiene	87-68-3	0.2	2.13
hexane	110-54-3	0.2	0.7
isopropyl alcohol	67-63-0	0.5	1.23
methylene chloride	75-09-2	0.5	1.74
MIBK	108-10-1	0.5	2.1
MTBE	1634-04-4	0.2	0.72
m+p-xylene	108-38-3 106-42-3	0.4	1.74
n-heptane	142-82-5	0.2	0.82
o-xylene	95-47-6	0.2	0.87
propylene	115-7-1	0.5	0.85
styrene	100-42-5	0.2	0.85
tetrachloroethene	127-18-4	0.2	1.36
tetrahydrofuran	109-99-9	0.5	1.48
toluene	108-88-3	0.2	0.75
trans-1,2-dichloroethene	156-60-5	0.2	0.79
trans-1,3-dichloropropene	10061-02-6	0.2	0.91
trichloroethene	79-01-6	0.2	1.07
trichlorofluoromethane	75-69-4	0.2	1.12
vinyl acetate	108-05-4	0.5	1.75
vinyl bromide	593-60-2	0.2	0.87
vinyl chloride	75-01-4	0.2	0.51

Table 9B

TO-15 Target Analytes and Reporting Limits
Additional Analytes

COMPOUND	CAS #	Standard Reporting Limit, ppbV	Standard Reporting Limit, ug/m^3
AP-42 Analytes			
acrolein	107-02-8	0.50	1.15
acrylonitrile	107-13-1	0.50	1.08
butane	106-97-8	0.20	0.48
Chlorodifluoromethane	75-45-6	0.20	0.71
Dichlorofluoromethane	75-71-8	0.20	0.84
n-Pentane	109-66-0	0.20	0.59
Propane	74-98-6	0.50	0.90
MADEP MCP 8260 Analytes			
1,1,1,2-tetrachloroethene	630-20-6	0.20	1.37
1,1-dichloropropene	563-58-6	0.20	0.91
1,2,3-trichlorobenzene	87-61-6	0.20	1.48
1,2,3-Trichloropropane	96-18-4	0.20	1.20
1,3-dichloropropane	142-28-9	0.20	0.92
2,2-dichloropropane	594-20-7	0.20	0.92
2-chlorotoluene	95-49-8	0.20	1.03
4-chlorotoluene	106-43-4	0.20	1.03
bromobenzene	108-86-1	0.20	1.28
1,2-dibromo-3-chloropropane	96-12-8	0.20	1.93
dibromomethane	74-95-3	0.20	1.42
diisopropyl ether	108-20-3	0.20	0.84
isopropylbenzene	98-82-8	0.20	0.98
isopropyltoluene	99-87-6	0.20	1.10
naphthalene	91-20-3	0.20	1.05
n-butylbenzene	104-51-8	0.20	1.10
n-propylbenzene	103-65-1	0.20	0.98
sec-butylbenzene	135-98-8	0.20	1.10
tert-amyl methyl ether	994-05-8	0.20	0.84
tert-Butyl ethyl ether	637-92-3	0.20	0.84
tert-butylbenzene	98-06-6	0.20	1.10

COMPOUND	CAS #	Standard Reporting Limit, ppbV	Standard Reporting Limit, ug/m^3
NYDEC Petroleum Indicator Compounds			
nonane	111-84-2	0.20	1.05
octane	111-65-9	0.20	0.93
undecane	1120-21-4	0.20	1.28
decane	124-18-5	0.20	1.16
dodecane	112-40-3	0.20	1.39
indene	95-13-6	0.20	0.95
Indan	496-11-7	0.20	0.97
thiophene	110-02-1	0.20	0.69
2-methylthiophene	554-13-3	0.20	0.80
3-methylthiophene	616-44-4	0.20	0.80
2-ethyl thiophene	872-55-9	0.20	0.92
benzothiophene	934-80-5	0.50	2.74
1,2,3-trimethylbenzene	526-73-8	0.20	0.98
1,2,4,5-tetramethylbenzene	95-93-2	0.20	1.10
2-methylnaphthalene	91-57-6	1.0	5.8
1-methylnaphthalene	90-12-0	1.0	5.8
Project Specific Analytes			
acetaldehyde	75-07-0	2.5	4.51
Acetonitrile	75-05-8	0.20	0.34
butyl acetate	123-86-4	0.50	2.38
ethyl ether	60-29-7	0.20	0.61
methanol	67-56-1	5.0	6.55
tert-butyl alcohol	75-65-0	0.50	1.51
Methyl methacrylate	80-62-6	0.50	2.05
All reporting limits are subject to change.			

Appendix A

Cold Trap Dehydration technique (CTD) for Analysis of Sulfides and Mercaptans by EPA TO-15

Target analytes:

Compound	CAS#	Reporting Limit, ppbV
Hydrogen sulfide	7783-06-4	2.0
Carbonyl sulfide	463-58-1	2.0
Methyl mercaptan	74-93-1	2.0
Ethyl mercaptan	75-08-1	0.5
Dimethyl sulfide	75-18-3	0.5
carbon disulfide	75-15-0	0.5
Isopropyl Mercaptan	75-33-2	0.5
tert-Butyl Mercaptan	75-66-1	0.5
n-Propyl Mercaptan	107-03-9	0.5
Ethyl Methyl Sulfide	624-89-5	0.5

Compound	CAS#	Reporting Limit, ppbV
Thiophene	110-02-1	0.5
Isobutyl Mercaptan	513-44-0	0.5
diethyl sulfide	352-93-2	0.5
Butyl Mercaptan	109-75-5	2.0
dimethyl disulfide	624-92-0	0.5
3-Methylthiophene	616-44-4	0.5
Tetrahydrothiophene	110-01-0	0.5
2-Ethylthiophene	872-55-9	0.5
2,5-Dimethylthiophene	638-02-8	0.5
Diethyl Disulfide	110-81-6	0.5
All reporting limits are subject to change.		

The cold trap dehydration method requires a blank trap (i.e. no trapping material) be installed in module 1 of the Entech 7200 or 7200A concentrator. This trap is cooled and a 250 mL aliquot of sample is allowed to pass through this trap and then directly onto the Tenax trap in module 2, which is also cooled (see Table A-5 for setpoints). The sample is then transferred to module 3 (cryofocusser) via ballistic heating. All requirements stated in this SOP must be applied to any TO15-Sulfide/Mercaptan analysis conducted in the laboratory.

SOP modifications:

Standard preparation and calibration procedures for these analytes are listed in Table A-1 through A-5. Quantitation parameters are listed in Table A-8. Table A-7 lists modified GC conditions.

Section 9.2.5 and 9.5.3.1: Use the Entech method alpha_H2S&SULF.CTD in place of the alpha_TO15.MPT method.

A second source laboratory check standard (LCS) is not readily available for these analytes. An LCS standard is prepared at a different concentration than the initial calibration standards using the same stock standard.

Table A-1

Sulfide/Mercaptan Primary Standard Mix #1

COMPOUND	CAS#	Molecular Weight	Concentration, ppmV
hydrogen sulfide	7783-06-4	34.08	5.0
Carbonyl sulfide	463-58-1	60.08	5.0
Methyl mercaptan	74-93-1	48.11	5.0
ethyl mercaptan	75-08-1	62.14	1.0
dimethyl sulfide	75-18-3	62.14	1.0
carbon disulfide	75-15-0	76.1	1.0
Isopropyl Mercaptan	75-33-2	76.2	1.0
tert-Butyl Mercaptan	75-66-1	90.19	1.0
n-Propyl Mercaptan	107-03-9	76.16	1.0
Ethyl Methyl Sulfide	624-89-5	76.16	1.0
Thiophene	110-02-1	84.1	1.0
Isobutyl Mercaptan	513-44-0	90.19	1.0
diethyl sulfide	352-93-2	90.2	1.0
Butyl Mercaptan	109-79-5	90.19	4.0
3-Methylthiophene	616-44-4	98.17	1.0
Tetrahydrothiophene	110-01-0	88.17	1.0
2-Ethylthiophene	872-55-9	112.19	1.0
2,5-Dimethylthiophene	638-02-8	112.19	1.0

Table A-2

Sulfide/Mercaptan Primary Standard Mix #2

COMPOUND	CAS#	Molecular Weight	Concentration, ppmV
dimethyl disulfide	624-92-0	94.2	1.0

Table A-3

Sulfide/Mercaptan Primary Standard Mix #3

COMPOUND	CAS#	Molecular Weight	Concentration, ppmV
Diethyl Disulfide	110-81-6	122.25	1.0

Table A-4

Summary of Secondary Standards Preparation for Sulfides and Mercaptan Analysis

Primary Standard	Primary Standard Conc. ppmV	Volume of Primary Standard Injected into Tedlar® Bag	Primary Standard Transfer Data	Final Volume Tedlar® Bag (L)	Final Concentration ppbV
Secondary standards prepared using gas-tight syringes					
Tedlar® bag primary standard-Low	1- 5ppmV	20 mL	Syringe Injection	4.0	5.0 / 20.0 / 20
Tedlar® bag primary standard-High	1- 5ppmV	400 mL	Syringe Injection	4.0	100 / 400 / 500
Tedlar® bag primary standard-LCS	1- 5ppmV	40 mL	Syringe Injection	4.0	10 / 40 / 50

Table A-5

Calibration Standard Levels

Calibration Level	Amount (ppbV)	Volume / Secondary Standard
1	0.50	25 mL of 5.0 ppbV sec. standard
2	1.0	50 mL of 5.0 ppbV sec. standard
3	5.0	250 mL of 5.0 ppbV sec. standard
4	10	25 mL of 100 ppbV sec. standard
5	20	50 mL of 100 ppbV sec. standard
6	50	125 mL of 100 ppbV sec. standard
7	80	200 mL of 100 ppbV sec. standard
8	100	250 mL of 100 ppbV sec. standard

Table A-6

ENTECH & 7016D/7200 or 7200A Operating Parameters for CTD Method

Module 1 (Blank Trap)	
Parameter	**Setting**
Trapping Temperature	-20° C
Internal standard volume	100 mL
Internal standard flow rate	60 mL / min
Sample volume (may vary depending on sample concentrations)	250 mL
Sample flow rate	100 mL / min
Preheat Temperature	10° C
Desorb Temperature	10° C
Bake Temperature	220° C
Bake Time	10 min.
Module 2 (Tenax trap)	
Parameter	**Setting**
Trapping Temperature	-70° C
Desorb Temperature	180° C
Bake Temperature	220° C
Module 2 to Module 3 desorb time	3.5 min
Module 3 (Cryofocusser)	
Parameter	**Setting**
Cryofocusing Temperature	-130° C
Desorb Temperature	Approx. 70° C
Module 3 to GC desorb time	2 min
Bake temperature / event	Approx. 90° C / event 3
Delay time	10 min

Table A-7

Internal Standard (IS) Assignments and Quantitation Ions for Sulfides & Mercaptans

Compound	Quant Ion	Sec. Ion(s)
Bromochloromethane (IS)	49	130
Hydrogen sulfide	34	33, 36
Carbonyl sulfide	60	62, 32
Methyl mercaptan	47	48, 45
ethyl mercaptan	62	47, 29
dimethyl sulfide	62	45, 47
carbon disulfide	76	44, 78
Isopropyl Mercaptan	43	41, 76
tert-Butyl Mercaptan	41	57, 90
n-Propyl Mercaptan	76	47, 43
Ethyl Methyl Sulfide	61	76, 48

Compound	Quant Ion	Sec. Ion(s)
1,4-difluorobenzene (IS)	114	63
Thiophene	84	58, 45
Isobutyl Mercaptan	41	56, 90
diethyl sulfide	75	90, 47
Butyl Mercaptan	56	41, 90
dimethyl disulfide	94	79, 45

Compound	Quant Ion	Sec. Ion(s)
Chlorobenzene-D5 (IS)	54	82, 117
3-Methylthiophene	97	98, 45
Tetrahydrothiophene	60	88, 45
2-Ethylthiophene	97	112, 45
2,5-Dimethylthiophene	111	112,97
Diethyl Disulfide	122	66, 94

Appendix B

Data Acquistion Parameters and Analysis Modifications for Conducting SIM Analysis

SIM analysis is conducted when full scan sensitivity does not meet the data quality objectives (DQO) of the project and/or regulatory criteria. The acquisition method used to acquire full scan data simultaneously acquires SIM data using the SIM ions and windows specified in Table B-1. The following modifications to the full scan SOP must be done to generate data using the SIM signal:

- SIM level calibration standards must be analyzed w/ the full scan curve (0.02,0.05, and 0.1 ppbV)
- A calibration curve is generated using the SIM signal utilizing the lower level calibration standards and must meet the same criteria as the full scan calibration criteria.
- The continuing calibration /LCS should be analyzed at a lower concentration (5.0 ppbV). If a separate continuing calibration run is needed, the continuing calibration level of 10 ppbV may be utilized. Laboratory Method Blanks must be evaluated for the SIM reporting limit as listed in Table B-2.

The SIM signal only acquires data for a limited target analyte list. These target analytes and reporting limits are listed in Table B-2. Additional ions have been added to allow for more analytes to be added, if requested by client. All requirements stated in this SOP must be applied to any TO15-SIM analysis conducted in the laboratory.

Table B-1

Calibration Standard Levels for SIM Analysis

Calibration Level	Amount (ppbV)	Volume / Secondary Standard
1	0.02	50 mL of 0.10 ppbV sec. standard
2	0.05	125 mL of 0.1 ppbV sec. standard
3	0.10	250 mL of 0.1 ppbV sec. standard
4	0.20	50 mL of 1.0 ppbV sec. standard
5	0.50	125 mL of 1.0 ppbV sec. standard
6	1.0	250 mL of 1.0 ppbV sec. standard
7	5.0	125 mL of 10 ppbV sec. standard
8	10	250 mL of 10 ppbV sec. standard
9	20	50 mL of 100 ppbV sec. standard
10	50	125 mL of 100 ppbV sec. standard

Table B-2

Seletive Ion Monitoring (SIM) Groupings

Group #	1	2	3	5	6	7	8	9	10	11	12
Group Start Time, min	0	5.9	8.75	10.1	10.9	11.6	13.8	14.6	16.6	18.8	20.5
Dwell time, sec	25	10	25	25	25	15	25	15	3	5	25
Cycles/sec (calc)	2	2.5	3.3	2.1	2.3	1.8	5.7	2.2	7	7	2.3
Analyte Range, Compund #	C2-C7	C8-C20	C21-C26	C27-C29, BCM (IS)	C30-C34	C35-C44, 1,4-DFB (IS)	C45-C46	C47-C55	C56-C67, CHB-D5 (IS)	C68-C76	C77-C80
Ions	29	29 63	43	41	42	39 85	39	39 92	39 106	39	43
	31	31 64	57	43	49	41 87	43	41 94	43 110	43	57
	32	39 66	61	45	51	43 88	58	43 97	45 112	57	63
	39	40 67	63	47	57	45 93	75	45 98	54 114	71	89
	41	41 69	65	49	59	52 95	77	49 100	57 117	75	102
	42	43 72	72	57	62	56 97	100	56 107	75 120	89	109
	43	44 76	73	59	63	57 99		57 109	77 126	91	115
	44	45 84	86	61	64	58 100		58 114	78 128	105	118
	50	47 85	96	70	65	62 110		61 127	82 131	111	128
	51	49 94	98	77	67	63 114		73 129	83 133	115	134
	52	51 96	117	83	71	69 117		75 131	85 156	116	141
	54	52 101	198	85	72	73 119		76 166	91 171	117	142
	58	53 103		86	87	75 129		77	95 173	118	145
	62	55 106		87	97	78 130		83	97 174	119	180
	64	56 108		96	102	82 132		85	103 175	120	225
	67	57 151		97	119	83 174		91	104	126	260
	85	58		98		84			105	134	
	87	59		130						142	
	135	61								146	
										156	
										157	

Table B-3

TO15-SIM Target Analytes and Reporting Limits

COMPOUND	CAS #	SIM Reporting Limit, ppbV	SIM Reporting Limit, ug/m^3
1,1,1-trichloroethane	71-55-6	0.02	0.109
1,1,2,2-tetrachloroethane	79-34-5	0.02	0.137
1,1,2-trichloroethane	79-00-5	0.02	0.109
1,1-dichloroethane	75-34-3	0.02	0.081
1,1-dichloroethene	75-35-5	0.02	0.079
1,2,4-trimethylbenzene	95-63-6	0.02	0.098
1,2-dibromoethane	106-93-4	0.02	0.154
1,2-dichlorobenzene	95-50-1	0.02	0.12
1,2-dichloroethane	107-06-2	0.02	0.081
1,2-dichloropropane	78-87-5	0.02	0.092
1,2-dibromo-3-chloropropane	96-12-8	0.02	0.193
1,3,5-trimethylbenzene	108-67-8	0.02	0.098
1,3-butadiene	106-99-0	0.02	0.044
1,3-dichlorobenzene	541-73-1	0.02	0.12
1,4-dichlorobenzene	106-46-7	0.02	0.12
1,4-dioxane	123-91-1	0.10	0.36
2-hexanone	591-78-6	0.20	0.82
2,2,4-trimethylpentane	540-84-1	0.20	0.93
3-chloropropene	107-05-1	0.20	0.63
4-Ethyltoluene	622-96-8	0.02	0.098
benzene	71-43-2	0.10	0.223
benzyl chloride	100-44-7	0.20	1.03
bromodichloromethane	75-27-4	0.02	0.134
bromoform	75-25-2	0.02	0.207
bromomethane	74-83-9	0.02	0.078
carbon disulfide	75-15-0	0.20	0.62
hexachlorobutadiene	87-68-3	0.05	533
hexane	110-54-3	0.20	0.7
heptane	142-82-5	0.20	0.82
isopropyl alcohol	67-63-0	0.50	1.23
methylene chloride	75-09-2	0.50	1.74
MTBE	1634-04-4	0.02	0.072
m+p-xylene	108-38-3 106-42-3	0.04	0.174
o-xylene	95-47-6	0.02	0.087
propylene	115-7-1	0.50	0.85
styrene	100-42-5	0.02	0.085
tetrachloroethene	127-18-4	0.02	0.136
tetrahydrofuran	109-99-9	0.5	1.48
toluene	108-88-3	0.05	0.188
trans-1,2-dichloroethene	156-60-5	0.02	0.079
trans-1,3-dichloropropene	10061-02-6	0.02	0.091
trichlorofluoromethane	75-69-4	0.05	0.280
trichloroethene	79-01-6	0.02	0.107
1,2,4-trichlorobenzene	120-82-1	0.05	0.371
vinyl acetate	108-05-4	1.00	3.50
vinyl bromide	593-60-2	0.20	0.87
vinyl chloride	75-01-4	0.02	0.051
CT RSR Additional Analytes			
1,1,1,2-tetrachloroethane	630-20-6	0.02	0.137
acrylonitrile	107-13-1	0.50	1.08
isopropyltoluene	99-87-6	0.20	1.1
n-butylbenzene	104-51-8	0.20	1.1

carbon tetrachloride	56-23-5	0.02	0.126
chlorobenzene	108-90-7	0.10	0.460
chloroethane	75-00-3	0.10	0.265
chloroform	67-66-3	0.02	0.098
chloromethane	74-87-3	0.20	0.41
cis-1,2-dichloroethene	156-59-2	0.02	0.079
cis-1,3-dichloropropene	10061-01-5	0.02	0.091
cyclohexane	110-82-7	0.2	0.69
dibromochloromethane	124-48-1	0.02	0.17
dichlorodifluoromethane	75-71-8	0.20	0.99
ethanol	64-17-5	5.0	9.42
ethyl acetate	141-78-6	0.50	1.8
ethylbenzene	100-41-4	0.02	0.087
Freon-113	76-13-1	0.05	0.383
Freon-114	76-14-2	0.05	0.349
sec-butylbenzene	135-98-8	0.20	1.1
tert-butylbenzene	98-06-6	0.20	1.1
isopropylbenzene	98-82-8	0.20	0.98
2-butanone (MEK)	78-93-3	0.50	1.48
Acetone	67-64-1	1.00	2.35
4-methyl-2-pentanone (MIBK)	108-10-1	0.50	2.05
Project & State Specific Analytes			
1,2,3-trichlorobenzene	87-61-6	0.05	0.371
1,2,3-Trichloropropane	96-18-4	0.02	0.12
acrolein	107-02-8	0.05	0.115
bromobenzene	108-86-1	0.20	1.28
Dibromomethane	74-95-3	0.20	1.42
Naphthalene	91-20-3	0.05	0.262
tertiary butyl alcohol	75-65-0	0.50	1.51
All reporting limits are subject to change.			

Appendix C

Modifications to Data Review and Case Narrative to Comply with MADEP MCP TO-15 Method

This addendum addresses modifications to this SOP required to be in compliance with the MADEP MCP TO-15 method, specifically "Quality Control Requirements and Performance Standards for the ***Analysis of Volatile Organic Compounds in Air Samples (TO-15) by Gas Chromatography/Mass Spectrometry (GC/MS)*** in Support of Response Actions under the Massachusetts Contingency Plan (MCP)" Revision No. 0, Section IX B.

1) For duplicate analyses, the 25% RPD criteria stated in Sect. 9.6 of this SOP does not need to be applied to concentrations less than 5X the reporting limit.

2) Samples cannot be analyzed if any of the target analytes if the LCS recovery criteria stated in sect. 9.2 of this SOP is below 70% recovery. For compounds listed as difficult analytes (hexachlorobutadiene, 1,2,4-trichlorobenzene, naphthalene, acetone, and 1,4-dioxane), LCS recovery cannot be less than 50%.

3) Any analyte exceeding %RSD criteria of 30% during initial calibration that is a not listed in the MCP TO-15 method, but may still be reported to the client, must be noted in the case narrative.

Appendix E

Modifications to Data Review and Case Narrative to Comply with 2014 NJDEP Technical Guidance for EPA Method TO-15

This addendum addresses modifications to this SOP required to be in compliance with the NJDEP 2014 Technical Guidance, **"NJDEP Site Remediation Program, Data of Known Quality Protocol, Version 1, April 2014**". This guidance is to be used when analyzing samples via the EPA Method TO-15.

1) Per the Data of Know Quality Protocols Technical Guidance, surrogates are not required to be reported via EPA Method TO-15.

2) A target analyte list and reporting limits are specified in Table E-1, per the Analytical Laboratory Data Generation, Assessment and Usability Technical Guidance.

3) For the analytes ethanol and isopropyl alcohol, results are allowed to be reported outside the calibration range of the instrument, per the Analytical Laboratory Data Generation, Assessment and Usability Technical Guidance. Results reported that exceed the calibration range will be designated with an "E" qualifier.

4) **Laboratory Control Sample (LCS) criteria -** Must contain all target analytes, recovery range is 70-130%. Exceptions for difficult analytes (hexachlorobutadiene, 1,2,4-trichlorobenzene, naphthalene, acetone, dichlorodifluoromethane, and 1,4-dioxane) must exhibit percent recoveries between 40-160%. In addition, the CCAL analysis cannot be reported as the LCS even if it meets LCS requirements. The LCS must be a separate analysis, analyzed after a passing CCAL standard.

5) **Duplicate analyses** - The 25% RPD criteria stated in Sect. 9.6 of this SOP does not need to be applied to concentrations less than 5X the reporting limit.

6) **Tentatively Identified Compounds (TICs)** – up to 15 TICs must be reported, if present. If a reduced target analyte list is requested by client, TICs are not reported.

Table E-1

NJDEP 2014 Target Analytes and Reporting Limits via EPA Method TO-15

Required Compound Name	CAS Number	Molecular Weight	Reporting Limit ppbV	Reporting Limit ug/m³
Acetone	67-64-1	58.08	5.0	12
Allyl chloride	107-05-1	76.53	0.2	0.6
Benzene	71-43-2	78.11	0.2	0.6
Bromodichloromethane	75-27-4	163.8	0.2	1
Bromoform	75-25-2	252.8	0.2	2
Bromomethane	74-83-9	94.94	0.2	0.8
1,3-Butadiene	106-99-0	54.09	0.2	0.4
Chlorobenzene	108-90-7	112.6	0.2	0.9
Chloroethane	75-00-3	64.52	0.5	1
Chloroform	67-66-3	119.4	0.2	1
Chloromethane	74-87-3	50.49	0.5	1
Carbon disulfide	75-15-0	76.14	0.5	2
Carbon tetrachloride	56-23-5	153.8	0.2	1
2-Chlorotoluene	95-49-8	126.6	0.2	1
Cyclohexane	110-82-7	84.16	0.2	0.7
Dibromochloromethane	124-48-1	208.3	0.2	2
1,2-Dibromoethane	106-93-4	187.9	0.2	2
1,2-Dichlorobenzene	95-50-1	147.0	0.2	1
1,3-Dichlorobenzene	541-73-1	147.0	0.2	1
1,4-Dichlorobenzene	106-46-7	147.0	0.2	1
Dichlorodifluoromethane	75-71-8	120.9	0.5	2
1,1-Dichloroethane	75-34-3	98.96	0.2	0.8
1,2-Dichloroethane	107-06-2	98.96	0.2	0.8
1,1-Dichloroethene	75-35-4	96.94	0.2	0.8
1,2-Dichloroethene (cis)	156-59-2	96.94	0.2	0.8
1,2-Dichloroethene (trans)	156-60-5	96.94	0.2	0.8
1,2-Dichloropropane	78-87-5	113.0	0.2	0.9
1,3-Dichloropropene (cis)	10061-01-5	111.0	0.2	0.9
1,3-Dichloropropene (trans)	10061-02-6	111.0	0.2	0.9
1,2-Dichlorotetrafluoroethane	76-14-2	170.9	0.2	1
1,4-Dioxane	123-91-1	88.12	5	18
Ethanol	64-17-5	46.07	5	9
Ethylbenzene	100-41-4	106.2	0.2	0.9
4-Ethyltoluene	622-96-8	120.2	0.2	1
n-Heptane	142-82-5	100.2	0.2	0.8
1,3-Hexachlorobutadiene	87-68-3	260.8	0.2	2
n-Hexane	110-54-3	86.17	0.2	0.7
Isopropanol	67-63-0	60.10	5	12

Table E-1 continued

Required Compound Name	CAS Number	Molecular Weight	Reporting Limit ppbV	Reporting Limit ug/m^3
Methylene chloride	75-09-2	84.94	0.5	2
Methyl ethyl ketone	78-93-3	72.11	0.5	1
Methyl isobutyl ketone	108-10-1	100.2	0.5	2
Methyl methacrylate	80-62-6	100.1	0.5	2
Methyl tert-butyl ether	1634-04-4	88.15	0.2	0.7
Styrene	100-42-5	104.1	0.2	0.9
Tert-butyl alcohol	75-65-0	74.12	5	15
1,1,2,2-Tetrachloroethane	79-34-5	167.9	0.2	1
Tetrachloroethene	127-18-4	165.8	0.2	1
Tetrahydrofuran	109-99-9	72.11	5	15
Toluene	108-88-3	92.14	0.2	0.8
1,2,4-Trichlorobenzene	120-82-1	181.5	0.5	4
1,1,1-Trichloroethane	71-55-6	133.4	0.2	1
1,1,2-Trichloroethane	79-00-5	133.4	0.2	1
Trichloroethene	79-01-6	131.4	0.2	1
Trichlorofluoromethane	75-69-4	137.4	0.2	1
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	187.4	0.2	2
1,2,4-Trimethylbenzene	95-63-6	120.2	0.2	1
1,3,5-Trimethylbenzene	108-67-8	120.2	0.2	1
2,2,4-Trimethylpentane	540-84-1	114.2	0.2	0.9
Vinyl bromide	593-60-2	106.9	0.2	0.9
Vinyl chloride	75-01-4	62.50	0.2	0.5
Xylenes (m&p)	179601-23-1	106.2	0.5	2
Xylenes (o)	95-47-6	106.2	0.2	0.9
Naphthalene (reported on request)	91-20-3	128.2	0.2	1

All reporting limits are subject to change.

Appendix F

Modifications to EPA TO-15 SOP to comply with Ohio EPA Voluntary Action Program (VAP) Requirements

This Appendix defines requirements that are necessary to perform TO-15 analysis for any samples submitted via the VAP Program. No deviations from the SOP are allowed under the VAP program.

1) Sec. 3 caveat – reporting limits defined in this SOP are subject to change.

2) Sec. 7 caveat – Equipment and supplies are subject to change.

3) Initial calibration acceptance – %RSD criteria must be as defined in the EPA TO-15 method; only 2 analytes allowed greater than 30% RSD, and must be less than 40%.

4) The Laboratory check standard (LCS) may not be used as the continuing calibration verification (CCV). A CCV and LCS must be analyzed prior to samples.

5) Tentatively Identified Compounds (TICs) may not be reported as certified values.

6) CCV-10% rule not allowed. All analytes reported must be +/- 30% D. (Criteria in sections 10.4.2.6 and 2.1 do not apply to VAP samples.) All analytes in the CCV must be less than 30% RSD for VAP samples (criteria in Section 2.1, 10.4.2.6 and 10.4.2.7 do not apply.)

7) 10% Duplicate criteria not allowed. All duplicate %RPD results must be below 25%.

8) For Ohio projects, only the analytes listed in Table F-1 or as explained in the footnote to Table F-1 will be reported as certified data.

9) Affidavits are required with each report or for a series of reports generated for a particular project.

10) Surrogates are not required and will not be added to Ohio VAP samples.

11) The analysis of a Laboratory Control Sample Duplicate (LCSD) is not required and will not be analyzed for Ohio VAP samples.

12) The LCS is evaluated at +/- 30. Criteria in section 2.1 does not apply to VAP samples.

13) Corrective actions for the method blank are required if it contains analyte concentrations at or above the RL for reportable analytes.

Table F-1

Ohio EPA VAP Program Target Analyte List *		
chloromethane	1,2-dichloropropane	1,1-Dichloropropene
vinyl chloride	1,4-dioxane	1,2,3-Trichloropropane
1,3-butadiene	trichloroethene	1,2,4-Trimethylbenzene
acetaldehyde	2,2,4-trimethylpentane	1,2-Dichlorobenzene
bromomethane	cis-1,3-dichloropropene	1,3,5-Trimethylbenzene
chloroethane	4-methyl-2-pentanone	1,3-Dichlorobenzene
vinyl bromide	1,1,2-trichloroethane	1,3-Dichloropropane
acrolein	toluene	Acetone
acetonitrile	1,2-dibromoethane	Bromodichloromethane
acrylonitrile	tetrachloroethene	Butyl acetate
1,1-dichloroethene	chlorobenzene	cis-1,2-Dichloroethene
methylene chloride	ethylbenzene	Cyclohexane
3-chloropropene	m+p-xylene	Dibromochloromethane
carbon disulfide	bromoform	Dibromomethane
1,1-dichloroethane	styrene	Dichlorodifluoromethane
MTBE	1,1,2,2-tetrachloroethane	Ethyl acetate
vinyl acetate	o-xylene	Ethyl ether
2-butanone	isopropylbenzene	Methyl alcohol (methanol)
chloroform	Benzyl Chloride	Methyl Methacrylate
1,2-dichloroethane	1,4-dichlorobenzene	Naphthalene
hexane	1,2-dibromo-3-chloropropane	Tetrahydrofuran
1,1,1-trichloroethane	1,2,4-trichlorobenzene	trans-1,2-Dichloroethene
benzene	hexachlorobutadiene	trans-1,3-Dichloropropene
carbon tetrachloride	1,1,1,2-Tetrachloroethane	Trichlorofluoromethane

***** The analytes appearing in this table are subject to change, however, any changes will not include identification of compounds that are not included in the TO-15 method referenced at the beginning of this document. However, it is acceptable to analyze and report, as certified data, compound(s) not included in the TO-15 method referenced at the beginning of this document if the compound(s) appear on the current and valid certificate issued by VAP on the date of analysis and if the laboratory has followed all applicable VAP approved documents.

ATTACHMENT 3

Roux's Standard Operating Procedures

Date: May 5, 2000

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to establish the guidelines for decontamination of all field equipment potentially exposed to contamination during drilling, and soil and water sampling. The objective of decontamination is to ensure that all drilling, and soil-sampling and water-sampling equipment is decontaminated (free of potential contaminants): 1) prior to being brought onsite to avoid the introduction of potential contaminants to the site; 2) between drilling and sampling events/activities onsite to eliminate the potential for cross-contamination between boreholes and/or wells; and 3) prior to the removal of equipment from the site to prevent the transportation of potentially contaminated equipment offsite.

In considering decontamination procedures, state and federal regulatory agency requirements must be considered because of potential variability between state and federal requirements and because of variability in the requirements of individual states. Decontamination procedures must be in compliance with state and/or federal protocols in order that regulatory agency(ies) scrutiny of the procedures and data collected do not result in non acceptance (invalidation) of the work undertaken and data collected.

2.0 PROCEDURE FOR DRILLING EQUIPMENT

The following is a minimum decontamination procedure for drilling equipment. Drilling equipment decontamination procedures, especially any variation from the method itemized below, will be documented on an appropriate field form or in the field notebook.

2.1 The rig and all associated equipment should be properly decontaminated by the contractor before arriving at the test site.

2.2 The augers, drilling casings, rods, samplers, tools, rig, and any piece of equipment that can come in contact (directly or indirectly) with the soil, will be steam cleaned onsite prior to set up for drilling to ensure proper decontamination.

2.3 The same steam cleaning procedures will be followed between boreholes (at a fixed on-site location[s], if appropriate) and before leaving the site at the end of the study.

2.4 All on-site steam cleaning (decontamination) activities will be monitored and documented by a member(s) of the staff of Roux Associates, Inc.

2.5 If drilling activities are conducted in the presence of thick, sticky oils (e.g., PCBs) which coat drilling equipment, then special decontamination procedures may have to be utilized before steam cleaning (e.g., hexane scrub and wash).

2.6 Containment of decontamination fluids may be necessary (e.g., rinseate from steam cleaning) or will be required (e.g., hexane), and disposal must be in accordance with state and/or federal procedures.

3.0 PROCEDURE FOR SOIL-SAMPLING EQUIPMENT

The following is a minimum decontamination procedure for soil-sampling equipment (e.g., split spoons, stainless-steel spatulas). Soil-sampling equipment decontamination procedures, especially any variation from the method itemized below, will be documented on an appropriate field form or in the field notebook.

3.1 Wear disposable gloves while cleaning equipment to avoid cross-contamination and change gloves as needed.

3.2 Steam clean the sampler or rinse with potable water. If soil-sampling activities are conducted in the presence of thick, sticky oils (e.g., PCBs) which coat sampling equipment, then special decontamination procedures may have to be utilized before steam cleaning and washing in detergent solution (e.g., hexane scrub and wash).

3.3 Prepare a non-phosphate, laboratory-grade detergent solution and distilled or potable water in a clean bucket.

3.4 Disassemble the sampler, as necessary and immerse all parts and other sampling equipment in the solution.

3.5 Scrub all equipment in the bucket with a brush to remove any adhering particles.

3.6 Rinse all equipment with copious amounts of potable water followed by distilled or deionized water.

3.7 Place clean equipment on a clean plastic sheet (e.g., polyethylene)

3.8 Reassemble the cleaned sampler, as necessary.

3.9 Transfer the sampler to the driller (or helper) making sure that this individual is also wearing clean gloves, or wrap the equipment with a suitable material (e.g., plastic bag, aluminum foil.

As part of the decontamination procedure for soil-sampling equipment, state and/or federal protocols must be considered. These may require procedures above those specified as minimum for Roux Associates, Inc., such as the use of nitric acid, acetone, etc. Furthermore, the containment and proper disposal of decontamination fluids must be considered with respect to regulatory agency(ies) requirements.

4.0 PROCEDURE FOR WATER-SAMPLING EQUIPMENT

The following is a decontamination procedure for water-sampling equipment (e.g., bailers, pumps). Water-sampling equipment decontamination procedures, especially any variation from the method itemized below, will be documented on an appropriate field form or in the field notebook.

4.1 Decontamination procedures for bailers follow:

a. Wear disposable gloves while cleaning bailer to avoid cross-contamination and change gloves as needed.

b. Prepare a non-phosphate, laboratory-grade detergent solution and potable water in a bucket.

c. Disassemble bailer (if applicable) and discard cord in an appropriate manner, and scrub each part of the bailer with a brush and solution.

d. Rinse with potable water and reassemble bailer.

e. Rinse with copious amounts of distilled or deionized water.

f. Air dry.

g. Wrap equipment with a suitable material (e.g., clean plastic bag, aluminum foil).

h. Rinse bailer at least three times with distilled or deionized water before use.

4.2 Decontamination procedures for pumps follow:

a. Wear disposable gloves while cleaning pump to avoid cross-contamination and change gloves as needed.

b. Prepare a non-phosphate, laboratory-grade detergent solution and potable water in a clean bucket, clean garbage can, or clean 55-gallon drum.

c. Flush the pump and discharge hose (if not disposable) with the detergent solution, and discard disposable tubing and/or cord in an appropriate manner.

d. Flush the pump and discharge hose (if not disposable) with potable water.

e. Place the pump on clear plastic sheeting.

f. Wipe any pump-related equipment (e.g., electrical lines, cables, discharge hose) that entered the well with a clean cloth and detergent solution, and rinse or wipe with a clean cloth and potable water.

g. Air dry.

h. Wrap equipment with a suitable material (e.g., clean plastic bag).

As part of the decontamination procedure for water-sampling equipment, state and/or federal protocols must be considered. These may require procedures above those specified as minimum for Roux Associates, Inc., such as the use of nitric acid, acetone, etc. Furthermore, the containment and proper disposal of decontamination fluids must be considered with respect to regulatory agency(ies) requirements.

Date: May 5, 2000

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish guidelines for the collection of soil samples for laboratory analysis. This SOP is applicable to soil samples collected from split-spoon samplers during drilling, hand auger samples, grab samples from stockpiled soils, surface samples, test pit samples, etc.

2.0 CONSIDERATIONS

Soil samples may be collected in either a random or biased manner. Random samples can be based on a grid system or statistical methodology. Biased samples can be collected in areas of visible impact or suspected source areas. Soil samples can be collected at the surface, shallow subsurface, or at depth. When samples are collected at depth the water content should be noted, since generally "soil sampling" is restricted to the unsaturated zone. Equipment selection will be determined by the depth of the sample to be collected. A thorough description of the sampling locations and proposed methods of sample collection should be included in the work plan.

Commonly, surface sampling refers to the collection of samples at a 0 to 6 inch depth interval. Certain regulatory agencies may define the depth interval of a surface sample differently, and this must be defined in the work plan. Collection of surface soil samples is most efficiently accomplished with the use of a stainless steel trowel or scoop. For samples at greater depths a decontaminated bucket auger or power auger may be needed to advance the hole to the point of sample collection. Another clean bucket auger should then be used to collect the sample. To collect samples at depths of greater than approximately six feet the use of a drill rig and split spoon samples will usually be necessary. In some situations, sample locations are accessed with the use of a backhoe.

3.0 MATERIALS/EQUIPMENT

a. A work plan which outlines soil sampling requirements.

b. Field notebook, field form(s), maps, chain-of-custody forms, and custody seals.

c. Decontamination supplies (including: non-phosphate, laboratory grade detergent, buckets, brushes, potable water, distilled water, regulatory-required reagents, aluminum foil, plastic sheeting, etc.).

d. Sampling device (split-spoon sampler, stainless steel hand auger, stainless steel trowel, etc.).

e. Stainless steel spoons or spatulas.

f. Disposable sampling gloves.

g. Laboratory-supplied sample containers with labels.

h. Cooler with blue or wet ice.

i. Plastic sheeting.

j. Black pen and indelible marker.

k. Zip-lock bags and packing material.

l. Tape measure.

m. Paper towels or clean rags.

n. Masking and packing tape.

o. Overnight (express) mail forms.

4.0 DECONTAMINATION

All reusable sampling equipment will be thoroughly cleaned according to the decontamination SOP. Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves, aluminum foil, and plastic sheeting will be changed after each use and discarded in an appropriate manner.

5.0 PROCEDURE

5.1 Prior to collecting soil samples, ensure that all sampling equipment has been thoroughly cleaned according to the decontamination SOP. If samples are to be collected at depth, then the boring must be advanced with thoroughly cleaned equipment to the desired sampling horizon and a different thoroughly cleaned sampler must be used to collect the sample.

5.2 Using disposable gloves and a pre-cleaned, stainless steel spatula or spoon, extract the soil sample from the sampler, measure the recovery, and separate the wash from the true sample. Where allowed by regulatory agency(ies), disposable plastic spoons may be used.

5.3 Place the sample in a laboratory-supplied, pre-cleaned sample container. This should be done as quickly as possible and this is especially important when sampling for volatile organic compounds (VOCs). Samples to be analyzed for VOCs must be collected prior to other constituents.

5.4 The sample container will be labeled with appropriate information such as, client name, site location, sample identification (location, depth, etc.), date and time of collection, and sampler's initials.

5.5 Using the remaining portion of soil from the sampler, log the sample in detail and record sediment characteristics (color, odor, moisture, texture, density, consistency, organic content, layering, grain size, etc.).

5.6 If soil samples are to be composited in the field, then equal portions from selected locations will be placed on a clean plastic sheet and homogenized. Alternately, several samples may be submitted to the laboratory for compositing by weight. The method used is dependent upon regulatory requirements. Specific compositing procedures shall be approved by the appropriate regulatory agency and described in the work plan. Samples to be analyzed for VOCs will not be composited unless required by a regulatory agency.

5.7 After the sample has been collected, labeled, and logged in detail, it is placed in a zip-lock bag and stored in a cooler at 4°C.

5.8 A chain-of-custody form is completed for all samples collected. One copy is retained and two are sent with the samples in a zip-lock bag to the laboratory. A custody seal is placed on the cooler prior to shipment.

5.9 Samples collected from Monday to Friday are to be delivered to the laboratory within 24 hours of collection. If Saturday delivery is unavailable, samples collected on Friday must be delivered by Monday morning. Check the work plan to determine if any analytes require a shorter delivery time.

5.10 The field notebook and appropriate forms should include, but not be limited to the following: client name, site location, sample location, sample depth, sample identification, date and time collected, sampler's name, method of sample collection, number and type of containers, geologic description of material, description of decontamination procedures, etc. A site map should be prepared with exact measurements to each sample location in case follow-up sampling is necessary.

5.11 All reusable sampling equipment must be thoroughly cleaned in accordance with the decontamination SOP. Following the final decontamination (after all samples are collected) the sampling equipment is wrapped in aluminum foil. Discard any gloves, foil, plastic, etc. in an appropriate manner that is consistent with site conditions.

END OF PROCEDURE

Date: May 5, 2000

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for sample handling which will allow consistent and accurate results. Valid chemistry data are integral to investigations that characterize media-quality conditions. Thus, this SOP is designed to ensure that once samples are collected, they are preserved, packed and delivered in a manner which will maintain sample integrity to as great an extent as possible. The procedures outlined are applicable to most sampling events and any required modifications must be clearly described in the work plan.

2.0 CONSIDERATIONS

Sample containers, sampling equipment decontamination, quality assurance/quality control (QA/QC), sample preservation, and sample handling are all components of this SOP.

2.1 Sample Containers

Prior to collection of a sample, considerations must be given to the type of container that will be used to store and transport the sample. The type and number of containers selected is usually based on factors such as sample matrix, potential contaminants to be encountered, analytical methods requested, and the laboratory's internal quality assurance requirements. In most cases, the overriding considerations will be the analytical methodology, or the state or federal regulatory requirements because these regulations generally encompass the other factors. The sample container selected is usually based on some combination of the following criteria:

a. Reactivity of Container Material with Sample

Choosing the proper composition of sample containers will help to ensure that the chemical and physical integrity of the sample is maintained. For sampling potentially hazardous material, glass is the recommended container type because it is chemically inert to most substances. Plastic containers are not recommended for most hazardous wastes because the potential exists for contaminants to adsorb to the surface of the plastic or for the plasticizer to leach into the sample.

In some instances, however, the sample characteristics or analytes of interest may dictate that plastic containers be used instead of glass. Because some metals species will adhere to the sides of the glass containers in an aqueous matrix, plastic bottles (e.g., nalgene) must be used for samples collected for metals analysis. A separate, plastic container should accompany glass containers if metals analysis is to be

performed along with other analyses. Likewise, other sample characteristics may dictate that glass cannot be used. For example, in the case of a strong alkali waste or hydrofluoric solution, plastic containers may be more suitable because glass containers may be etched by these compounds and create adsorptive sites on the container's surface.

b. Volume of the Container

The volume of sample to be collected will be dictated by the analysis being performed and the sample matrix. The laboratory must supply bottles of sufficient volume to perform the required analysis. In most cases, the methodology dictates the volume of sample material required to complete the analysis. However, individual laboratories may provide larger volume containers for various analytes to ensure sufficient quantities for duplicates or other QC checks.

To facilitate transfer of the sample from the sampler into the container and to minimize spillage and sample disturbance, wide-mouth containers are recommended. Aqueous volatile organic samples must be placed into 40-milliliter (ml) glass vials with polytetrafluoroethylene (PTFE) (e.g., TeflonTM) septums. Non-aqueous volatile organic samples should be collected in the same type of vials or in 4-ounce (oz) wide-mouth jars provided by the laboratory. These jars should have PTFE-lined screw caps.

c. Color of Container

Whenever possible, amber glass containers should be used to prevent photodegradation of the sample, except when samples are being collected for metals analysis. If amber containers are not available, then containers holding samples should be protected from light (i.e., place in cooler with ice immediately after filling).

d. Container Closures

Container closures must screw on and off the containers and form a leak-proof seal. Container caps must not be removed until the container is ready to be filled with the sample, and the container cap must be replaced (securely) immediately after filling it. Closures should be constructed of a material which is inert with respect to the sampled material, such as PTFE (e.g., TeflonTM). Alternately, the closure may be separated from the sample by a closure liner that is inert to the sample material such as PTFE sheeting. If soil or sediment samples are being collected, the threads of the container must be wiped clean with a dedicated paper towel or cloth so the cap can be threaded properly.

e. Decontamination of Sample Containers

Sample containers must be laboratory cleaned by the laboratory performing the analysis. The cleaning procedure is dictated by the specific analysis to be performed on the sample. Sample containers must be carefully examined to ensure that all containers appear clean. Do not mistake the preservative as unwanted residue. The bottles should not be field cleaned. If there is any question regarding the integrity of the bottle, then the laboratory must be contacted immediately and the bottle(s) replaced.

f. Sample Bottle Storage and Transport

No matter where the sample bottles are, whether at the laboratory waiting to be packed for shipment or in the field waiting to be filled with sample, care must be taken to avoid contamination. Sample shuttles or coolers, and sample bottles must be stored and transported in clean environments. Sample bottles and clean sampling equipment must never be stored near solvents, gasoline, or other equipment that is a potential source of cross-contamination. When under chain of custody, sample bottles must be secured in locked vehicles, and custody sealed in shuttles or in the presence of authorized personnel. Information which documents that proper storage and transport procedures have been followed must be included in the field notebook and on appropriate field forms.

2.2 Decontamination of Sampling Equipment

Proper decontamination of all re-usable sampling equipment is critical for all sampling episodes. The SOP for Decontamination of Field Equipment and SOPs for method-specific or instrument-specific tasks must also be referred to for guidance for decontamination of various types of equipment.

2.3 Quality Assurance/Quality Control Samples

QA/QC samples are intended to provide control over the proper collection and tracking of environmental measurements, and subsequent review, interpretation and validation of generated analytical data. The SOPs for Collection of Quality Control Samples, for Evaluation and Validation of Data, and for Field Record Keeping and Quality Assurance/Quality Control must be referred to for detailed guidance regarding these respective procedures. SOPs for method-specific or instrument-specific tasks must also be referred to for guidance for QA/QC procedures.

2.4 Sample Preservation Requirements

Certain analytical methodologies for specific analytes require chemical additives in order to stabilize and maintain sample integrity. Generally, this is accomplished under the following two scenarios:

a. Sample bottles are preserved at the laboratory prior to shipment into the field.

b. Preservatives are added in the field immediately after the samples are collected.

Many laboratories provide pre-preserved bottles as a matter of convenience and to help ensure that samples will be preserved immediately upon collection. A problem associated with this method arises if not enough sample could be collected, resulting in too much preservative in the sample. More commonly encountered problems with this method include the possibility of insufficient preservative provided to achieve the desired pH level or the need for additional preservation due to chemical reactions caused by the addition of sample liquids to pre-preserved bottles. The use of pre-preserved bottles is acceptable; however, field sampling teams must always be prepared to add additional preservatives to samples if the aforementioned situations occur. Furthermore, care must be exercised not to overfill sample bottles containing preservatives to prevent the sample and preservative from spilling and therefore diluting the preservative (i.e., not having enough preservative for the volume of sample).

When samples are preserved after collection, special care must be taken. The transportation and handling of concentrated acids in the field requires additional preparation and adherence to appropriate preservation procedures. All preservation acids used in the field should be trace-metal or higher-grade.

2.5 Sample Handling

After the proper sample bottles have been received under chain-of-custody, properly decontaminated equipment has been used to collect the sample, and appropriate preservatives have been added to maintain sample integrity, the final step for the field personnel is checking the sample bottles prior to proper packing and delivery of the samples to the laboratory.

All samples should be organized and the labels checked for accuracy. The caps should be checked for tightness and any 40-ml volatile organic compound (VOC) bottles must be checked for bubbles. Each sample bottle must be placed in an individual "zip-lock" bag to protect the label, and placed on ice. The bottles must be carefully packed to prevent breakage during transport. When several bottles have been collected for an individual sample, they should not be placed adjacent to each other in the cooler to prevent possible breakage of all bottles for a given sample. If there are any samples which are known or suspected to be highly contaminated, these should be placed in an individual cooler under separate chain-of-custody to prevent possible cross contamination. Sufficient ice (wet or blue packs) should be placed in the cooler to maintain the temperature at 4 degrees Celsius (°C) until delivery at the laboratory. Consult the work plan to determine if a particular ice is specified as the preservation for transportation (e.g., the United States Environmental Protection Agency does not like the use of

blue packs because they claim that the samples will not hold at 4°C). Blue ice packs will not be used to transport samples being analyzed for Per- and Polyfluoroalkyl Substances (PFAS). If additional coolers are required, then they should be purchased. The chain-of-custody form should be properly completed, placed in a "zip-lock" bag, and placed in the cooler. One copy must be maintained for the project files. The cooler should be sealed with packing tape and a custody seal. The custody seal number should be noted in the field book. Samples collected from Monday through Friday will be delivered to the laboratory within 24 hours of collection. If Saturday delivery is not available, samples collected on Friday must be delivered by Monday morning. Check the work plan to determine if certain analytes require a shorter delivery time. If overnight mail is utilized, then the shipping bill must be maintained for the files and the laboratory must be called the following day to confirm receipt.

3.0 EQUIPMENT AND MATERIALS

3.1 General equipment and materials may include, but not necessarily be limited to, the following:

a. Sample bottles of proper size and type with labels.

b. Cooler with ice (wet or blue pack; no blue packs for PFAS samples).

c. Field notebook, appropriate field form(s), chain-of-custody form(s), custody seals.

d. Black pen and indelible marker.

e. Packing tape, "bubble wrap," and "zip-lock" bags.

f. Overnight (express) mail forms and laboratory address.

g. Health and safety plan (HASP).

h. Work plan/scope of work.

i. Pertinent SOPs for specified tasks and their respective equipment and materials.

3.2 Preservatives for specific samples/analytes as specified by the laboratory. Preservatives must be stored in secure, spillproof glass containers with their content, concentration, and date of preparation and expiration clearly labeled.

3.3 Miscellaneous equipment and materials including, but not necessarily limited to, the following:

a. Graduated pipettes.

b. Pipette bulbs.

c. Litmus paper.

d. Glass stirring rods.

e. Protective goggles.

f. Disposable gloves.

g. Lab apron.

h. First aid kit.

i. Portable eye wash station.

j. Water supply for immediate flushing of spillage, if appropriate.

k. Shovel and container for immediate containerization of spillage-impacted soils, if appropriate.

4.0 PROCEDURE

4.1 Examine all bottles and verify that they are clean and of the proper type, number, and volume for the sampling to be conducted.

4.2 Label bottles carefully and clearly with project name and number, site location, sample identification, date, time, and the sampler's initials using an indelible marker.

4.3 Collect samples in the proper manner (refer to specific sampling SOPs).

4.4 Conduct preservation activities as required after each sample has been collected. Field preservation must be done immediately and must not be done later than 30 minutes after sample collection.

4.5 Conduct QC sampling, as required.

4.6 Seal each container carefully and place in an individual "zip lock" bag.

4.7 Organize and carefully pack all samples in the cooler immediately after collection (e.g., bubble wrap). Insulate samples so that breakage will not occur.

4.8 Complete and place the chain-of-custody form in the cooler after all samples have been collected. Maintain one copy for the project file. If the cooler is to be transferred several times prior to shipment or delivery to the laboratory, it may be easier to tape the chain-of-custody to the exterior of the sealed cooler. When exceptionally hazardous samples are known or suspected to be present, this should be identified on the chain-of-custody as a courtesy to the laboratory personnel.

4.9 Add additional ice as necessary to ensure that it will last until receipt by the laboratory.

4.10 Seal the cooler with packing tape and a custody seal. Record the number of the custody seal in the field notebook and on the field form. If there are any exceptionally hazardous samples, then shipping regulations should be examined to ensure that the sample containers and coolers are in compliance and properly labeled.

4.11 Samples collected from Monday through Friday will be delivered to the laboratory within 24 hours of collection. If Saturday delivery is not available, samples collected on Friday must be delivered by Monday morning. Check the work plan to determine if certain analytes require a shorter delivery time.

4.12 Maintain the shipping bill for the project files if overnight mail is utilized and call the laboratory the following day to confirm receipt.

END OF PROCEDURE

Date: May 5, 2000

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to establish guidelines for the sampling of ground-water monitoring wells for dissolved constituents. As part of the SOP for the sampling of ground-water monitoring wells, sample collection equipment and devices must be considered, and equipment decontamination and pre-sampling procedures (e.g., measuring water levels, sounding wells, and purging wells) must be implemented. Sampling objectives must be firmly established in the work plan before considering the above.

Valid water-chemistry data are integral to a hydrogeologic investigation that characterizes ground-water quality conditions. Water-quality data are used to evaluate both current and historic aquifer chemistry conditions, as well as to estimate future conditions (e.g., trends, migration pathways). Water-quality data can be used to construct ground-water quality maps to illustrate chemical conditions within the flow system, to generate water-quality plots to depict conditions with time and trends, and to perform statistical analyses to quantify data variability, trends, and cleanup levels.

2.0 EQUIPMENT AND MATERIALS

2.1 In order to sample ground water from monitoring wells, specific equipment and materials are required. The equipment and materials list may include, but not necessarily be limited to, the following:

a. Bailers (Teflon™ or stainless steel).

b. Pumps (centrifugal, peristaltic, bladder, electric submersible, bilge, hand-operated diaphragm, etc.).

c. Gas-displacement device(s).

d. Air-lift device(s).

e. Teflon™ tape, electrical tape.

f. Appropriate discharge hose.

g. Appropriate discharge tubing (e.g., polypropylene, teflon, etc.) if using a peristaltic pump.

h. Appropriate compressed gas if using bladder-type or gas-displacement device.

i. Portable generator and gasoline or alternate power supply if using an electric submersible pump.

j. Non-absorbent cord (e.g., polypropylene, etc.).

k. Plastic sheeting.

l. Tape measure (stainless steel, steel, fiberglass) with 0.01-foot measurement increments and chalk (blue carpenter's).

m. Electronic water-level indicators (e.g., m-scope, etc.) or electric water-level/product level indicators.

n. Non-phosphate, laboratory-grade detergent.

o. Distilled/Deionized water.

p. Potable water.

q. Paper towels, clean rags.

r. Roux Associates' field forms (e.g., daily log, well inspection checklist, sampling, etc.) and field notebook.

s. Well location and site map.

t. Well keys.

u. Stop watch, digital watch with second increments, or watch with a second hand.

v. Water Well Handbook.

w. Calculator.

x. Black pen and water-proof marker.

y. Tools (e.g., pipe wrenches, screwdrivers, hammer, pliers, flashlight, pen knife, etc.).

z. Appropriate health and safety equipment, as specified in the site health and safety plan (HASP).

aa. pH meter(s) and buffers.

bb. Conductivity meter(s) and standards.

cc. Thermometer(s).

dd. Extra batteries (meters, thermometers, flashlight).

ee. Filtration apparatus, filters, pre-filters.

ff. Plasticware (e.g., premeasured buckets, beakers, flasks, funnels).

gg. Disposable gloves.

hh. Water jugs.

ii. Laboratory-supplied sample containers with labels.

jj. Cooler(s).

kk. Ice (wet, blue packs).

ll. Masking, duct, and packing tape.

mm. Chain-of-custody form(s) and custody seal(s).

nn. Site sampling and analysis plan (SAP).

oo. Site health and safety plan (HASP).

pp. Packing material (e.g., bubble wrap)

qq. "Zip-lock" plastic bags.

rr. Overnight (express) mail forms.

3.0 DECONTAMINATION

3.1 Make sure all equipment is decontaminated and cleaned before use (refer to the SOP for Decontamination of Field Equipment for detailed decontamination methods, summaries for bailers and pumps are provided below). Use new, clean materials when decontamination is not appropriate (e.g., non-absorbent cord, disposable gloves). Document, and initial and date the decontamination procedures on the appropriate field form and in the field notebook.

a. Decontaminate a bailer by: 1) wearing disposable gloves, 2) disassembling (if appropriate) and scrubbing in a non-phosphate, laboratory-grade detergent and distilled/deionized water solution, and 3) rinsing first with potable water and then distilled/deionized water.

b. Decontaminate a pump by: 1) wearing disposable gloves, 2) flushing the pump and discharge hose (if not disposable) first with a non-phosphate, laboratory-grade detergent and potable water solution in an appropriate container (clean bucket, garbage can, or 55-gallon drum) and then with

distilled/deionized water or potable water, and 3) wiping pump-related equipment (e.g., electrical lines, cables, discharge hose) first with a clean cloth and detergent solution and then rinsing or wiping with a clean cloth and distilled/deionized water or potable water.

3.2 Note that the decontamination procedures for bailers and pumps are the minimum that must be performed. Check the work plan to determine if chemicals specified by individual state regulatory agencies must also be used for decontamination procedures (e.g., hexane, nitric acid, acetone, isopropanol, etc.).

4.0 CALIBRATION OF FIELD ANALYSIS EQUIPMENT

Calibrate field analysis equipment before use (e.g., thermometers, pH and conductivity meters, etc.). Refer to the specific SOP for field analysis for each respective piece of equipment. Document, and initial and date the calibration procedures on the appropriate field form, in the field notebook, and in the calibration log book.

5.0 PROCEDURE

5.1 Document, and initial and date well identification, pre-sampling information, and problems encountered on the appropriate field form and in the field notebook as needed.

5.2 Inspect the protective casing of the well and the well casing, and note any items of concern such as a missing lock, or bent or damaged casing(s).

5.3 Place plastic sheeting around the well to protect sampling equipment from potential cross contamination.

5.4 Remove the well cap or plug and, if necessary, clean the top of the well off with a clean rag. Place the cap or plug on the plastic sheeting. If the well is not vented, allow several minutes for the water level in the well to equilibrate. If fumes or gases are present, then diagnose these with the proper safety equipment. Never inhale the vapors.

5.5 Measure the depth to water (DTW) from the measuring point (MP) on the well using a steel tape and chalk or an electronic sounding device (m-scope). Refer to the specific SOPs for details regarding the use of a steel tape or a m-scope for measuring water levels. Calculate the water-level elevation. Document, and initial and date the information on the appropriate field form and in the field notebook.

5.6 Measuring the total depth of the well from the MP with a weighted steel tape. Calculate and record the volume of standing water in the well casing on the appropriate field form and in the field notebook.

5.7 Decontaminate the equipment used to measure the water level and sound the well with a non-phosphate, laboratory-grade detergent solution followed by a distilled/deionized water rinse.

5.8 Purge the well prior to sampling (refer to the SOP for Purging a Well). The well should be pumped or bailed to remove the volume of water specified in the work plan. Usually three to five casing volumes are removed if the recharge rate is adequate to accomplish this within a reasonable amount of time.

If the formation cannot produce enough water to sustain purging, then one of two options must be followed. These include: 1) pumping or bailing the well dry, or 2) pumping or bailing the well to "near-dry" conditions (i.e., leaving some water in the well). The option employed must be specified in the work plan and be in accordance with regulatory requirements.

If the well is purged dry, then all the standing water has been removed and upon recovery the well is ready for sampling. However, depending on the rate of recovery and the time needed to complete the sampling round, one of the following procedures may have to be implemented: 1) the well may have to be sampled over a period of more than one day; 2) the well may not yield enough water to collect a complete suite of samples and only select (most important) samples will be collected; or 3) the well may not recover which will preclude sampling. Regardless of the option that must be followed, the sampling procedure must be fully documented. When preparing to conduct a sampling round, review drilling, development and previous sampling information (if available) to identify low-yielding wells in order to purge them first, and potentially allow time for the well to recover for sampling.

5.9 Record the physical appearance of the water (i.e., color, turbidity, odor, etc.) on the appropriate field form and in the field notebook, as it is purged. Note any changes that occur during purging.

5.10 If a bailer is used to collect the sample, then:

a. Flush the decontaminated bailer three times with distilled/deionized water.

b. Tie the non-absorbent cord (polypropylene) to the bailer with a secure knot and then tie the free end of the bailer cord to the protective casing or, if possible, some nearby structure to prevent losing the bailer and cord down the well.

c. Lower the bailer slowly down the well and into the water column to minimize disturbance of the water surface. If a bottom-filling bailer is used, then do not submerge the top of the bailer; however, if a top-filling bailer is used, then submerge the bailer several feet below the water surface.

d. Remove and properly discard one bailer volume from the well to rinse the bailer with well water before sampling. Again, lower the bailer slowly down the well to the appropriate depth depending on the bailer type (as discussed above in 5.11 c). When removing the bailer from the well, do not allow the bailer cord to rest on the ground but coil it on the protective plastic sheeting placed around the well. Certain regulatory agencies require that the first bailer volume collected be utilized for the samples.

5.11 If a pump is used to collect the sample, then use the same pump used to purge the well and, if need be, reduce the discharge rate to facilitate filling sample containers and to avoid problems that can occur while filling sample containers (as listed in Number 5.14, below). Alternately, the purge pump may be removed and a thoroughly decontaminated bailer can be used to collect the sample.

5.12 Remove each appropriate container's cap only when ready to fill each with the water sample, and then replace and secure the cap immediately.

5.13 Fill each appropriate, pre-labeled sample container carefully and cautiously to prevent: 1) agitating or creating turbulence; 2) breaking the container; 3) entry of, or contact with, any other medium; and 4) spilling/splashing the sample and exposing the sampling team to contaminated water. Immediately place the filled sample container in a ice-filled (wet ice or blue pack) cooler for storage. If wet ice is used it is recommended that it be repackaged in zip-lock bags to help keep the cooler dry and the sample labels secure. Check the work plan as to whether wet ice or blue packs are specified for cooling the samples because certain regulatory agencies may specify the use of one and not the other.

5.14 "Top-off" containers for volatile organic compounds (VOCs) and tightly seal with Teflon™-lined septums held in place by open-top screw caps to prevent volatilization. Ensure that there are no bubbles by turning the container upside down and tapping it gently.

5.15 Filter water samples (Procedure 4.6) collected for dissolved metals analysis prior to preservation to remove the suspended sediment from the sample. If water samples are to be collected for total metals analysis, then collect a second set of samples without field filtering.

In the event that the regulatory agency(ies) want unfiltered samples for metals analysis, a second set of filtered samples should also be collected. Because unfiltered samples are indications of total metals (dissolved and suspended) they are not representative of aquifer conditions because ground water does not transport sediment (except in some rare cases). Thus, the results for dissolved metals in ground water should be based on filtered samples even if both filtered and unfiltered sets are presented in a report.

5.16 Add any necessary preservative(s) to the appropriate container(s) prior to, or after (preferred), the collection of the sample, unless the appropriate preservative(s) have already been added by the laboratory before shipment.

5.17 Collect quality control (QC) samples as required in the work plan to monitor sampling and laboratory performance. Refer to the SOP for Collection of Quality Control Samples.

5.18 Conduct field analyses after sample collection is complete by measuring and recording the temperature, conductivity, pH, etc. (as called for in the work plan). Note and record the "final" physical appearance of the water (after purging and sampling) on an appropriate field form and in the field notebook.

5.19 Wipe the well cap with a clean rag, replace the well cap and protective cover (if present). Lock the protective cover.

5.20 Verify that each sample is placed in an individual "zip-lock" bag, wrapped with "bubble wrap," placed in the cooler, and that the cooler has sufficient ice (wet ice or blue packs) to preserve the samples for transportation to the analytical laboratory.

5.21 Decontaminate bailers, hoses, and pumps as discussed in the decontamination SOP. Wrap decontaminated equipment with a suitable material (e.g., clean plastic bag or aluminum foil). Discard cords, rags, gloves, etc. in a manner consistent with site conditions.

5.22 Complete all necessary field forms, field notebook entries, and the chain-of-custody forms. Retain one copy of each chain-of-custody form. Secure the cooler with sufficient packing tape and a custody seal.

5.23 Samples collected from Monday through Friday will be delivered within 24 hours of collection. If Saturday delivery is not available, samples collected on Friday must be delivered by Monday morning. Consult the work plan to determine if any of the analytes require a shorter delivery time.

END OF PROCUDURE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish guidance to obtain accurate and consistent samples of soil gas.

2.0 MATERIALS/EQUIPMENT

- Teflon or Nylaflow tubing, one-quarter or one-eighth inch diameter sample tubing.
- Swagelok® ¼-inch nut and ferrule sets for connecting the probe tubing to the sampling manifold, as appropriate for the collection method
- Helium leak check equipment, as dictated by Site-specific data quality objectives (DQOs), including the enclosure, helium cylinder (high purity helium), and helium detector (Dialectric MGD is preferred). The enclosure and helium detector may be provided by the driller.
- Air pump for purging and electric supply for the pump (either battery, generator, or power inverter with adapter for car battery). Must be capable of a flow of 200 milliliters per minute (mL/min) and a vacuum of 20” Hg.
- Canister, tedlar bag or syringe, as appropriate for the collection method.

3.0 DECONTAMINATION

All reusable sampling equipment will be thoroughly cleaned according to the decontamination SOP. Where possible, thoroughly pre-cleaned and wrapped sampling equipment should be used and dedicated to individual sampling locations. Disposable items such as sampling gloves and plastic sheeting will be changed after each use and discarded in an appropriate manner.

4.0. SITE-SPECIFIC CONSIDERATIONS

Prior to attempting soil gas sampling there should be an understanding of subsurface conditions at the Site. Soil gas samples should be collected in the vadose zone and generally, soil gas samples should not be collected at a depth less than above 5 feet below ground surface (bgs), unless sub-slab soil gas samples are needed. It may also not be feasible to collect soil gas from tighter grain soils with little pore volume, such as clays, and these layers should be avoided.

Soil gas sampling should not be performed until 24-hours after a significant rain event (>1/2 inch of rainfall).

5.0 PROCEDURE

5.1 System Set-up

1. Acquire all the necessary hardware and sampling equipment. Be sure to use one-quarter or one-eighth inch diameter Teflon or Nylaflow sample tubing.

2. Assemble or obtain the necessary fittings and vacuum gauge to create a soil gas probe and sampling manifold (vacuum gauge and valving). This manifold must be clean, free of oils, and flushed free of VOCs prior to use. If appropriate, be sure to place the helium leak check enclosure over the probe, and push the sample tubing through the hole in the cap before attaching the sampling manifold.

3. Adjust the purge system evacuation pump sampling rate to achieve the desired flow rate of 200 mL/min. This should be performed at the outlet of the vacuum pump prior to purging, either by using a suitable flow meter, or determining the amount of time required to fill a 1-liter Tedlar bag.

5.2 Shut-In Test

Prior to purging or sampling, a shut-in test should be conducted to check for leaks in the above-ground sampling system.

1. Assemble the above-ground valves, lines and fittings downstream from the top of the probe.

2. Evacuate the system to a minimum measured vacuum of about 100 inches of water using the purge pump.

3. Observe the vacuum gauge for 1-2 minutes. If there is any observable loss of vacuum, adjust the above-ground sampling system until the vacuum is maintained.

5.3 System Leak Checking and Purging

Perform a leak check of the sample manifold system by:

1. Make sure the gas probe valve is off and the sample valves are closed.

2. Open the purge valve and start the purge pump. Verify that the flow is set to 200 mL/min until a vacuum of approximately 15" Hg is achieved.

3. Turn off the purge pump and observe the vacuum gauge for 1-2 minutes. If there is any observable loss of vacuum, the leaks must be fixed prior to sampling.

4. Record the leak check date and time on the field notebook.

5.4 Purge Volume Test (Mobile Laboratory Only)

The purpose of the purge volume test is to ensure that stagnant air is removed from the sampling system and to ensure that samples are representative of subsurface conditions. The test well should be located where soil gas concentrations are anticipated to be elevated, if possible.

Perform a purge test of the test well by:

1. Purge the well one purge volume and collect a sample.

2. Have the mobile laboratory analyze the sample for target compounds. Sample procedures are explained in Section 5.6, below.

3. Purge an additional two purge volumes (for a total of 3 purge volumes), collect a sample and submit to the mobile laboratory for analysis.

    a. One purge volume is equal to the sum of the following volumes:

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

4. Repeat for a purge of 10 total purge volumes.

5. The site purge volume will be chosen based on the sample with the highest concentration of target compounds from the purge test. All of other sample locations will utilize this purge volume (either one, three, or ten).

5.5 Helium Leak Check (as dictated by DQOs)

The helium leak check procedure is accomplished by:

1. Start the flow of helium under the leak check enclosure. Position the tube so the helium is directed at the interface of the probe and the ground. Let the helium fill the enclosure for a couple of minutes.

2. Turn the helium leak detector on and make sure that the detector is not reading any helium before proceeding.

3. Verify that the helium concentration inside the leak check enclosure is >10% by placing the probe of the helium detector into the hole where the sample tubing comes out or under the enclosure wall. It is not necessary to verify that the helium concentration is 100% as this is bad for the detector.

4. Purging is carried out by pulling soil gas through the system at a rate of 200 mL/min for a time period sufficient to achieve three purge volumes, equal to the sum of the internal volume of the in-ground annular space, sample line, and sampling manifold system.

   Note: When calculating the purge volume, be sure to take into account the inside diameter and length of the sample tubing, as well as the probe outside diameter and retract distance for the annular space for temporary probes. If during the purge (or sampling) the vacuum exceeds 7 "Hg, then reduce the pump flow rate. The system vacuum must stay below this level at all times.

5. To start the soil gas probe purge, open the gas probe valve and close the sample valve at the same time, and start timing. Verify that the flow rate is still 200 mL/min.

6. During the last 5 minutes of the purge (or the entire purge time if less than 5 minutes), attach a Tedlar bag to the purge pump exhaust and open the bag's valve.

7. At the end of the purge time, close the purge valve, close the valve to the Tedlar bag, and turn off the pump.

8. Attach the Tedlar bag to the helium detector and open the valve. If a helium reading of greater than or equal to 5% of the helium concentration inside the leak check enclosure is observed, then the probe leak check has failed and corrective action should be taken.

9. Record the purge date, time, purge rate, leak check result, and purge volume on the field sampling log.

10. Immediately move on to the sampling phase. Little to no delay should occur between purging and sampling.

5.6 Sample Collection

'Clean' sampling protocols must be followed when handling and collecting samples. This requires care in the shipping, storage, and use of sampling equipment. Sharpie markers should not be used for labeling or note-taking during sampling.

1. Attach the canister, tedlar bag or syringe to the sample tubing.

2. Before taking the sample, confirm that the sampling system valves are set as follows: the purge valve is confirmed to be closed, gas probe valve is open, and the sample valve is open.

3. After sampling for the appropriate amount of time, close the sample valve and the canister/tedlar bag valve. Remove the sample container from the sampling manifold.

4. Record the sampling date, time, canister identification (ID), flow controller ID, and any other observation pertinent to the sampling event on the field sampling log. The temperature and barometric pressure should be recorded.

5. Fill out all appropriate documentation (sampling forms, sample labels, chain of custody, sample tags, etc.).

6. Disassemble the sampling system.

END OF PROCEDURE

1.0 PURPOSE

The purpose of this standard operating procedure (SOP) is to describe the considerations and procedures, and to establish the guidelines for drilling (soil borings, wells, or piezometers) and formation sampling activities in unconsolidated formations. There are several drilling techniques available which include: direct push (Geoprobe® or cone penetrometer testing [CPT]), hollow-stem auger, cable tool, hydraulic rotary, cased-hole rotary, air rotary, and Sonic. Formation (sediment/soil) sample collection options include: disturbed (drill cuttings), intact (split-spoon or continuous core), and undisturbed (Shelby-tube or Denison-core). Borehole abandonment (closure) procedures will also be addressed in this SOP.

The objective of drilling is to collect accurate subsurface information. Consequently, the lithologic data is essential information that characterizes subsurface conditions and describes geologic coefficients qualitatively and/or quantitatively.

2.0 DRILLING TECHNIQUE-SELECTION

Verify that the drilling technique is the one specified in the investigation work plan, and that the drilling equipment mobilized by the driller is in good condition and proper working order. Do not permit the driller to use a drilling rig that appears to be substandard, in disrepair, etc., and/or is questionable as to whether or not the rig has the capabilities to accomplish the goals of the drilling program. Complete a drill rig inspection checklist before starting any drilling activities. The drilling rig must be capable of:

a. Penetration of all anticipated subsurface materials and formations at a desired rate, and construction of a borehole of desired diameter.

b. Identification of lithology for development of a geologic log of all unconsolidated formations and materials penetrated, including physical characteristics and visual description of color, grain sizes, sorting and mineralogy.

c. Collection of intact and/or undisturbed soil samples from the center line or sidewall of the borehole. This objective requires the drilling to be halted while soil samples are taken from the bottom or side of the incomplete borehole.

d. Implementation of borehole geophysical logging (when applicable and possible) to enable more accurate vertical and horizontal extrapolation of borehole data to the lithology of the hydrogeologic system.

Drilling will not commence until the following have been completed:

- Development and approval of a drilling specific job safety analysis (JSA)
- a utility mark-out/one call has been conducted at the drilling location(s); and
- the completion of a subsurface clearance procedure checklist.

3.0 DRILLING TECHNIQUE - DESCRIPTION

3.1 Direct Push – The direct push technology includes several types of drilling rigs and drilling equipment that advances a drill string by pushing or hammering without rotating the drill string. Direct push rigs include both Geoprobe® and CPT rigs. Geoprobe® rigs are typically limited to drilling in unconsolidated soil up to approximately 100 feet below ground surface (bgs) under compatible conditions. Formation samples are collected in acetate/plastic sleeves. Advantages include: access and maneuverability due to the rig's small size; fluids are not introduced into the subsurface during drilling; and sampling is relatively inexpensive. Disadvantages include: limitation to drilling depth; limitation to unconsolidated or soft rock drilling; and limitation to small diameter borings. CPT rigs also provide a continuous profile of the soil strata as the rig's sensing equipment is advanced.

3.2 Hollow-Stem Auger - This drilling method is rapid and extremely effective in most cohesive sediments but less so in loose sandy material. A major advantage of this technique is that normally no fluids are introduced into the formation. If the auger flights can be removed and the integrity of the borehole maintained, then electrical and radiation (e.g., gamma, neutron, etc.) geophysical logs can be run. If the auger flights must remain in the borehole, then only radiation geophysical logs can be run. Casing, screen, and sampling devices can then be lowered through the hollow stem by removing the removable plug at the bottom of the auger flights, and gravel/sand packing and cementing can be accomplished within the hollow stem. However, this can be difficult especially below the water table. Auger flight outside diameters (OD) range from 5 inches (in.) to 12 in.

3.3 Cable Tool (Percussion) - This drilling method is slow because the borehole is advanced by lifting and dropping a heavy string of drilling tools. Cuttings accumulate in the drill casing and are removed by a sand bailer. A steel casing is driven in as the hole is deepened. Cable-tool rigs can be used in unconsolidated sediment and bedrock to depths of hundreds or thousands of feet and often employ telescoping techniques for drilling deep boreholes. Electrical geophysical logs cannot be run through the steel cased borehole, but radiation logs (e.g., gamma, neutron, etc.) can be run. Well casing and screen can be installed within the cased hole after which the outer casing is pulled back (removed). Because the boring is cased as it is being drilled, cross-contamination between various depths is practically eliminated. The method provides an excellent means to collect good, representative formation samples.

3.4 Hydraulic Rotary - This drilling method uses a rotating bit to drill (advance) the borehole. Drill cuttings are removed using a recirculated drilling fluid (mud or water). Although setting up the drilling equipment is slow, the drilling process is reasonably fast. In the mud-rotary method, drilling mud forms a cake on the borehole wall which prevents excessive loss of fluid to the formation being drilled. The hydrostatic pressure combined with the weight and density of the mud slurry keeps the hole open. This allows the drill rods to be removed from the

borehole and geophysical logs (electric and radiation) to be run in the open borehole.

In reverse hydraulic rotary drilling, the drilling fluid moves downward through annular space and then upward inside the drill pipe. If the drilling fluid does not contain mud, then sufficient water flow is required as make-up water because the borehole wall is not sealed; therefore, significant water loss can occur to the formation being drilled. The borehole is held open by hydrostatic pressure only. A serious obstacle to this drilling method occurs when the static water level is less than 15 feet below land surface because of insufficient hydrostatic head difference between the borehole and the water table. However, the problems of excessive water loss and shallow depths to water may be overcome by using mud as the drilling fluid.

In mud-rotary drilling, the drilling fluid (mud or polymer) moves downward through the drill pipe and then upward through the annular space. Therefore, the borehole is held open by hydrostatic pressure and the mud cake lining the wall of the borehole. The mud-rotary method can be used to construct moderate to deep wells in unconsolidated (and consolidated material), while the reverse rotary technique can be used to construct moderate to deep wells in unconsolidated materials. The principal disadvantage may be the difficulty in removing mud cake from the formation at the screened zone. Extensive well development may be required to remove the mud cake.

3.5 Cased-Hole Rotary - Several rotary drilling techniques have been developed in which a steel casing is advanced with an air-rotary or mud-rotary drill. This technique is highly desirable for use in exploratory drilling at monitoring sites because water and soil samples may be collected under conditions which preclude contamination from shallower depths. Furthermore, this technique is extremely effective in boulder or cavernous zones which would inhibit or preclude drilling using other techniques. Drilling results are comparable to cable-tool drilling but with greatly enhanced speeds. In all the cased-hole techniques, the main benefit is that the only portion of the borehole which is open, is at the bottom of the drill casing; thus, no soil or water from shallower depths can move down and impact the depth drilled and/or sampled. Electrical geophysical logs cannot be run through the steel-cased borehole, however, radiation logs (e.g., gamma, neutron, etc.) can be run.

Presently, there are three cased-hole rotary techniques which include:

a. The drill-thru casing hammer technique in which the casing is advanced by percussion with a casing hammer or vibratory driver similar to the method used in a borehole drilled by the air-rotary method. The casing hammer can also pull out the casing (air drilling only).

b. The Odex™ Drilling System (European system) which “pulls” the casing using a fixture attached to an air-hammer type drill bit (air drilling only).

c. The Barber™ Drilling System in which drilling is done with a top-head drive and a rotary table that spins casing into the ground. Casing can be fitted with a carbide "shoe" to cut boulders and an air hammer can be used above the bit. Air or mud rotary can be used to lift cuttings.

Two potential problems may be encountered using the cased-hole rotary technique which include: 1) "sand heave" when drilling stops (which can be quickly drilled or bailed out) and 2) possible aeration of water in the cased borehole if volatiles are being tested (which can be overcome by pumping or bailing the standing water out before sampling). The minimum drill casing diameter is 6 inches and depth is limited to approximately 450 feet.

3.6 Air Rotary - This drilling method uses a rotating bit to drill, and high-velocity compressed air to remove cuttings from the borehole. A pneumatic down-hole hammer is often used to add percussion to the rotary drilling action. This drilling method is very fast and, although it is most suitable for penetrating hard bedrock, it can be used in unconsolidated formations. The borehole may be cased or uncased depending on geologic conditions. If an open borehole is drilled, then electrical and radiation (e.g., gamma, neutron, etc.) geophysical logs can be run. If a cased borehole is drilled, then only radiation geophysical logs can be run.

Four potential problems may be encountered when using the air-rotary technique:

a. When a prolific aquifer is tapped, the compressed air may not be able to lift the water to the surface.

b. Aeration of water in the borehole (and finished well) immediately prior to sampling can interfere with a number of inorganic and organic water-quality parameters.

c. Low yield water entry zones may not be identified because the air pressure prevents water from entering the borehole. Care should be taken to prevent overdrilling of the borehole.

d. Air rotary drilling can induce the migration of volatile organics to the surface or adjacent structures causing potential aesthetic or health and safety concerns.

If the air-rotary technique is used then the following special procedures will be implemented:

a. The type of air compressor and lubricating oil will be documented on an appropriate field form and in the field notebook and a 1-pint sample of the oil will be retained for characterization in the event organic compounds are detected in a well sample.

b. An air line oil filter will be required and changed per manufacturer's recommendations during operation with documentation of this

maintenance on an appropriate field form and in the field notebook. More frequent oil filter changes will be made if oil is visibly detected in the filtered air.

c. The use of any additive will be prohibited, except approved water (e.g., potable water) for dust control and cuttings removal.

3.7 Sonic - This drilling method uses a rotating bit to drill, and high-frequency resonant vibrations created by a Sonic drill head. The drill head contains the mechanism necessary for rotary motion as well as an oscillator, which causes a high frequency force to be superimposed on the drill string. The frequency can be varied to suit operating conditions and is generally between 50 and 120 hertz (cycles per second). The vibrations are sent down the drill string to the drill bit, magnifying the amplitude of the drill bit, which (in overburden) fluidizes the soil particles at the bit face. The drill bit is physically vibrating up and down in addition to being pushed down and rotated. These three combined forces allow for relatively fast and easy penetration through most geological formations. The oscillator is driven by a hydraulic motor and uses out of balance weights to generate high sinusoidal forces that are transmitted to the drill bit. An internal spring system isolates these vibrational forces from the rest of the drill rig. Typically, Sonic drilling uses a drilling fluid (i.e., potable water) to facilitate the advancement of the drill bit. The amount of drilling fluid used should be limited during soil collection as to minimize wash-out of the sample.

4.0 DECONTAMINATION

Drilling equipment decontamination procedures are outlined in the field equipment decontamination SOP. Proper decontamination in accordance with regulatory guidelines must be clearly documented in the field notebook.

5.0 PROCEDURE FOR DRILLING

5.1 Safety first. Obtain the appropriate work permit, Job Safety Analysis (JSA) and personal protection equipment (PPE), as specified in the site Health and Safety Plan (HASP).

5.2 Document all drilling-related activities (e.g., starting, stopping, footage, problems, decontamination, etc.) on the daily log form and in the field notebook. Record dates and times of activities, and names of Roux Associates personnel providing oversight.

5.3 Monitor and record drill fluid mix, speed of rotation, pressure on the drill fluid, rate of drilling, and length of drill rods or casing in the borehole, as applicable.

5.4 Confirm that the drill rods and core barrel are straight, or discontinue drilling.

5.5 Pay particular attention to the advancement of the boring because differences in the rate of drilling may be indicative of differences in subsurface geologic conditions (e.g., sand and gravel versus clay).

5.6 Maintain a continuous dialogue with the driller to track and keep informed of all drilling activities (e.g., the speed of the drill and drilling pressure, difficult and easy drilling conditions, etc.).

5.7 Collect formation samples as described in accordance with the work plan. Sample jars must be labeled appropriately (e.g., project number and name, site location, boring number, date, sample interval, blow counts, and initials of Roux Associates personnel collecting sample).

5.8 Record geologic information in the soil boring log form and in the field notebook.

5.9 Handle and ship split-spoon sample jars carefully to avoid breakage and handle and ship tubes or cores carefully to prevent disturbance.

6.0 PROCEDURE FOR FORMATION SAMPLING

6.1 Safety first. Obtain the appropriate JSA and PPE, as specified in the site HASP.

6.2 Intact formation sampling will be implemented using continuous core or split-spoon samplers (which are driven), Shelby-tube samplers (which are pushed), or Denison-core samplers (which are rotated) depending on the drilling technique employed. Formation samples will be retained in core barrel liners/tubes or suitable size jars for physical descriptions and potential physical and chemical analysis. The appropriately labeled jars and tubes will be stored in a safe place to avoid breakage, agitation, and over-heating/freezing. Intact formation samples will be collected at specified intervals as described in the work plan. Geologic information will be recorded on a geologic log form on the appropriate field form. Detailed descriptions of the type(s) of intact sample(s) collected, sampling intervals and conditions, and objective(s) of the sample collection will be provided in the work plan.

6.3 Soil cores from the wells drilled at the Site are used for lithologic identification and physical property analysis. Soil core samples will be collected using a direct push continuous core (acetate/PVC liners) or split-spoon sampler (6-inch stainless steel sample containers). The soil core sample intervals will be specified in the work plan.

6.4 Sampling equipment will be decontaminated by steam cleaning and/or a non-phosphate, laboratory-grade and distilled/deionized wash followed by a distilled/deionized water rinse. (Refer to the field equipment decontamination SOP for a detailed description of minimum and special decontamination procedures.) Decontamination of sediment sampling equipment will take place prior to the collection of the first sample and following the collection of each subsequent sample.

7.0 BOREHOLE ABANDONMENT OR CLOSURE

7.1 Safety first. Obtain the appropriate JSA and PPE, as specified in the site HASP.

7.2 Upon the completion of the investigation, boreholes will be abandoned as specified in the workplan.

7.3 For each abandoned borehole, the procedure will be documented in the field notebook.

END OF PROCEDURE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for the installation of temporary soil gas probes for the collection of shallow soil gas samples. This SOP should be used where its application is consistent with the project's data quality objectives (DQOs) and in conjunction with the SOP for soil gas collection.

2.0 MATERIALS

- 1/8 to 1/4 inch sampling tubing – metal, nylon, PEEK, Teflon
- Appropriate Fittings
- Bentonite Chips
- Water
- Drilling Apparatus

Note: It is necessary to coordinate the hardware (i.e. size of tubing, fittings, sampling interface assembly, etc.) for the soil gas probe sampling line with the sampling system (i.e. Tedlar bags, Summa canisters, etc.). This step is critical to achieve a leak free system.

3.0 PROCEDURE

Temporary soil gas probe installation procedures are described below to ensure that a quality sample is able to be obtained and to minimize ambient air migrating into the sample. Soil gas wells may be installed using various types of drilling methods, however, some drilling methods can disrupt the surrounding soil gas and will require a longer equilibration time prior to sampling. The steps to installing the temporary point are:

1) Drill a borehole to the required depth as shown on the sample plan or scope of work.

2) Install a 6-12 inches sand pack at the bottom and install the probe tip (with attached tubing) approximately 3-4 inches into the sand pack. Use extra tubing so that sufficient amount (1-2 feet) will be left above ground. Plug the exposed end of the tubing.

3) Install 12 inches of dry granular bentonite on top of the sand pack.

4) Fill the remaining annular space with hydrated bentonite in 6" lifts.

   - If multiple probes depths are to be installed at the same location, the hydrated bentonite shall be installed to the top the next testing interval. Sand pack and the dry bentonite will then be installed as normal.

5) Repair the ground surface to original condition.

6) Secure and mark the tubing at the surface with the location ID and depth.

END OF PROCEDURE

ATTACHMENT 4

NYSDEC PFAS Sampling Guidance

NEW YORK STATE OF OPPORTUNITY.

Department of Environmental Conservation

SAMPLING, ANALYSIS, AND ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

Under NYSDEC's Part 375 Remedial Programs

April 2023



www.dec.ny.gov

Table of Contents

Objective 1
Applicability 1
Field Sampling Procedures 1
Analysis and Reporting 2
Routine Analysis 2
Additional Analysis 2
Data Assessment and Application to Site Cleanup 3
Water Sample Results 3
Soil Sample Results 3
Testing for Imported Soil 4
Appendix A - Quality Assurance Project Plan (QAPP) Guidelines for PFAS 5
Appendix B - Sampling Protocols for PFAS in Soils, Sediments and Solids 6
Appendix C - Sampling Protocols for PFAS in Monitoring Wells 8
Appendix D - Sampling Protocols for PFAS in Surface Water 10
Appendix E - Sampling Protocols for PFAS in Private Water Supply Wells 12
Appendix F - Sampling Protocols for PFAS in Fish 14
Appendix G - PFAS Analyte List 22
Appendix H - Data Review Guidelines for Analysis of PFAS in Non-Potable Water and Solids 24

ERRATA SHEET for

SAMPLING, ANALYSIS, AND ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) Under NYSDEC's Part 375 Remedial Programs Issued January 17, 2020

Citation and Page Number	Current Text	Corrected Text	Date
Title of Appendix I, page 32	Appendix H	Appendix I	2/25/2020
Document Cover, page 1	Guidelines for Sampling and Analysis of PFAS	Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) Under NYSDEC's Part 375 Remedial Programs	9/15/2020
Data Assessment and Application to Site Cleanup Page 3	Until such time as Ambient Water Quality Standards (AWQS) and Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published	Until such time as Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published	3/28/2023
Water Sample Results Page 3	PFOA and PFOS should be further assessed and considered as potential contaminants of concern in groundwater or surface water if PFOA or PFOS is detected in any water sample at or above 10 ng/L (ppt) and is determined to be attributable to the site, either by a comparison of upgradient and downgradient levels, or the presence of soil source areas, as defined below.	NYSDEC has adopted ambient water quality guidance values for PFOA and PFOS. Groundwater samples should be compared to the human health criteria of 6.7 ng/l (ppt) for PFOA and 2.7 ng/l (ppt) for PFOS. These guidance values also include criteria for surface water for PFOS applicable for aquatic life, which may be applicable at some sites. Drinking water sample results should be compared to the NYS maximum contaminant level (MCL) of 10 ng/l (ppt).Analysis to determine if PFOA and PFOS concentrations are attributable to the site should include a comparison between upgradient and downgradient levels, and the presence of soil source areas, as defined below.	3/28/2023
Soil Sample Results Page 3	Soil cleanup objectives for PFOA and PFOS have been proposed in an upcoming revision to 6 NYCRR Part 375-6. Until SCOs are in effect, the following are to be used as guidance values:	NYSDEC will delay adding soil cleanup objectives for PFOA and PFOS to 6 NYCRR Part 375-6 until the PFAS rural soil background study has been completed. Until SCOs are in effect, the following are to be used as guidance values:	3/28/2023
Protection of Groundwater Page 3	PFOA (ppb) 1.1 PFOS (ppb) 3.7	PFOA (ppb) 0.8 PFOS (ppb) 1.0	3/28/2023

Citation and Page Number	Current Text	Corrected Text	Date
Footnote 2 Page 3	The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the guidance value for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).	The Protection of Groundwater values are based on the above referenced ambient groundwater guidance values. Details on that calculation are available in the following document, prepared for the February 2022 proposed changes to Part 375 (https://www.dec.ny.gov/docs/remediation_hudson_pdf/part375techsupport.pdf). The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the guidance value for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).	3/28/2023
Testing for Imported Soil Page 4	If the concentrations of PFOA and PFOS in leachate are at or above 10 ppt (the Maximum Contaminant Levels established for drinking water by the New York State Department of Health), then the soil is not acceptable.	If the concentrations of PFOA and PFOS in leachate are at or above the ambient water quality guidance values for groundwater, then the soil is not acceptable.	3/28/2023
Routine Analysis, page 9	"However, laboratories analyzing environmental samples…PFOA and PFOS in drinking water by EPA Method 537, 537.1 or ISO 25101."	"However, laboratories analyzing environmental samples…PFOA and PFOS in drinking water by EPA Method 537, 537.1, ISO 25101, or Method 533."	9/15/2020
Additional Analysis, page 9, new paragraph regarding soil parameters	None	"In cases where site-specific cleanup objectives for PFOA and PFOS are to be assessed, soil parameters, such as Total Organic Carbon (EPA Method 9060), soil pH (EPA Method 9045), clay content (percent), and cation exchange capacity (EPA Method 9081), should be included in the analysis to help evaluate factors affecting the leachability of PFAS in site soils."	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Data Assessment and Application to Site Cleanup Page 10	Until such time as Ambient Water Quality Standards (AWQS) and Soil Cleanup Objectives (SCOs) for PFAS are published, the extent of contaminated media potentially subject to remediation should be determined on a case-by-case basis using the procedures discussed below and the criteria in DER-10. Target levels for cleanup of PFAS in other media, including biota and sediment, have not yet been established by the DEC.	Until such time as Ambient Water Quality Standards (AWQS) and Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published, the extent of contaminated media potentially subject to remediation should be determined on a case-by-case basis using the procedures discussed below and the criteria in DER-10. Preliminary target levels for cleanup of PFOA and PFOS in other media, including biota and sediment, have not yet been established by the DEC.	9/15/2020
Water Sample Results Page 10	PFAS should be further assessed and considered as a potential contaminant of concern in groundwater or surface water (…) If PFAS are identified as a contaminant of concern for a site, they should be assessed as part of the remedy selection process in accordance with Part 375 and DER-10.	PFOA and PFOS should be further assessed and considered as potential contaminants of concern in groundwater or surface water (…) If PFOA and/or PFOS are identified as contaminants of concern for a site, they should be assessed as part of the remedy selection process in accordance with Part 375 and DER-10.	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Soil Sample Results, page 10	"The extent of soil contamination for purposes of delineation and remedy selection should be determined by having certain soil samples tested by Synthetic Precipitation Leaching Procedure (SPLP) and the leachate analyzed for PFAS. Soil exhibiting SPLP results above 70 ppt for either PFOA or PFOS (individually or combined) are to be evaluated during the cleanup phase."	"Soil cleanup objectives for PFOA and PFOS will be proposed in an upcoming revision to 6 NYCRR Part 375-6. Until SCOs are in effect, the following are to be used as guidance values. " [Interim SCO Table] "PFOA and PFOS results for soil are to be compared against the guidance values listed above. These guidance values are to be used in determining whether PFOA and PFOS are contaminants of concern for the site and for determining remedial action objectives and cleanup requirements. Site-specific remedial objectives for protection of groundwater can also be presented for evaluation by DEC. Development of site-specific remedial objectives for protection of groundwater will require analysis of additional soil parameters relating to leachability. These additional analyses can include any or all the parameters listed above (soil pH, cation exchange capacity, etc.) and/or use of SPLP. As the understanding of PFAS transport improves, DEC welcomes proposals for site-specific remedial objectives for protection of groundwater. DEC will expect that those may be dependent on additional factors including soil pH, aqueous pH, % organic carbon, % Sand/Silt/Clay, soil cations: K, Ca, Mg, Na, Fe, Al, cation exchange capacity, and anion exchange capacity. Site-specific remedial objectives should also consider the dilution attenuation factor (DAF). The NJDEP publication on DAF can be used as a reference: https://www.nj.gov/dep/srp/guidance/rs/daf.pdf. "	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Testing for Imported Soil Page 11	Soil imported to a site for use in a soil cap, soil cover, or as backfill is to be tested for PFAS in general conformance with DER-10, Section 5.4(e) for the PFAS Analyte List (Appendix F) using the analytical procedures discussed below and the criteria in DER-10 associated with SVOCs. If PFOA or PFOS is detected in any sample at or above 1 µg/kg, then soil should be tested by SPLP and the leachate analyzed for PFAS. If the SPLP results exceed 10 ppt for either PFOA or PFOS (individually) then the source of backfill should be rejected, unless a site-specific exemption is provided by DER. SPLP leachate criteria is based on the Maximum Contaminant Levels proposed for drinking water by New York State's Department of Health, this value may be updated based on future Federal or State promulgated regulatory standards. Remedial parties have the option of analyzing samples concurrently for both PFAS in soil and in the SPLP leachate to minimize project delays. Category B deliverables should be submitted for backfill samples, though a DUSR is not required.	Testing for PFAS should be included any time a full TAL/TCL analyte list is required. Results for PFOA and PFOS should be compared to the applicable guidance values. If PFOA or PFOS is detected in any sample at or above the guidance values then the source of backfill should be rejected, unless a site-specific exemption is provided by DER based on SPLP testing, for example. If the concentrations of PFOA and PFOS in leachate are at or above 10 ppt (the Maximum Contaminant Levels established for drinking water by the New York State Department of Health), then the soil is not acceptable. PFOA, PFOS and 1,4-dioxane are all considered semi-volatile compounds, so composite samples are appropriate for these compounds when sampling in accordance with DER-10, Table 5.4(e)10. Category B deliverables should be submitted for backfill samples, though a DUSR is not required.	9/15/2020

Citation and Page Number	Current Text	Corrected Text	Date
Footnotes	None	[1] TOP Assay analysis of highly contaminated samples, such as those from an AFFF (aqueous film-forming foam) site, can result in incomplete oxidation of the samples and an underestimation of the total perfluoroalkyl substances. [2] The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the soil cleanup objective for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).	9/15/2020
Additional Analysis, page 9	In cases… soil parameters, such as Total Organic Carbon (EPA Method 9060), soil…	In cases… soil parameters, such as Total Organic Carbon (Lloyd Kahn), soil…	1/8/2021
Appendix A, General Guidelines, fourth bullet	List the ELAP-approved lab(s) to be used for analysis of samples	List the ELAP- certified lab(s) to be used for analysis of samples	1/8/2021
Appendix E, Laboratory Analysis and Containers	Drinking water samples collected using this protocol are intended to be analyzed for PFAS by ISO Method 25101.	Drinking water samples collected using this protocol are intended to be analyzed for PFAS by EPA Method 537, 537.1, 533, or ISO Method 25101	1/8/2021
Water Sample Results Page 9	"In addition, further assessment of water may be warranted if either of the following screening levels are met: a. any other individual PFAS (not PFOA or PFOS) is detected in water at or above 100 ng/L; or b. total concentration of PFAS (including PFOA and PFOS) is detected in water at or above 500 ng/L"	Deleted	6/15/2021

Citation and Page Number	Current Text	Corrected Text	Date
Routine Analysis, Page XX	Currently, New York State Department of Health's Environmental Laboratory Approval Program (ELAP)… criteria set forth in the DER's laboratory guidelines for PFAS in non-potable water and solids (Appendix H - Laboratory Guidelines for Analysis of PFAS in Non-Potable Water and Solids).	Deleted	5/31/2022
Analysis and Reporting, Page XX	As of October 2020, the United States Environmental Protection Agency (EPA) does not have a validated method for analysis of PFAS for media commonly analyzed under DER remedial programs (non-potable waters, solids). DER has developed the following guidelines to ensure consistency in analysis and reporting of PFAS.	Deleted	5/31/2022
Routine Analysis, Page XX	LC-MS/MS analysis for PFAS using methodologies based on EPA Method 537.1 is the procedure to use for environmental samples. Isotope dilution techniques should be utilized for the analysis of PFAS in all media.	EPA Method 1633 is the procedure to use for environmental samples.	
Soil Sample Results, Page XX	Soil cleanup objectives for PFOA and PFOS will be proposed in an upcoming revision to 6 NYCRR Part 375-6	Soil cleanup objectives for PFOA and PFOS have been proposed in an upcoming revision to 6 NYCRR Part 375-6	
Appendix A	"Include in the text… LC-MS/MS for PFAS using methodologies based on EPA Method 537.1"	"Include in the text ….EPA Method 1633"	
Appendix A	"Laboratory should have ELAP certification for PFOA and PFOS in drinking water by EPA Method 537, 537.1, EPA Method 533, or ISO 25101"	Deleted	
Appendix B	"Samples collected using this protocol are intended to be analyzed for PFAS using methodologies based on EPA Method 537.1"	"Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633"	

Citation and Page Number	Current Text	Corrected Text	Date
Appendix C	"Samples collected using this protocol are intended to be analyzed for PFAS using methodologies based on EPA Method 537.1"	"Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633"	
Appendix D	"Samples collected using this protocol are intended to be analyzed for PFAS using methodologies based on EPA Method 537.1"	"Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633"	
Appendix G		Updated to include all forty PFAS analytes in EPA Method 533	
Appendix H		Deleted	
Appendix I	Appendix I	Appendix H	
Appendix H	"These guidelines are intended to be used for the validation of PFAS analytical results for projects within the Division of Environmental Remediation (DER) as well as aid in the preparation of a data usability summary report."	"These guidelines are intended to be used for the validation of PFAS using EPA Method 1633 for projects within the Division of Environmental Remediation (DER)."	
Appendix H	"The holding time is 14 days…"	"The holding time is 28 days…"	
Appendix H, Initial Calibration	"The initial calibration should contain a minimum of five standards for linear fit…"	"The initial calibration should contain a minimum of six standards for linear fit…"	
Appendix H, Initial Calibration	Linear fit calibration curves should have an R^2 value greater than 0.990.	Deleted	
Appendix H, Initial Calibration Verification	Initial Calibration Verification Section	Deleted	
Appendix H	secondary Ion Monitoring Section	Deleted	
Appendix H	Branched and Linear Isomers Section	Deleted	

Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) Under NYSDEC's Part 375 Remedial Programs

Objective

New York State Department of Environmental Conservation's Division of Environmental Remediation (DER) performs or oversees sampling of environmental media and subsequent analysis of PFAS as part of remedial programs implemented under 6 NYCRR Part 375. To ensure consistency in sampling, analysis, reporting, and assessment of PFAS, DER has developed this document which summarizes currently accepted procedures and updates previous DER technical guidance pertaining to PFAS.

Applicability

All work plans submitted to DEC pursuant to one of the remedial programs under Part 375 shall include PFAS sampling and analysis procedures that conform to the guidelines provided herein.

As part of a site investigation or remedial action compliance program, whenever samples of potentially affected media are collected and analyzed for the standard Target Analyte List/Target Compound List (TAL/TCL), PFAS analysis should also be performed. Potentially affected media can include soil, groundwater, surface water, and sediment. Based upon the potential for biota to be affected, biota sampling and analysis for PFAS may also be warranted as determined pursuant to a Fish and Wildlife Impact Analysis. Soil vapor sampling for PFAS is not required.

Field Sampling Procedures

DER-10 specifies technical guidance applicable to DER's remedial programs. Given the prevalence and use of PFAS, DER has developed "best management practices" specific to sampling for PFAS. As specified in DER-10 Chapter 2, quality assurance procedures are to be submitted with investigation work plans. Typically, these procedures are incorporated into a work plan, or submitted as a stand-alone document (e.g., a Quality Assurance Project Plan). Quality assurance guidelines for PFAS are listed in Appendix A - Quality Assurance Project Plan (QAPP) Guidelines for PFAS.

Field sampling for PFAS performed under DER remedial programs should follow the appropriate procedures outlined for soils, sediments, or other solids (Appendix B), non-potable groundwater (Appendix C), surface water (Appendix D), public or private water supply wells (Appendix E), and fish tissue (Appendix F).

QA/QC samples (e.g. duplicates, MS/MSD) should be collected as specified in DER-10, Section 2.3(c). For sampling equipment coming in contact with aqueous samples only, rinsate or equipment blanks should be collected. Equipment blanks should be collected at a minimum frequency of one per day per site or one per twenty samples, whichever is more frequent.

Analysis and Reporting

The investigation work plan should describe analysis and reporting procedures, including laboratory analytical procedures for the methods discussed below. As specified in DER-10 Section 2.2, laboratories should provide a full Category B deliverable. In addition, a Data Usability Summary Report (DUSR) should be prepared by an independent, third-party data validator. Electronic data submissions should meet the requirements provided at: https://www.dec.ny.gov/chemical/62440.html.

DER has developed a *PFAS Analyte List* (Appendix G) for remedial programs to understand the nature of contamination at sites. It is expected that reported results for PFAS will include, at a minimum, all the compounds listed. If lab and/or matrix specific issues are encountered for any analytes, the DER project manager, in consultation with the DER chemist, will make case-by-case decisions as to whether certain analytes may be temporarily or permanently discontinued from analysis at each site. As with other contaminants that are analyzed for at a site, the *PFAS Analyte List* may be refined for future sampling events based on investigative findings.

Routine Analysis

EPA Method 1633 is the procedure to use for environmental samples. Reporting limits for PFOA and PFOS in aqueous samples should not exceed 2 ng/L. Reporting limits for PFOA and PFOS in solid samples should not exceed 0.5 µg/kg. Reporting limits for all other PFAS in aqueous and solid media should be as close to these limits as possible. If laboratories indicate that they are not able to achieve these reporting limits for the entire *PFAS Analyte List*, site-specific decisions regarding acceptance of elevated reporting limits for specific PFAS can be made by the DER project manager in consultation with the DER chemist. Data review guidelines were developed by DER to ensure data comparability and usability (Appendix H - Data Review Guidelines for Analysis of PFAS in Non-Potable Water and Solids).

Additional Analysis

Additional laboratory methods for analysis of PFAS may be warranted at a site, such as the Synthetic Precipitation Leaching Procedure (SPLP) and Total Oxidizable Precursor Assay (TOP Assay).

In cases where site-specific cleanup objectives for PFOA and PFOS are to be assessed, soil parameters, such as Total Organic Carbon (Lloyd Kahn), soil pH (EPA Method 9045), clay content (percent), and cation exchange capacity (EPA Method 9081), should be included in the analysis to help evaluate factors affecting the leachability of PFAS in site soils.

SPLP is a technique used to determine the mobility of chemicals in liquids, soils and wastes, and may be useful in determining the need for addressing PFAS-containing material as part of the remedy. SPLP by EPA Method 1312 should be used unless otherwise specified by the DER project manager in consultation with the DER chemist.

Impacted materials can be made up of PFAS that are not analyzable by routine analytical methodology. A TOP Assay can be utilized to conceptualize the amount and type of oxidizable PFAS which could be liberated in the environment, which approximates the maximum concentration of perfluoroalkyl substances that could be generated if all polyfluoroalkyl substances were oxidized. For example, some polyfluoroalkyl substances may degrade or transform to form perfluoroalkyl substances (such as PFOA or PFOS), resulting in an increase in perfluoroalkyl substance concentrations as contaminated groundwater moves away from a source. The TOP Assay converts, through oxidation, polyfluoroalkyl substances (precursors) into perfluoroalkyl substances that can be detected by routine analytical methodology.[1]

[1] TOP Assay analysis of highly contaminated samples, such as those from an AFFF (aqueous film-forming foam) site, can result in incomplete oxidation of the samples and an underestimation of the total perfluoroalkyl substances.

Commercial laboratories have adopted methods which allow for the quantification of targeted PFAS in air and biota. The EPA's Office of Research and Development (ORD) is currently developing methods which allow for air emissions characterization of PFAS, including both targeted and non-targeted analysis of PFAS. Consult with the DER project manager and the DER chemist for assistance on analyzing biota/tissue and air samples.

Data Assessment and Application to Site Cleanup

Until such time as Soil Cleanup Objectives (SCOs) for PFOA and PFOS are published, the extent of contaminated media potentially subject to remediation should be determined on a case-by-case basis using the procedures discussed below and the criteria in DER-10. Preliminary target levels for cleanup of PFOA and PFOS in other media, including biota and sediment, have not yet been established by the DEC.

Water Sample Results

NYSDEC has adopted ambient water quality guidance values for PFOA and PFOS. Groundwater samples should be compared to the human health criteria of 6.7 ng/l (ppt) for PFOA and 2.7 ng/l (ppt) for PFOS. These human health criteria should also be applied to surface water that is used as a water supply. This guidance also includes criteria for surface water for PFOS applicable for aquatic life, which may be applicable at some sites. Drinking water sample results should be compared to the NYS maximum contaminant level (MCL) of 10 ng/l (ppt). Analysis to determine if PFOA and PFOS concentrations are attributable to the site should include a comparison between upgradient and downgradient levels, and the presence of soil source areas, as defined below.

If PFOA and/or PFOS are identified as contaminants of concern for a site, they should be assessed as part of the remedy selection process in accordance with Part 375 and DER-10.

Soil Sample Results

NYSDEC will delay adding soil cleanup objectives for PFOA and PFOS to 6 NYCRR Part 375-6 until the PFAS rural soil background study has been completed. Until SCOs are in effect, the following are to be used as guidance values:

Guidance Values for Anticipated Site Use	PFOA (ppb)	PFOS (ppb)
Unrestricted	0.66	0.88
Residential	6.6	8.8
Restricted Residential	33	44
Commercial	500	440
Industrial	600	440
Protection of Groundwater[2]	0.8	1.0

PFOA and PFOS results for soil are to be compared against the guidance values listed above. These guidance values are to be used in determining whether PFOA and PFOS are contaminants of concern for the site and for determining remedial action objectives and cleanup requirements. Site-specific remedial objectives for protection of groundwater can also be presented for evaluation by DEC. Development of site-specific remedial objectives for protection of groundwater will require analysis of additional soil parameters relating to leachability. These

[2] The Protection of Groundwater values are based on the above referenced ambient groundwater guidance values. Details on that calculation are available in the following document, prepared for the February 2022 proposed changes to Part 375 (https://www.dec.ny.gov/docs/remediation_hudson_pdf/part375techsupport.pdf). The movement of PFAS in the environment is being aggressively researched at this time; that research will eventually result in more accurate models for the behaviors of these chemicals. In the meantime, DEC has calculated the guidance value for the protection of groundwater using the same procedure used for all other chemicals, as described in Section 7.7 of the Technical Support Document (http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf).

additional analyses can include any or all the parameters listed above (soil pH, cation exchange capacity, etc.) and/or use of SPLP.

As the understanding of PFAS transport improves, DEC welcomes proposals for site-specific remedial objectives for protection of groundwater. DEC will expect that those may be dependent on additional factors including soil pH, aqueous pH, % organic carbon, % Sand/Silt/Clay, soil cations: K, Ca, Mg, Na, Fe, Al, cation exchange capacity, and anion exchange capacity. Site-specific remedial objectives should also consider the dilution attenuation factor (DAF). The NJDEP publication on DAF can be used as a reference: https://www.nj.gov/dep/srp/guidance/rs/daf.pdf.

Testing for Imported Soil

Testing for PFAS should be included any time a full TAL/TCL analyte list is required. Results for PFOA and PFOS should be compared to the applicable guidance values. If PFOA or PFOS is detected in any sample at or above the guidance values then the source of backfill should be rejected, unless a site-specific exemption is provided by DER based on SPLP testing, for example. If the concentrations of PFOA and PFOS in leachate are at or above the ambient water quality guidance values for groundwater, then the soil is not acceptable.

PFOA, PFOS and 1,4-dioxane are all considered semi-volatile compounds, so composite samples are appropriate for these compounds when sampling in accordance with DER-10, Table 5.4(e)10. Category B deliverables should be submitted for backfill samples, though a DUSR is not required.

Appendix A - Quality Assurance Project Plan (QAPP) Guidelines for PFAS

The following guidelines (general and PFAS-specific) can be used to assist with the development of a QAPP for projects within DER involving sampling and analysis of PFAS.

General Guidelines in Accordance with DER-10

- Document/work plan section title – Quality Assurance Project Plan
- Summarize project scope, goals, and objectives
- Provide project organization including names and resumes of the project manager, Quality Assurance Officer (QAO), field staff, and Data Validator
    - The QAO should not have another position on the project, such as project or task manager, that involves project productivity or profitability as a job performance criterion
- List the ELAP certified lab(s) to be used for analysis of samples
- Include a site map showing sample locations
- Provide detailed sampling procedures for each matrix
- Include Data Quality Usability Objectives
- List equipment decontamination procedures
- Include an "Analytical Methods/Quality Assurance Summary Table" specifying:
    - Matrix type
    - Number or frequency of samples to be collected per matrix
    - Number of field and trip blanks per matrix
    - Analytical parameters to be measured per matrix
    - Analytical methods to be used per matrix with minimum reporting limits
    - Number and type of matrix spike and matrix spike duplicate samples to be collected
    - Number and type of duplicate samples to be collected
    - Sample preservation to be used per analytical method and sample matrix
    - Sample container volume and type to be used per analytical method and sample matrix
    - Sample holding time to be used per analytical method and sample matrix
- Specify Category B laboratory data deliverables and preparation of a DUSR

Specific Guidelines for PFAS

- Include in the text that sampling for PFAS will take place
- Include in the text that PFAS will be analyzed by EPA Method 1633
- Include the list of PFAS compounds to be analyzed (*PFAS Analyte List*)
- Include the laboratory SOP for PFAS analysis
- List the minimum method-achievable Reporting Limits for PFAS
    - Reporting Limits should be less than or equal to:
        - Aqueous – 2 ng/L (ppt)
        - Solids – 0.5 µg/kg (ppb)
- Include the laboratory Method Detection Limits for the PFAS compounds to be analyzed
-
- Include detailed sampling procedures
    - Precautions to be taken
    - Pump and equipment types
    - Decontamination procedures
    - Approved materials only to be used
- Specify that regular ice only will be used for sample shipment
- Specify that equipment blanks should be collected at a minimum frequency of 1 per day per site for each matrix

Appendix B - Sampling Protocols for PFAS in Soils, Sediments and Solids

General

The objective of this protocol is to give general guidelines for the collection of soil, sediment and other solid samples for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Containers

Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633.

The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in to contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials including sample bottle cap liners with a PTFE layer.

A list of acceptable equipment is provided below, but other equipment may be considered appropriate based on sampling conditions.

- stainless steel spoon
- stainless steel bowl
- steel hand auger or shovel without any coatings

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Sampling is often conducted in areas where a vegetative turf has been established. In these cases, a pre-cleaned trowel or shovel should be used to carefully remove the turf so that it may be replaced at the conclusion of sampling. Surface soil samples (e.g. 0 to 6 inches below surface) should then be collected using a pre-cleaned, stainless steel spoon. Shallow subsurface soil samples (e.g. 6 to ~36 inches below surface) may be collected by digging a hole using a pre-cleaned hand auger or shovel. When the desired subsurface depth is reached, a pre-cleaned hand auger or spoon shall be used to obtain the sample.

When the sample is obtained, it should be deposited into a stainless steel bowl for mixing prior to filling the sample containers. The soil should be placed directly into the bowl and mixed thoroughly by rolling the material into the middle until the material is homogenized. At this point the material within the bowl can be placed into the laboratory provided container.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- Request appropriate data deliverable (Category B) and an electronic data deliverable

Documentation

A soil log or sample log shall document the location of the sample/borehole, depth of the sample, sampling equipment, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate. Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appropriate rain gear (PVC, polyurethane, or rubber rain gear are acceptable), bug spray, and sunscreen should be used that does not contain PFAS. Well washed cotton coveralls may be used as an alternative to bug spray and/or sunscreen.

PPE that contains PFAS is acceptable when site conditions warrant additional protection for the samplers and no other materials can be used to be protective. Documentation of such use should be provided in the field notes.

Appendix C - Sampling Protocols for PFAS in Monitoring Wells

General

The objective of this protocol is to give general guidelines for the collection of groundwater samples for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Container

Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633.

The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include: stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials including plumbers tape and sample bottle cap liners with a PTFE layer.

A list of acceptable equipment is provided below, but other equipment may be considered appropriate based on sampling conditions.

- stainless steel inertia pump with HDPE tubing
- peristaltic pump equipped with HDPE tubing and silicone tubing
- stainless steel bailer with stainless steel ball
- bladder pump (identified as PFAS-free) with HDPE tubing

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Monitoring wells should be purged in accordance with the sampling procedure (standard/volume purge or low flow purge) identified in the site work plan, which will determine the appropriate time to collect the sample. If sampling using standard purge techniques, additional purging may be needed to reduce turbidity levels, so samples contain a limited amount of sediment within the sample containers. Sample containers that contain sediment may cause issues at the laboratory, which may result in elevated reporting limits and other issues during the sample preparation that can compromise data usability. Sampling personnel should don new nitrile gloves prior to sample collection due to the potential to contact PFAS containing items (not related to the sampling equipment) during the purging activities.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- Collect one equipment blank per day per site and minimum 1 equipment blank per 20 samples. The equipment blank shall test the new and decontaminated sampling equipment utilized to obtain a sample for residual PFAS contamination. This sample is obtained by using laboratory provided PFAS-free water and passing the water over or through the sampling device and into laboratory provided sample containers
- Additional equipment blank samples may be collected to assess other equipment that is utilized at the monitoring well
- Request appropriate data deliverable (Category B) and an electronic data deliverable

Documentation

A purge log shall document the location of the sample, sampling equipment, groundwater parameters, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate. Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appropriate rain gear (PVC, polyurethane, or rubber rain gear are acceptable), bug spray, and sunscreen should be used that does not contain PFAS. Well washed cotton coveralls may be used as an alternative to bug spray and/or sunscreen.

PPE that contains PFAS is acceptable when site conditions warrant additional protection for the samplers and no other materials can be used to be protective. Documentation of such use should be provided in the field notes.

Appendix D - Sampling Protocols for PFAS in Surface Water

General

The objective of this protocol is to give general guidelines for the collection of surface water samples for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Container

Samples collected using this protocol are intended to be analyzed for PFAS using EPA Method 1633.

The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include: stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials including sample bottle cap liners with a PTFE layer.

A list of acceptable equipment is provided below, but other equipment may be considered appropriate based on sampling conditions.

- stainless steel cup

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Where conditions permit, (e.g. creek or pond) sampling devices (e.g. stainless steel cup) should be rinsed with site medium to be sampled prior to collection of the sample. At this point the sample can be collected and poured into the sample container.

If site conditions permit, samples can be collected directly into the laboratory container.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- Collect one equipment blank per day per site and minimum 1 equipment blank per 20 samples. The equipment blank shall test the new and decontaminated sampling equipment utilized to obtain a sample for residual PFAS contamination. This sample is obtained by using laboratory provided PFAS-free water and passing the water over or through the sampling device and into laboratory provided sample containers
- Request appropriate data deliverable (Category B) and an electronic data deliverable

Documentation

A sample log shall document the location of the sample, sampling equipment, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate. Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appropriate rain gear (PVC, polyurethane, or rubber rain gear are acceptable), bug spray, and sunscreen should be used that does not contain PFAS. Well washed cotton coveralls may be used as an alternative to bug spray and/or sunscreen.

PPE that contains PFAS is acceptable when site conditions warrant additional protection for the samplers and no other materials can be used to be protective. Documentation of such use should be provided in the field notes.

Appendix E - Sampling Protocols for PFAS in Private Water Supply Wells

General

The objective of this protocol is to give general guidelines for the collection of water samples from private water supply wells (with a functioning pump) for PFAS analysis. The sampling procedure used should be consistent with Sampling Guidelines and Protocols – Technological Background and Quality Control/Quality Assurance for NYS DEC Spill Response Program – March 1991 (http://www.dec.ny.gov/docs/remediation_hudson_pdf/sgpsect5.pdf), with the following limitations.

Laboratory Analysis and Container

Drinking water samples collected using this protocol are intended to be analyzed for PFAS by EPA Method 537, 537.1, 533, or ISO Method 25101. The preferred material for containers is high density polyethylene (HDPE). Pre-cleaned sample containers, coolers, sample labels, and a chain of custody form will be provided by the laboratory.

Equipment

Acceptable materials for sampling include stainless steel, HDPE, PVC, silicone, acetate, and polypropylene. Additional materials may be acceptable if pre-approved by New York State Department of Environmental Conservation's Division of Environmental Remediation.

No sampling equipment components or sample containers should come in contact with aluminum foil, low density polyethylene, glass, or polytetrafluoroethylene (PTFE, Teflon™) materials (e.g. plumbers tape), including sample bottle cap liners with a PTFE layer.

Equipment Decontamination

Standard two step decontamination using detergent (Alconox is acceptable) and clean, PFAS-free water will be performed for sampling equipment. All sources of water used for equipment decontamination should be verified in advance to be PFAS-free through laboratory analysis or certification.

Sampling Techniques

Locate and assess the pressure tank and determine if any filter units are present within the building. Establish the sample location as close to the well pump as possible, which is typically the spigot at the pressure tank. Ensure sampling equipment is kept clean during sampling as access to the pressure tank spigot, which is likely located close to the ground, may be obstructed and may hinder sample collection.

Prior to sampling, a faucet downstream of the pressure tank (e.g., washroom sink) should be run until the well pump comes on and a decrease in water temperature is noted which indicates that the water is coming from the well. If the homeowner is amenable, staff should run the water longer to purge the well (15+ minutes) to provide a sample representative of the water in the formation rather than standing water in the well and piping system including the pressure tank. At this point a new pair of nitrile gloves should be donned and the sample can be collected from the sample point at the pressure tank.

Sample Identification and Logging

A label shall be attached to each sample container with a unique identification. Each sample shall be included on the chain of custody (COC).

Quality Assurance/Quality Control

- Immediately place samples in a cooler maintained at 4 ± 2º Celsius using ice
- Collect one field duplicate for every sample batch, minimum 1 duplicate per 20 samples. The duplicate shall consist of an additional sample at a given location
- Collect one matrix spike / matrix spike duplicate (MS/MSD) for every sample batch, minimum 1 MS/MSD per 20 samples. The MS/MSD shall consist of an additional two samples at a given location and identified on the COC
- If equipment was used, collect one equipment blank per day per site and a minimum 1 equipment blank per 20 samples. The equipment blank shall test the new and decontaminated sampling equipment utilized to obtain a sample for residual PFAS contamination. This sample is obtained by using laboratory provided PFAS-free water and passing the water over or through the sampling device and into laboratory provided sample containers.
- A field reagent blank (FRB) should be collected at a rate of one per 20 samples. The lab will provide a FRB bottle containing PFAS free water and one empty FRB bottle. In the field, pour the water from the one bottle into the empty FRB bottle and label appropriately.
- Request appropriate data deliverable (Category B) and an electronic data deliverable
- For sampling events where multiple private wells (homes or sites) are to be sampled per day, it is acceptable to collect QC samples at a rate of one per 20 across multiple sites or days.

Documentation

A sample log shall document the location of the private well, sample point location, owner contact information, sampling equipment, purge duration, duplicate sample, visual description of the material, and any other observations or notes determined to be appropriate and available (e.g. well construction, pump type and location, yield, installation date). Additionally, care should be performed to limit contact with PFAS containing materials (e.g. waterproof field books, food packaging) during the sampling process.

Personal Protection Equipment (PPE)

For most sampling Level D PPE is anticipated to be appropriate. The sampler should wear nitrile gloves while conducting field work and handling sample containers.

Field staff shall consider the clothing to be worn during sampling activities. Clothing that contains PTFE material (including GORE-TEX®) or that have been waterproofed with PFAS materials should be avoided. All clothing worn by sampling personnel should have been laundered multiple times.

Appendix F - Sampling Protocols for PFAS in Fish

This appendix contains a copy of the current SOP developed by the Division of Fish and Wildlife (DFW) entitled "General Fish Handling Procedures for Contaminant Analysis" (Ver. 8). This SOP should be followed when collecting fish for contaminant analysis. Note, however, that the Bureau of Ecosystem Health will not be supplying bags or tags. All supplies are the responsibility of the collector

Procedure Name: General Fish Handling Procedures for Contaminant Analysis

Number: FW-005

Purpose: This procedure describes data collection, fish processing and delivery of fish collected for contaminant monitoring. It contains the chain of custody and collection record forms that should be used for the collections.

Organization: Environmental Monitoring Section
Bureau of Ecosystem Health
Division of Fish and Wildlife (DFW)
New York State Department of Environmental Conservation (NYSDEC)
625 Broadway
Albany, New York 12233-4756

Version: 8

Previous Version Date: 21 March 2018

Summary of Changes to this Version: Updated bureau name to Bureau of Ecosystem Health. Added direction to list the names of all field crew on the collection record. Minor formatting changes on chain of custody and collection records.

Originator or Revised by: Wayne Richter, Jesse Becker

Date: 26 April 2019

Quality Assurance Officer and Approval Date: Jesse Becker, 26 April 2019

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

GENERAL FISH HANDLING PROCEDURES FOR CONTAMINANT ANALYSES

A. Original copies of all continuity of evidence (i.e., Chain of Custody) and collection record forms must accompany delivery of fish to the lab. A copy shall be directed to the Project Leader or as appropriate, Wayne Richter. All necessary forms will be supplied by the Bureau of Ecosystem Health. Because some samples may be used in legal cases, it is critical that each section is filled out completely. Each Chain of Custody form has three main sections:

   1. The top box is to be filled out **and signed** by the person responsible for the fish collection (e.g., crew leader, field biologist, researcher). This person is responsible for delivery of the samples to DEC facilities or personnel (e.g., regional office or biologist).

   2. The second section is to be filled out **and signed** by the person responsible for the collections while being stored at DEC, before delivery to the analytical lab. This may be the same person as in (1), but it is still required that they complete the section. Also important is the **range of identification numbers** (i.e., tag numbers) included in the sample batch.

   3. Finally, the bottom box is to record any transfers between DEC personnel and facilities. Each subsequent transfer should be **identified, signed, and dated**, until laboratory personnel take possession of the fish.

B. The following data are required on each **Fish Collection Record** form:

   1. Project and Site Name.

   2. DEC Region.

   3. All personnel (and affiliation) involved in the collection.

   4. Method of collection (gill net, hook and line, etc.)

   5. Preservation Method.

C. The following data are to be taken on each fish collected and recorded on the **Fish Collection Record** form:

   1. Tag number - Each specimen is to be individually jaw tagged at time of collection with a unique number. Make sure the tag is turned out so that the number can be read without opening the bag. Use tags in sequential order. For small fish or composite samples place the tag inside the bag with the samples. The Bureau of Ecosystem Health can supply the tags.

   2. Species identification (please be explicit enough to enable assigning genus and species). Group fish by species when processing.

   3. Date collected.

   4. Sample location (waterway and nearest prominent identifiable landmark).

   5. Total length (nearest mm or smallest sub-unit on measuring instrument) and weight (nearest g or

smallest sub-unit of weight on weighing instrument). Take all measures as soon as possible with calibrated, protected instruments (e.g. from wind and upsets) and prior to freezing.

6. Sex - fish may be cut enough to allow sexing or other internal investigation, but do not eviscerate. Make any incision on the right side of the belly flap or exactly down the midline so that a left-side fillet can be removed.

D. General data collection recommendations:

1. It is helpful to use an ID or tag number that will be unique. It is best to use metal striped bass or other uniquely numbered metal tags. If uniquely numbered tags are unavailable, values based on the region, water body and year are likely to be unique: for example, R7CAY11001 for Region 7, Cayuga Lake, 2011, fish 1. If the fish are just numbered 1 through 20, we have to give them new numbers for our database, making it more difficult to trace your fish to their analytical results and creating an additional possibility for errors.

2. Process and record fish of the same species sequentially. Recording mistakes are less likely when all fish from a species are processed together. Starting with the bigger fish species helps avoid missing an individual.

3. If using Bureau of Ecosystem Health supplied tags or other numbered tags, use tags in sequence so that fish are recorded with sequential Tag Numbers. This makes data entry and login at the lab and use of the data in the future easier and reduces keypunch errors.

4. Record length and weight as soon as possible after collection and before freezing. Other data are recorded in the field upon collection. An age determination of each fish is optional, but if done, it is recorded in the appropriate “Age” column.

5. For composite samples of small fish, record the number of fish in the composite in the Remarks column. Record the length and weight of each individual in a composite. All fish in a composite sample should be of the same species and members of a composite should be visually matched for size.

6. Please submit photocopies of topographic maps or good quality navigation charts indicating sampling locations. GPS coordinates can be entered in the Location column of the collection record form in addition to or instead for providing a map. These records are of immense help to us (and hopefully you) in providing documented location records which are not dependent on memory and/or the same collection crew. In addition, they may be helpful for contaminant source trackdown and remediation/control efforts of the Department.

7. When recording data on fish measurements, it will help to ensure correct data recording for the data recorder to call back the numbers to the person making the measurements.

E. Each fish is to be placed in its own individual plastic bag. For small fish to be analyzed as a composite, put all of the fish for one composite in the same bag but use a separate bag for each composite. It is important to individually bag the fish to avoid difficulties or cross contamination when processing the fish for chemical analysis. Be sure to include the fish’s tag number inside the bag, preferably attached to the fish with the tag number turned out so it can be read. Tie or otherwise secure the bag closed. **The Bureau of Ecosystem Health will supply the bags.** If necessary, food grade bags may be procured from a suitable vendor (e.g., grocery store). It is preferable to redundantly label each bag with a manila tag tied between the knot and the body of the bag. This tag should be labeled with the project name, collection location, tag number, collection date, and fish species. If scales are collected, the scale envelope should be labeled with

the same information.

F. Groups of fish, by species, are to be placed in one large plastic bag per sampling location. **The Bureau of Ecosystem Health will supply the larger bags.** Tie or otherwise secure the bag closed. Label the site bag with a manila tag tied between the knot and the body of the bag. The tag should contain: project, collection location, collection date, species and **tag number ranges**. Having this information on the manila tag enables lab staff to know what is in the bag without opening it.

G. Do not eviscerate, fillet or otherwise dissect the fish unless specifically asked to. If evisceration or dissection is specified, the fish must be cut along the exact midline or on the right side so that the left side fillet can be removed intact at the laboratory. If filleting is specified, the procedure for taking a standard fillet (SOP PREPLAB 4) must be followed, including removing scales.

H. Special procedures for PFAS: Unlike legacy contaminants such as PCBs, which are rarely found in day to day life, PFAS are widely used and frequently encountered. Practices that avoid sample contamination are therefore necessary. While no standard practices have been established for fish, procedures for water quality sampling can provide guidance. The following practices should be used for collections when fish are to be analyzed for PFAS:

No materials containing Teflon.
No Post-it notes.
No ice packs; only water ice or dry ice.
Any gloves worn must be powder free nitrile.
No Gore-Tex or similar materials (Gore-Tex is a PFC with PFOA used in its manufacture).
No stain repellent or waterproof treated clothing; these are likely to contain PFCs.
Avoid plastic materials, other than HDPE, including clipboards and waterproof notebooks.
Wash hands after handling any food containers or packages as these may contain PFCs.
Keep pre-wrapped food containers and wrappers isolated from fish handling.
Wear clothing washed at least six times since purchase.
Wear clothing washed without fabric softener.
Staff should avoid cosmetics, moisturizers, hand creams and similar products on the day of sampling as many of these products contain PFCs (Fujii et al. 2013). Sunscreen or insect repellent should not contain ingredients with “fluor” in their name. Apply any sunscreen or insect repellent well downwind from all materials. Hands must be washed after touching any of these products.

I. All fish must be kept at a temperature <45° F (<8° C) immediately following data processing. As soon as possible, freeze at -20° C ± 5° C. Due to occasional freezer failures, daily freezer temperature logs are required. The freezer should be locked or otherwise secured to maintain chain of custody.

J. In most cases, samples should be delivered to the Analytical Services Unit at the Hale Creek field station. Coordinate delivery with field station staff and send copies of the collection records, continuity of evidence forms and freezer temperature logs to the field station. For samples to be analyzed elsewhere, non-routine collections or other questions, contact Wayne Richter, Bureau of Ecosystem Health, NYSDEC, 625 Broadway, Albany, New York 12233-4756, 518-402-8974, or the project leader about sample transfer. Samples will then be directed to the analytical facility and personnel noted on specific project descriptions.

K. A recommended equipment list is at the end of this document.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF FISH AND WILDLIFE
FISH COLLECTION RECORD

Project and Site Name _____ DEC Region _____

Collections made by (include all crew) _____

Sampling Method: □Electrofishing □Gill netting □Trap netting □Trawling □Seining □Angling □Other _____

Preservation Method: □Freezing □Other _____ Notes (SWFDB survey number): _____

FOR LAB USE ONLY- LAB ENTRY NO.	COLLECTION OR TAG NO.	SPECIES	DATE TAKEN	LOCATION	AGE	SEX &/OR REPROD. CONDIT	LENGTH ( )	WEIGHT ( )	REMARKS

richter: revised 2011, 5/7/15, 10/4/16, 3/20/17; becker: 3/23/17, 4/26/19

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
CHAIN OF CUSTODY

I, _____, of _____ collected the
(Print Name) (Print Business Address)

following on _____, 20____ from _____
(Date) (Water Body)

in the vicinity of _____
(Landmark, Village, Road, etc.)

Town of _____, in _____ County.

Item(s) _____

_____

Said sample(s) were in my possession and handled according to standard procedures provided to me prior to collection. The sample(s) were placed in the custody of a representative of the New York State Department of Environmental Conservation on _____, 20_____.

_____ _____
Signature Date

I, _____, received the above mentioned sample(s) on the date specified and assigned identification number(s) _____ to the sample(s). I have recorded pertinent data for the sample(s) on the attached collection records. The sample(s) remained in my custody until subsequently transferred, prepared or shipped at times and on dates as attested to below.

_____ _____
Signature Date

SECOND RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
THIRD RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
FOURTH RECIPIENT (Print Name)	TIME & DATE	PURPOSE OF TRANSFER
SIGNATURE	UNIT	
RECEIVED IN LABORATORY BY (Print Name)	TIME & DATE	REMARKS
SIGNATURE	UNIT	
LOGGED IN BY (Print Name)	TIME & DATE	ACCESSION NUMBERS
SIGNATURE	UNIT	

richter: revised 21 April 2014; becker: 23 March 2017, 26 April, 2019

NOTICE OF WARRANTY

By signature to the chain of custody (reverse), the signatory warrants that the information provided is truthful and accurate to the best of his/her ability. The signatory affirms that he/she is willing to testify to those facts provided and the circumstances surrounding the same. Nothing in this warranty or chain of custody negates responsibility nor liability of the signatories for the truthfulness and accuracy of the statements provided.

HANDLING INSTRUCTIONS

On day of collection, collector(s) name(s), address(es), date, geographic location of capture (attach a copy of topographic map or navigation chart), species, number kept of each species, and description of capture vicinity (proper noun, if possible) along with name of Town and County must be indicated on reverse.

Retain organisms in manila tagged plastic bags to avoid mixing capture locations. Note appropriate information on each bag tag.

Keep samples as cool as possible. Put on ice if fish cannot be frozen within 12 hours. If fish are held more than 24 hours without freezing, they will not be retained or analyzed.

Initial recipient (either DEC or designated agent) of samples from collector(s) is responsible for obtaining and recording information on the collection record forms which will accompany the chain of custody. This person will seal the container using packing tape and writing his signature, the time and the date across the tape onto the container with indelible marker. Any time a seal is broken, for whatever purpose, the incident must be recorded on the Chain of Custody (reason, time, and date) in the purpose of transfer block. Container then is resealed using new tape and rewriting signature, with time and date.

EQUIPMENT LIST

Scale or balance of appropriate capacity for the fish to be collected.

Fish measuring board.

Plastic bags of an appropriate size for the fish to be collected and for site bags.

Individually numbered metal tags for fish.

Manila tags to label bags.

Small envelops, approximately 2” x 3.5”, if fish scales are to be collected.

Knife for removing scales.

Chain of custody and fish collection forms.

Clipboard.

Pens or markers.

Paper towels.

Dish soap and brush.

Bucket.

Cooler.

Ice.

Duct tape.

Appendix G – PFAS Analyte List

Group	Chemical Name	Abbreviation	CAS Number
Perfluoroalkyl sulfonic acids	Perfluorobutanesulfonic acid	PFBS	375-73-5
	Perfluoropentanesulfonic acid	PFPeS	2706-91-4
	Perfluorohexanesulfonic acid	PFHxS	355-46-4
	Perfluoroheptanesulfonic acid	PFHpS	375-92-8
	Perfluorooctanesulfonic acid	PFOS	1763-23-1
	Perfluorononanesulfonic acid	PFNS	68259-12-1
	Perfluorodecanesulfonic acid	PFDS	335-77-3
	Perfluorododecanesulfonic acid	PFDoS	79780-39-5
Perfluoroalkyl carboxylic acids	Perfluorobutanoic acid	PFBA	375-22-4
	Perfluoropentanoic acid	PFPeA	2706-90-3
	Perfluorohexanoic acid	PFHxA	307-24-4
	Perfluoroheptanoic acid	PFHpA	375-85-9
	Perfluorooctanoic acid	PFOA	335-67-1
	Perfluorononanoic acid	PFNA	375-95-1
	Perfluorodecanoic acid	PFDA	335-76-2
	Perfluoroundecanoic acid	PFUnA	2058-94-8
	Perfluorododecanoic acid	PFDoA	307-55-1
	Perfluorotridecanoic acid	PFTrDA	72629-94-8
	Perfluorotetradecanoic acid	PFTeDA	376-06-7
Per- and Polyfluoroether carboxylic acids	Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6
	4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
	Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
	Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5
	Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
Fluorotelomer sulfonic acids	4:2 Fluorotelomer sulfonic acid	4:2-FTS	757124-72-4
	6:2 Fluorotelomer sulfonic acid	6:2-FTS	27619-97-2
	8:2 Fluorotelomer sulfonic acid	8:2-FTS	39108-34-4
Fluorotelomer carboxylic acids	3:3 Fluorotelomer carboxylic acid	3:3 FTCA	356-02-5
	5:3 Fluorotelomer carboxylic acid	5:3 FTCA	914637-49-3
	7:3 Fluorotelomer carboxylic acid	7:3 FTCA	812-70-4
Perfluorooctane sulfonamides	Perfluorooctane sulfonamide	PFOSA	754-91-6
	N-methylperfluorooctane sulfonamide	NMeFOSA	31506-32-8
	N-ethylperfluorooctane sulfonamide	NEtFOSA	4151-50-2
Perfluorooctane sulfonamidoacetic acids	N-methylperfluorooctane sulfonamidoacetic acid	N-MeFOSAA	2355-31-9
	N-ethylperfluorooctane sulfonamidoacetic acid	N-EtFOSAA	2991-50-6
Perfluorooctane sulfonamide ethanols	N-methylperfluorooctane sulfonamidoethanol	MeFOSE	24448-09-7
	N-ethylperfluorooctane sulfonamidoethanol	EtFOSE	1691-99-2

Group	Chemical Name	Abbreviation	CAS Number
Ether sulfonic acids	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (F-53B Major)	9Cl-PF3ONS	756426-58-1
	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (F-53B Minor)	11Cl-PF3OUdS	763051-92-9
	Perfluoro(2-ethoxyethane) sulfonic acid	PFEESA	113507-82-7

Appendix H - Data Review Guidelines for Analysis of PFAS in Non-Potable Water and Solids

General

These guidelines are intended to be used for the validation of PFAS using EPA Method 1633 for projects within the Division of Environmental Remediation (DER). Data reviewers should understand the methodology and techniques utilized in the analysis. Consultation with the end user of the data may be necessary to assist in determining data usability based on the data quality objectives in the Quality Assurance Project Plan. A familiarity with the laboratory's Standard Operating Procedure may also be needed to fully evaluate the data. If you have any questions, please contact DER's Quality Assurance Officer, Dana Barbarossa, at dana.barbarossa@dec.ny.gov.

Preservation and Holding Time

Samples should be preserved with ice to a temperature of less than 6°C upon arrival at the lab. The holding time is 28 days to extraction for aqueous and solid samples. The time from extraction to analysis for aqueous samples is 28 days and 40 days for solids.

Temperature greatly exceeds 6ºC upon arrival at the lab*	Use professional judgement to qualify detects and non-detects as estimated or rejected
Holding time exceeding 28 days to extraction	Use professional judgement to qualify detects and non-detects as estimated or rejected if holding time is grossly exceeded

*Samples that are delivered to the lab immediately after sampling may not meet the thermal preservation guidelines. Samples are considered acceptable if they arrive on ice or an attempt to chill the samples is observed.

Initial Calibration

The initial calibration should contain a minimum of six standards for linear fit and six standards for a quadratic fit. The relative standard deviation (RSD) for a quadratic fit calibration should be less than 20%.

The low-level calibration standard should be within 50% - 150% of the true value, and the mid-level calibration standard within 70% - 130% of the true value.

%RSD >20%	J flag detects and UJ non detects

Continuing Calibration Verification

Continuing calibration verification (CCV) checks should be analyzed at a frequency of one per ten field samples. If CCV recovery is very low, where detection of the analyte could be in question, ensure a low level CCV was analyzed and use to determine data quality.

CCV recovery <70 or >130%	J flag results

Blanks

There should be no detections in the method blanks above the reporting limits. Equipment blanks, field blanks, rinse blanks etc. should be evaluated in the same manner as method blanks. Use the most contaminated blank to evaluate the sample results.

Blank Result	Sample Result	Qualification
Any detection	<Reporting limit	Qualify as ND at reporting limit
Any detection	>Reporting Limit and >10x the blank result	No qualification
>Reporting limit	>Reporting limit and <10x blank result	J+ biased high

Field Duplicates

A blind field duplicate should be collected at rate of one per twenty samples. The relative percent difference (RPD) should be less than 30% for analyte concentrations greater than two times the reporting limit. Use the higher result for final reporting.

RPD >30%	Apply J qualifier to parent sample

Lab Control Spike

Lab control spikes should be analyzed with each extraction batch or one for every twenty samples. In the absence of lab derived criteria, use 70% - 130% recovery criteria to evaluate the data.

Recovery <70% or >130% (lab derived criteria can also be used)	Apply J qualifier to detects and UJ qualifier to non detects

Matrix Spike/Matrix Spike Duplicate

One matrix spike and matrix spike duplicate should be collected at a rate of one per twenty samples. Use professional judgement to reject results based on out of control MS/MSD recoveries.

Recovery <70% or >130% (lab derived criteria can also be used)	Apply J qualifier to detects and UJ qualifier to non detects of parent sample only
RPD >30%	Apply J qualifier to detects and UJ qualifier to non detects of parent sample only

Extracted Internal Standards (Isotope Dilution Analytes)

Problematic analytes (e.g. PFBA, PFPeA, fluorotelomer sulfonates) can have wider recoveries without qualification. Qualify corresponding native compounds with a J flag if outside of the range.

Recovery <50% or >150%	Apply J qualifier
Recovery <25% or >150% for poor responding analytes	Apply J qualifier
Isotope Dilution Analyte (IDA) Recovery <10%	Reject results

Signal to Noise Ratio

The signal to noise ratio for the quantifier ion should be at least 3:1. If the ratio is less than 3:1, the peak is discernable from the baseline noise and symmetrical, the result can be reported. If the peak appears to be baseline noise and/or the shape is irregular, qualify the result as tentatively identified.

Reporting Limits

If project-specific reporting limits were not met, please indicate that in the report along with the reason (e.g. over dilution, dilution for non-target analytes, high sediment in aqueous samples).

Peak Integrations

Target analyte peaks should be integrated properly and consistently when compared to standards. Ensure branched isomer peaks are included for PFAS where standards are available. Inconsistencies should be brought to the attention of the laboratory or identified in the data review summary report.

APPENDIX B

Site Specific Health and Safety Plan

Site-specific Health and Safety Plan (HASP)

213 Meadow Street
Brooklyn, New York 11237

MTA Facilities Project Site #C224422

October 12, 2026

Prepared for:

Go Quay, LLC
c/o Gotham Organization, Inc.
111 Fifth Avenue, 9th Floor
Brooklyn, New York 10003

Prepared by:

Roux Environmental Engineering and Geology, D.P.C.
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Islandia, New York 11749

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Table of Contents

Site-Specific Emergency Information 1
Emergency Phone Numbers 1

1. Introduction 4
1.1 Roles and Responsibilities 4

2. Background 7
2.1 Site Description 7
2.2 Site History 7
2.3 Known and Potential Releases of Hazardous Substances at the Site 8

3. Scope of Work 9

4. Site Control 10
4.1 Site Map 10
4.2 Site Access 10
4.3 Buddy System 10
4.4 Site Communications 10
4.5 Site Work Zones 11

5. Job Hazard Evaluation 13
5.1 Hazard Communication and Overall Site Information Program 14
5.2 Noise 14
5.3 Slip, Trip, and Fall Hazards 14
5.4 Biological Hazards 14

6. Emergency Response Plan 15
6.1 Emergency Response 15
6.2 Emergency Alerting and Evacuation 15
6.3 Emergency Medical Treatment and First Aid 15

7. Environmental Conditions and Response 17
7.1 Adverse Weather Conditions 17
7.2 Electrical Storm Guidelines 17
7.3 Environmental Stressors, Heat Stress, Heat Exhaustion, and Heat Stroke 17
7.3.1 Heat Stress 18
7.3.2 Heat Cramps 18
7.3.3 Heat Exhaustion 19
7.3.4 Heat Stroke 19
7.4 Cold Stress 19

8. Safety Procedures 21
8.1 Training 21
8.2 Site-Specific Safety Briefings for Visitors 21
8.3 HASP Information and Site-Specific Briefings for Workers 21
8.4 Medical Surveillance 22
8.4.1 Site Medical Surveillance Program 22

Table of Contents (Continued)

8.4.2 Medical Recordkeeping Procedures 22
8.4.3 Program Review 23
8.5 Personnel Protection 23
8.5.1 Hearing Conservation 24
8.6 Monitoring 24
8.6.1 Action Levels for Air Monitoring 24
8.6.2 Explosive Hazard 25
8.6.3 Air Monitoring Equipment and Calibration 25
8.7 Tailgate Safety Meetings 26
8.8 Spill Containment 26
8.8.1 Initial Spill Notification and Response 26
8.8.2 Spill Evaluation and Response 26
8.9 Decontamination 26
8.9.1 Decontamination Procedures for Personnel and PPE 26
8.9.2 Decontamination Procedures for Equipment 27
8.9.3 Monitoring the Effectiveness of Decontamination Procedures 27
8.10 Confined Space Entry 28
8.11 Client and Site-Specific 28
8.12 Unusual or Significant Risks 28
8.13 Activity-Specific Hazards 29
8.13.1 Electrical and Other Utility Assessment and Accommodations 29
8.13.2 Subsurface Work 29
8.13.2.1 Excavations and Trenching 29
8.13.3 Heavy Equipment 31
8.14 Traffic Control 31
8.15 Sanitation 31
9. Field Team Review 32
10. Approvals 33

Tables

1. Toxicological Properties of Hazardous Substances Present at the Site

Figures

1. Site Location Map
2. Site Plan with Emergency Muster Area

Table of Contents (Continued)

Appendices

A. Job Safety Analysis (JSA) Forms
B. SDSs for Chemicals Used
C. Heat Illness Prevention Program
D. Personal Protective Equipment (PPE) Management Program
E. Subsurface Utility Clearance Management Program
F. Heavy Equipment Exclusion Zone Management Program
G. Resumes of Key Personnel

Site-Specific Emergency Information

Emergency Phone Numbers

Most emergency services can be obtained by calling 911. Where 911 service is not available, use the telephone numbers provided in the below table. The following is a master emergency phone list for use by the project management personnel. A more condensed version of the emergency numbers listed below will be posted throughout project work areas. Emergencies encountered on the site will be responded to by a combination of off-site emergency services and on-site personnel.

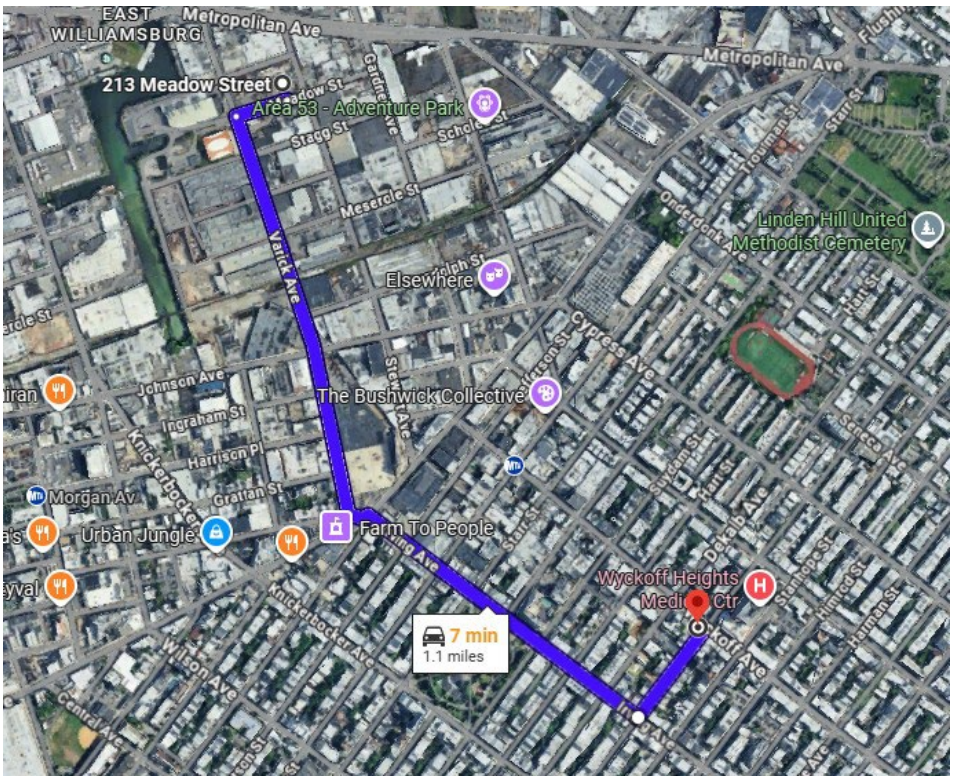
Emergency Contact Information			
Site Personnel			
Title	**Contact**		**Telephone**
Operations Manager (OM)	Jeffrey Wills		(516) 637-0213
Project Principal (PP)	Jessica Taylor		(631) 766-0607
Project Manager (PM)	Levi Curnutte		(727) 743-0304
Site Supervisor (SS)	TDB		TDB
Site Health and Site Safety Officer (SHSO)	TBD		TBD
Office Health and Safety Manager (OHSM)	Nevin Pahlad		(347) 885-6930
Corporate Health and Safety Director (CHSD)	Brian Hobbs, CIH, CSP		(631) 807-0193
WorkCare, Inc.	Occupational Health Care Management Provider		(888) 449-7787
Client Emergency Contact	Simeon Maleh		(646) 937-1655
Outside Assistance			
Agency	**Contact**	**Telephone**	**Address/Location**
Ambulance/emergency medical services (EMS)	Wyckoff Heights Medical Center Emergency Room	(718) 963-7391	346 Stanhope St Brooklyn, NY 11237
Police	New York City Police Department 83rd Precinct	(718) 574-1605	480 Knickerbocker Ave Brooklyn, NY 11237
Fire	FDNY Engine 237	(805) 458-1207	43 Morgan Ave Brooklyn, NY 11237
Site Address	213 Meadow Street, Brooklyn, New York		

Route to Hospital

Wyckoff Heights Medical Center

374 Stockholm St, Brooklyn, NY 11237

- Head towards Varick Ave
- Turn left onto Varick Ave
- Turn left onto Irving Ave
- Turn left onto Stockholm St
- Destination will be on the left

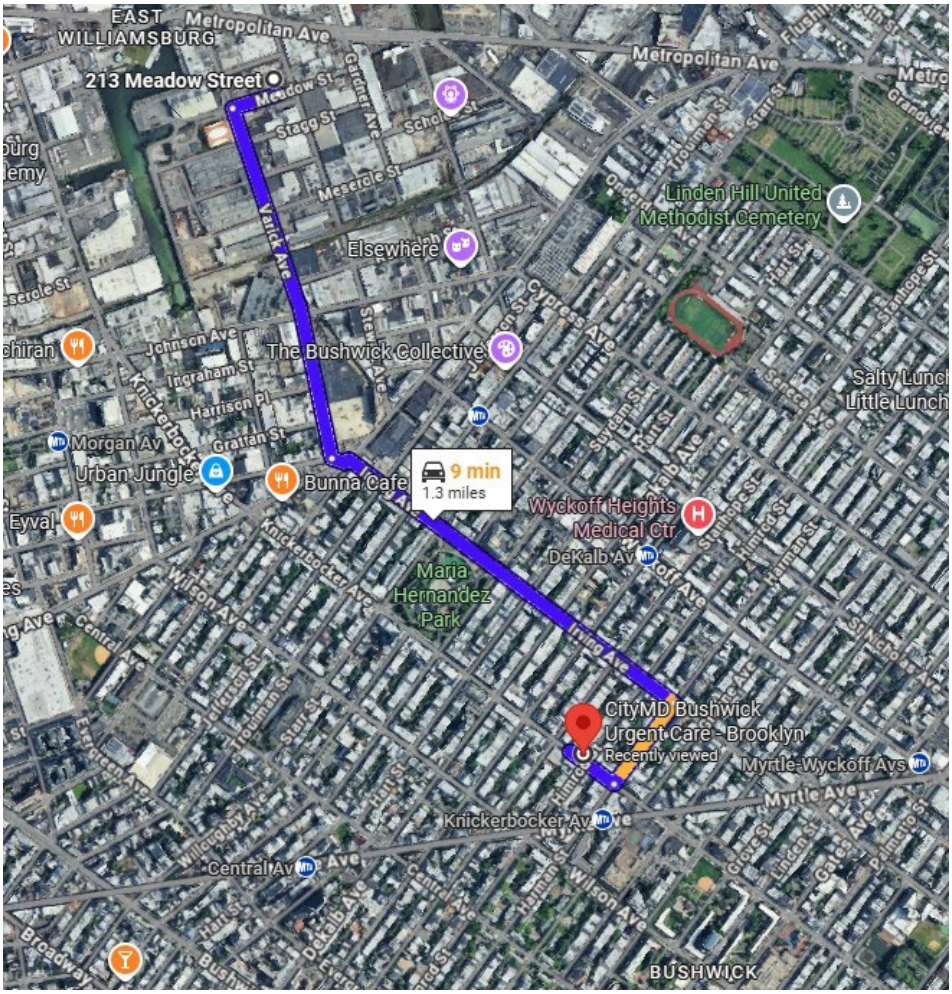


Route to Urgent Care Facility

CityMD Bushwick Urgent Care

399 Knickerbocker Ave, Brooklyn, NY 11237

- Turn left towards Varick Ave
- Turn left onto Irving Ave
- Turn right onto Harman St
- Turn right at the 1st cross street onto Knickerbocker Ave
- Destination will be on the right



1. Introduction

This Site-specific Health and Safety Plan (HASP) has been prepared by Roux Environmental Engineering and Geology, D.P.C. (Roux) for use during the Remedial Investigation, soil waste characterization sampling, excavation, and construction oversight activities being performed by Roux at the on behalf of GO Quay, LLC (Go Quay), located at 213 Meadow Street, Brooklyn, New York (Site; **Figure 1**). Go Quay entered into a Brownfield Cleanup Agreement (BCA), Index No. C224433-10-2025, with the New York State Department of Environmental Conservation (NYSDEC) as a Volunteer on March 22, 2026. This HASP was prepared in general accordance with the requirements of the Occupational Safety and Health Administration (OSHA) standards promulgated at 29 CFR 1910.120 and 29 CFR 1926.65, both commonly referred to as the Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard. In accordance with the HAZWOPER Standard, this Site-specific HASP was prepared to address the safety and health hazards associated with the Remedial Investigation, soil waste characterization sampling, excavation, and construction oversight activities being performed at the Site by Roux and to provide requirements and procedures for the protection of Roux employees, subcontractor personnel, government oversight personnel, Site personnel, and the general public. It also addresses client- and Site-specific requirements for health and safety. Additionally, subcontractors may be required to submit their own HASP as it relates to their specific work activities and will be kept onsite during such work.

Implementation of this HASP is the joint responsibility of the Project Manager (PM), the Site Health and Safety Officer (SHSO), and all field staff, with assistance from the Project Principal (PP), Office Health and Safety Manager (OHSM), and Corporate Health and Safety Director (CHSD). The PM for this project is Levi Curnutte. The Site Supervisor (SS) is TBD and Site Health and Safety Officer (SHSO) is TDB.

This HASP will be introduced to, reviewed, and signed off on by all Roux personnel through a formal training session prior to commencing work. A copy of the HASP will be kept at the Site at all times. The Roux SHSO or PM will be responsible for posting any changes, amendments, memos, etc. to the HASP. Any revisions to this HASP will be signed by appropriate personnel, which can include Roux's PP, CHSD, and SS. Any changes will be announced to all workers at the next safety meeting.

1.1 Roles and Responsibilities

Overall Roles and Responsibilities (R&Rs) of Roux personnel are provided in Roux's Policies and Procedures Manual. Only those R&Rs specific to HASP requirements are listed below.

Project Manager (PM)

The PM has responsibility and authority to direct all work operations. The PM coordinates safety and health functions with the Site Health and Safety Officer (SHSO), has the authority to oversee and monitor the performance of the SHSO, and bears ultimate responsibility for the proper implementation of this HASP. The specific duties of the PM are:

- Preparing and coordinating the Site work plan;
- Providing Site supervisor(s) with work assignments and overseeing their performance; Coordinating safety and health efforts with the SSHO;
- Ensuring effective emergency response through coordination with the Emergency Response Coordinator (ERC); and
- Serving as primary Site liaison with public agencies and officials and Site contractors.

Site Health and Safety Officer (SHSO)

The SHSO has the full responsibility and authority to develop and implement this HASP and to verify compliance. The SHSO reports to the Project Manager. The SHSO is on Site or readily accessible to the Site during all work operations and has the authority to halt Site work if unsafe conditions are detected. The specific responsibilities of the SHSO include:

- Managing the safety and health functions on this Site;
- Serving as the Site's point of contact for safety and health matters;
- Ensuring Site monitoring, worker training, and effective selection and use of PPE;
- Assessing Site conditions for unsafe acts and conditions and providing corrective action;
- Assisting the preparation and review of this HASP;
- Maintaining effective safety and health records as described in this HASP; and
- Coordinating with the SS and others as necessary for safety and health efforts.

Site Supervisor (SS)

The Site Supervisor (SS) is responsible for field operations and reports to the Project Manager (PM). The SS ensures the implementation of the HASP requirements and procedures in the field. The specific responsibilities of the Site Supervisor include:

- Executing the work plan and schedule as detailed by the PM;
- Coordination with the SHSO on safety and health; and
- Ensuring Site work compliance with the requirements of this HASP.

Employees

All Roux employees are responsible for reading and following all provisions of the Corporate Health and Safety Manual, including this HASP. Employees report to the SS at the project Site. Each employee is also responsible for the following:

- Wearing all appropriate PPE as outlined within this HASP;
- Attending all safety meetings;
- Inspecting tools and equipment prior to use, and taking any defective tools or equipment out of service;
- Appropriately documenting field events as they occur within a logbook or equivalent;
- Properly operating machinery and/or equipment only if trained to do so;
- Stopping work operations if unsafe conditions exist;
- Identifying and mitigating hazards when observed;
- Reporting all incidents and near misses to the Roux SHSO and SS immediately; and
- Knowing where emergency equipment is located (e.g., first aid kit, fire extinguisher).

Subcontractors and Visitors

Subcontractors and visitors are responsible for complying with the same health and safety requirements. It is the responsibility of all to make sure subcontractors and visitors comply and uphold the HASP. Subcontractors and visitors have the following additional responsibilities:

- Designating a qualified safety representative for the project that can make the necessary changes in work practices, as necessary;
- Attending all safety meetings while participating in Roux Site work activities;
- Reporting all incidents and near misses to Roux SHSO and SS immediately;
- Conducting initial and periodic equipment inspections in accordance with manufacturer and regulatory guidelines; and
- Providing copies of all Safety Data Sheets (SDS) to Roux SHSO for materials brought to the Site.

2. Background

Relevant background information is provided below, including a general description of the Site; a brief review of the Site's history with respect to hazardous material use, handling, and/or storage; and a review of known and potential releases of hazardous substances at the Site.

2.1 Site Description

Property Location	
Property Address:	213 Meadow Street
Property Town, County, State:	Brooklyn, Kings County, New York
Property Tax Identification:	Block 2951; Lot 1 (formerly Lots 1, 5, and 45)
Property Topographic Quadrangle:	USGS-Brooklyn, New York
Nearest Intersection:	Ten Eyck Street and Varick Street to the northwest, Stewart Avenue and Meadow Street to the southeast, and Varick Avenue and Meadow Street to the southeast.
Site Description:	The Site encompasses an area of 1.29-acres and is paved with concrete and contains a one-story structure located on the eastern portion of the Site. The Site is occupied by Castle Sanitation for truck storage and repairs, a demolition business by Titan Industrial Services and Roma Scaffolding for scaffolding storage.

Property Information	
Property Acreage:	1.29 acres
Property Shape:	L-shaped
Improvements:	Small one-story structure at the southeast corner.

2.2 Site History

According to the previous environmental investigations, the Site was operated for oil truck parking, junk yards, and auto wrecking on the western portion of the Site as of 1965. In the early 1980s, the east side of former Lot 45 was used for truck parking, a repair shop, and storage and the west side of former Lot 45 was previously a temporary C&D transfer station from approximately 1985 until it was shut down around 1995. The current use of the Site is for truck storage and repairs and the Site's property listings in the City Directory Abstract consist of auto wrecking and demolition and salvage companies. Former Lot 1 was an auto wrecking junk yard and is now used for scaffolding storage. Former Lot 5 was previously known to be vacant and is now used for scaffolding storage.

2.3 Known and Potential Releases of Hazardous Substances at the Site

According to a Phase II Environmental Site Investigation (ESI) Report by Langan, a field investigation was performed at the Site in February 2022 and consisted of soil, groundwater, and soil vapor sampling. Results of the Phase II ESI identified semivolatile organic compounds (SVOCs) and metals in soil at concentrations above Industrial Use Soil Cleanup Objectives (IUSCOs) at intervals from 2 to 8 feet below land surface (ft bls). IUSCOs are the applicable regulatory standards for the planned Site redevelopment, which includes vehicle storage, maintenance, and repair with limited office space. The Phase II ESI also identified concentrations of volatile organic compounds (VOCs), SVOCs, and metals in groundwater in exceedance of Ambient Water Quality Standards and Guidance Values (AWQSGVs), and VOCs (cyclohexane and hexane) in soil vapor at concentrations above the lowest Sub-Slab Vapor Concentration on the New York State Department of Health (NYSDOH) Matrix

3. Scope of Work

This HASP will cover several tasks related to assisting GO Quay, LLC with several Brownfields Cleanup Program (BCP)-related and construction tasks:

- Installation of soil borings, monitoring wells and soil vapor sampling points via a direct-push method Geoprobe® drill rig and sampling;
- *In-situ* soil waste characterization sampling;
- Excavation and soil disposal oversight during remedial construction activities;
- Implementation of the Community Air Monitoring Plan (CAMP);
- Endpoint soil sampling; and
- General oversight of construction activities, including, but not limited to, vapor barrier/waterproofing application, sub-slab depressurization system (SSDS) installation and other remedial measures that have not been decided (e.g., groundwater injections, etc.)

If there are any changes with the scope a revision of the HASP will be required to address any new hazards.

4. Site Control

This Site control program is designed to reduce the spread of hazardous substances from contaminated areas to clean areas, to identify and isolate contaminated areas of the Site, to facilitate emergency evacuation and medical care, to prevent unauthorized entry to the Site, and to deter vandalism and theft.

4.1 Site Map

A map of this Site, showing Site boundaries, designated work zones, and points of entry and exit is provided in Figure 2.

4.2 Site Access

Access to the work areas at the Site is restricted to reduce the potential for exposure to its safety and health hazards. During hours of Site operation, Site entry and exit are authorized only at the points identified in Figure 2. Entry and exit at these points are controlled by the following: construction gates. When the Site is not operating, access to the Site is controlled by the following: locked construction gates.

4.3 Buddy System

This section is not applicable for all components of the SOW described in Section 3. Some Site inspections, sampling and oversight are completed by a single Roux employee. However, when completing these tasks, the single Roux employee is accompanied either by Roux subcontractors or the Site caretaker/other representatives from GO Quay. Any time Roux is on-site, GO Quay, LLC is made aware and communications with GO Quay and the Roux PM is maintained via cellular phone.

While working in the Exclusion Zone, Site workers use the buddy system. The buddy system means that personnel work in pairs and stay in close visual contact to be able to observe one another and summon rapid assistance in case of an emergency. The responsibilities of workers using the buddy system include:

- Remaining in close visual contact with partner;
- Providing partner with assistance as needed or requested;
- Observing partner for signs of heat stress, chemical overexposure or other difficulties;
- Periodically checking the integrity of partner's PPE; and
- Notifying the SS or other Site personnel if emergency assistance is needed.

4.4 Site Communications

The following communication equipment is used to support on-site communication: cellphones and visual hand signals.

As applicable, hand signals will be used according to the following:

Hand Signals

SIGNAL	MEANING
Hand gripping throat	Out of air; I cannot breathe

Hand Signals

SIGNAL	MEANING
Grip partner's wrist	Leave area immediately
Hands on top of head	Need assistance
Thumbs up	I am all right; okay
Thumbs down	No; negative

A current list of emergency contact numbers is included in the Site-Specific Emergency Information at the beginning of this HASP

4.5 Site Work Zones

This Site is divided into three (3) major zones, described below. These zones are characterized by the likely presence or absence of biological, chemical, or physical hazards and the activities performed within them. Zone boundaries are clearly marked at all times and the flow of personnel among the zones is controlled. The Site is monitored for changing conditions that may warrant adjustment of zone boundaries. Zone boundaries are adjusted as necessary to protect personnel and clean areas. Whenever boundaries are adjusted, zone markings are also changed and workers are immediately notified of the change.

Exclusion Zone

The area where contamination exists is the Exclusion Zone (EZ). All areas where excavation and handling of contaminated materials take place are considered part of the EZ. This zone will be clearly delineated by chain link fencing, caution tape, cones or other effective barriers, as necessary. Safety tape may be used as a secondary delineation within the EZ. The zone delineation markings may be opened in areas for varying lengths of time to accommodate equipment operation or specific construction activities. The SHSO may establish more than one EZ where different levels of protection may be employed or where different hazards exist. Personnel are not allowed in the EZ without:

- A buddy (co-worker);
- Required minimum level PPE;
- Medical authorization;
- Training certification; and
- Requirement to be in the zone.

Contamination Reduction Zone

A Contamination Reduction Zone (CRZ) is established between the exclusion zone and the support zone. The CRZ contains the Contamination Reduction Corridor (CRC) and provides an area for decontamination of personnel and equipment. The CRZ will be used for general Site entry and egress in addition to access for heavy equipment and emergency support services. Personnel are not allowed in the CRZ without:

- A buddy (co-worker);
- Appropriate PPE;
- Medical authorization;

- Training certification; and
- Requirement to be in the zone.

Support Zone

The Support Zone (SZ) is an uncontaminated area that will be the field support area for the Site operations. The SZ will contain the if required, temporary project trailers and provides for field team communications and staging for emergency response. Appropriate sanitary facilities and safety equipment will be located in this zone. Potentially contaminated personnel or materials are not allowed in this zone. The only exception will be appropriately packaged/decontaminated and labeled samples.

5. Job Hazard Evaluation

Roux's work at the Site is expected to entail a variety of physical, chemical, and biological hazards, all of which must be sufficiently managed to allow the work to be performed safely. Some of the hazards are Site-specific (i.e., they are associated with the nature, physical characteristics, and/or routine operation of the Site itself), while others are activity-specific (i.e., they are associated with [or arise from] the particular activity being performed). The various hazards can be grouped into the following categories:

- **Caught/Crushed** – the potential to become caught in, under, between, or by an object or parts of an object, such as equipment with parts that open and close or move up and down ("pinch points") or equipment that rotates, and the accompanying potential to have body parts cut, mangled, or crushed thereby.
- **Contact** – the potential to be struck by or against moving or stationary objects that can cause physical injury, such as heavy machinery, overhead piping, moving vehicles, falling objects, and equipment (including tools and hand-held equipment) or infrastructure with the ability to cut or impale.
- **Energy Sources** – the potential for bodily harm associated with energy sources, most notably electricity, but also including latent energy sources such as compressed air and equipment under tension (which when released could cause injurious contact or a fall).
- **Ergonomics** – the potential for musculoskeletal injury associated with lifting/carrying, pushing/pulling, bending, reaching, and other physical activity attributable to poor body position/mechanics, repetitive motion, and/or vibration.
- **Exposure** – the potential for injury/illness due to physical, chemical, or biological exposures in the work environment, including, but not limited to, temperature extremes, solar radiation, and noise (physical), chemical splashes and hazardous atmospheres (chemical), and animal/insect bites and poisonous plants (biological).
- **Falls** – the potential to slip or trip and thus fall or drop a load, resulting in bodily injury to oneself or others.

The foregoing is intended to provide Roux employees with a general awareness of the hazards involved with Site work. A more detailed review of the potential hazards associated with each specific activity planned for the Site (or on-going activity, as the case may be) is provided in the activity-specific Job Safety Analysis (JSA) forms in **Appendix A**. As can be seen in the JSA forms, the hazards are identified by category per the above, and specific measures designed to mitigate/manage those hazards are also identified. In preparing the JSA forms, all categories of hazards were considered, and all anticipated potential hazards were identified to the extent possible based on the experience of the personnel preparing and reviewing the JSA forms. However, there is always the possibility for an unanticipated hazard to arise, potentially as condition change over the course of the workday. Roux personnel must maintain a continual awareness of potential hazards in the work zone, regardless of whether the hazard is identified in the JSA form. Particular attention should be paid to hazards associated with exposure to hazardous substances (see **Table 1** for a listing of the hazardous substances most likely to be encountered in environmental media at the Site) and to Site personnel being located "in the line of fire" with respect to moving equipment, pinch points, and latent energy (e.g., being located or having body parts located within the swing radius of an excavator, between two sections of pipe being connected, below a piece of suspended equipment, or adjacent to a compressed air line).

5.1 Hazard Communication and Overall Site Information Program

The information in the JSAs and SDSs is made available to all employees and subcontractors who could be affected by it prior to the time they begin their work activities.

Modifications to JSAs are communicated during routine pre-work briefings, and periodically updated as needed in the HASP. SDSs will be maintained by the SHSO/SS for new chemicals brought on-site as needed. Copies of SDSs can be found in **Appendix B**.

5.2 Noise

Noise is associated with the operation of heavy equipment, power tools, pumps, and generators. Noise is also a potential hazard when working near operating equipment such as excavators, drill rigs or pole drivers. High noise (i.e., < 85 dBA) operations may be evaluated by the SHSO utilizing a type 2 handheld sound level meter (SLM) operating on the "A"-weighted scale with slow response because this scale most closely resembles human response to noise and complies with OSHA 29 CFR 1910.95. Hearing protection is required in areas with noise exposure greater than 85 dBA. Double hearing protection (ear plugs and earmuffs) should be donned in areas where the noise exposure is more than 95 dBA. Noise exposure will be controlled by hearing protection as described above or by maintaining set-backs from high-noise equipment, as warranted. Personnel handling heavy equipment and using power tools that produce noise levels exceeding those described levels above are required by OSHA 29 CFR 1910.95 to wear the appropriate Noise Reduction Rating (NRR) level of hearing protection. Appropriate hearing protection will be evaluated by the SHSO as necessary in consultation with the OHSM and CHSD.

5.3 Slip, Trip, and Fall Hazards

Slip, trip, and fall hazards may include, but are not limited to, general slip and trip hazards associated with uneven ground, possible debris, wet grass, and equipment. Prior to work, walking paths will be assessed for solid footings, any ground penetrations that may cause a tripping hazard will be appropriately marked, and other areas will be noted and discussed with the field team.

Personnel shall be aware of their surroundings and footings at all time, and all accommodations should be made for proper housekeeping and organized equipment placement at the Site, where possible, to help prevent any slip, trip, and fall-related incidents. All tools and materials should be appropriately stored when not in use and placed in appropriate storage containers.

5.4 Biological Hazards

Biological hazards that may potentially be present at a Site, include poisonous plants, insects (ticks, spiders, bees), animals (snakes, dogs), etc. Information on biological hazards can be found within Roux's Biological Hazard Awareness Management Program located within Roux's Corporate Health and Safety Manual. There is also potential for transmission and/or exposure to SARS-CoV-2, the virus that causes COVID-19. Prior to beginning work, on-Site protocols shall be established by the project team, including subcontractors, in accordance with federal, state, county, city, and/or other guidance, as applicable.

6. Emergency Response Plan

This emergency response plan details actions to be taken in the event of Site emergencies. The PM and SHSO is responsible for the implementation of emergency response procedures onsite. The SHSO/PM provides specific direction for emergency action based upon information available regarding the incident and response capabilities and initiates emergency procedures and notification of appropriate authorities. In the event of an emergency, Site personnel are evacuated and do not participate in emergency response activities, response is facilitated through external emergency services.

6.1 Emergency Response

The SHSO, after investigating the incident and relevant information, shall determine the level of response required for containment, rescue and medical care. Limited on-site emergency response activities could occur therefore the SHSO is responsible for notifying external emergency response agencies. The SHSO provides relevant information to the responding organizations, including, but not limited to, the hazards associated with the emergency incident, potential containment problems, and missing Site personnel.

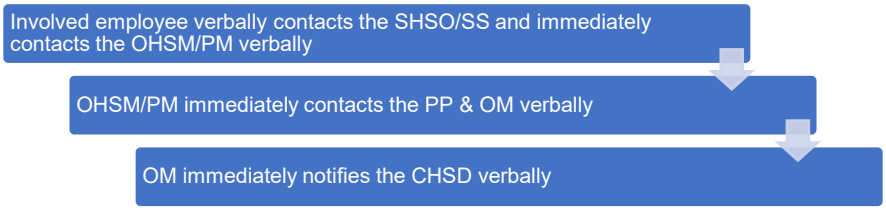
6.2 Emergency Alerting and Evacuation

If evacuation notice is given, Site workers leave the worksite, if possible, by way of the nearest exit. Appropriate primary and alternate evacuation routes and assembly areas have been identified and are shown on the Site Plan with Emergency Muster Area (**Figure 2**). The routes and assembly area will be determined by conditions at the time of the evacuation based on wind direction, the location of the hazard source, and other factors as determined by SHSO/PM.

Personnel exiting the Site gather at a designated assembly point. To determine that everyone has successfully exited the Site, personnel will be accounted for at the assembly point. If any worker cannot be accounted for, notification is given to the SHSO, PM, and any arriving response authorities so that appropriate action can be initiated. Subcontractors on this Site have coordinated their emergency response plans to ensure that these plans are compatible and potential emergencies are recognized, alarm systems are clearly understood, and evacuation routes are accessible to all personnel relying upon them.

6.3 Emergency Medical Treatment and First Aid

In the event of a work-related injury or illness, employees are required to follow the procedures outlined below. All work-place injury and illness situations require Roux's Project and Corporate Management Team to be notified when an injury/illness incident occurs, and communication with the contracted Occupational Health Care Management Provider, WorkCare, Inc., is initiated, as necessary. The Injury/Illness Notification Flowchart is provided below and within Roux's Incident Investigation and Reporting program included within Roux's Corporate Health and Safety Manual.



If on-Site personnel require any medical treatment, the following steps will be taken:

a. Notify Roux's Project and Corporate Management Team for any work-related injury and/or illness occurrence, and communicate with the contracted Occupational Health Care Management Provider, WorkCare, immediately following the notifications provided above.

b. Based on discussions with the Project Team, Corporate Management and the WorkCare evaluation, if medical attention beyond onsite first aid is warranted, transport the injured / ill person (IP) to the Urgent Care Center, or notify the Fire Department or Ambulance Emergency service and request an ambulance or transport the victim to the hospital, and continue communications with Corporate Management Team. An Urgent Care/Hospital Route map with location to CityMD Bushwick Urgent Care/ Wyckoff Heights Medical Center is included as **Figure 3**.

c. Decontaminate to the extent possible prior to administration of first aid or movement to medical or emergency facilities.

d. First aid medical support will be provided by onsite personnel trained and certified in First Aid, Cardio Pulmonary Resuscitation (CPR), Automatic External Defibrillation (AED), and Blood-Borne Pathogens (BBP) Awareness, until relieved by emergency medical services (EMS).

e. The SHSO and PM will perform a Loss Investigation (LI) and the Project Team will complete the final Loss Report. If a Roux employee is involved in a vehicular incident, the employee must also complete the Acord Automobile Loss Notice.

7. Environmental Conditions and Response

7.1 Adverse Weather Conditions

In the event of adverse weather conditions, the SHSO or project principal will determine if work can continue without jeopardizing the health and safety of field workers. Some of the items related to adverse weather conditions to be considered prior to determining if work should continue include:

- Potential for heat stress and heat-related injuries;
- Potential for cold stress and cold-related injuries;
- Treacherous weather-related conditions. If wind speed is greater than 15 mph averaged over a 15-minute period or wind gusts over 25 mph, earthmoving operations will be ceased
- Limited visibility; and
- Electrical storm potential.

Site activities will be limited to daylight hours and acceptable weather conditions. Inclement working conditions may include heavy rain, fog, high winds, and lightning. The SHSO and/or PM shall observe daily weather reports and evacuate, if necessary, in case of inclement weather conditions.

7.2 Electrical Storm Guidelines

In the event that lightning and/or thunder are observed while working onsite, all onsite activities shall stop and personnel shall seek proper shelter (e.g., substantial building, enclosed vehicle, etc.). Work shall not resume until the threat of lighting has subsided and no lightning or thunder has been observed for 30 minutes. If the possibility of lightning is forecast for the day, advise the onsite personnel on the risks and proper procedure at the pre-work safety briefing. Continuously monitor for changing weather conditions and allow enough time to properly stop work if lightning is forecast.

7.3 Environmental Stressors, Heat Stress, Heat Exhaustion, and Heat Stroke

It is the employer's responsibility to monitor weather forecasts and ambient air temperatures, both prior to the work shift and during the shift. The National Oceanic and Atmospheric Administration records average minimum/maximum temperatures of 28°F / 84°F degrees Fahrenheit during the year in Brooklyn, New York.

To prevent potential heat illness, the following strategies will be implemented:

- Adjusting personnel work/rest intervals;
- Monitoring for symptoms of heat illness;
- Providing shaded rest areas;
- Providing cool potable water so that each employee has access to at least one quart per hour for the entire shift, free of charge;
- Allowing for employees to acclimatize to the weather conditions and work demands;
- Observe workers during a heat wave (i.e., when the temperature is at least 80oF, and 10 degrees hotter than the average temperature of the five preceding days); and
- Implementing high heat procedures when the temperature reaches 95oF.

Roux's Heat Illness Prevention Plan is implemented when the when ambient temperatures exceed 80oF. Roux's Heat Illness Prevention Program can be found within **Appendix C**. Additional information regarding heat illnesses is provided below. This can include, but is not limited to, access to shade that is sufficient in size to fit all workers who are on break; a car with air conditioning is acceptable, too. Preventative cool-down breaks shall be allowed at any time, and anyone taking such a break will be monitored for heat illness symptoms and not required to return to work until all symptoms (if present) of heat illness have disappeared. If necessary, first aid will be offered, but if symptoms are severe, emergency response procedures will be implemented per Section 6.3. Anyone who has shown symptoms of severe heat illness will not be sent home without being offered first aid or medical treatment.

High heat procedures must be implemented when temperatures reach 95oF. These procedures include:

- Ensuring that effective communication by voice, observation, or electronic means is maintained so that employees at the work site can contact a supervisor when necessary. An electronic device, such as a cell phone or text messaging device, may be used for this purpose only if the reception in the area is reliable.
- Observing employees for alertness and signs or symptoms of heat illness. The employer shall ensure effective employee observation/monitoring by implementing one or more of the following:
    - Supervisor or designee observation of 20 or fewer employees;
    - Mandatory buddy system; and
    - Regular communication with sole employee such as by radio or cellular phone, or other effective means of observation.
- Designating one or more employees on each worksite as authorized to call for emergency medical services and allowing other employees to call for emergency services when no designated employee is available.
- Encouraging employees throughout the work shift to drink plenty of water.
- A review of the high heat procedures during the daily tailgate meeting and remind employees of their right to take a cool-down rest when necessary.

7.3.1 Heat Stress

Heat stress is the body's response to excessive heat and can be a significant potential hazard. The risk of heat stress can be increased with heavy physical activity and/or the use of personal protective equipment in hot, humid weather environments. There are also personal risk factors that can contribute to the risk of suffering from heat stress, such as obesity, water intake, alcohol and caffeine consumption, pregnancy, age, medication, etc. Heat illness includes heat cramps, heat exhaustion, heat syncope, and heat stroke.

7.3.2 Heat Cramps

Heat cramps may be brought on by prolonged exposure to heat. As an individual sweats, water and salts are lost by the body resulting in painful muscle cramps, typically in the legs.

First aid treatment includes, but is not limited to, shade, rest, and fluid replacement. Typically, the individual should recover within one-half hour while being monitored constantly. If the individual has not improved substantially within 30 minutes and the body temperature has not decreased, the individual should be transported to a hospital for medical attention.

Per Roux's Heat Illness Prevention Plan, employees shall have access to potable drinking water that is fresh, pure, suitably cool, free of charge and in sufficient quantities. Access to shade shall be present when temperatures exceed 80 degrees Fahrenheit and shall be available when temperatures do not exceed 80 degrees Fahrenheit.

7.3.3 Heat Exhaustion

Heat exhaustion may occur in an individual who has been exposed to excessive heat while working or exercising. The circulatory system of the individual fails as blood collects near the skin to rid the body of excess heat through transference. The signs and symptoms of heat exhaustion are as follows:

- Rapid and shallow breathing;
- Weak pulse;
- Cold and clammy skin with heavy perspiration;
- Skin appears pale;
- Fatigue and weakness;
- Dizziness; and
- Elevated body temperature.

First aid treatment includes, but is not limited to, cooling the victim, elevating the feet, and replacing fluids.

If the individual is not substantially improved within 30 minutes and the body temperature has not decreased, the individual should be transported to the hospital for medical attention.

7.3.4 Heat Stroke

Heat stroke occurs when an individual is exposed to excessive heat and stops sweating. This condition is classified as a MEDICAL EMERGENCY requiring immediate cooling of the victim and transport to a medical facility. The signs and symptoms of heat stroke are as follows:

- Dry, hot, red skin;
- Body temperature approaching or above 105oF;
- Confusion, altered mental state, slurred speech;
- Seizures;
- Large (dilated) pupils; and
- Loss of consciousness – the individual may go into a coma.

First aid treatment requires immediate cooling and transportation to a medical facility. Heat stress is a significant hazard if any type of protective equipment (semi-permeable or impermeable) that prevents evaporative cooling when worn in hot weather environments.

7.4 Cold Stress

Cold stress is a danger at low temperatures and when the wind-chill factor is low. Prevention of cold-related illnesses is a function of whole-body protection. Adequate insulating clothing must be used when the air temperature is below 60°F. A work/rest regimen will be initiated when ambient temperatures and protective

clothing cause a stressful situation. In addition, reduced work periods followed by rest in a warm area may be necessary in extreme conditions. The signs and symptoms of cold stress include the following:

- Severe shivering;
- Abnormal behavior;
- Slowing;
- Weakness;
- Stumbling or repeated falling;
- Inability to walk;
- Collapse; and/or
- Unconsciousness.

First aid requires removing the victim from the cold environment and seeking medical attention immediately. Also, prevent further body heat loss by covering the victim lightly with blankets. Do not cover the victim's face. If the victim is still conscious, administer hot drinks and encourage activity such as walking, wrapped in a blanket.

8. Safety Procedures

This section of the HASP presents the specific safety procedures to be implemented during Roux's activities at the Site in order to protect the health and safety of various on-site personnel. Minimum OSHA-mandated procedures are presented first, followed by client- and Site-specific procedures. Lastly, activity-specific procedures are discussed. These Site and activity-specific procedures supplement the general safety procedures included in Roux's Corporate Health and Safety Manual, which also must be followed in their entirely.

8.1 Training

At a minimum, Site personnel who will perform work in areas where there exists the potential for toxic exposure will be health and safety-trained prior to performing work onsite per OSHA 29 CFR 1910.120(e) and 29 CFR 1926.65(e). More specifically, all Roux, subcontractor, and other personnel engaged in sampling and remedial activities at the Site and who are exposed or potentially exposed to hazardous substances, health hazards, or safety hazards must have received at a minimum the 40 hour initial HAZWOPER training consistent with the requirements of 29CFR 1910.120(e)(3)(i) training and a minimum of 3 days' actual field experience under the direct supervision of a trained experienced supervisor, plus 8 hours of refresher training on an annual basis. Depending on tasks performed, less training may be permitted. Evidence of such training must be maintained at the Site at all times. Furthermore, all on-Site management and supervisory personnel directly responsible for or who supervise the employees engaged in Site remedial operations, must have received an additional 8 hours of specialized training at the time of job assignment on topics including, but not limited to, the employer's safety and health program and the associated employee training program, personal protective equipment program, spill containment program, and health hazard monitoring procedure and techniques, plus 8 hours of refresher training on an annual basis. Additionally, all workers who will be required to don a respirator will be properly trained on their employer's Respiratory Protection Program, which also includes being medically cleared to wear a respirator and passed a fit test, at least initially prior to use, and then annually thereafter in accordance with 29 CFR 1910.134, Respiratory Protection.

Roux personnel training records are maintained in a corporate database with records available upon request from either the OHSM/SHSO/CHSD or Human Resources Department.

8.2 Site-Specific Safety Briefings for Visitors

A site-specific briefing is provided to all site visitors who enter this site beyond the site entry point. For visitors, the site-specific briefing provides information about site hazards, the site lay-out including work zones and places of refuge, the emergency alarm system and emergency evacuation procedures, and other pertinent safety and health requirements as appropriate.

8.3 HASP Information and Site-Specific Briefings for Workers

Site personnel review this HASP and are provided a Site-specific tailgate briefing prior to the commencement of work to ensure employees are familiar with this HASP and the information and requirements it contains, as well as the relevant JSAs included in **Appendix A**. Additional briefings are provided as necessary to notify employees of any changes to this HASP as a result of information gathered during on-going Site characterization and analysis of changing conditions. Conditions for which we

schedule additional briefings include, but are not limited to: changes in site conditions, changes in the work schedule/plan, newly discovered hazards, and incidents occurring during Site work.

8.4 Medical Surveillance

The medical surveillance section of the Health and Safety Plan describes how worker health status is monitored at this site. Medical surveillance is used when there is the potential for worker exposure to hazardous substance at levels above OSHA Permissible Exposure Limits (PEL) or other published limits. The purpose of a medical surveillance program is to medically monitor worker health to ensure that personnel are not adversely affected by site hazards. The provisions for medical surveillance at this site are based on the site characterization and job hazard analysis found in Section 4 of this HASP and are consistent with OSHA requirements in 29 CFR 1910.120(f) as applicable.

8.4.1 Site Medical Surveillance Program

Medical surveillance requirements are based on a worker's potential for exposure as determined by the site characterization and job hazard analysis documented in Section 4 and JSAs within **Appendix A** of this HASP and in compliance with the requirements of 29 CFR 1910.120(f)(2). Based on site information and use of direct reading instruments, limited use of respirators (less than 30 days per year), and the absence of an employee-staffed HAZMAT team, a limited medical surveillance program is required and implemented at this site. The medical surveillance program provides that:

1. Workers assigned to tasks requiring the use of respirators receive medical examinations in accordance with 29 CFR 1910.134(e) to ensure they are physically capable to perform the work and use the equipment, and
2. If a worker is injured, becomes ill, or develops signs or symptoms of possible over-exposure to hazardous substance or health hazards, medical examinations are provided to that worker as soon as possible after the occurrence and as required by the attending physician.
3. These medical examinations and procedures are performed by or under the supervision of a licensed physician and are provided to workers free of cost, without loss of pay, and at a reasonable time and place. In addition, the need to implement a more comprehensive medical surveillance program will be re-evaluated after any apparent over-exposure.

8.4.2 Medical Recordkeeping Procedures

Medical recordkeeping procedures are consistent with the requirements of 29 CFR 1910.1020 and are described in the company's overall safety and health program. A copy of that program is available at our Islandia, New York office.

The following items are maintained in worker medical records:

- Respirator fit test and selection;
- Physician's medical opinion of fitness for duty (pre-placement, periodic, termination);
- Physician's medical opinion of fitness for respirator protection (pre-placement, periodic); and
- Exposure monitoring results.

8.4.3 Program Review

The medical program is reviewed to ensure its effectiveness. The Corporate Health and Safety Manager, in coordination with the Human Resources Director, is responsible for this review. At minimum, this review consists of:

- Review of accident and injury records and medical records to determine whether the causes of accidents and illness were promptly investigated and whether corrective measures were taken wherever possible;
- Evaluation of the appropriateness of required medical tests based on site exposures; and
- Review of emergency treatment procedures and emergency contacts list to ensure they were site specific, effective, and current.

8.5 Personnel Protection

Site safety and health hazards are eliminated or reduced to the greatest extent possible through engineering controls and work practices. Where hazards are still present, a combination of engineering controls, work practices and PPE are used to protect employees. Appropriate personal protective equipment (PPE) shall be worn by Site personnel when there is a potential exposure to chemical, biological or physical hazards (e.g., falling objects, flying particles, sharp edges, electricity, and noise), as determined by the SHSO. The level of personal protection, type and kind of equipment selected will depend on the hazardous conditions and in some cases cost, availability, compatibility with other equipment, and performance. An accurate assessment of all these factors will be made before work can be safely executed.

Roux maintains a comprehensive written PPE program that addresses proper PPE selection, use, maintenance, storage, fit and inspection. Roux's PPE program can be found within **Appendix D**. PPE to be used at the Site will meet the appropriate American National Standards Institute (ANSI) standards and the following OSHA (General/Construction Industry) standards for minimum PPE requirements.

The minimum level of PPE for entry onto the Site is Level D. The following equipment shall be worn:

- Work uniform (long pants, sleeved shirt);
- Hard hat;
- Steel or composite toe work boots (must comply with American Society for Testing and Materials [ASTM]) F 2412-05, Standard Test Methods for Foot Protection and ASTM F 2413-05, Standard Specification for Performance Requirements for Foot Protection);
- Safety Glasses (must comply with one of the following ANSI/ISEA Z87.1-2010, ANSI Z87.1-2003, ANSI Z87.1-2003);
- Boot Covers (as needed);
- Hearing protection (as needed);
- High visibility clothing (shirt/vest); and
- Hand protection (e.g., minimum cut resistance meeting ANSI 105-2000 Level 2).

Note that jewelry shall be removed or appropriately secured to prevent it from becoming caught in rotating equipment or unexpectedly snagged on a fixed object (e.g., wrist watches, bracelets, rings, chains and necklaces, open earrings). Do not wear loose clothing and all shoulder-length hair should be tied back.

Site specific PPE ensembles and materials are identified within task specific JSAs located within **Appendix A**, and any upgrades or downgrades of the level of protection (i.e., not specified in the JSA) must be approved by the PP and immediately communicated to all Roux personnel and subcontractors as applicable. PPE is used in accordance with manufacturer's recommendations.

8.5.1 Hearing Conservation

Hearing protection is made available when noise exposures equal or exceed an 8-hour time-weighted average sound level of 85 dBA. Hearing protection is required when the 8-hour time weighted average sound level > 85 dBA, or when noise levels exceed 140 dBA at any point or exceeds 115 dBA for at least 15 minutes. Where noise exposure meets or exceeds this level, noise is listed as a physical hazard in the JSA for the tasks/operation, and hearing protection is included as one of the control measures (PPE).

8.6 Monitoring

An air monitoring program is important to the safety of on- and off-Site personnel, and the surrounding area. A preliminary survey, to establish background conditions in the immediate sampling area, may be made prior to the initiation of Site work including, but not limited to, monitoring wind direction (e.g., wind socks) and approximate temperature during all invasive Site activities. This survey will be conducted with the appropriate pre-calibrated air monitoring instrument(s), as warranted by the field activity. Once this survey has been complete, any changes in the type of PPE will be determined and relayed to those working on Site.

Work zone air monitoring will be performed to verify that the proper level of PPE is used, and to determine if increased protection or work stoppage is required. The following equipment shall be used to monitor conditions:

- A Photoionization Detector (PID) with a lamp energy of 10.6 eV will be used to provide direct readings of organic vapor concentrations during intrusive activities to determine that personnel protection is adequate. Concentrations shall be recorded during intrusive activities with the potential to encounter contaminant vapors.

Personal exposure monitoring utilizing activated charcoal tubes may be considered based on whether or not the area sample results are at or above half of the PEL. The decision to perform the monitoring will be made by, and under the control of, the CHSD.

Below are monitoring action levels for Site-specific chemicals of concern. In the event PID readings above the thresholds identified below are sustained for 5 minutes in the breathing zone, worker protection will require upgrading following notification to the OHSM and applicable parties.

8.6.1 Action Levels for Air Monitoring

PPE can remain at Level D if breathing zone VOC concentrations are less than 5 ppm and benzene is non detect. Personnel are required to evacuate the Site when breathing zone VOC readings exceed 25 ppm.

The following tables include summaries of the air monitoring, work practices, and action levels for the expected contaminants. The action levels to initiate testing with colorimetric tubes for airborne volatiles is 1 ppm (PID reading) and is based on the Permissible Exposure Limit (PEL) for benzene (1 ppm). The colorimetric tubes are used to confirm the presence or absence of specific constituents, and they do not provide a measured concentration.

PPE can remain at Level D if breathing zone VOC concentrations are less than 5 ppm, is non-detect. Personnel are required to evacuate the Site when breathing zone VOC readings exceed 25 ppm.

The following tables include summaries of the air monitoring, work practices, and action levels for the expected contaminants.

Air Monitoring Summary and Action Levels Organic Vapors	
PID Reading in Breathing Zone (ppm)	**Action**
0-1 ppm above background	Continue monitoring
>1-5 ppm sustained 60 seconds	Continue monitoring
<5 ppm	Continue Monitoring, ventilate space
≥ 5 ppm - ≤ 25 ppm	Ventilate space until PID reads < 5 ppm. If < 5 ppm cannot be achieved, upgrade to Level C[1].
≥ 25 ppm	Ventilate space and evacuate area. Consult with CHSD.

Background concentrations should be established at the beginning of each work day. It may be necessary to re-establish background concentrations and ambient conditions vary through the day.

1 Measured air concentrations of known organic vapors will be reduced by the respirator to one half of the PEL or lower, and the individual and combined compound concentrations shall be within the service limit of the respirator cartridge.

8.6.2 Explosive Hazard

Methane is a common gas constituent that is generated during the decomposition of organics. Methane, a non-toxic compound, does not have an OSHA PEL or other exposure limits based on toxicity; however, methane is explosive under certain conditions. The Lower Explosive Limit (LEL) for methane is 5% in air, or 50,000 parts per million by volume. At high concentrations, methane can also displace oxygen and cause asphyxiation. Since methane is lighter than air, it does not tend to accumulate in low-lying areas and will rapidly mix with atmospheric air if encountered during drilling activities. Methane concentrations will be continuously monitored using a pre-calibrated gas meter while excavation takes place.

8.6.3 Air Monitoring Equipment and Calibration

A PID calibrated to an appropriate calibration mixture will be used to detect organic vapors in and around the work areas. Monitoring will be conducted in and around all work areas and at the workers breathing zone before activities commence to establish a background level, then at 15-minute intervals throughout the day. All equipment will be calibrated according to the manufacturer's recommendation. A calibration log will be maintained and will include the name of the person who performed the calibration, the date and time calibrated, and the instrument reading at the time of calibration. A manual bellows pump or equivalent with colorimetric tubes for specific compounds will be utilized to determine the course of action related to upgrading or downgrading the level of respiratory protection, as applicable.

If air monitoring data indicate safe levels of potentially harmful constituents at consistent intervals (5-minute intervals), then monitoring can be conducted less frequently (every 30 minutes). This determination will be made by the onsite SHSO. Monitoring data, including background readings and calibration records, will be documented. Work to be performed on-Site will conform to Roux's Standard Operating Procedures (SOPs). Conformance with these guidelines as well as the guidelines described in this HASP will aid in mitigating the physical and chemical hazards mentioned throughout this HASP.

8.7 Tailgate Safety Meetings

A designated Site worker will provide daily safety briefings (e.g., tailgate meetings) including, but not limited to, the following scenarios:

- When new operations are to be conducted;
- Whenever changes in work practices must be implemented; and
- When new conditions are identified and/or information becomes available.

Daily safety briefings shall be recorded on the Roux Daily Tailgate Health and Safety Meeting Log/Daily Site Safety Checklist, and all completed forms will become a part of the project file.

8.8 Spill Containment

Spill containment equipment and procedures should, at a minimum, meet the requirements of the facility's Spill Prevention, Control and Countermeasure Plan, if applicable. Otherwise, spill containment equipment and procedures must be considered depending on the task, including, but not limited to, chemical/product transfer points and handling.

8.8.1 Initial Spill Notification and Response

Any worker who discovers a hazardous substance spill will immediately notify the SHSO. The worker will, to his/her best ability, report the hazardous substance involved, the location of the spill, the estimated quantity of material spilled, the direction/flow of the spill material, related fire/explosion incidents, and any associated injuries without compromising their own safety.

8.8.2 Spill Evaluation and Response

The SHSO is responsible for evaluating spills and determining the appropriate response. When this evaluation is being made, the spill area will be isolated and demarcated to the extent possible. If necessary to protect nearby community members, notification of the appropriate authorities is made by the PM as appropriate. On-Site response is limited to small spills (e.g., <10 gallons); large spills require external emergency responders who will be contacted by the SHSO.

8.9 Decontamination

The decontamination section of the HASP describes how personnel and equipment are decontaminated when they leave the Exclusion Zone. This section also describes how residual waste from decontamination processes is disposed. The site decontamination procedures are designed to achieve an orderly, controlled removal or neutralization of contaminants that may accumulate on personnel or equipment. These procedures minimize worker contact with contaminants and protect against the transfer of contaminants to clean areas of the site and off-site. They also extend the useful life of PPE by reducing the amount of time that contaminants contact and can permeate PPE surfaces. Decontamination is facilitated within the CRZ at this site, if applicable.

8.9.1 Decontamination Procedures for Personnel and PPE

The following are general decontamination procedures established and implemented at this site.

1. Decontamination is required for all workers exiting a contaminated area. Personnel may re-enter the SZ only after undergoing the decontamination procedures described below in the next section.

2. Protective clothing is decontaminated, cleaned, laundered, maintained and/or replaced as needed to ensure its effectiveness.
3. PPE used at this site that requires maintenance or parts replacement is decontaminated prior to repairs, or
4. PPE used at this site is decontaminated or prepared for disposal on the premises. Personnel who handle contaminated equipment have been trained in the proper means to do so to avoid hazardous exposure.
5. This site uses an off-site laundry for decontamination of PPE. The site has informed that facility of the hazards associated with contaminated PPE from this site.
6. The site requires and trains workers that if their permeable clothing is splashed or becomes wetted with a hazardous substance, they will immediately exit the work zone, perform applicable decontamination procedures, shower, and change into uncontaminated clothing.
7. Procedures for disposal of decontamination waste meet applicable local, State, and Federal regulations.

8.9.2 Decontamination Procedures for Equipment

All tools, equipment, and machinery from the EZ or CRZ are decontaminated in the CRZ prior to removal to the SZ. Equipment decontamination procedures are designed to minimize the potential for hazardous skin or inhalation exposure and to avoid cross-contamination and chemical incompatibilities.

General Equipment Decontamination Procedures:

1. Decontamination is required for all equipment exiting a contaminated area. Equipment may re-enter the SZ only after undergoing the equipment decontamination procedures.
2. Vehicles that travel regularly between the contaminated and clean areas of the site are carefully decontaminated each time they exit the EZ and the effectiveness of that decontamination is monitored to reduce the likelihood that contamination will be spread to other parts of the site.
3. Particular attention is given to decontaminating tires, scoops, and other parts of heavy equipment that are directly exposed to contaminants and contaminated soil.
4. Procedures for disposal of decontamination waste shall meet applicable local, State, and Federal regulations.

The following items may be used to decontaminate equipment:

- Fresh water rinse;
- Non-phosphorus detergent wash;
- Acetone rinse;
- Distilled water rinse; and
- A steam cleaner or pressure washer (heavy equipment only).

8.9.3 Monitoring the Effectiveness of Decontamination Procedures

Visual examination and sampling are used to evaluate the effectiveness of decontamination procedures. Visual examination is used to ensure that procedures are implemented as described and that they appear to control the spread of contaminants under changing site conditions. Visual examination is also used to inspect for signs of residual contamination or for contaminant permeation of PPE.

Personnel who work in contaminated areas of the site, either the Contamination Reduction Zone (CRZ) or the Exclusion Zone, are trained in the principles and practices of decontamination described in this section of the HASP and in related SOPs. If site procedures are changed as a result of inspection and monitoring, all affected employees are notified of these changes.

8.10 Confined Space Entry

Confined space entry will not be performed by Roux personnel.

The following is a list of the safety requirements for confined space entry at the Site:

- **ROUX PERSONNEL ARE NOT AUTHORIZED TO ENTER AN OSHA PERMIT REQUIRED CONFINED SPACE;**
- Currently the scope of work **DOES NOT** require personnel to enter permitted confined space for this project; and
- Any changes to the field activities that may necessitate confined space entry will be reported to the Project Principal and OHSM.

Confined space is defined as any space, depression, or enclosure that:

- Has limited opening for entry and egress;
- Is large enough for and employee to enter and perform assigned work; and
- Is not intended for continuous occupancy.

A permit required confined space is one that meets the definition of a confined space and has one or more of the following characteristics:

- May contain or produce life-threatening atmospheres due to oxygen deficiency the presence of toxic, flammable, or corrosive contaminants;
- Contains a material that has the potential for engulfment;
- Has an internal configuration that may cause an entrant to be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section; and
- Contains any other serious safety or health hazards.

Although Roux personnel will not perform confined space entry, it is expected that subcontractors performing cleaning and mitigation and/or remedial measures activities may be required to enter structures that are considered to be a permit required confined space. Permitting of the confined space as well as hazard mitigation for entry will be completed by the subcontractor in accordance with 29 CFR 1910.146 or 1926.1201-1213 and/or applicable local/client requirements.

8.11 Client and Site-Specific

In addition to the OSHA-specific procedures discussed above, there may be client and site-specific safety procedures that must be adhered to during the performance of remedial activities at the Site.

8.12 Unusual or Significant Risks

Field activities that appear to have unusual or significant risks that cannot be adequately managed with existing risk tools such as LPS, HASPs, traffic safety plans, work permits, design and O&M practices,

equipment HAZOPS or other safety tools must be referred to the CHSD to help with the assessment and management of the associated potential safety risks. Examples include the use of explosives for demolition, use of firearms to control wildlife, rappelling, demolition over water, diving, etc.

8.13 Activity-Specific Hazards

In addition to the general hazards discussed above, there are activity-specific hazards associated with each work activity planned for the Site. An activity-specific JSA has been completed for each of the activities planned for the Site. JSAs are provided in **Appendix A**. In the event that new work activities or tasks are planned, JSAs will be developed and implemented prior to performing the new activities. In the absence of a JSA, the personnel performing work must prepare a field JSA and receive clearance from a designated competent safety official prior to performing any task with significant risk. In emergency situations where time is critical, Last Minute Risk Assessments (LMRAs) will be utilized to identify the task, associated hazards and mitigative actions to take. For lower risk activities (as deemed by the discretion of a Competent Person) where a JSA is determined to not be needed, the individual(s) conducting the activities must perform LMRAs prior to and during the work.

8.13.1 Electrical and Other Utility Assessment and Accommodations

Roux shall perform a site walk to identify any potential overhead electrical or utility lines. All applicable guidelines will be followed in the vicinity of overhead power and utility lines (see Section 8.13.3 below).

Roux has also reviewed all available Site maps showing buried utility lines to identify potential hazards; the review revealed no underground hazards are known to exist in the vicinity of the areas of the Site pertinent to this HASP.

8.13.2 Subsurface Work

Subsurface work activities will require adherence to Roux's Corporate Subsurface Utility Clearance Management program found within Appendix E.

8.13.2.1 Excavations and Trenching

Trenching and excavation work activities carried out by Roux and their subcontractors shall comply with applicable OSHA standards (i.e., 29 CFR 1926.650-652). Regional Notification Centers (i.e., Underground Services Alert) shall be notified at least two working days prior to the start of any digging or excavation work per state requirements (i.e., 811-One Call). Personnel responsible for excavation activities will be trained in their job responsibilities. Additionally, for trenches 4 feet or deeper, where employees will enter, the trench needs to have a stairway, ladder or other safe means of egress, and located so that employees do not have to travel farther than 25 feet horizontally. Where employees will enter trenches greater than 5 feet deep, the trench must have some type of protective system or sloped sidewalls appropriately to prevent cave-ins.

The SHSO or other responsible Roux personnel will be present on-Site during all Roux contracted excavation and backfill operations and will supplement health and safety monitoring conducted by Subcontractor air quality screening to ensure that appropriate levels of protection and safety procedures are utilized. The proximity of chemical, water, sewer, and electrical lines will be identified by Roux and/or their subcontractor before any subsurface activity or sampling is attempted. Prior to any excavation activities, trees, shrubbery, and other objects that can potentially pose as a hazard during excavation should

be supported or removed from the excavation area. The following safe work practices will be implemented during this task.

- The proximity of chemical, water, sewer, and electrical lines will be identified by a facility representative prior to beginning any subsurface activity;
- At the start of every day, a competent person will inspect excavations to evaluate if the area is stable and safe to enter. Inspections will be conducted as needed throughout the excavation operations. If deemed necessary, a competent person may also conduct inspections after rainfall or any other event that can potentially affect the integrity of the excavation. Employees will not enter excavations where water has accumulated until protective measures have been implemented.
- Prior to entering excavations greater than 4 feet in depth, air monitoring for oxygen and hazardous atmospheres must be conducted to assure atmospheric conditions are within normal levels described in Section 8.6. Continuous air monitoring with a standard multi-gas detector (O2, LEL%, CO, H2S) shall be used during the course of work within an excavation; if action limits are reached workers shall safely exit the excavation. Upgrades to worker protection should be evaluated with the SHSO and PP in consultation with the CHSD. Emergency rescue equipment, such as breathing apparatuses and safety harnesses connected to an extraction device, will be readily available in the event of hazardous atmospheric conditions;
- While earthmoving, stay out of the excavator's delineated heavy equipment exclusion zone and away from the excavation sides where there is potential for cave in (within excavations that are 6 feet or more in depth, a delineated perimeter 6 feet away from the excavated edge is required);
- During loading and unloading operations, stand away from haul trucks and other vehicles to avoid contact with any falling loads; and
- Traffic cones, caution tape, or other barriers will be set up around the perimeter of the excavation when employees are working along the excavation edge and for any excavation that will be left open overnight or unattended for more than two days.

Maximum Allowable Slopes

Soil or Rock Type	Maximum Allowable Slopes (H:V)[1] for Excavations Less Than 20 Feet Deep[3]
Stable Rock	Vertical (90°)
Type A[2]	3/4 : 1 (53°)
Type B	1 : 1 (45°)
Type C	1 1/2 : 1 (34°)

29 CFR 1926 Subpart P Appendix B Sloping and Benching Table B-1

Notes:

[1] Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.

[2] A short-term maximum allowable slope of 1/2H : 1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 meters) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 meters) in depth shall be 3/4H : 1V (53°).

[3] Sloping or benching for excavations greater than 20 feet deep shall be designed and stamped by a registered professional engineer.

Proper stockpiling (i.e., 2 feet minimum distance from the excavation edge), containment, transport, storage, and disposal practices will be utilized and is dependent upon the potential type and amount of waste generated during operations. The location of safety equipment and evacuation procedures will be established prior to initiation of operations according to this HASP.

8.13.3 Heavy Equipment

Use of heavy equipment at the Site will require adherence to Roux's Corporate Heavy Equipment Exclusion Zone Management Program found within Appendix F. Additionally, operation of the drill rig/other heavy equipment will maintain clearances from overhead power lines in accordance with 29 CFR 1926.1408 Table A Minimum Clearance Distances provided below.

Minimum Required Clearances for Energized Overhead Power Lines

Nominal System Voltage of Power Line (K V)	Minimum Required Clearance (feet)
0-50	10
51-100	12
101-200	15
201-300	20
301-500	25
501-750	35
751-1000	45

1 kilovolt (KV) = 1,000 volts

8.14 Traffic Control

If Site operations encroach upon public streets or highways and a hazard exists to Site personnel because of traffic conditions, a traffic control plan will be implemented in accordance with the United States Department of Transportation's (DOT's) "Manual on Uniform Traffic Control Devices."

8.15 Sanitation

Sanitation facilities will be provided in accordance with the sanitation standards (29 CFR 1910.141, 29 CFR 1926.51 and 29 CFR 1928.110). Sanitation facilities will be maintained and kept in good conditions at all times.

9. Field Team Review

Each person performing work at or visiting this site shall sign this section after site-specific training is completed and before being permitted to access the CRZ or Exclusion Zone.

I have read and understand this Site-Specific Health and Safety Plan. I will comply with the provision contained therein.

Site/Project: 213 Meadow Street MTA Facilities Project Site

Name & Company	Signature	Date

10. Approvals

By their signature, the undersigned certify that this HASP is approved and will be utilized at the **213 Meadow Street MTA Facilities Project Site**.

TDB – Site Health and Safety Officer	Date
Nevin Pahlad – Office Health and Safety Manager	Date
Levi Curnutte – Project Manager	Date
Jessica L. Taylor, P.G. – Project Principal	Date

TABLES

1. Toxicological Properties of Hazardous Substances Present at the Site

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
ORGANOCHLORINE PESTICIDES (OCP)									
DDT	50-29-3	TWA 1 mg/m3	TWA 0.5 mg/m3	TWA 1 mg/m3	500 mg/m3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin; paresthesia tongue, lips, face; tremor; anxiety, dizziness, confusion, malaise (vague feeling of discomfort), headache, lassitude (weakness, exhaustion); convulsions; paresis hands; vomiting; [potential occupational carcinogen]	Eyes, skin, central nervous system, kidneys, liver, peripheral nervous system	White, odorless and tasteless, very stable, water-insoluble, synthetic BP: 260°F Fl.Pt. = 162-171°F LEL: NA UEL: NA
Aldrin	309-00-2	TWA 0.1 mg/m3	TWA 0.25 mg/m3	TWA 0.25 mg/m3	25 mg/m3	Inhalation, ingestion, skin and/or eye contact	headache, dizziness; nausea, vomiting, malaise (vague feeling of discomfort); myoclonic jerks of limbs; clonic, tonic convulsions; coma; hematuria (blood in the urine), azotemia; [potential occupational carcinogen]	Developmemntal, Endocrine, Liver, Immune System, Nervous System,	Colorless to dark-brown crystalline solid with a mild chemical odor. BP: 293°F Fl.Pt. = 150°F LEL: NA UEL: NA
Lindane (gamma-BHC)	58-89-9	TWA 0.5 mg/m3	TWA 0.5 mg/m3	TWA 0.5 mg/m3	50 mg/m3	Inhalation, ingestion, skin and/or eye contact	irritation eyes, skin, nose, throat; headache; nausea; clonic convulsions; resp difficulty; cyanosis; aplastic anemia; muscle spasm; In Animals: liver, kidney damage	Eyes, skin, respiratory system, central nervous system, blood, liver, kidneys	White to yellow, crystalline powder with a slight, musty odor. BP: 614°F Fl.Pt. = 150°F LEL: NA UEL: NA
Dieldrin	860-57-1□	TWA 0.1 mg/m3	TWA 0.25 mg/m3	TWA 0.25 mg/m3	25 mg/m3	Inhalation, ingestion, skin and/or eye contact	headache, dizziness; nausea, vomiting, malaise (vague feeling of discomfort), sweating; myoclonic limb jerks; clonic, tonic convulsions; coma; ; In Animals: liver, kidney damage [potential occupational carcinogen]	Developmemntal, Endocrine, Liver, Immune System, Nervous System,	Colorless to light-tan crystals with a mild, chemical odor. BP: NA (Decomposes) Fl.Pt. = NA LEL: NA UEL: NA
VOLATILE ORGANIC COMPOUNDS (VOCs)									
1,1,1-Trichloroethane	71-55-6	TWA 350 ppm STEL 450 ppm	C 350 ppm (1900 mg/m^3) [15-minute]	TWA 350 ppm (1900 mg/m^3)	700 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin; headache, lassitude (weakness, exhaustion), central nervous system depression, poor equilibrium; dermatitis; cardiac arrhythmias; liver damage	Eyes, skin, central nervous system, cardiovascular system, liver	Colorless liquid with a mild, chloroform-like odor. BP: 165°F Fl.Pt. = NA LEL: 7.5% UEL: 12.5% Combustible Liquid, but burns with difficulty
1,1,2,2-Tetrachloroethane	79-34-5	TWA 1 ppm [skin]	Ca TWA 1 ppm (7 mg/m^3) [skin]	TWA 5 ppm (35 mg/m^3) [skin]	Ca [100 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Nausea, vomiting, abdominal pain; tremor fingers; jaundice, hepatitis, liver tenderness; dermatitis; leukocytosis (increased blood leukocytes); kidney damage; [potential occupational carcinogen]	Skin, liver, kidneys, central nervous system, gastrointestinal tract	Colorless to pale-yellow liquid with a pungent, chloroform-like odor BP: 296°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Liquid
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	TWA 1000 ppm STEL 1250 ppm	TWA 1000 ppm (7600 mg/m3) ST 1250 ppm (9500 mg/m3)	TWA 1000 ppm (7600 mg/m3)	2000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation skin, throat, drowsiness, dermatitis; central nervous system depression; In Animals: cardiac arrhythmias, narcosis	Skin, heart, central nervous system, cardiovascular system	Colorless to water-white liquid with an odor like carbon tetrachloride at high concentrations. [Note: A gas above 118°F.] BP: 118°F Fl.Pt. = NA LEL: NA UEL: NA
1,1,2-Trichloroethane	79-00-5	TWA 10 ppm [skin]	Ca TWA 10 ppm (45 mg/m3) [skin]	TWA 10 ppm (45 mg/m3) [skin]	Ca [100 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, nose; central nervous system depression; liver, kidney damage; dermatitis; [potential occupational carcinogen]	Eyes, respiratory system, central nervous system, liver, kidneys	Colorless liquid with a sweet, chloroform-like odor BP: 237°F Fl.Pt. = NA LEL: 6% UEL: 15.5% Combustible Liquid, forms dense soot
1,1-Dichloroethane	75-34-3	TWA 100 ppm	TWA 100 ppm (400 mg/m^3)	TWA 100 ppm (400 mg/m^3)	3,000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation skin; central nervous system depression; liver, kidney, lung damage	Skin, liver, kidneys, lungs, central nervous system	Colorless, oily liquid with a chloroform-like odor. BP: 135°F Fl.Pt. = 2°F LEL: 5.4% UEL: 11.4% Class IB Flammable Liquid Fl.P. below 73°F and BP at or above 100°F.

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
1,1-Dichloroethene	75-35-4	TWA 5 ppm	Ca	None	Ca	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, throat; dizziness, headache, nausea, dyspnea (breathing difficulty); liver, kidney disturbance; pneumonitis; [potential occupational carcinogen]	Eyes, skin, respiratory system, central nervous system, liver, kidneys	Colorless liquid or gas (above 89°F) with a mild, sweet, chloroform-like odor BP: 89°F Fl.Pt. = -2°F LEL: 6.5% UEL: 15.5% Class IA Flammable Liquid: Fl.P. below 73°F and BP below 100°F
1,2,3-Trichlorobenzene	87-61-6	Cameo Chemicals Source https://cameochemicals.noaa.gov/chemical/10051	NA	NA	NA	Inhalation, skin absorption, ingestion, skin and/or eye contact	Inhalation may cause irritation of respiratory tract. Irritating to the eyes. May redden skin on contact. Ingestion may cause liver damage.	Skin, eyes, respiratory tract, liver	A white solid with a sharp chlorobenzene odor. Insoluble in water and denser than water. Hence sinks in water Fl.Pt. = 234.9°F
1,2,4-Trichlorobenzene	120-82-1	C 5 ppm	C 5 ppm (40 mg/m3)	None	N.D.	inhalation, skin absorption, ingestion, skin and/or eye contact	irritation eyes, skin, mucous membrane; In Animals: liver, kidney damage; possible teratogenic effects	Eyes, skin, respiratory system, liver, reproductive system	Colorless liquid or crystalline solid (below 63°F) with an aromatic odor BP: 416°F Fl.Pt. = 222°F LEL (302°F): 2.5% UEL (302°F): 6.6% Class IIIB Combustible Liquid: Fl.P. at or above 200°F. Combustible Solid
1,2-Dibromo-3-chloropropane	96-12-8	NA	Ca	TWA 0.001 ppm	Ca	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; drowsiness; nausea, vomiting; pulmonary edema; liver, kidney injury; sterility; [potential occupational carcinogen]	Eyes, skin, respiratory system, central nervous system, liver, kidneys, spleen, reproductive system, digestive system	Dense yellow or amber liquid with a pungent odor at high concentrations. [pesticide] [Note: A solid below 43°F.] BP: 384°F Fl.Pt. = (oc) 170°F LEL: NA UEL: NA Class IIIA Combustible Liquid: Fl.P. at or above 140°F and below 200°F.
1,2-Dibromoethane	106-93-4	None listed Skin	Ca TWA 0.045 ppm C 0.13 ppm [15-minute]	TWA 20 ppm C 30 ppm 50 ppm [5-minute maximum peak]	Ca [100 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, respiratory system; dermatitis with vesiculation; liver, heart, spleen, kidney damage; reproductive effects; [potential occupational carcinogen]	Eyes, skin, respiratory system, liver, kidneys, reproductive system	Colorless liquid or solid (below 50°F) with a sweet odor. [fumigant] BP: 268°F Fl.Pt. = 50°F LEL: NA UEL: NA Noncombustible Liquid
1,2-Dichlorobenzene	95-50-1	TWA 25 ppm STEL 50 ppm	C 50 ppm (300 mg/m3)	C 50 ppm (300 mg/m3)	200 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, nose; liver, kidney damage; skin blisters	Eyes, skin, respiratory system, liver, kidneys	Colorless to pale-yellow liquid with a pleasant, aromatic odor. [herbicide] BP: 357°F Fl.Pt. = 1°F LEL: 2.2% UEL: 9.2% Class IIIA Combustible Liquid: Fl.P. at or above 140°F and below 200°F.
1,2-Dichloroethane	107-06-2	TWA 10 ppm	Ca TWA 1 ppm (4 mg/m3) ST 2 ppm (8 mg/m3)	TWA 50 ppm C 100 ppm 200 ppm [5-minute maximum peak in any 3 hours]	Ca [50 ppm]	Inhalation, ingestion, skin absorption, skin and/or eye contact	Irritation eyes, corneal opacity; central nervous system depression; nausea, vomiting; dermatitis; liver, kidney, cardiovascular system damage; [potential occupational carcinogen]	Eyes, skin, kidneys, liver, central nervous system, cardiovascular system	Colorless liquid with a pleasant, chloroform-like odor. [Note: Decomposes slowly, becomes acidic & darkens in color.] BP: 182°F Fl.Pt. = 56°F LEL: 6.2% UEL: 16% Class IB Flammable Liquid Fl.P. below 73°F and BP at or above 100°F.
1,2-Dichloropropane	78-87-5	TWA 10 ppm Dermal Sensitizer (DSEN)	Ca	TWA 75 ppm (350 mg/m3)	Ca [400 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, respiratory system; drowsiness, dizziness; liver, kidney damage; In Animals: central nervous system depression; [potential occupational carcinogen]	Eyes, skin, respiratory system, liver, kidneys, central nervous system	Colorless liquid with a chloroform-like odor. [pesticide] BP: 206°F Fl.Pt. = 60°F LEL: 3.4% UEL: 14.5% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.
1,3-Dichlorobenzene	541-73-1	https://cameochemicals.noaa.gov/chemical/8514				Inhalation, skin absorption, ingestion, skin and/or eye contact	INHALATION: Causes headache, drousiness, unsteadiness. Irritating to mucous membranes. EYES: Severe irritation. SKIN: Severe irritation. INGESTION: Irritation of gastric mucosa, nausea, vomiting, diarrhea, abdominal cramps and cyanosis.		Colorless liquid. Sinks in water. BP: 343°F Fl.Pt. = 146°F LEL: 2.02% UEL: 9.2%
1,4-Dichlorobenzene	106-46-7	TWA 10 ppm	Ca	TWA 75 ppm (450 mg/m3)	Ca [150 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Eye irritation, swelling periorbital (situated around the eye); profuse rhinitis; headache, anorexia, nausea, vomiting; weight loss, jaundice, cirrhosis; In Animals: liver, kidney injury; [potential occupational carcinogen]	Liver, respiratory system, eyes, kidneys, skin	Colorless or white crystalline solid with a mothball-like odor. [insecticide] BP: 345°F Fl.Pt. = 150°F LEL: 2.5% UEL: NA Combustible Solid, but may take some effort to ignite.

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
1,4-Dioxane	123-91-1	TWA 20 ppm [skin]	Ca C 1 ppm (3.6 mg/m3) [30-minute]	TWA 100 ppm (360 mg/m3) [skin]	Ca [500 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	irritation eyes, skin, nose, throat; drowsiness, headache; nausea, vomiting; liver damage; kidney failure; [potential occupational carcinogen]	Eyes, skin, respiratory system, liver, kidneys	Colorless liquid or solid (below 53°F) with a mild, ether-like odor. BP: 214°F Fl.Pt. = 55°F LEL: 2.0% UEL: 22% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F
2-Butanone	78-93-3	TWA 200 ppm STEL 300 ppm	TWA 200 ppm (590 mg/m3) ST 300 ppm (885 mg/m3)	TWA 200 ppm (590 mg/m3)	3000 ppm	inhalation, ingestion, skin and/or eye contact	irritation eyes, skin, nose; headache; dizziness; vomiting; dermatitis	Eyes, skin, respiratory system, central nervous system	Colorless liquid with a moderately sharp, fragrant, mint- or acetone-like odor BP: 175°F Fl.Pt. = 16°F LEL (200°F): 1.4% UEL (200°F): 11.4% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F
2-Hexanone	591-78-6	TWA 5 ppm STEL 10 ppm [skin]	TWA 1 ppm (4 mg/m3)	TWA 100 ppm (410 mg/m3)	1600 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, nose; peripheral neuropathy: lassitude (weakness, exhaustion), paresthesia; dermatitis; headache, drowsiness	Eyes, skin, respiratory system, central nervous system, peripheral nervous system	Colorless liquid with an acetone-like odor BP: 262°F Fl.Pt. = 77°F LEL: NA UEL: 8.0% Class IC Flammable Liquid: Fl.P. at or above 73°F and below 100°F
4-Methyl-2-pentanone	108-10-1	TWA 20 ppm STEL 75 ppm	TWA 50 ppm (205 mg/m3) ST 75 ppm (300 mg/m3)	TWA 100 ppm (410 mg/m3)	500 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, mucous membrane; headache, narcosis, coma; dermatitis; In Animals: liver, kidney damage	Eyes, skin, respiratory system, central nervous system, liver, kidneys	Colorless liquid with a pleasant odor BP: 242°F Fl.Pt. = 64°F LEL (200°F): 1.2% UEL (200°F): 8.0% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F
Acetone	67-64-1	TWA 250 ppm STEL 500 ppm	TWA 250 ppm (590 mg/m^3)	TWA 1000 ppm (2400 mg/m^3)	2500 ppm [10% LEL]	Inhalation, ingestion, skin and/or eye contact	irritation eyes, nose, throat; headache, dizziness, central nervous system depression; dermatitis	Eyes, skin, respiratory system, central nervous system	Colorless liquid with a fragrant, mint-like odor BP: 133°F Fl.Pt. = 0°F LEL: 12.8% UEL: 2.5% Class IB Flammable liquid: Fl.P. below 73°F and BP at or above 100°F.
Benzene	71-43-2	TWA 0.5 ppm STEL 2.5 ppm	Ca TWA 0.1 ppm ST 1 ppm	TWA 1 ppm ST 5 ppm	Ca [500 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, respiratory system; dizziness; headache, nausea, staggered gait; anorexia, lassitude (weakness, exhaustion); dermatitis; bone marrow depression; [potential occupational carcinogen]	Eyes, skin, respiratory system, blood, central nervous system, bone marrow	Colorless to light yellow liquid with an aromatic odor [Note: Solid below 42 °F] BP: 176°F Fl.Pt. = 12°F LEL: 1.2% UEL: 7.8% Class IB Flammable liquid. Fl.P. below 73°F and BP at or above 100°F
Bromochloromethane	74-97-5	TWA 200 ppm	TWA 200 ppm (1050 mg/m3)	TWA 200 ppm (1050 mg/m3)	2000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, throat; confusion, dizziness, central nervous system depression; pulmonary edema	Eyes, skin, respiratory system, liver, kidneys, central nervous system	Colorless to pale-yellow liquid with a chloroform-like odor. [Note: May be used as a fire extinguishing agent.] BP: 155°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Liquid
Bromodichloromethane	75-27-4	https://cameochemicals.noaa.gov/chemical/16064				Inhalation, ingestion, skin and/or eye contact	Symptoms of exposure to this compound may include irritation of the skin, eyes, mucous membranes and respiratory tract. It may also cause narcosis. Other symptoms may include nausea, dizziness and headache.	Liver and kidney damage. Central nervous system effects may also occur.	Clear colorless liquid BP: 189°F Fl.Pt. = NA LEL: NA UEL: NA
Bromoform	75-25-2	TWA 0.5 ppm	TWA 0.5 ppm (5 mg/m3) [skin]	TWA 0.5 ppm (5 mg/m3) [skin]	850 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, respiratory system; central nervous system depression; liver, kidney damage	Eyes, skin, respiratory system, central nervous system, liver, kidneys	Colorless to yellow liquid with a chloroform-like odor. [Note: A solid below 47°F.] BP: 301°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Liquid
Bromomethane	74-83-9	TWA 1 ppm [skin]	Ca	C 20 ppm (80 mg/m3) [skin]	Ca [250 ppm]	Inhalation, skin absorption (liquid), skin and/or eye contact (liquid)	Irritation eyes, skin, respiratory system; muscle weak, incoordination, visual disturbance, dizziness; nausea, vomiting, headache; malaise (vague feeling of discomfort); hand tremor; convulsions; dyspnea (breathing difficulty); skin vesiculation; liquid: frostbite; [potential occupational carcinogen]	Eyes, skin, respiratory system, central nervous system	Colorless gas with a chloroform-like odor at high concentrations. [Note: A liquid below 38°F. Shipped as a liquefied compressed gas.] BP: 38°F Fl.Pt. = NA (Gas) LEL: 10% UEL: 16.0% Flammable Gas, but only in presence of a high energy ignition source.

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
Carbon disulfide	75-15-0	TWA 1 ppm [skin]	TWA 1 ppm (3 mg/m3) ST 10 ppm (30 mg/m3) [skin]	TWA 20 ppm C 30 ppm 100 ppm (30-minute maximum peak)	500 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Dizziness, headache, poor sleep, lassitude (weakness, exhaustion), anxiety, anorexia, weight loss; psychosis; polyneuropathy; Parkinson-like syndrome; ocular changes; coronary heart disease; gastritis; kidney, liver injury; eye, skin burns; dermatitis; reproductive effects	Central nervous system, peripheral nervous system, cardiovascular system, eyes, kidneys, liver, skin, reproductive system	Colorless to faint-yellow liquid with a sweet ether-like odor. [Note: Reagent grades are foul smelling.] BP: 116°F Fl.Pt. = -22°F LEL: 1.3% UEL: 50.0% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.
Carbon tetrachloride	56-23-5	TWA 5 ppm STEL 10 ppm [skin]	Ca ST 2 ppm (12.6 mg/m3) [60-minute]	TWA 10 ppm C 25 ppm 200 ppm (5-minute maximum peak in any 4 hours)	Ca [200 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; central nervous system depression; nausea, vomiting; liver, kidney injury; drowsiness, dizziness, incoordination; [potential occupational carcinogen]	Central nervous system, eyes, lungs, liver, kidneys, skin	Colorless liquid with a characteristic ether-like odor BP: 170°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Liquid
Chlorobenzene	108-90-7	TWA 10 ppm	NA	TWA 75 ppm (350 mg/m3)	1000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose; drowsiness, incoordination; central nervous system depression; In Animals: liver, lung, kidney injury	Eyes, skin, respiratory system, central nervous system, liver	Colorless liquid with an almond-like odor BP: 270°F Fl.Pt. = 82°F LEL: 1.3% UEL: 9.6% Class IC Flammable Liquid: Fl.P. at or above 73°F and below 100°F.
Chloroethane	75-00-3	TWA 100 ppm [skin]	Handle with caution in the workplace	TWA 1000 ppm (2600 mg/m3)	3800 ppm [10%LEL]	Inhalation, skin absorption (liquid), ingestion (liquid), skin and/or eye contact	Incoordination, inebriation; abdominal cramps; cardiac arrhythmias, cardiac arrest; liver, kidney damage	Liver, kidneys, respiratory system, cardiovascular system, central nervous system	Colorless gas or liquid (below 54°F) with a pungent, ether-like odor. [Note: Shipped as a liquefied compressed gas.] BP: 54°F Fl.Pt. = NA (gas), -58°F (liquid) LEL: 3.8% UEL: 15.4% Flammable Gas
Chloroform	67-66-3	TWA 10 ppm	Ca ST 2 ppm (9.78 mg/m3) [60-minute]	C 50 ppm (240 mg/m3)	Ca [500 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; dizziness, mental dullness, nausea, confusion; headache, lassitude (weakness, exhaustion); anesthesia; enlarged liver; [potential occupational carcinogen]	Liver, kidneys, heart, eyes, skin, central nervous system	Colorless liquid with a pleasant odor BP: 143°F Fl.Pt. = -82°F LEL: NA UEL: NA Noncombustible Liquid
Chloromethane	74-87-3	TWA 50 ppm STEL 100 ppm	Ca	TWA 100 ppm C 200 ppm 300 ppm (5-minute maximum peak in any 3 hours)	Ca [2000 ppm]	Inhalation, skin and/or eye contact (liquid)	Dizziness, nausea, vomiting; visual disturbance, stagger, slurred speech, convulsions, coma; liver, kidney damage; liquid: frostbite; reproductive, teratogenic effects; [potential occupational carcinogen]	Central nervous system, liver, kidneys, reproductive system	Colorless gas with a faint, sweet odor which is not noticeable at dangerous concentrations. [Note: Shipped as a liquefied compressed gas.] BP: -12°F Fl.Pt. = NA (Gas) LEL: 8.1% UEL: 17.4% Flammable Gas
cis-1,2-Dichloroethene	156-59-2	TWA 200 ppm (All isomers)	TWA 200 ppm (790 mg/m3)	TWA 200 ppm (790 mg/m3)	1000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, respiratory system; central nervous system depression	Eyes, respiratory system, central nervous system	Colorless liquid (usually a mixture of the cis & trans isomers) with a slightly acrid, chloroform-like odor. BP: 118-140°F Fl.Pt. = 36-39°F LEL: 5.6% UEL: 12.8% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F
cis-1,3-Dichloropropene	10061-01-5	https://cameochemicals.noaa.gov/chemical/20168				Inhalation, ingestion, skin and/or eye contact	Symptoms of exposure to this compound may include local irritation of the eyes skin and respiratory tract; dermatitis, gasping, coughing, substernal pain, extreme respiratory distress, lacrimation, central nervous system depression, skin irritation, acute gastrointestinal distress with pulmonary congestion and edema. It also may cause injury to the liver, kidneys and heart.	Skin, eyes, mucous membranes, liver, kidney, heart	Colorless to amber liquid with a sweetish odor. BP: 219.7°F Fl.Pt. = NA LEL: NA UEL: NA
Cyclohexane	110-82-7	TWA 100 ppm	TWA 300 ppm (1050 mg/m3)	TWA 300 ppm (1050 mg/m3)	1300 ppm [10%LEL]	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, respiratory system; drowsiness; dermatitis; narcosis, coma	Eyes, skin, respiratory system, central nervous system	Colorless liquid with a sweet, chloroform-like odor. [Note: A solid below 44°F.] BP: 177°F Fl.Pt. = 0°F LEL: 1.3% UEL: 8.0% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.
Dibromochloromethane	124-48-1	https://cameochemicals.noaa.gov/chemical/16183				Inhalation, ingestion, skin and/or eye contact	Symptoms of exposure to this compound may include irritation of the skin, eyes, mucous membranes and upper respiratory tract. It may also cause fatigue. Other symptoms may include central nervous system effects, lung and cornea irritation and liver and kidney damage. Prolonged exposure can cause nausea, dizziness, headache and narcosis.	Skin, eyes, mucous membranes, upper respiratory tract	Clear colorless to yellow-orange liquid BP: 246-248°F Fl.Pt. = Greater than 200°F LEL: NA UEL: NA

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
Dichlorodifluoromethane	75-71-8	TWA 1000 ppm	TWA 1000 ppm (4950 mg/m3)	TWA 1000 ppm (4950 mg/m3)	15,000 ppm	Inhalation, skin and/or eye contact (liquid)	Dizziness, tremor, asphyxia, unconsciousness, cardiac arrhythmias, cardiac arrest; liquid: frostbite	Cardiovascular system, peripheral nervous system	Colorless gas with an ether-like odor at extremely high concentrations. [Note: Shipped as a liquefied compressed gas.] BP: -22°F Fl.Pt. = NA LEL: NA UEL: NA Nonflammable Gas
Ethyl benzene	100-41-4	TWA 20 ppm	TWA 100 ppm (435 mg/m^3) ST 125 ppm (545 mg/m^3)	TWA 100 ppm (435 mg/m^3)	800 ppm [10%LEL]	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, mucous membrane; headache; dermatitis; narcosis, coma	Eyes, skin, respiratory system, central nervous system	Colorless liquid with an aromatic odor. BP: 277°F Fl.Pt. = 55°F LEL: 0.8% UEL: 6.7% Class IB Flammable Liquid below 73°F and BP at or above 100°F.
Isopropyl benzene	98-82-8	TWA 5 ppm	TWA 50 ppm (245 mg/m3) [skin]	TWA 50 ppm (245 mg/m3) [skin]	900 ppm [10%LEL]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, mucous membrane; dermatitis; headache, narcosis, coma	Eyes, skin, respiratory system, central nervous system	Colorless liquid with a sharp, penetrating, aromatic odor BP: 306°F Fl.Pt. = 96°F LEL: 0.9% UEL: 6.5% Class IC Flammable Liquid: Fl.P. at or above 73°F and below 100°F
Methyl Acetate	79-20-9	TWA 200 ppm STEL 250 ppm	TWA 200 ppm (610 mg/m3) ST 250 ppm (760 mg/m3)	TWA 200 ppm (610 mg/m3)	3100 ppm [10%LEL]	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; headache, drowsiness; optic nerve atrophy; chest tightness; In Animals: narcosis	Eyes, skin, respiratory system, central nervous system	Colorless liquid with a fragrant, fruity odor BP: 135°F Fl.Pt. = 14°F LEL: 3.1% UEL: 16% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.
Methylcyclohexane	108-87-2	TWA 400 ppm	TWA 400 ppm (1600 mg/m3)	TWA 500 ppm (2000 mg/m3)	1200 ppm [LEL]	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; dizziness, drowsiness; In Animals: narcosis	Eyes, skin, respiratory system, central nervous system	Colorless liquid with a faint, benzene-like odor BP: 214°F Fl.Pt. = 25°F LEL: 1.2% UEL: 6.7% Class IB Flammable Liquid: Fl.P. below 73°F and BP at or above 100°F.
Methylene chloride	75-09-2	TWA 50 ppm [skin] STEL 100 ppm	Ca	[1910.1052] TWA 25 ppm ST 125 ppm	Ca [2300 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; lassitude (weakness, exhaustion), drowsiness, dizziness; numb, tingle limbs; nausea; [potential occupational carcinogen]	Eyes, skin, cardiovascular system, central nervous system	Colorless liquid with a chloroform-like odor. [Note: A gas above 104°F.] BP: 104°F Fl.Pt. = NA LEL: 13% UEL: 23% Combustible Liquid
Methyl-t-butyl ether	1634-04-4	TWA 50 ppm	NA	NA	NA	Inhalation, skin absorption, ingestion, skin and/or eye contact	May cause dizziness or suffocation. Contact may irritate or burn eyes or skin. May be harmful if swallowed.	Eyes, skin	A colorless liquid with a distinctive anesthetic-like odor. BP: 131°F Fl.Pt. = -14°F LEL: NA UEL: NA
o-Xylene	95-47-6	TWA 20 ppm (All isomers) STEL 150 ppm (655 mg/m3)	TWA 100 ppm (435 mg/m3) ST 150 ppm (655 mg/m3)	TWA 100 ppm (435 mg/m3)	900 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; dizziness, excitement, drowsiness, incoordination, staggering gait; corneal vacuolization; anorexia, nausea, vomiting, abdominal pain; dermatitis	Eyes, skin, respiratory system, central nervous system, gastrointestinal tract, blood, liver, kidneys	Colorless liquid with an aromatic odor BP: 292°F Fl.Pt. = 90°F LEL: 0.9% UEL: 6.7% Class IC Flammable Liquid: Fl.P. at or above 73°F and below 100°F
Styrene	100-42-5	TWA 10 ppm STEL 20 ppm OTO (ototoxicant)	TWA 50 ppm (215 mg/m3) ST 100 ppm (425 mg/m3)	TWA 100 ppm C 200 ppm 600 ppm (5-minute maximum peak in any 3 hours)	700 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, nose, respiratory system; headache, lassitude (weakness, exhaustion), dizziness, confusion, malaise (vague feeling of discomfort), drowsiness, unsteady gait; narcosis; defatting dermatitis; possible liver injury; reproductive effects	Eyes, skin, respiratory system, central nervous system, liver, reproductive system	Colorless to yellow, oily liquid with a sweet, floral odor BP: 293°F Fl.Pt. = 88°F LEL: 0.9% UEL: 6.8% Class IC Flammable Liquid: Fl.P. at or above 73°F and below 100°F
Tetrachloroethene	127-18-4	TWA 25 ppm STEL 100 ppm	Ca Minimize workplace exposure concentrations	TWA 100 ppm C 200 ppm (for 5 minutes in any 3-hour period), with a maximum peak of 300 ppm	Ca [150 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat, respiratory system; nausea; flush face, neck; dizziness, incoordination; headache, drowsiness; skin erythema (skin redness); liver damage; [potential occupational carcinogen]	Eyes, skin, respiratory system, liver, kidneys, central nervous system	Colorless liquid with a mild, chloroform-like odor BP: 250°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Liquid, but decomposes in a fire to hydrogen chloride and phosgene

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
Sodium Hydroxide	1310-73-2	Ceiling 2 mg/m^3	C 2 mg/m^3	TWA 2 mg/m^3	10 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, mucous membrane; pneumonitis; eye, skin burns; temporary loss of hair	Eyes, skin, respiratory system	Colorless to white, odorless solid (flakes, beads, granular form). BP: 2534°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solid, but when in contact with water may generate sufficient heat to ignite combustible materials.
Sulfuric Acid	7664-93-9	TWA 0.2 mg/m^3 (as thoracic particulate mass)	TWA 1 mg/m^3	TWA 1 mg/m^3	15 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; pulmonary edema, bronchitis; emphysema; conjunctivitis; stomatis; dental erosion; eye, skin burns; dermatitis	Eyes, skin, respiratory system, teeth	Colorless to dark-brown, oily, odorless liquid.[Note: Pure compound is a solid below 51°F. Often used in an aqueous solution.] BP = 554°F Fl.Pt. = NA LEL = NA UEL = NA Noncombustible Liquid, but capable of igniting finely divided combustible materials.
trans-1,2-Dichloroethene	156-60-5	200 ppm (All isomers)	TWA 200 ppm (790 mg/m3)	TWA 200 ppm (790 mg/m3)	1000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, respiratory system; central nervous system depression	Eyes, respiratory system, central nervous system	Colorless liquid (usually a mixture of the cis & trans isomers) with a slightly acrid, chloroform-like odor. BP: 118-140°F Fl.P: 36-39°F LEL: 5.6% UEL: 12.8% Class IB Flammable Liquid Fl.P. below 73°F and BP at or above 100°F.
trans-1,3-Dichloropropene	10061-02-6	https://cameochemicals.noaa.gov/chemical/18110				Inhalation, ingestion, skin and/or eye contact	Symptoms of exposure to this compound may include local irritation of the eyes skin and respiratory tract, dermatitis, gasping, coughing, substernal pain, extreme respiratory distress, lacrimation, central nervous system depression, acute gastrointestinal distress with pulmonary congestion and edema. It may also cause injury to the liver, kidneys and heart	Skin, eyes, mucous membranes, liver, kidney, heart	A clear colorless liquid with chloroform odor BP: 234°F Fl.P: NA LEL: NA UEL: NA
Toluene	108-88-3	TWA 20 ppm (ototoxicant)	TWA 100 ppm (375 mg/m^3) ST 150 ppm (560 mg/m^3)	TWA 200 ppm C 300 ppm 500 ppm (10-minute maximum peak)	500 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	irritation eyes, nose; lassitude (weakness, exhaustion), confusion, euphoria, dizziness, headache; dilated pupils, lacrimation (discharge of tears); anxiety, muscle fatigue, insomnia; paresthesia; dermatitis; liver, kidney damage	Eyes, skin, respiratory system, central nervous system, liver, kidneys	Colorless liquid with a sweet, pungent, benzene-like odor. BP: 232°F Fl.P: 40°F LEL: 1.1% UEL: 7.1% Class IB Flammable Liquid Fl.P. below 73°F and BP at or above 100°F.
Trichloroethene (TCE)	79-01-6	TWA 10 ppm STEL 25 ppm	Ca	TWA 100 ppm C 200 ppm 300 ppm (5-minute maximum peak in any 2 hours)	Ca [1000 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; headache, visual disturbance, lassitude (weakness, exhaustion), dizziness, tremor, drowsiness, nausea, vomiting; dermatitis; cardiac arrhythmias, paresthesia; liver injury; [potential occupational carcinogen]	Eyes, skin, respiratory system, heart, liver, kidneys, central nervous system	Colorless liquid (unless dyed blue) with a chloroform-like odor. BP: 189°F Fl.Pt. = NA LEL(77°F): 8.0% UEL(77°F): 10.5% Combustible Liquid, but burns with difficulty
Trichlorofluoromethane	75-69-4	STEL C 1000 ppm	C 1000 ppm (5600 mg/m3)	TWA 1000 ppm (5600 mg/m3)	2000 ppm	Inhalation, ingestion, skin and/or eye contact	Incoordination, tremor; dermatitis; cardiac arrhythmias, cardiac arrest; asphyxia; liquid: frostbite	Skin, respiratory system, cardiovascular system	Colorless to water-white, nearly odorless liquid or gas (above 75°F) BP: 75°F Fl.P: NA LEL: NA UEL: NA Noncombustible Liquid Nonflammable Gas
Vinyl Chloride (chloroethylene)	75-01-4	TWA 1 ppm	Ca	TWA 1 ppm C 5 ppm [15-minute]	Ca (ND)	Inhalation, skin and/or eye contact (liquid)	Lassitude (weakness, exhaustion); abdominal pain, gastrointestinal bleeding; enlarged liver; pallor or cyanosis of extremities; liquid: frostbite; [potential occupational carcinogen]	Liver, central nervous system, blood, respiratory system, lymphatic system	Colorless gas or liquid (below 7°F) with a pleasant odor at high concentrations.[Note: Shipped as a liquefied compressed gas.] BP: 7°F Fl.Pt. = NA (Gas) LEL: 3.6% UEL: 33.0% Flammable Gas
Xylene (m, o & p isomers)	108-38-3, 95-47-6, 106-42-3	TWA 20 ppm	NA	NA	NA	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; dizziness, excitement, drowsiness, incoordination, staggering gait; corneal vacuolization; anorexia, nausea, vomiting, abdominal pain; dermatitis	Eyes, skin, respiratory system, central nervous system, gastrointestinal tract, blood, liver, kidneys	Colorless liquid with an aromatic odor BP: 282°F, 292°F, 281°F Fl. Pt. 82°F, 90°F, 81°F LEL: 1.1%, 0.9%, 1.1% UEL: 7.0%, 6.7%, 7.0% Class IC Flammable Liquid at or above 73°F and below 100°F.
Zinc Oxide (dust)	7440-66-6	TWA 2 mg/m3 (repsirable) STEL 10 mg/m^3 (respirable)	TWA 5 mg/m^3 C 15 mg/m^3	TWA 15 mg/m^3 (total dust) TWA 5 mg/m^3 (resp dust) TWA 5 mg/m^3 (fume)	500 mg/m^3	Inhalation	Metal fume fever: chills, muscle ache, nausea, fever, dry throat, cough; lassitude (weakness, exhaustion); metallic taste; headache; blurred vision; low back pain; vomiting; malaise (vague feeling of discomfort); chest tightness; dyspnea (breathing difficulty), rales, decreased pulmonary function	Respiratory system	White, odorless solid. BP: NA Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solid.
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOCs)									

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
2-Chloronaphthalene	91-58-7	https://cameochemicals.noaa.gov/chemical/16185				Inhalation, ingestion, skin and/or eye contact	Chloracne, cysts, headache, fatigue, vertigo, anorexia and jaundice		Monoclinic plates or off-white crystalline powder BP: NA Fl.Pt. = NA LEL: NA UEL: NA
2-Methylnaphthalene	91-57-6	TWA 0.5 ppm TLV-SL 3 mg/100 cm2 [skin]	https://cameochemicals.noaa.gov/chemical/20668			Inhalation, ingestion, skin and/or eye contact	Headaches, nausea, vomiting, diarrhea, anemia, jaundice, euphoria, dermatitis, visual disturbances, convulsions and comatose	Skin, eyes, mucous membranes and upper respiratory tract	White crystalline solid Combustible solid BP: 466-468 ° F Fl.Pt. = 208 ° F LEL: NA UEL: NA
Acenaphthene	83-32-9	https://cameochemicals.noaa.gov/chemical/10358				Inhalation, ingestion, skin and/or eye contact	Irritation of the skin, eyes, mucous membranes and upper respiratory tract, vomiting	Skin, eyes, mucous membranes and upper respiratory tract	White needles BP: 534 ° F Fl.Pt. = NA LEL: 0.6% UEL: NA
Acenaphthylene	208-96-8	https://cameochemicals.noaa.gov/chemical/16157				Inhalation, ingestion, skin and/or eye contact			Colorless crystalline solid BP: 509 to 527 ° F at 760 mm Hg Fl.Pt. = NA LEL: NA UEL: NA
Anthracene (as coal tar pitch volatiles)	120-12-7	TWA 0.2 mg/m3 (as Benzene solubles)	Ca TWA 0.1 mg/m3 (cyclohexane-extractable fraction)	TWA 0.2 mg/m3 (benzene-soluble fraction) [1910.1002]	Ca [80 mg/m3]	Inhalation, skin and/or eye contact	Dermatitis, bronchitis, [potential occupational carcinogen]	Respiratory system, skin, bladder, kidneys	Black or dark-brown amorphous residue BP: NA Fl.Pt. = NA LEL: NA UEL: NA Combustible Solids
Benzo[a]anthracene	56-55-3	https://cameochemicals.noaa.gov/chemical/16171				Inhalation, injestion, skin and/or eye contact			Colorless leaflets or plates or coarse gold powder with a greenish-yellow fluorescence. May reasonably be expected to be a carcinogen. BP: 815° F at 760 mm Hg Fl.Pt. = NA LEL: NA UEL: NA
Benzo[a]pyrene (as coal tar pitch volatiles)	50-32-8	TWA 0.2 mg/m3 (as Benzene solubles)	Ca TWA 0.1 mg/m3 (cyclohexane-extractable fraction)	TWA 0.2 mg/m3 (benzene-soluble fraction) [1910.1002]	Ca [80 mg/m3]	Inhalation, skin and/or eye contact	Dermatitis, bronchitis, [potential occupational carcinogen]	Respiratory system, skin, bladder, kidneys	Black or dark-brown amorphous residue BP: NA Fl.Pt. = NA LEL: NA UEL: NA Combustible Solids
Benzo[b]fluoranthene	205-99-2	None listed	https://cameochemicals.noaa.gov/chemical/16172			Inhalation, injestion, skin and/or eye contact			Needles or yellow fluffy powder BP: NA Fl.Pt. = NA LEL: NA UEL: NA
Benzo[g,h,i]perylene	191-24-2	https://cameochemicals.noaa.gov/chemical/16174				Inhalation, injestion, skin and/or eye contact	Inhalation of material may be harmful. Contact may cause burns to skin and eyes. Inhalation of Asbestos dust may have a damaging effect on the lungs. Fire may produce irritating, corrosive and/or toxic gases. Some liquids produce vapors that may cause dizziness or suffocation. Runoff from fire control may cause pollution.	Lungs, skin, eyes	Colorless to white crystalline solid. Water insoluble. BP: NA Fl.Pt. = NA LEL: NA UEL: NA
Benzo[k]fluoranthene	207-08-9	https://cameochemicals.noaa.gov/chemical/16173				Inhalation, injestion, skin and/or eye contact	When heated to decomposition this compound emits acrid smoke and irritating fumes.		Pale yellow needles or yellow crystalline solid BP: 896° F Fl.Pt. = NA LEL: NA UEL: NA
Chrysene (as coal tar pitch volatiles	218-01-9	TWA 0.2 mg/m3 (as Benzene solubles)	Ca TWA 0.1 mg/m3 (cyclohexane-extractable fraction)	TWA 0.2 mg/m3 (benzene-soluble fraction) [1910.1002]	Ca [80 mg/m3]	Inhalation, skin and/or eye contact	Dermatitis, bronchitis, [potential occupational carcinogen]	Respiratory system, skin, bladder, kidneys	Black or dark-brown amorphous residue BP: NA Fl.Pt. = NA LEL: NA UEL: NA Combustible Solids
Dibenzo(a,h)anthracene	53-70-3	https://cameochemicals.noaa.gov/chemical/16192				Inhalation, injestion, skin and/or eye contact	Symptoms of exposure to this compound may include irritation. This compound is harmful if swallowed or inhaled. It may cause irritation. When heated to decomposition it emits acrid smoke, irritating fumes and toxic fumes of carbon monoxide and carbon dioxide.	Lungs	White crystals or pale yellow solid. Sublimes BP: 975° F Fl.Pt. = NA LEL: NA UEL: NA
Fluoranthene	206-44-0	https://cameochemicals.noaa.gov/chemical/16213				Inhalation, injestion, skin and/or eye contact	When heated to decomposition this compound emits acrid smoke and fumes.		Light yellow fine crystals BP: 482° F Fl.Pt. = NA LEL: NA UEL: NA

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
Fluorene	86-73-7	https://cameochemicals.noaa.gov/chemical/16214				Inhalation, injestion, skin and/or eye contact			White leaflets. Sublimes easily under a vacuum. Fluorescent when impure. BP: 563° F Fl.Pt. = NA LEL: NA UEL: NA
Indeno[1,2,3-cd]pyrene	193-39-5	https://cameochemicals.noaa.gov/chemical/16218				Inhalation, injestion, skin and/or eye contact			Yellow crystals BP: 997° F Fl.Pt. = NA LEL: NA UEL: NA
Naphthalene	91-20-3	TWA 10 ppm [skin]	TWA 10 ppm (50 mg/m3) ST 15 ppm (75 mg/m3)	TWA 10 ppm (50 mg/m3)	250 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes; headache, confusion, excitement, malaise (vague feeling of discomfort); nausea, vomiting, abdominal pain; irritation bladder; profuse sweating; jaundice; hematuria (blood in the urine), renal shutdown; dermatitis, optical neuritis, corneal damage	Eyes, skin, blood, liver, kidneys, central nervous system	Colorless to brown solid with an odor of mothballs. [Note: Shipped as a molten solid.] BP: 424°F Fl.P: 174°F LEL: 0.9% UEL: 5.9% Combustible Solid, but will take some effort to ignite
Phenanthrene	85-01-8	https://cameochemicals.noaa.gov/chemical/16236				Inhalation, injestion, skin and/or eye contact	Symptoms following exposure to this compound may include skin sensitization, dermatitis, bronchitis, cough, dyspnea, respiratory neoplasm, kidney neoplasm, skin irritation, and respiratory irritation.	Skin, respiratory tract	Colorless monoclinic crystals with a faint aromatic odor. Solutions exhibit a blue fluorescence. BP: 642° F Fl.Pt. = 340° F LEL: NA UEL: NA
Pyrene (see coal tar pitch volatiles)	129-00-0	TWA 0.2 mg/m3 (as Benzene solubles)	Ca TWA 0.1 mg/m3 (cyclohexane-extractable fraction)	TWA 0.2 mg/m3 (benzene-soluble fraction) [1910.1002]	Ca [80 mg/m3]	Inhalation, skin and/or eye contact	Dermatitis, bronchitis, [potential occupational carcinogen]	Respiratory system, skin, bladder, kidneys	Black or dark-brown amorphous residue BP: NA Fl.Pt. = NA LEL: NA UEL: NA Combustible Solids
METALS									
Aluminum	7429-90-5	TWA 1 mg/m3	TWA 10 mg/m^3 (total) TWA 5 mg/m^3 (resp)	TWA 15 mg/m^3 (total) TWA 5 mg/m^3 (resp)	N.D.	Inhalation, skin and/or eye contact	Irritation eyes, skin, respiratory system	Eyes, skin, respiratory system	Silvery-white, malleable, ductile, odorless metal BP: 4221°F Fl.Pt. = NA LEL: NA UEL: NA Combustible Solid, finely divided dust is easily ignited; may cause explosions
Antimony	7440-36-0	TWA 0.5 mg/m3 (as Sb)	TWA 0.5 mg/m3 [*Note: The REL also applies to other antimony compounds (as Sb).]	TWA 0.5 mg/m3 [*Note: The PEL also applies to other antimony compounds (as Sb).]	50 mg/m3 (as Sb)	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat, mouth; cough; dizziness; headache; nausea, vomiting, diarrhea; stomach cramps; insomnia; anorexia; unable to smell properly	Eyes, skin, respiratory system, cardiovascular system	Silver-white, lustrous, hard, brittle solid; scale-like crystals; or a dark-gray, lustrous powder BP: 2975°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solid in bulk form, but a moderate explosion hazard in the form of dust when exposed to flame.
Arsenic	7440-38-2	TWA 0.01 mg/m3	Ca C 0.002 mg/m3 [15-minute]	[1910.1018] TWA 0.010 mg/m3	Ca [5 mg/m3 (as As)]	Inhalation, skin absorption, skin and/or eye contact, ingestion	Ulceration of nasal septum, dermatitis, gastrointestinal disturbances, peripheral neuropathy, resp irritation, hyperpigmentation of skin, [potential occupational carcinogen]	Liver, kidneys, skin, lungs, lymphatic system	Metal: Silver-gray or tin-white, brittle, odorless solid BP: Sublimes Fl.Pt. = NA LEL: NA UEL: NA Metal: Noncombustible Solid in bulk form, but a slight explosion hazard in the form of dust when exposed to flame
Barium	7440-39-3	TWA 0.5 mg/m3	0.5 mg Ba/m3 TWA	0.5 mg Ba/m3 TWA	50 mg Ba/m3	Inhalation, ingestion, skin and/or eye contact	Inhalation or contact with vapors, substance or decomposition products may cause severe injury or death. Contact may cause burns to skin, eyes, and mucous membranes. May be toxic by ingestion, inhalation and skin absorption. Used to make other chemicals.	Lungs, skin, eyes, and mucous membrane	A silver to white metallic solid BP: 1337°F Fl.Pt. = NA LEL: NA UEL: NA
Beryllium	7440-41-7	TWA 0.00005 mg/m^3	Ca C 0.0005 mg/m^3	TWA 0.002 mg/m^3 C 0.005 mg/m^3 0.025 mg/m3 [30-minute maximum peak]	Ca [4 mg/m^3 (as Be)]	Inhalation, skin and/or eye contact	Berylliosis (chronic exposure): anorexia, weight loss, lassitude (weakness, exhaustion), chest pain, cough, clubbing of fingers, cyanosis, pulmonary insufficiency; irritation eyes; dermatitis; [potential occupational carcinogen]	Eyes, skin, respiratory system	Hard, brittle, gray-white solid BP: 4532°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solid in bulk form, but a slight explosion hazard in the form of a powder or dust

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
Cadmium	7440-43-9	TWA 0.01 mg/m^3 total dust TWA 0.002 mg/m^3 (as Cd) respirable fraction	Ca	TWA 0.005 mg/m^3	Ca [9 mg/m3 (as Cd)]	Inhalation, ingestion	Pulmonary edema, dyspnea (breathing difficulty), cough, chest tightness, substernal (occurring beneath the sternum) pain; headache; chills, muscle aches; nausea, vomiting, diarrhea; anosmia (loss of the sense of smell), emphysema, proteinuria, mild anemia; [potential occupational carcinogen]	Respiratory system, kidneys, prostate, blood	Silver-white/blue tinged lustrous, odorless solid. BP: 1409°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible - will burn in powder form
Calcium	7440-70-2	https://cameochemicals.noaa.gov/chemical/309				Inhalation, ingestion, skin and/or eye contact	Contact with eyes or skin produces caustic burns.	Eyes, skin	A silvery, soft metal that turns grayish white on exposure to air. BP: 2714°F Fl.Pt. = NA LEL: NA UEL: NA
Chromium	7440-47-3	TWA 0.5 mg/m^3 (metal) TWA 0.003 mg/m^3 (water-soluble Cr III compounds) TWA 0.0002 mg/m^3 (water-soluble Cr VI compounds) STEL 0.0005 mg/m3 (water-soluble Cr VI compounds)	TWA 0.5 mg/m^3	TWA 1 mg/m^3	250 mg/m^3 (as Cr)	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin; lung fibrosis (histologic)	Eyes, skin, respiratory system	Blue-white to steel-gray, lustrous, brittle, hard, odorless solid. BP: 4788°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible - will burn in dust form if heated in a flame
Cobalt	7440-48-4	TWA 0.02 mg/m3 [DSEN] [RSEN]	TWA 0.05 mg/m3	TWA 0.1 mg/m3	20 mg/m3 (as Co)	Inhalation, ingestion, skin and/or eye contact	Cough, dyspnea (breathing difficulty), wheezing, decreased pulmonary function; weight loss; dermatitis; diffuse nodular fibrosis; resp hypersensitivity, asthma	Skin, respiratory system	Odorless, silver-gray to black solid BP: 5612°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solid in bulk form, but finely divided dust will burn at high temperatures.
Copper	7440-50-8	TWA 0.2 mg/m^3 (fume) TWA 1 mg/m3 (dusts and mists)	TWA 1 mg/m^3	TWA 1 mg/m^3	100 mg/m^3 (as Cu)	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, nose, pharynx; nasal septum perforation; metallic taste; dermatitis; In Animals: lung, liver, kidney damage; anemia	Eyes, skin, respiratory system, liver, kidneys (increased risk with Wilson's disease)	Reddish, lustrous, malleable, odorless solid. BP: 4703°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible - powdered form may ignite
Iron (as iron oxide)	7439-89-6	TWA 5 mg/m3 (respirable particulate mass)	TWA 1 mg/m^3	NA	NA	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, mucous membrane; abdominal pain, diarrhea, vomiting; possible liver damage	Eyes, skin, respiratory system, liver, gastrointestinal tract	Appearance and odor vary depending upon the specific soluble iron salt. BP: NA Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solids
Lead	7439-92-1	TWA 0.05 mg/m3	TWA (8-hour) 0.050 mg/m3	[1910.1025] TWA 0.050 mg/m3	100 mg/m3 (as Pb)	Inhalation, ingestion, skin and/or eye contact	Lassitude (weakness, exhaustion), insomnia; facial pallor; anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis wrist, ankles; encephalopathy; kidney disease; irritation eyes; hypertension	Eyes, gastrointestinal tract, central nervous system, kidneys, blood, gingival tissue	A heavy, ductile, soft, gray solid BP: 3164°F Fl.Pt. = NA LEL: NA UEL: NA Noncombustible Solid in bulk form
Magnesium	7439-95-4	https://cameochemicals.noaa.gov/chemical/6949				Eye and/or skin contact	Dust irritates eyes in same way as any foreign material. Penetration of skin by fragments of metal is likely to produce local irritation, blisters, and ulcers which may become infected.	Eyes	A light silvery metal BP: 1202°F Fl.Pt. = NA LEL: NA UEL: NA
Manganese	7439-96-5	TWA 0.02 mg/m3 [R] TWA 0.1 mg/m3 [I]	TWA 1 mg/m3 ST 3 mg/m3	C 5 mg/m3	500 mg/m3 (as Mn)	inhalation, ingestion	Manganism; asthenia, insomnia, mental confusion; metal fume fever: dry throat, cough, chest tightness, dyspnea (breathing difficulty), rales, flu-like fever; low-back pain; vomiting; malaise (vague feeling of discomfort); lassitude (weakness, exhaustion); kidney damage	respiratory system, central nervous system, blood, kidneys	A lustrous, brittle, silvery solid BP: 3564°F Fl.Pt. = NA LEL: NA UEL: NA Metal: Combustible Solid
Mercury	7439-97-6	TWA 0.1 mg/m3, as Hg Aryl compounds TWA 0.025 mg/m3 as Hg, inorganic forms including metallic mercury	Hg Vapor: TWA 0.05 mg/m3 [skin] Other: C 0.1 mg/m3 [skin]	TWA 0.1 mg/m3	10 mg/m3 (as Hg)	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; cough, chest pain, dyspnea (breathing difficulty), bronchitis, pneumonitis; tremor, insomnia, irritability, indecision, headache, lassitude (weakness, exhaustion); stomatitis, salivation; gastrointestinal disturbance, anorexia, weight loss; proteinuria	Eyes, skin, respiratory system, central nervous system, kidneys	Metal: Silver-white, heavy, odorless liquid. [Note: "Other" Hg compounds include all inorganic & aryl Hg compounds except (organo) alkyls.] BP: 674°F Fl.Pt. = NA LEL: NA UEL: NA Metal: Noncombustible Liquid
Nickel	7440-02-0	TWA 1.5 mg/m^3 [elemental] TWA 0.1 mg/m^3 [soluble inorganic compound] TWA 0.2 mg/m^3 [insoluble inorganic compound] TWA 0.1 mg/m^3 [Nickel subsulfide]	Ca TWA 0.015 mg/m^3	TWA 1 mg/m^3	Ca [10 mg/m3 (as Ni)]	Inhalation, ingestion, skin and/or eye contact	Sensitization dermatitis, allergic asthma, pneumonitis; [potential occupational carcinogen]	Nasal cavities, lungs, skin	Lustrous, silvery, odorless solid. BP: 5139°F Fl.Pt. = NA LEL: NA UEL: NA Combustible Solid; nickel sponge catalyst may ignite spontaneously in air.

Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties
Potassium	9/7/7440	https://cameochemicals.noaa.gov/chemical/4289				Eye and/or skin contact	Will burn skin and eyes	Skin, eyes	Potassium is a soft silvery metal though normally grayish white due to oxidation BP: 1425°F Fl.Pt. = NA LEL: NA UEL: NA
Selenium	7782-49-2	TWA 0.2 mg/m3	TWA 0.2 mg/m3	TWA 0.2 mg/m3	1 mg/m3 (as Se)	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; visual disturbance; headache; chills, fever; dyspnea (breathing difficulty), bronchitis; metallic taste, garlic breath, gastrointestinal disturbance; dermatitis; eye, skin burns; In Animals: anemia; liver necrosis, cirrhosis; kidney, spleen damage	Eyes, skin, respiratory system, liver, kidneys, blood, spleen	Amorphous or crystalline, red to gray solid. [Note: Occurs as an impurity in most sulfide ores.] BP: 1265°F Fl.Pt. = NA LEL: NA UEL: NA Combustible Solid
Silver	7440-22-4	TWA 0.1 mg/m3 [Metal, dust, and fume] TWA 0.01 mg/m3 [Soluble compounds, as Ag]	TWA 0.01 mg/m3	TWA 0.01 mg/m3	10 mg/m3 (as Ag)	Inhalation, ingestion, skin and/or eye contact	Blue-gray eyes, nasal septum, throat, skin; irritation, ulceration skin; gastrointestinal disturbance	Nasal septum, skin, eyes	Metal: White, lustrous solid BP: 3632°F Fl.Pt. = NA LEL: NA UEL: NA Metal: Noncombustible Solid, but flammable in form of dust or powder
Sodium	7440-23-5	https://cameochemicals.noaa.gov/chemical/7794				Skin contact	Severe burns caused by burning metal or by caustic soda formed by reaction with moisture on skin	Skin	A silvery soft metal that becomes grayish white upon exposure to air BP: 1621°F Fl.Pt. = NA LEL: NA UEL: NA
Thallium	7440-28-0	0.02 mg/m3 inhallable particulate matter	TWA 0.1 mg/m3 [skin]	TWA 0.1 mg/m3 [skin]	15 mg/m3 (as Tl)	Inhalation, skin absorption, ingestion, skin and/or eye contact	Nausea, diarrhea, abdominal pain, vomiting; ptosis, strabismus; peri neuritis, tremor; retrosternal (occurring behind the sternum) tightness, chest pain, pulmonary edema; convulsions, chorea, psychosis; liver, kidney damage; alopecia; paresthesia legs	Eyes, respiratory system, central nervous system, liver, kidneys, gastrointestinal tract, body hair	Appearance and odor vary depending upon the specific soluble thallium compound BP: NA Fl.Pt. = NA LEL: NA UEL: NA
Vanadium	7440-62-2	https://cameochemicals.noaa.gov/chemical/16147				Inhalation, skin absorption, ingestion, skin and/or eye contact	Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution	Skin	Silvery-whitish powder BP: NA Fl.Pt. = NA LEL: NA UEL: NA
Zinc	7440-66-6	https://cameochemicals.noaa.gov/chemical/4814				Inhalation, skin absorption, ingestion, skin and/or eye contact	Inhalation or contact with vapors, substance or decomposition products may cause severe injury or death. May produce corrosive solutions on contact with water. Fire will produce irritating, corrosive and/or toxic gases. Runoff from fire control may cause pollution	Lungs	A grayish powder BP: NA Fl.Pt. = NA LEL: NA UEL: NA
PCBs									
PCBs (total)	11097-69-1, 53469-21-9	TWA 0.5 mg/m3 [skin] TWA 1 mg/m3 [skin]	Ca TWA 0.001 mg/m3 Ca TWA 0.001 mg/m3	TWA 0.5 mg/m3 [skin] TWA 1 mg/m3 [skin]	Ca [5 mg/m3] Ca [5 mg/m3]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, chloracne; liver damage; reproductive effects; [potential occupational carcinogen]	Skin, eyes, liver, reproductive system	Colorless to pale-yellow, viscous liquid or solid (below 50°F) with a mild, hydrocarbon odor BP: 689-734°F, 617-691°F Fl.Pt. = NA, NA LEL: NA UEL: NA Nonflammable Liquid, but exposure in a fire results in the formation of a black soot containing PCBs, polychlorinated dibenzofurans, and chlorinated dibenzo-p-dioxins.
Petroleum Hydrocarbons									
Gasoline	86290-81-5	TWA 300 ppm STEL 500 ppm	Ca	None	Ca [N.D.]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, mucous membrane; dermatitis; headache, lassitude (weakness, exhaustion), blurred vision, dizziness, slurred speech, confusion, convulsions; chemical pneumonitis (aspiration liquid); possible liver, kidney damage; [potential occupational carcinogen]	Eyes, skin, respiratory system, central nervous system, liver, kidneys	Clear liquid with a characteristic odor BP: 102°F Fl.Pt. = -45°F LEL: 1.4% UEL: 7.6%

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Abbreviations:

ACGIH – American Conference of Governmental Industrial Hygienists.
BP – boiling point at 1 atmosphere, °F
C – Ceiling, is a concentration that should not be exceeded during and part of the working exposure.
Ca – Carcinogenic.
CAS# - Chemical Abstracts Service registry number which is unique for each chemical.

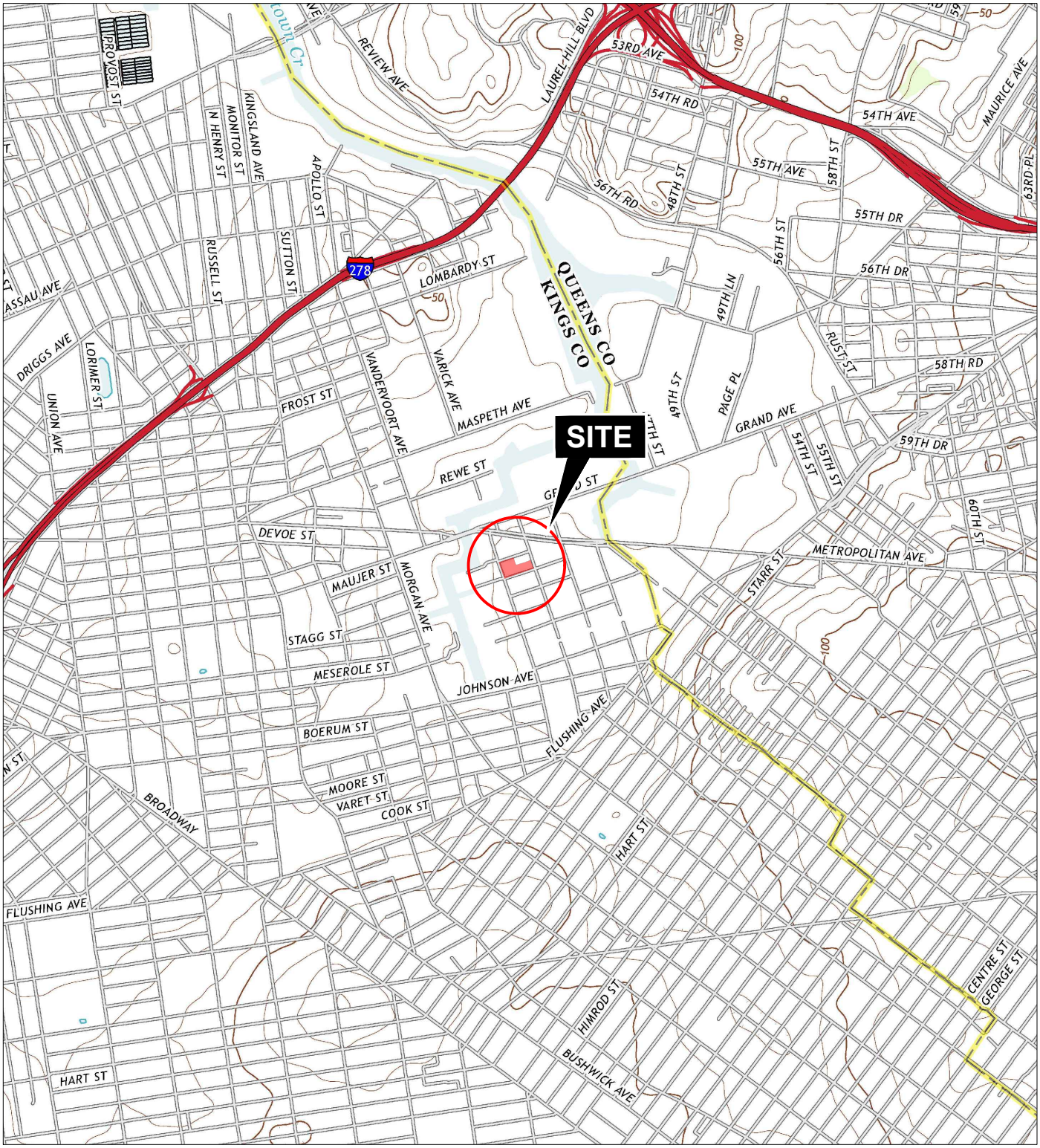
Table 1. Toxicological, Physical, and Chemical Properties of Compounds Potentially Present at the Site.

Compound	CAS #	ACGIH TLV	NIOSH REL	OSHA PEL	IDLH	Routes of Exposure	Toxic Properties	Target Organs	Physical/Chemical Properties

DSEN - Dermal Sensitization
Ft Pt. – Flash point
IDLH - Immediately Dangerous to Life and Health concentrations represent the maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without a respirator and without experiencing any escape-impairing or irreversible health effects.
LEL – Lower explosive (flammable) limit in air, % by volume (at room temperature)
mg/m^3 – Milligrams of substance per cubic meter of air
NIOSH - National Institute for Occupational Safety and Health.
OSHA – Occupational Safety and Health Administration
OTO - Ototoxicant
PEL - OSHA Permissible Exposure Limit (usually) a time weighted average concentration that must not be exceeded during any 8 hour work shift of a 40 hr work week.
ppm – parts per million
REL – NIOSH Recommended Limit indicated a time weighted average concentration that must not be exceeded during any 10 hour work shift of a 40 hr work week
RSEN - Respiratory Sensitization
SG - Specific Gravity
STEL – ACGIH Short-term exposure limit (ST)
TLV - ACGIH Threshold Limit Values (usually 8 hour time weighted average concentrations).
TWA – 8-hour, time-weighted average
UEL – Upper explosive (flammable) limit in air, % by volume (at room temperature)
VP - Vapor Pressure

FIGURES

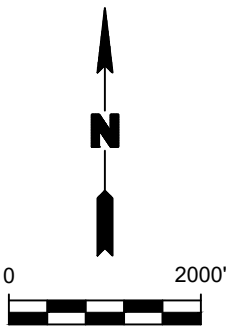
1. Site Location Map
2. Site Plan with Emergency Muster Area



QUADRANGLE LOCATION



SOURCE:
USGS, 2013, Brooklyn, NY
7.5 Minute Topographic Quadrangle



Title:

SITE LOCATION MAP

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: T.B.	Date: 4/16/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	1
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.02.DWG		

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LEGEND

SITE BOUNDARY

EMERGENCY MUSTER POINT

N

40' 0 40'

Title:

SITE PLAN WITH EMERGENCY MUSTER POINT

BCP SITE NO. C224422
213 MEADOW STREET, BROOKLYN, NEW YORK

Prepared for:

GO QUAY, LLC

ROUX

Compiled by: T.B.	Date: 4/17/2026	FIGURE
Prepared by: G.M.	Scale: AS SHOWN	2
Project Mgr: L.C.	Project: 3084.0003Y000	
File: 3084.0003Y1001.01.DWG		

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APPENDICES

A. Job Safety Analysis (JSA) Forms
B. Safety Data Sheets (SDSs) for Chemicals Used
C. Heat Illness Prevention Program
D. Personal Protective Equipment (PPE) Management Program
E. Subsurface Utility Clearance Management Program
F. Heavy Equipment Exclusion Zone Policy
G. Resumes of Key Personnel

APPENDIX A

Job Safety Analysis (JSA) Forms

JOB SAFETY ANALYSIS	Ctrl. No. GEN-003	DATE 4/10/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)
GENERIC	**Construction - Excavation**	**Backfilling Excavation & Compaction**

DEVELOPMENT TEAM	POSITION / TITLE	REVIEWED BY:	POSITION / TITLE
David Kaiser	Project Engineer	Brian Hobbs	CHSD
Edward Lacina	Senior Construction Manager		

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ AIR PURIFYING RESPIRATOR	☒ GLOVES: Leather/ cut-resistant level 2
☒ HARD HAT	☐ FACE SHIELD	☐ SUPPLIED RESPIRATOR	☐ OTHER _____
☐ LIFELINE / BODY HARNESS	☒ HEARING PROTECTION	☒ PPE CLOTHING: reflective DOT approved safety	
☒ SAFETY GLASSES	☒ SAFETY TOE BOOTS		

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Payloader, Backhoe, Dump Trucks, Mechanical gas powered tampers, Excavator with hydraulic tamper. APR when tamping if dust present. Two-way radios.

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs.

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone (HEEZ) around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Pre-construction meeting: Review proposed excavation locations	**1a. CONTACT:** Potential for contact with subsurface utilities and above ground utilities	1a. Call state 811 for mark out service and one call ticket. 1a. Obtain private utility mark out service as necessary. 1a. Review and mark proposed excavations w/white paint. 1a. Identify all "Critical" zones. A Critical zone is any area within 10 feet of any operating utility. 1a. Complete subsurface clearance checklist. 1a. Soft dig must be conducted within 2 lateral feet of any suspected underground utility. 1a. Protection of aboveground utilities identified as being located within the work zone must be coordinated w/ client and utility owner.
2. Secure Work Area	**2a. CONTACT:** Potential for personnel to enter the work area. Potential for equipment to contact, or crush personnel. **2b. EXERTION:** Potential for muscle strain or tear while installing traffic cones and barrel	2a. Ensure work area is secure and inform others of work activity. Establish a HEEZ using 42" traffic cones, barrels & snow fencing or telescoping poles. Use of flag persons to maintain clear traffic and to minimize motorist confusion during set-up of new traffic pattern. HEEZ to include tip/swing radius of equipment. 2a. Dump Truck/Excavator/Payloader/Backhoe equipment to be set-up by personnel who are familiar with machinery. Spotters shall be in place for all equipment. and to control access to the HEEZ 2a. Truck wheels are chocked when driver is not in truck and engine shut off. 2a. Personnel shall stay out of the exclusion zone (10' minimum or greater than the equipment boom) while equipment is maneuvering. 2b. Keep back straight, keep load close to the body and bend knees while lifting and working. If over 50 lbs., use 2 or more laborers for lifting or use of equipment.

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3. Backfilling excavation, and compaction	**3a. CONTACT:** Traffic and live equipment. . **3b. EXPOSURE:** Fumes from gas powered tamper **3c. FALL:** Slips, trips, fall hazards. **3d. OVEREXERTION:** Muscle strain, or tear. **3e. EXPOSURE:** Noise from tamper. Dust inhalation.	3a. Equipment and trucks shall be isolated from other workers, subcontractors and third party traffic with 42" traffic cones, barricades, snow fencing or telescoping poles, and/or Jersey barriers. Spotters shall direct dump truck for placement of fill near excavation. Pay loader/ Excavator, as directed by spotter, shall move fill into trench where it shall be placed in layers and compacted by mechanical means. 3a. Spotters will wear florescent vests at all times. 3a. Spotters will remain out of the exclusion zone, line-of-fire from equipment and third-party vehicles. 3a. Spotters and operators will have radios for communication, when other visual and/or hand signals are insufficient. 3a. Locate all overhead utilities. All personnel and machinery should maintain a minimum 10' distance from overhead electric lines. Refer to OSHA chart for distances and voltage. 3a. For excavations engineered (shored, sloped, benched} all personnel, equipment, and materials must remain a minimum of 2 feet from edge of excavation. 3b. Fueling of all equipment will be done outside of work area in a well-ventilated area. Refueling will be done only after a 2-5-minute cool down. 3c. Work area will be clean and free of any debris to remove slip, trip and fall hazards. All tools will be kept in designated areas. Insure work area is well illuminated. 3c. Workers should only be working in areas that have been leveled with a machine. 3c. All persons working at elevations over 6' shall use a guardrail system or personal fall arrest system while around excavation. 3d. Keep knees bent and back straight while transferring/ lifting/lowering tamper from elevated areas. Utilize a co-worker to avoid staining muscles. 3d. Keep knees bent and back straight while maneuvering tamper. Utilize a co-worker to avoid staining muscles. 3e. Workers will wear hearing protection during compaction tamper activities. 3e. Wear NIOSH approved dust mask for personal comfort. If dust is visible for extended time, limit by wetting down area. 3e. If dust continues stop work and evaluate if increase in APR is needed with approval and clearance.
4. Secure/leave site.	**4a. FALL:** Slip, trip, fall	4a. Clear work area of all debris and store all equipment in designated areas/containers before opening to traffic. 4a. Replace fencing and barricades as needed to secure path before opening roadway or area up to traffic(vehicle, pedestrian and/or bicycle).

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-006	DATE 4/10/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY:	WORK TYPE:	WORK ACTIVITY (Description):	
Generic	**Drilling**	**Direct Push Soil Borings / Well Installation**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
Timothy Zei	Project Hydrogeologist	Raymond Olson	OHSM
		Brian Hobbs	CHSD

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST ☒ HARD HAT ☐ LIFELINE / BODY HARNESS ☒ SAFETY GLASSES	☐ GOGGLES ☐ FACE SHIELD ☒ HEARING PROTECTION: (as needed) ☒ SAFETY SHOES: Composite-toe or steel toe boots	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☒ PPE CLOTHING: Fluorescent reflective vest or high visibility clothing, Long Sleeve Shirt	☒ GLOVES: Leather, Nitrile and cut resistant ☒ OTHER: Insect Repellant, sunscreen (as needed)

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Geoprobe or Truck-Mounted Direct Push Drill Rig, Hand Tools, Photoionization Detector, Multi-Gas Meter (or equivalent), Macrocore liners, Liner Opening Tool, 20 lb. Type ABC Fire Extinguisher, 42" Cones & Flags, "Work Area" Signs, Water

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

"SHOW ME YOUR HANDS"
Driller and helper should show that hands are clear from controls and moving parts

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Mobilization of drilling rig (ensure the Subsurface Clearance Protocol and Drill Rig Checklist are completed)	**1a. CONTACT:** Equipment/property damage.	1a. The drill rig's tower/derrick will be lowered and secured prior to mobilization. 1a. A spotter should be utilized while moving the drill rig. If personnel move into the path of the drill rig, the drill rig will be stopped until the path is again clear. Use a spotter for all required backing operations. 1a. Set-up the work area and position equipment in a manner that eliminates or reduces the need for backing of support trucks and trailers. 1a. When backing up truck rig with an attached trailer use a second spotter if there is tight clearance simultaneously on multiple sides of the equipment or if turning angles limit driver visibility. 1a. Inspect the driving path for uneven terrain. Level or avoid if needed. 1a. Drill rig should have a minimum **exclusion zone which encompasses its tip radius** for non-essential personnel (i.e., driller helper, geologist) when the rig is moving/ in operation.
	1b. FALL: Slip/trip/fall hazards.	1b. Inspect walking path for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions prior to mobilizing equipment. 1b. Do not climb over stored materials/equipment; walk around. Practice good housekeeping. 1b. Use established pathways and walk on stable, secure ground.
	1c. CONTACT: Crushing from roll-over.	1c Geoprobe should cross all hills/obstructions head on with the mast down to reduce risk of roll-over.
2. Raising tower/derrick of drill rig	**2a. CONTACT:** Overhead hazards.	2a. Prior to raising the tower/derrick, the area above the drilling rig will be inspected for wires, tree limbs, piping, or other structures, that could come in contact with the rig's tower and/or drilling rods or tools. 2a. Maintain a safe distance of 10' from overhead structures.
	2b. CONTACT: Pinch Points/Amputation Points when raising the rig and instability of rig	2b. Inspect the equipment prior to use and avoid pinch/amputation points. 2b. Lower outriggers to ensure stability prior to raising rig tower/derrick. 2b. If the rig needs to be mounted, be sure to use three points of contact.
3. Advancement of drilling equipment and well installation	**3a. CONTACT:** Flying debris	3a. Be aware of and avoid potential line-of-fire hazards and wear required PPE such as eye, ear, and hand protection.
	3b. EXPOSURE: Noise and dust.	3b. Wet borehole area with sprayer to minimize dust. 3b. Stand upwind and keep body away from rig. 3b. Dust mask should be worn if conditions warrant. 3b. Wear hearing protection when the drill rig is in operation.
Assess [1]JOB STEPS	**Analyze [2]POTENTIAL HAZARDS**	**Act [3]CRITICAL ACTIONS**

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3. Advancement of drilling equipment and well installation (Continued)	**3a. CONTACT:** Flying debris **3b. EXPOSURE:** Noise and dust. **3c. FALL:** Slip/trip/fall hazards. **3d. CAUGHT:** Limb/extremity pinching; abrasion/crushing. **3e. CONTACT:** Equipment imbalance during advancement of drill equipment. **3f. EXPOSURE:** Inhalation of contamination/vapors. **3g. EXERTION:** Potential for muscle strain/injury while lifting and installing well casings, lifting sand bags, and/or lifting rods.	3c. Contain drill cuttings and drilling water to prevent fall hazards from developing in work area. 3c. See 1b. 3d. Ensure all Emergency Safety Stop buttons function properly. 3d. Always wear leather gloves when making connections and using hand tools; wear cut-resistant (i.e., Kevlar) gloves when handling cutting tools. 3d. Inspect the equipment prior to use for potential pinch/amputation points. Keep hands away from pinch/amputation points and use of tools is preferable compared to fingers and hands. 3d. Inspect drill head for worn surface or missing teeth; replace if damaged or blunt. 3d. Ensure all jewelry is removed, loose clothing is secured, and PPE is secured close to the body. 3d. All non-essential personnel should stay away from the immediate work area; position body out of the line-of-fire of equipment. 3d. Drillers and helpers will understand and use the "Show Me Your Hands" Policy. 3d. Spinning rods/casing have an **exclusion zone of tip radius** while in operation. 3e. Drillers will advance the borehole with caution to avoid causing the rig to become imbalanced and/or tip. 3e. The blocking and leveling devices used to secure the rig will be inspected by drillers and Roux personnel regularly to see if shifting has occurred. 3e. In addition, personnel and equipment that are non-essential to the advancement of the borehole will be positioned away from the rig at a distance that is at least as far as the boom is high (**minimum exclusion zone**). 3f. Monitor ambient air for dangerous conditions using a calibrated photoionization detector (PID) to periodically monitor the breathing zone of the work area. 3f. If a reading of >5ppm is recorded, the Roux field personnel must temporarily cease work, instruct all Site personnel to step away from the area of elevated readings and inform the Roux PM of the condition. The Roux PM will then recommend additional precautions in accordance with the site specific health and safety plan. 3f. Use a multi-gas meter to monitor ambient air for dangerous conditions (i.e. unsafe levels of carbon monoxide when drilling indoors or the presence of explosive vapors). 3g. Keep back straight and bend at the knees. 3g. Utilize team lifting or mechanical means for objects over 50lbs. 3g. Use mechanical lifting device for odd shaped objects.
4. Remove sample liner.	**4a. EXERTION:** Potential for muscle strain/injury while removing liner from probe rod. **4b. CONTACT:** Pinch points and cuts **4c. EXPOSURE:** Inhalation and/or dermal contact with contaminants.	4a Utilize team lifting or mechanical means for objects over 50lbs. 4a. Use hydraulic liner extruder if available. 4b. Place liner on sturdy surface when opening. 4b. Don cut-resistant gloves and use appropriate liner cutter when opening liners. 4b. Always cut away from the body. 4c. Wear chemical-resistant disposable gloves when handling liners. 4c. See 3f.
5. Decontaminate equipment.	**5a. EXPOSURE/CONTACT**: To contamination (e.g., Separate Phase Hydrocarbons (SPH), contaminated groundwater, vapors). **5b. EXPOSURE:** To chemicals in cleaning solution including ammonia.	5a. Wear chemical-resistant disposable gloves and safety glasses. 5a. Contain decontamination water so that it does not spill. 5a. Use an absorbent pad to clean spills, if necessary. 5a. Spray equipment from side angle, not straight on, to avoid backsplash. 5a. See 3b and 3f. 5b. See 4a. Review SDS to ensure appropriate precautions are taken and understood.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-009	DATE: 4/10/2023	☐ NEW ☒ REVISED	PAGE 1 of 1

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)
Generic	**O&M**	**Movement of 55-Gallon Drums/Drum Handling with Mobile Carrier**

DEVELOPMENT TEAM	POSITION / TITLE	REVIEWED BY:	POSITION / TITLE
Michael Sarni	Technician	Brian Hobbs	CHSD

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ AIR PURIFYING RESPIRATOR	☒ GLOVES: Cut-resistant gloves
☒ HARD HAT	☐ FACE SHIELD	☐ SUPPLIED RESPIRATOR	☐ OTHER:
☐ LIFELINE / BODY HARNESS	☐ HEARING PROTECTION	☒ PPE CLOTHING: Fluorescent long sleeve shirt or long sleeve shirt and reflective safety vest.	
☒ SAFETY GLASSES	☒ SAFETY SHOES: Steel or composite toe		

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Mobile Drum Carrier, over-pack drum container, safety cones, and caution tape

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment (i.e. forklift) and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Preparing for and Inspection of Drum	**1a. FALL:** Tripping/falling due to uneven surface. Loose debris/garbage in work area.	1a. Clear area of loose garbage and debris. Inspect 55-gal drums for proper condition, labeling, check drum ring and bolts for tightness, inspect mobile drum carrier. 1a. Do a Test Lift to get a general sense of the weight of the drum. 1a. Inspect and use established pathways to avoid uneven terrain, weather-related hazards (i.e., debris, puddles, ice, etc.), and other obstructions. 1a. Secure work area and coordinate and communicate the planned work activities with other personnel working in the area. 1a. Delineate work area with 42" safety cones.
	1b. CONTACT/EXPOSURE: Drums could potentially be damaged or contain hazardous material. Mobile drum carrier could potentially be in poor working condition causing malfunctioning during operation.	1b. Prior to inspecting drums don cut-resistant gloves. If drum is not properly labeled, do not open and cease all drum transport activities. Immediately contact project manager and inform him/her of drum situation. 1b. Do not continue drum transport activities until further actions are determined by the project manager. 1b. If the drum is properly labeled, but leaking, improperly sealed or in poor condition, place drum in an over-pack drum. 1b. Inspect mobile drum carrier to ensure its overall integrity. Look for rust marks or potential weak points where the drum carrier could malfunction. Inspect the wheels to ensure that they easily turn and nothing is impeding their movement.
	1c. EXERTION/CAUGHT: Potential pinching/exertion hazards while securing ring/ tightening bolts	1c. Keep back straight and knees slightly bent while securing drum ring/tightening bolt. Wear cut-resistant gloves.
2. Position drum clamp tightly in between drum ribs, securing drum clamp to drum with chain	**2a. CAUGHT:** Pinching fingers between drum clamp and handle/chain.	2a. Attach drum clamp with chain and tighten until snug. Do not place hands between drum clamp and drum as the chain is tightened; wear cut resistant gloves. Keep face away from drum when handling in case of escaping vapors.

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Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
3. Disengage safety latches on handle, pull handle down until drum is lifted off ground and safety latches are reengaged; slightly suspending drum off the ground	**3a. EXERTION/ CONTACT:** Potential muscle strain associated with lifting/engaging drum/handle. Drum could shift/slip downward and crush toes.	3a. Ascertain whether the drum is overweight; if it is, then two people are needed to lower handle while drum is secured with clamp so that safety latches can be engaged. Keep body out of the lin-of-fire of the handle (do not position head above handle) as it is being pushed down. Do not allow feet/toes to be positioned under the drum as it is being lifted; wear steel/composite-toed boots.
	3b. CAUGHT: Fingers could be pinched while engaging/disengaging safety latches on handle	3b. Wear cut-resistant gloves while disengaging/reengaging safety latches. 3b. Avoid placing hands in pinch points.
4. Transport drums to designated location and disengage drum clamp (repeat Step 3 in reverse order)	**4a. FALL:** Tripping/ falling due to obstructions and uneven terrain. Potential for drum to fall during transport.	4a. Ensure transport path is free of potential obstructions that may cause the drum/carrier to become unstable. Position drum clamp between the ribs on the drum to prevent possible slipping.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-011	DATE: 4/10/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)
Generic	**Construction - Excavation**	**Excavation / Trenching**

DEVELOPMENT TEAM	POSITION / TITLE	REVIEWED BY:	POSITION / TITLE
David Kaiser	Senior Engineer	Brian Hobbs	CHSD
Tim Unalp	SHSO		

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ AIR PURIFYING RESPIRATOR	☒ GLOVES: Leather or cut resistant
☒ HARD HAT	☐ FACE SHIELD	☐ SUPPLIED RESPIRATOR	☐ OTHER
☒ LONG SLEEVED SHIRT	☒ HEARING PROTECTION	☒ PPE CLOTHING: Fluorescent reflective vest or high visibility long sleeved clothing	
☐ LIFELINE / BODY HARNESS	☒ SAFETY SHOES: Steel-toe boots		
☒ SAFETY GLASSES			

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Jackhammer, Excavator, Backhoe, Hand Tools, Photoionization Detector, barrels, 42" traffic cones, snow fencing, telescoping poles, temporary chain link fence, ladders, shovels, digging bars, power tools (cut-off saw), Two-way radios, Sheeting, Trench box, Retractable lanyard, Harness

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Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Pre-Clearance Protocol.	**1a. CONTACT:** Damage to underground utility.	1a. Confirm that (if applicable) "Call Before You Dig" and local utility companies were contacted prior to trenching in order to confirm utility mark outs. Must have a case # before digging.
	1b. ENERGY SOURCE/CONTACT: Property damage; Pressurized water mains may cause lacerations or broken bones. Pressurized gas mains may explode causing serious injury, or death. Underground electric may cause severe burns, shock, or death.	1b. Pre-clearing of the trenching location must be conducted to a minimum of 5 vertical feet below the ground surface (10 feet minimum for Critical Zone) using soft digging methods or hand tools (shovel and non-metallic dig bar) prior to trenching. Supervisor should be contacted to discuss appropriate pre-clearing depth. **1b. Complete subsurface clearance checklist**.
	1c. FALL: Slip, Trip or Fall may cause muscle strains or tears, abrasions, lacerations, or broken bones.	1c. Be aware of the conditions when walking or loading equipment and working. Walk within established pathway avoiding uneven surfaces. Remove potential slip/trip/fall hazards.
2. Set up work zone.	**2a. CONTACT/CAUGHT:** Cuts/lacerations from equipment. Broken bones from contact by vehicle.	2a. Isolate work area from hazards with cones, barricades, and snow fencing, telescoping poles or temporary chain link fence. Utilize a flag person when necessary (i.e., third party traffic in area). Install traffic signs in roadways and for detours. Spotters will maintain and enforce exclusion zone.
	2b. FALL: Slip, Trip or Fall may cause muscle strains or tears, abrasions, lacerations, or broken bones.	2b. See 1c.

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Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
3. Trenching Activity.	**3a. CONTACT:** Serious injury including broken bones, muscle strains or tears, and possibly death due to contact with machine.	3a. Spotter(s) required for all heavy equipment operation. No worker shall be allowed inside the exclusion zone or along the trench/excavation area while any equipment is in operation. A minimum exclusion zone greater than the length of the equipment boom must be established. Workers only allowed in exclusion zone if the operator is in "Hands Off "mode. Operator will not operate equipment until worker is out of exclusion zone. Spotters and operators will have radios for communication, when either loses sight of one another, and/or in case of emergency.
	3b. FALL: Slip, Trip or Fall may cause muscle strains or tears, abrasions, lacerations, or broken bones	3b. Any trench/excavation deeper than 3' must have a ladder within 25' of any worker in the excavation. At least 3'(rungs) of the ladder shall be above the top of the excavation. All spoil piles shall be maintained 2' minimum from edge of excavation. 3b. Any trench/excavation deeper than 6' must have fall protection, retractable lanyard for ladder use, and 42" high guardrails along the edge of the trench/excavation.
	3c. EXPOSURE: Noise, Dust, Concrete- Asphalt, petroleum hydrocarbon vapors may cause damage to ears and lungs	3c. Air monitoring using a calibrated photoionization detector (PID) will be used to monitor the breathing zone of the work area. If a reading of >5ppm is recorded, the oversight personnel must temporarily cease work and instruct all Site personnel to step away from the area of elevated readings.
4. Setting Trench protections if necessary.	**4a. CAUGHT:** Injury due to contact with failed trench, may include muscle strains or tears, abrasions or lacerations, broken bones and possibly death.	4a. To prevent cave-ins and avoid caught by/between, excavations over 4' in depth, unless working in stable rock, shall have engineer approved shoring, sheeting or trench box. Top of protection shall be at least 2' above top of excavation.
	4b. CONTACT/CAUGHT: Injury due to rigging activities and entering exclusion zone during lifting and/or transport of shoring/trench box/material may include muscle strains or tears, abrasions or lacerations, broken bones and possibly death.	4b. Use only inspected rigging with 2, 3 or 4 lift points; wear cut-resistant gloves. Rigging to be hooked up to factory installed hook up points on equipment. Control load with non-conductive tag lines with workers out of exclusion zone. Don't stand underneath suspended load; wear steel toed boots and hard hat.
	4c. FALL: Possible injury due to fall into excavation may include muscle strains or tears, abrasions or lacerations, or broken bones.	4c. Shoring to be set and sides will be backfilled to avoid fall hazards before workers are allowed to enter area. Operator will be in "HANDS OFF" mode before workers enter work area to unhook rigging. An inspected ladder extending 3' above top of the shoring will be used to enter and exit the excavation. Workers will use three points of contact when using the ladder.
5. Secure/Leave Site. If backfilling, see excavation backfilling and compaction JSA for potential hazards and critical actions.	**5a. FALL:** Potential Slip, Trip or Fall - may cause muscle strains or tears, abrasions or lacerations, or broken bones.	5a. See 1c. 5a. All open excavations must be backfilled or secured prior to departure with steel plates, orange construction fence or temporary chain link fencing.

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[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift". Avoid general statements such as, "be careful".

JOB SAFETY ANALYSIS Ctrl. No. GEN-013	DATE 4/10/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE:	WORK ACTIVITY (Description):	
Generic	**Gauging and Sampling**	**Gauging and Sampling**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
Tim Unalp	SHSO	Brian Hobbs	CHSD

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☒ LIFE VEST ☒ HARD HAT ☐ LIFELINE / BODY HARNESS ☒ SAFETY GLASSES	☐ GOGGLES ☐ FACE SHIELD ☐ HEARING PROTECTION ☒ SAFETY SHOES: Composite-toed or steel-toed boots	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☒ PPE CLOTHING: Fluorescent reflective vest or high visibility clothing	☒ GLOVES: Leather, Nitrile and cut resistant ☒ OTHER: Knee pads, Insect Repellant, sunscreen (as needed)

REQUIRED AND / OR RECOMMENDED EQUIPMENT

42-inch Safety Cones, Caution Tape, Interface Probe with Ground Clamp, and/or Water Level Meter, 20-lb., Type ABC Fire Extinguisher, Buckets. Tools as needed: Socket Wrench, Screw Driver, Crow Bar, Mallet, and Wire Brush.

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Mobilization to monitoring well(s).	**1a. FALL:** Personal injury from slip/trip/fall due to uneven terrain and/or obstructions.	1a. Inspect pathway and plan for most suitable designated pathway prior to mobilization. 1a. Use established pathways, walk and/or drive on stable, secure ground and avoid steep hills or uneven terrain. 1a. If working near open water with an unguarded edge, wear life vest.
	1b. CONTACT: With traffic/third parties.	1b. Identify potential traffic sources and delineate work area with 42-inch traffic safety cones. Position vehicle to protect against oncoming traffic. Use caution tape to provide a more visible delineation of the work area if necessary. 1b. Wear appropriate PPE including high visibility clothing or reflective vest. 1b. Face traffic, maintain eye contact with oncoming vehicles, and establish a safe exit route.
	1c. EXERTION: Muscle strain from lifting equipment	1c. Use proper lifting techniques when handling/moving equipment; bend knees and keep back straight. 4c. Use mechanical assistance or team lifting techniques when equipment is 50 lbs. or heavier. 4c. Make multiple trips to carry equipment.
	1d. EXPOSURE: To biological hazards.	1d. Inspect work area for bees and insects. 1d. Use insect/tick repellent as necessary.
2. Open/close well.	**2a. EXERTION:** Muscle strain.	2a. Use proper lifting techniques; keep back straight, lift with legs and bend knees when reaching to open/close well.
	2b. CAUGHT: Pinch/crush points associated with removing/replacing manholes and working with hand tools.	2b. Wear leather gloves or cut resistant gloves when working with well cover and hand tools. 2b. Use proper tools (ratchet and pry bar or magnet for well cover) and inspect before use. 2b. Do not put fingers under well cover.
	2c. CAUGHT: Pinch points associated with placing J-plug back onto PVC pipe.	2c. See 2b. 2c. Keep fingers out of line-of-fire when securing cap.
	2d. EXPOSURE: To potential hazardous vapors.	2d. No open flames/heat sources. 2d. To minimize exposure to vapors, allow well to vent after opening it and before sampling activities begin. 2d. Stand up-wind if possible, to avoid inhaling vapors.
3. Gauge well.	**3a. CONTACT:** With contamination (e.g. contaminated groundwater).	3a. Wear chemical-resistant disposable gloves (over cut-resistant gloves) and safety glasses when gauging well. 3a. Insert and remove probe slowly to avoid splashing. 3a. Use an absorbent pad to clean probe.
	3b. CONTACT: With traffic.	3b. See 1b.
	3c. Exposure: To static electricity, fire or explosion.	3c. Ground interface probe to a designated grounding point/rod, well casing or suitably electrically conductive surface to dissipate static electricity.

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[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift". Avoid general statements such as, "be careful".

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
4. Purge and sample well	**4a. EXPOSURE/CONTACT:** To contamination (e.g., SPH, contaminated groundwater, vapors) and/or sample preservatives.	4a. Open and fill sample jars slowly to avoid splashing and contact with preservatives. 4a. Wear cut-resistant gloves and chemical-resistant disposable gloves when sampling. 4a. Fill sample containers over purge container to avoid spilling water onto the ground. 4a. Use an absorbent pad to clean spills. 4a. When using a bailer to purge a well, pull the bailer slowly from the well to avoid splash hazards. 4a. When sampling or purging the water using a bailer, pour out water slowly to reduce the potential for splash hazards with groundwater. 4a. When using a tubing valve always remove the valve slowly after sample collection to release any pressure and avoid pressurized splash hazards. 4a. When collecting a groundwater sample always point sampling apparatus (tubing, bailer, etc.) away from face and body.
	4b. CONTACT: Personal injury from cuts, abrasions, or punctures by glassware or sharp objects.	4b. To avoid spills or breakage, place sample ware on even surface. 4b. Do not over tighten caps on glass sample ware. 4b. Wear chemical-resistant nitrile disposable gloves over cut-resistant (i.e., Kevlar) gloves when sampling and handling glassware (i.e., VOA vials) or when using cutting tools.
	4c. EXERTION: Muscle strain while carrying equipment.	4c. Use proper lifting techniques when handling/moving equipment, bend knees and keep back straight. 4c. Use mechanical assistance or team lifting techniques when equipment is 50 lbs. or heavier. 4c. Make multiple trips to carry equipment.
	4d. CONTACT: With traffic.	4d. See 1b.
	4e. CONTACT: Pinch points with groundwater pump components (i.e., wheel, line, clamps).	4e. Wear leather/cut-resistant gloves when working with groundwater pumps. 4e. Never place hands on or near pinch points such as the wheel, clamps or other moving parts during pump operations. 4e. Use the correct mechanisms, such as a pump reel, to lower pump into well. 4e. Never attempt to manually stop any moving part of equipment including hose reels and/or tubing.
	4f. EXERTION: Muscle strain from repetitive motion of bailing and sampling a well.	4f. See 4c. 4f. Include a stretch break when repetitive motions are part of the task.
5. Management of purge water.	**5a. EXPOSURE/CONTACT:** To contamination (e.g., SPH, contaminated groundwater, vapors).	5a. Do not overfill container and pour liquids slowly so that they do not splash. 5a. Properly dispose of used materials/PPE in appropriate container in designated storage area.
	5b. EXERTION: Muscle strain from lifting/carrying and moving containers.	5b. Use proper lifting techniques when lifting / carrying or moving container(s) (see 4c.). 5b. Do not overfill container(s).
6. Decontaminate equipment.	**6a. EXPOSURE/CONTACT:** To contamination (e.g., SPH, contaminated groundwater, vapors).	6a. Work on the upwind side, where possible, of decon area. 6a. Wear chemical-resistant disposable gloves and safety glasses. 6a. Use an absorbent pad to clean spills.
	6b. CAUGHT: Pinch points associated with handling hand tools	6b. See 2b. 6b. Inspect hand tools for sharp edges before decontaminating.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-014	DATE: 4/10/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY:	WORK TYPE:	WORK ACTIVITY (Description):	
Generic	**Drilling**	**Hollow Stem Auger Soil Borings / Well Installation**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
Douglas Ferraiolo	Project Geologist	Brian Hobbs	CHSD
Tim Unalp	SHSO		

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST ☒ HARD HAT ☐ LIFELINE / BODY HARNESS ☒ SAFETY GLASSES	☒ GOGGLES: Spoggles required if winds exceed 15 mph. ☐ FACE SHIELD ☒ HEARING PROTECTION: (as needed). ☒ SAFETY SHOES: Steel or Composite Toe.	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☒ PPE CLOTHING: Fluorescent long-sleeve shirt or long-sleeve shirt and reflective safety vest.	☒ GLOVES: Leather, Cut-Resistant, and Nitrile. ☒ OTHER: Insect Repellant, Sunscreen (as needed).

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Truck-Mounted Drilling Rig or Track Rig, Saw, Hand Tools, Photoionization Detector, Multi-Gas Meter (or equivalent), Interface Probe, 20 lb. Type ABC Fire Extinguisher, 42" Cones & Flags, "Work Area" Signs.

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

"SHOW ME YOUR HANDS"
Driller and helper should show that hands are clear from controls and moving parts

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Mobilization / demobilization and establish a work area.	**1a. See Mobilization/ Demobilization JSA GEN-015.**	1a. See Mobilization / Demobilization JSA GEN-015.
2. Raising tower / derrick of drilling rig.	**2a. CONTACT:** Overhead hazards.	2a. Prior to raising the tower / derrick, the area above the drilling rig will be inspected for overhead hazards (wires, tree limbs, piping or other structures) that may be contacted by the rig's tower or drilling rods. 2a. The tower / derrick must not be raised beneath overhead power lines unless approved by the Roux PM. 2a. Maintain a minimum of 10' from all overhead structures. 2a. Do not move the rig while the tower / derrick is raised.
	2b. CONTACT: Amputation / crush points when raising the rig and instability of rig.	2b. Inspect the equipment prior to use and avoid any potential amputation points. 2b. Lower outriggers to ensure stability prior to raising rig tower derrick. Keep feet and body out of the line of fire when lowering out-riggers. 2b. Inspect the set-up location for uneven terrain. Level or avoid area if needed. 2b. If the rig needs to be mounted, be sure to use three points of contact.
3. Advancement of augers for soil boring installation.	**3a. CONTACT:** Equipment imbalance during advancement of drill equipment.	3a. Drillers will advance the borehole with caution to avoid causing the rig to become imbalanced and / or tip. 3a. The blocking and leveling devices used to secure the rig will be inspected by drillers and Roux personnel regularly to see if shifting has occurred. **3a. Drillers will maintain the "Purple Zone" policy surrounding augers to ensure no personnel come into contact with augers while in use. Workers will spray paint a 3' semi-circle surrounding the augers to visually show that no personnel should enter the "Purple Zone" while drilling activities are being conducted.** 3a. In addition, personnel and equipment that are non-essential to the advancement of the borehole will be positioned away from the rig at a distance that is at least as far as the boom is high (minimum exclusion zone of 20 feet).
	3b. CONTACT: Flying / spraying debris.	3b. Wear all required PPE (especially hand, eye, and ear protection). 3b. Maintain minimum EZ distance (i.e. swing/tip radius of rig) when rig is in operation to avoid potential line of fire hazards from flying materials or debris.
	3c. CAUGHT: Limb/extremity amputation, abrasion, and crushing.	3c. Inspect the equipment prior to use for potential pinch points. 3c. Test all emergency shutdown devices prior to drilling. 3c. Inspect drill head for worn surface or missing teeth; replace if damaged or blunt. 3c. Inspect augers, do not use if auger flight is damaged or bent.
Assess	**Analyze**	**Act**

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[1]JOB STEPS	[2]POTENTIAL HAZARDS	[3]CRITICAL ACTIONS
3. Advancement of augers for soil boring installation (Continued).		3c. Ensure all jewelry is removed, loose clothing is secured, and PPE is secured close to the body. 3c. All non-essential personnel should stay away from the immediate work area; position body out of the line-of-fire of equipment particularly when installing auger flights and steel override casings. 3c. Drillers and helpers will understand and use the "Show Me Your Hands" Policy. 3c. Spinning augers should have an exclusion zone of 20 feet when in operation.
	3d. FALL: Slip/trip/fall hazards.	3d. Inspect walking path for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions prior to mobilizing equipment. 3d. Do not climb over stored materials/equipment; walk around. Practice good housekeeping. 3d. Use established pathways and walk on stable, secure ground. 3d. Use three points of contact when mounting or dismounting the rig. 3d. Remove soil cuttings to avoid a tripping hazard from developing near augers.
	3e. EXPOSURE: Inhalation of contamination / vapors.	3e. Air monitoring using a calibrated photoionization detector (PID) to periodically monitor the breathing zone of the work area. 3e. The Action Level for breathing zone air is five parts per million (sustained) as detected by the PID. 3e. If a reading of >5ppm is recorded, the Roux field personnel must temporarily cease work, instruct all Site personnel to step away from the area of elevated readings and inform the Roux PM of the condition. The Roux PM will then recommend additional appropriate precautions in accordance with the site specific health and safety plan.
	3f. EXPOSURE: Noise and dust.	3f. Wet borehole area with sprayer to minimize dust. Stand upwind and keep body positioned away from rig. 3f. Wear hearing protection while drill rig is operating and / or the noise levels exceed 85 dBA.
	3g. EXERTION: Installing well casings and lifting augers.	3g. Keep back straight and bend at the knees. 3g. Utilize team lifting for objects heavier than 50lbs. 3g. Use mechanical lifting device for odd shaped objects.
4. Installation of well materials.	**4a. CONTACT:** Installing well materials while also pulling up augers. **4b. CAUGHT:** Possible pinch or crush hazard assembling PVC and sending down the borehole. **4c. FALL:** Slip/trip/fall hazards with hand tools and materials. **4d. EXPOSURE:** Potential contamination, harmful vapors, dust, and / or noise. **4e. EXERTION:** Lifting heavy bags of materials to backfill borehole.	4a. Potential contact with augers during installation of well materials. 4a. Keep distance from augers and do not place any materials while augers are in motion. 4b. Keep all body parts out of potential pinch points while placing PVC together and sending down borehole. 4c. See 3d. 4d. See 3e and 3f. 4d. Stand upwind to avoid exposure to dust generated from packing materials. 4e. See 3g.
5. Cleaning the auger flights	**5a. CONTACT:** Cuts/scrapes or puncture wound from contacting auger.	5a. Follow "Show Me Your Hands" Procedure and make sure auger is out of gear before contacting auger with tool or hand. 5a. Pull cleaning tool across your body with handle away from body; do not push toward the auger. 5a. Do not clean more than ¾ turn around the auger at a time. 5a. Wear cut resistant and leather gloves. 5a. Always use two hands to operate cleaning tool. 5a. Inspect tool before use and remove from service if handle or metal are cracked/fatigued. 5a. Stand out of the line of fire.
6. Decontaminate equipment.	**6a. EXPOSURE / CONTACT:** To contamination (e.g., contaminated groundwater, vapors). **6b. EXPOSURE**: To chemicals in cleaning solution (including ammonia).	6a. Wear chemical-resistant disposable gloves and safety glasses. 6a. Contain decontamination water so that it does not spill. 6a. Use an absorbent pad to clean spills, if necessary. 6b. See 3e. Wear all appropriate PPE and stand upwind of any exposed cleaning solutions.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-015	DATE: 4/10/2023	☐NEW ☒REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)	
GENERIC	**Site Recon**	**Mobilization/Demobilization**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
Tim Unalp	SHSO	Brian Hobbs	CHSD

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST ☒ HARD HAT ☐ LIFELINE / BODY HARNESS ☒ SAFETY GLASSES	☐ GOGGLES ☐ FACE SHIELD ☒ HEARING PROTECTION (as needed) ☒ SAFETY SHOES: Steel Toe or composite toe	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☒ PPE CLOTHING: Fluorescent reflective vest of high-visibility clothing; long sleeve shirt; long pants	☒ GLOVES: Leather, nitrile, and cut resistant (as needed) ☐ OTHER

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Required Equipment: Varies

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Mobilize/demobilize and establish work area	**1a. FALL:** Slip/trips/falls from obstructions, uneven terrain, weather conditions, heavy loads, and/or poor housekeeping.	1a. Use 3 points-of-contact/ensure secure footing when entering and exiting vehicle. 1a. Inspect walking path for uneven terrain, steep hills, obstructions, and/or weather-related hazards (i.e., ice, snow, and puddles) prior to mobilizing equipment. Use established pathways. Walk on stable/secure ground. 1a. Do not climb over stored materials/equipment; walk around. Practice good housekeeping; organize and store equipment neatly in one area at its lowest potential energy. 1a. Wear boots with adequate treads. 1a. Delineate unsafe areas with 42” cones, caution tape and/or flagging.
	1b. CONTACT: Personal injury and/or property damage caused by being struck by Site traffic or equipment used in Site activities.	1b. Observe and maintain the posted speed limits. 1b. When first arriving onsite, park vehicles in designated parking space and/or out of the way locations. Use parking brake on all vehicles and tire chocks on work trucks and trailers. 1b. Check in with Site Manager/Supervisor to ensure coordination with other Site activities and to discuss any special hazards. Ensure that short-service employees (SSE) are identified. 1b. Identify potential traffic sources. 1b. Wear PPE including high visibility clothing or reflective vest. 1b. Use a spotter while moving work vehicles; plan ahead to avoid backing whenever possible. 1b. Maintain a minimum exclusion zone when vehicles are in motion (i.e. greater than swing/tip radius of equipment). When backing up truck rig with an attached trailer use a second spotter if there is tight clearance simultaneously on multiple sides of the equipment or if turning angles limit driver-to-spotter visibility. 1b. Delineate work area with 42” cones, flags, caution tape, and/or other barriers. 1b. Position “Work Area” signs at Site entrances, if possible, or at either side of work area.

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Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
		1b. Position largest vehicle to protect against oncoming traffic. 1b. Face traffic, maintain eye contact with oncoming vehicles, use a spotter, and establish a safe exit route. 1b. Observe potential overhead and ground surface features that may interfere with moving equipment. Clear the path of physical hazards prior to initiating mobilization.
	1c. CAUGHT: Personal injury from pinch points and being in line-of-fire of vehicle and/or equipment.	1c. Make sure driver has engaged parking brake and placed wheel chocks in a position to prevent movement. Be sure that vehicle is parked in front/down gradient (positioned to best block oncoming traffic) of work area. 1c. Wear leather gloves when handling any tools or equipment. Wear cut-resistant gloves (Kevlar or similar) when handling sharp objects/cutting tools/glass. 1c. Keep body parts away from line-of-fire of equipment. 1c. Always carry tools by the handles and/or designated carrier. Ensure sharp-edged tools are sheathed/secure. 1c. Remove any loose jewelry. Avoid wearing loose clothing and/or ensure loose clothing is secure. 1c. Secure all items on the equipment, tighten up any items or features that have potential to shift or break during mobilization.
	1d. OVEREXERTION: Muscle strains while lifting/carrying equipment.	1d. Use body positioning and lifting techniques that avoid muscle strain; keep back straight, lift with legs, turn with whole body, keep load close to body, and never reach with a load. 1d. Ensure that loads are balanced. Use assistance (mechanical or additional person) to carry equipment that is either unwieldy or over 50 lbs.
	1e. EXPOSURE: Personal injury from exposure to biological and environmental hazards.	1e. Inspect area to avoid contact with biological hazards (i.e. poisonous plants, stinging insects, ticks, etc.). 1e. Wear long sleeved clothes treated with Permethrin, apply insect repellant containing DEET to exposed skin, and inspect clothes and skin for ticks during and after work. 1e. Apply sunscreen (SPF 15+) if exposure to sun for 30 minutes or more is expected.
	1f. EXPOSURE: Weather related injuries.	1f. Watch for heat stress symptoms (muscle cramping, exhaustion, dizziness, nausea, rapid and shallow breathing). Take breaks in cool places and hydrate as needed. 1f. Watch for cold stress symptoms (severe shivering, slowing of body movement, weakness, stumbling or inability to walk, collapse). Take breaks in warm areas as needed. 1f. Wear clothing appropriate for weather and temperature conditions (e.g., rain jackets, snow pants, multiple layers). 1f. If lightning is observed, wait 30 minutes in a sheltered location (car is acceptable) before resuming work.
	1g. EXPOSURE: Personal injury from noise hazards.	1g. Wear hearing protection if sound levels exceed 85 dBA (if you must raise your voice for normal conversation).

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-019	DATE: 4/10/2023	☐NEW ☒REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)
GENERIC	**Site Reconnaissance**	**Site Walk and Inspection**

DEVELOPMENT TEAM	POSITION / TITLE	REVIEWED BY:	POSITION / TITLE
Sara Barrientos	Project Geologist	Brian Hobbs	Corporate Health and Safety Director
Tim Unalp	SHSO	Joe Duminuco	Executive Vice President

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST ☒ HARD HAT ☐ LIFELINE / BODY HARNESS ☒ SAFETY GLASSES	☐ GOGGLES ☐ FACE SHIELD ☒ HEARING PROTECTION: ear plugs as necessary ☒ SAFETY SHOES: Steel or composite toed	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☒ PPE CLOTHING: High-visibility vest or high-vis outerwear	☒ GLOVES: Leather/cut-resistant/chemical resistant ☒ OTHER: Tyvek and rubber boots as necessary, dust mask as necessary

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Required Equipment: Site map, emergency contact list, documentation of urgent care/hospital routes and / or guide familiar with Site, operating cell phone or walkie-talkie if Site allows, and bug spray.

Commitment to Safety – All personnel onsite will actively participate in SPSA performance by verbalizing SPSAs throughout the day.

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

SITE SECURITY: Prior to site inspection verify appropriate method to address Site Security concerns as it relates to potential criminal activity, homeless population, and/or isolation concerns. Work with the Project Principal and/or Project Manager to address appropriately.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Check in with Site contact.	**1a. CONTACT/EXPOSURE/FALL:** Personal injury caused by lack of awareness of site-specific hazards.	1a. Inquire about hazards and other activities taking place at the Site. 1a. Inform Site contact of work scope, timeline and location(s). 1a. Discuss emergency evacuation procedures and muster points with Site contact.
2. Traversing the Site	**2a. CONTACT:** Property damage and personal injury caused by obstructions/vehicles or unauthorized personnel at remote Sites.	2a. All equipment must be stowed and secured prior to moving. 2a. Maintain speed limit as posted on-site. 2a. When possible, drive on established roadways. 2a. Yield to all pedestrians. 2a. Use pull-through spots or back into parking spots. 2a. Don high visibility clothing/safety vest. If working at remote Site, add orange accessories during hunting season.
	2b. FALL: Uneven terrain and weather conditions. Overgrown shrubs and vines. Equipment in the work zone.	2b. Inspect walking path for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions prior to mobilizing equipment. 2b. When possible, use established pathways and walk on stable, secure ground. 2b. Communicate traversing hazards with others.
	2c. OVEREXERTION: Muscle strain while carrying equipment.	2c. When carrying equipment to/from work area, use proper lifting techniques; keep back straight, lift with legs, keep load close to body, never reach with a load. Ensure that loads are balanced to reduce the potential for muscle strain. Use the buddy system or mechanical means to maneuver items heavier than 50-lb. If necessary, make multiple trips to carry equipment.
	2d. EXPOSURE: Biological hazards – ticks; bees/wasps; poison ivy; insects; (Ticks are most active any time the temperature is above freezing, typically from March to November.)	2d. Inspect area to avoid contact with biological hazards. 2d. Ticks: • Treat outer clothing including pants, shirts, socks, boots and hats the evening before with Permethrin (allowing at least two hours before use). • Apply DEET to exposed skin before travelling to the Site and reapply after two hours. • Check for ticks during and after work. 2d. Bees: • Use bee spray as appropriate to deter/eliminate bees.

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[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift". Avoid general statements such as, "be careful".

	2e. EXPOSURE: Heat Stress & Cold Stress. Personal injury from working in inclement weather conditions.	• Protect exposed skin with insect repellent. 2d. Poison Ivy: • Identify areas of poison ivy and spray with weed killer. Don Tyvek and rubber boots while traversing poison ivy areas. • If skin contacts poison ivy, wash skin thoroughly with soap and water. 2e. Wear sunscreen with SPF 15 or greater on exposed skin whenever 30 minutes or more of sun exposure is expected. 2e. Watch for heat stress symptoms (muscle cramping, exhaustion, dizziness, rapid and shallow breathing). Take breaks as needed. 2e. Watch for cold stress symptoms (severe shivering, slowing of body movement, weakness, stumbling or inability to walk, collapse). Take breaks as needed. 2e. Wear appropriate rain gear as needed. 2e. Take frequent breaks if tired, wet, or cold/hot. Drink water. 2e. If lightning is observed, wait 30 minutes after last thunder boom/lightning bolt in a sheltered location (car acceptable) before starting work again.
3. Walking near heavy equipment and machinery.	**3a. CONTACT:** Personal injury from Site and roadway traffic. Personal injury from flying debris **3b. OVEREXERTION:** Personal injury from lifting/moving/rotating equipment. **3c. EXPOSURE:** Hearing damage from noise generating equipment/processes. Inhalation/exposure to hazardous vapors and or dust. **3d. EXPOSURE:** Working in a remote area.	3a. See 2a. 3a. Maintain an exclusion zone of at least 10'-25' feet from all engaged equipment. 3a. Keep body parts out of the line-of-fire of pinch points. 3a. Wear appropriate PPE always. 3b. See 2c. 3c. Wear hearing protection if >85 dBA. (i.e. noise levels which require you to raise your voice to communicate) 3c. Always wear leather gloves when handling any tools or equipment. 3c. Always wear appropriate PPE based off chemicals present. 3d. Use the "buddy system" whenever possible. If working alone, contact PM upon arrival/departure, as well as during work activities prior to commencing work if applicable. 3d. Always carry a communication device (i.e., cell phone, walkie-talkie) or directional (i.e., map, compass, etc.) when traversing remote areas. 3d. If available, follow Lone Worker Protocol/Procedure.
4. Working in adverse weather conditions.	**4a. EXPOSURE:** Heat Stress & Cold Stress. Personal injury from working in inclement weather conditions.	4a. Watch for heat stress symptoms (muscle cramping, exhaustion, dizziness, rapid and shallow breathing). Take breaks as needed. 4a. Watch for cold stress symptoms (severe shivering, slowing of body movement, weakness, stumbling or inability to walk, collapse). Take breaks as needed. 4a. Wear appropriate rain gear as needed. 4a. Take frequent breaks if tired, wet, or cold/hot. Drink water. 4a. If lightning is observed, wait 30 minutes after last thunder boom/lightning bolt in a sheltered location (car acceptable) before starting work again.
5. Departing Site.	**5a. EXPOSURE:** Exposure to unnecessary hazards should personnel believe Roux is on-Site during an emergency and conduct a search.	5a. Sign out or notify Site contact and Roux Project Manager of your departure.

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[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift". Avoid general statements such as, "be careful".

JOB SAFETYANALYSIS Ctrl. No. GEN-020	DATE: 04/11/2023	☐NEW ☒REVISED	PAGE 1 of 2

JSA TYPE CATEGORY:	WORK TYPE:	WORK ACTIVITY (Description):	
GENERIC	**Gauging & Sampling**	**Soil Sampling**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
MaryBeth Lyons	Project Scientist	Brian Hobbs	CHSD
Tim Unalp	SHSO		

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ AIR PURIFYING RESPIRATOR	☒ GLOVES: Leather, Nitrile and cut resistant
☒ HARD HAT	☐ FACE SHIELD:	☐ SUPPLIED RESPIRATOR	
☐ LIFELINE / BODY HARNESS	☒ HEARING PROTECTION: (as needed)	☒ PPE CLOTHING: Fluorescent reflective vest or high visibility clothing	☒ OTHER: Insect repellant, sunscreen (as needed)
☒ SAFETY GLASSES			
☒ FLAME RESISTANT CLOTHING (as needed)	☒ SAFETY SHOES: Composite-toe or steel toe boots		

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Recommended Equipment: 42” traffic cones, caution tape, trowel

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs.

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Secure location	**1a. CONTACT:** Personnel and vehicular traffic may enter the work area.	1a. If in an area with foot or vehicle traffic, delineate the work area with 42” traffic cones and/or caution tape to prevent exposure to traffic and inform others of work activity. 1a. Wear reflective vest and/or high visibility clothing. 1a. Face the direction of any vehicular traffic. Position vehicle to protect worker from traffic. 1a. Communicate work activity with adjacent work areas.
	1b. FALL: Tripping/falling due to uneven terrain or entry/exit from excavations.	1b. Inspect pathways and work area for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions. 1b. Use established pathways and walk on stable, secure ground. 1b. Stage equipment and tools in a convenient, stable, and orderly manner. Store equipment at lowest potential energy. 1b. Roux employees should stay 5 feet from in-progress excavations and trenches. Should entry to an excavation be required (when stabilization is complete), ladders must be employed for steep embankments, excavations, pits, and trenches.
	1c. EXPOSURE: Exposure to sun and excessive heat, possibly causing sunburn, heat exhaustion or heat stroke. Exposure to cold temperatures possibly causing cold stress. Skin burn as a result of fire, if applicable. Exposure to explosive vapors due to tank farm operations. Exposure to airborne dust due to high wind speeds. Biological hazards - ticks, bees/wasps, poison ivy, thorns, insects, etc.	1c. Wear sunscreen with an SPF 15 or greater whenever 30 minutes or more of exposure is expected. 1c. Use a tent to shade the work area from direct sunlight particularly when warm temperatures are expected. 1c. Be aware of the location of all Site personnel. 1c. Watch for heat stress symptoms (muscle cramping, exhaustion, dizziness, rapid and shallow breathing). 1c. Watch for cold stress symptoms (severe shivering, slowing of body movement, weakness, stumbling or inability to walk, collapse). 1c. Take breaks for rest and water as necessary. Move to an area that is well shaded or a climate controlled area (i.e., car, site trailer, etc.). 1c. No open flames/heat sources. 1c. Conduct air monitoring and ensure that harmul vapor concentrations are within the levels detailed in the Site Specific HASP. Follow procedures detailed in HASP for exceedances. 1c. Flame retardant clothing must be worn when specified by Site policy. 1c. Cell phones should be disabled when specified by Site policy. 1c. Pre-treat field clothing with Permethrin prior to site visit to kill ticks and insects. 1c. Wear long sleeved shirts and tuck in (or tape) pant legs into socks or boots to prevent ticks from reaching skin. 1c. Spray insect repellant containing DEET on exposed skin when working in overgrown areas of the Site. 1c. Inspect area to avoid contact with biological hazards. 1c. Wear cut-resistant gloves when handling branches, shrubs, etc. that may lie within the walking path. 1c. Wear spoggles if the average wind speeds are above 15 mph. 1c. Personnel shall examine themselves and co-worker’s outer clothing for ticks periodically when onsite. 1c. If skin comes in contact with poison ivy, wash skin thoroughly with soap and water. If rash persists after washing, immediately notify your supervisor, the OM and OHSM for possible consultation with a physician at an approved Occupational Health Clinic.

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Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
2. Collect Soil Sample	**2a. CONTACT:** Personal injury from pinch points, cuts, and abrasions from sampling equipment tools, and material within soil sample. Personal injury from contact with moving equipment while sampling. Personal injury from contact with glass sample jars.	2a. Wear cut-resistant (i.e., Kevlar) gloves under chemical-resistant (nitrile) disposable gloves when handling soil samples and sampling jars. 2a. Where possible, use trowel or equivalent tool to avoid contact with soil. 2a. If sampling from bucket of heavy equipment, ensure all equipment is off and operator utilizes the "show me your hands" policy. 2a. See 1a.
	2b. EXPOSURE: Exposure to contamination (impacted soil) and/or lab preservatives.	2b. Wear chemical-resistant (nitrile) disposable gloves over cut resistant gloves to protect hands when handling samples; use containment material or plastic sheeting to protect surrounding areas. 2b. Wear safety glasses to protect eyes from dust or air-borne contaminants that may results from disturbing the soil. 2b. Where possible, remain upgradient from sample location if collecting soil sample from stockpile, drill rig, etc. to avoid breathing contaminant vapors, if they are present. 2b. When collecting soil sample from hand auger, put large zip lock bag over entire auger to prevent spillage of soil on to the ground. 2b. Open sample jars slowly and fill carefully to avoid contact with preservatives.
	2c. EXERTION: Exertion due to repetitive motion and ergonomics.	2c. Utilize a table or raised surface for soil sampling if multiple soil samples are going to be taken to minimize repetitive bending motion.
3. Decontaminate equipment	**3a. EXPOSURE/CONTACT:** Contamination (e.g., Separate Phase Hydrocarbons (SPH), contaminated vapors and/or soil). **3b. EXPOSURE:** Chemicals in cleaning solution including ammonia.	3a. Wear chemical-resistant (nitrile) disposable gloves and safety glasses. 3a. Use an absorbent pad to clean spills. 3a. Properly dispose of used materials/PPE in provided drums in designated drum storage area. 3a. Remain upwind of sample and avoid breathing contaminant vapors, if they are present. 3b. Wear chemical-resistant (nitrile) disposable gloves and safety glasses. 3b. Work on the upwind side of decontamination area. 3b. Use an absorbent pad to clean spills. 3b. Properly dispose of used materials/PPE in provided drums in designated drum storage area. Ensure that all drums are properly labeled and secured.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-023	DATE: 04/11/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)	
Generic	**Construction**	**Spotting Heavy Machinery**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
Levi Curnutte	Senior Scientist	Brian Hobbs	CHSD
Tim Unalp	SHSO		

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ Particulate Respirator	☒ GLOVES: Cut resistant / leather
☒ HARD HAT	☐ FACE SHIELD	☐ SUPPLIED RESPIRATOR	☐ OTHER:
☒ LONG SLEEVED SHIRT	☐ HEARING PROTECTION	☒ PPE CLOTHING: Fluorescent reflective clothing	
☐ LIFELINE / BODY HARNESS	☒ SAFETY SHOES: Steel-/Composite-toe boots/shoes		
☒ SAFETY GLASSES			

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Heavy Machinery (i.e. excavator, payloader, truck, forklift, etc.), two-way radios.

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Prepare for machine activity.	**1a. CONTACT:** Obstructions in the work area may create contact hazards from machinery.	1a. Cordon off the work area with safety barrels/cones and a rigid barrier (snow fence, traffic bar, etc.). Communicate that only necessary personnel should be in the work area. Spotter and equipment operator shall enforce the **EZ.** Operator will not operate but shall remain in the hands-off mode while personnel are within the exclusion zone.
	1b. Fall : Slip/Trip/Fall	1b. Ensure that work area is flat, level and clear of any obstructions or debris before setting up work zone.
2. Spotting.	**2a. CONTACT:** Machine or load contact with personnel, property, or machinery.	2a. Discuss the specifics of the work with the operator and be clear about any hand signals that will be used. Clearly discuss the limits of the assigned work area and the machine's Exclusion Zone. Maintain Exclusion Zone. The Exclusion Zone shall be delineated by using 42-inch traffic cones/barrels and a fixed rigid barrier. 2a. The Minimum Heavy Equipment Exclusion zone is greater than the swing/tip radius of equipment. 2a. Both the spotter and equipment operators shall have 2-way radios/cellular devices on their persons to ensure audible communication in the event any changes or new hazards may arise. 2a. All workers should stay outside of the Exclusion Zone of all equipment unless operator is stopped and in "Hands Off" mode. **(This includes the spotter unless an exception has been established in the Site-specific JSA).** If the Exclusion Zone must be reduced due to work area restrictions, then the spotter and operator shall enforce the reduced Exclusion Zone. 2a. Spotters must make eye contact with the machine operator or all movement ceases until visual contact can be reestablished. 2a. Spotter shall keep an eye out for any issues with the machine the operator may not see and communicate with other work crews and spotters on behalf of the operator. 2a. If the spotter needs to take a break, he must find a replacement before leaving or have the machine stop operations. **No heavy equipment shall operate without a spotter under any circumstances.** 2a. Wear fluorescent clothing/safety vest. 2a. **Do not multitask. Only perform Spotting**

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Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
	2b. FALL: Slip/Trip/Fall	2b. Look where walking to identify and avoid slip/trip/fall hazards. Avoid icy and/or wet surfaces. Remove obstacles if possible. 2b. Use designated walkways during spotting whenever possible. 2b. **Do not walk backwards. Always face the direction you are walking towards.**
	2c. CAUGHT: Caught between machinery and nearby objects.	2c. **Maintain Exclusion Zone.** Do not stand between large, loose or fixed objects or structures and the machinery while it is in motion. Keep in sight of operator at all times while being aware of surrounding structures.
	2d. EXPOSURE: Inhalation of exhaust from machinery.	2d. The spotter will position him/herself upwind of the working machinery, when possible. Spotter will also inform others working within the vicinity of the EZ of proper positioning, if applicable.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-025	DATE: 04/11/2023	☐ NEW ☒ REVISED	PAGE 1 of 1

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)
Generic	**General**	**Trucking**

DEVELOPMENT TEAM	POSITION / TITLE	REVIEWED BY:	POSITION / TITLE
Lauren Dolginko	Project Geologist	Brian Hobbs	CHSD
Tim Unalp	SHSO		

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ AIR PURIFYING RESPIRATOR	☒ GLOVES: Leather or cut resistant
☒ HARD HAT	☐ FACE SHIELD	☐ SUPPLIED RESPIRATOR	☐ OTHER
☐ LONG SLEEVED SHIRT	☐ HEARING PROTECTION	☒ PPE CLOTHING: Fluorescent reflective vest or high visibility long sleeved clothing	
☐ LIFELINE / BODY HARNESS	☒ SAFETY SHOES: Steel-toe boots		
☒ SAFETY GLASSES			

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Heavy equipment (i.e. trucks)

COMMITMENT TO SAFETY- All personnel onsite will actively participate in Hazard recognition and mitigation throughout the day by verbalizing SPSAs.

EXCLUSION ZONE (EZ): Maintain Minimum Heavy Equipment Exclusion Zone around equipment and loads while it is in motion. The HEEZ must be greater than the swing zone of any moving part of the equipment, tip zone of the equipment, fall zone of the equipment and contents, distance that debris may travel during demolition activities and/or foot print of a structure to be demolished.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Set up work zone.	**1a. CONTACT:** Personal injury/property damage caused by obstruction/vehicle.	1a. Establish work zone for manifesting/paperwork by communicating with workers before task begins. Maintain a minimum **Exclusion Zone (EZ)** around all heavy equipment.
2. Loading of truck.	**2a. CONTACT:** Rolling Vehicle could cause bodily harm.	2a. All commercial vehicles without an operator must have their engines off and wheels chocked. Truck and loading area should be on level and stable ground.
	2b. CONTACT: Machine or load may crush personnel, property or machinery.	2b. All machines (Excavator, Lull, Backhoe) must have a spotter. Spotter must communicate contact hazards such as other personnel in the work area, objects in the machine's blind spot, and overhead lines to the operator. Spotter and operator should have 2-way radios or established hand signals to communicate when needed. 2b. Loads must not be swung over other vehicles or personnel. 2b. Maintain **EZ** around all equipment.
	2c. CONTACT: Load shifting during travel.	2c. Secure all loads prior to moving the truck with chains or straps or cribbing. 2c. Any loose soil or debris should be cleaned off truck sides prior to truck mobilization. 2c. All truck beds must be secured prior to traveling.
3. Dumping loads.	**3a. CONTACT:** Truck may flip sideways or backwards.	3a. All workers must stay behind and away from the side of trucks that are dumping to avoid contact with flying debris and the truck potentially tipping sideways or backwards. EZ must be maintained equal to the height of bed while lifted.
4. Exchanging paperwork with truck driver.	**4a. CONTACT/CAUGHT:** Broken bones from contact by vehicle.	4a. Truck driver should exit truck with proper PPE, using the three-point stance, and enter the established work zone to complete paperwork. If Site-specific safety prohibits drivers from exiting the truck, wait until truck is finished loading, with engine turned off, before approaching truck. 4a. Always establish eye contact with driver prior to approaching truck. 4a. Confirm sides of truck have been cleaned/brushed off prior to approaching truck.
	4b. FALL: Slip, Trip or Fall may cause muscle strains or tears, abrasions or lacerations, or broken bones.	4b. Survey walking route to identify slip/trip/fall hazards. Avoid icy/wet surfaces. Remove slip/trip/fall hazards if present. 4b. Communicate with driver and spotter prior to approaching truck. Maintain **EZ** around all heavy equipment.

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JOB SAFETY ANALYSIS	Cntrl. No. GEN-027	DATE: 04/11/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)
GENERIC	**Drilling**	**Pre-Drilling Clearance, Vactron and Air Knife**

DEVELOPMENT TEAM	POSITION / TITLE	REVIEWED BY:	POSITION / TITLE
Courtney Rempfer	Project Scientist	Joseph Midwig	Senior Engineer
Sara Redding	Senior Hydrogeologist	Brian Hobbs	CHSD

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST ☒ HARD HAT ☐ LIFELINE / BODY HARNESS ☒ SAFETY GLASSES	☐ GOGGLES ☒ FACE SHIELD (While Air Knifing) ☒ HEARING PROTECTION (As needed) ☒ SAFETY SHOES: Composite toe or steel toe boots	☐ AIR PURIFYING RESPIRATOR ☐ SUPPLIED RESPIRATOR ☒ PPE CLOTHING: Fluorescent reflective vest or high visibility clothing; long-sleeve shirt	☒ GLOVES: Leather, Nitrile, cut-resistant ☒ OTHER: Dusk mask, insect repellant, sunscreen (as needed)

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Vac-Truck or Vac Drum, Compressor, Jack Hammer, Air Knife. Circular Saw, Hand Tools, Dust Mask, Photoionization Detector, Multi Gas Meter, 42 inch safety cones and flags, Retractable Cone Bars, Caution Tape, 20 lb. Fire Extinguisher, "Work Area" Signs, Pressurized Water Sprayer

Commitment to Safety – All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs

EXCLUSION ZONE: All non-essential personnel will maintain a distance of 10 feet from drilling equipment while equipment is moving/engaged

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Verify pre-clearance protocol	**1a. CONTACT:** Underground utility damage; property damage; personal injury.	1a. Confirm that (if applicable) "Call Before You Dig" and local utility companies were contacted prior to starting work in order to confirm utility mark outs. Must have a case # before digging. 1a Walk the Site to evaluate utility markings and review maps (see Site Walk Inspection JSA - GEN-019). Utilities are not always properly marked out, ensure use of observational skills through the pre-clearing checklist. 1a. Review pre-clearing checklist form and sub-surface clearance form. Pre-clearing protocol indicates that clearance must be conducted to a minimum of 5 vertical feet below ground surface or 10 vertical feet below ground surface in the critical zone using hand tools.
	1b. ENERGY SOURCE/CONTACT: Property damage; Pressurized water mains may cause lacerations or broken bones. Pressurized gas mains may explode causing serious injury, or death. Underground electric may cause severe burns, shock, or death.	1b. Pre-clearing of each soil boring/monitoring well location must be conducted to a minimum of 5 vertical feet below the ground surface (10 feet minimum for Critical Zone) using hand tools (shovel and non-metallic dig bar and hand auger) prior to drilling. Supervisor should be contacted to discuss appropriate pre-clearing depth. 1b. MUST Complete subsurface clearance checklist prior to pre-clearance.
	1c. FALL: Slip, Trip or Fall may cause muscle strains or tears, abrasions, lacerations, or broken bones.	1c. Be aware of the conditions when walking or loading equipment and working. Walk within established pathway avoiding uneven surfaces. Remove potential slip/trip/fall hazards.
2. Mobilize/demobilize and establish work area	**2a. SEE MOBILIZATION / DEMOBILIZATION JSA – GEN-015**	2a. See Mobilization / Demobilization JSA.
3. Concrete saw cutting, jack hammer and hand clearance with hand tools, air knife	**3a. CONTACT:** Flying debris striking face or body	3a Maintain 10' minimum exclusion zone. Use the required PPE (i.e., leather/cut proof gloves, safety glasses/face shield). 3a. Use anti-whip devices on compressor hoses. Ensure hose couplings are secure. 3a Wear a face shield to protect face from flying debris when using air knife. 3a. Utilize a traffic cone, cage or physical barriers over the hole during air knife activities to keep flying debris close to ground.
	3b. EXPOSURE: Inhalation/exposure to hazardous vapors and/or concrete dust, noise exposure	3b. Monitor breathing zone with a calibrated PID and/or multi-gas meter. If meters sustain readings greater than recommeneded in the HASP for the specific contaminant of concerns (COCs) the Roux field personnel must temporarily cease work, instruct all Site personnel to step away from the area of elevated readings. Contact PM. 3b. Wet concrete while using saw to minimize dust and wear dust mask to prevent inhalation. 3b. Stand upwind and keep body behind saw. Observers and helpers should avoid line-of-fire for saw blade. Always cut away from body. 3b. No open flames/heat sources.

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[2] A hazard is a potential danger. Break hazards into five types: Contact - victim is struck by or strikes an object; Caught - victim is caught on, caught in or caught between objects; Fall - victim falls to ground or lower level (includes slips and trips); Exertion - excessive strain or stress / ergonomics / lifting techniques; Exposure - inhalation/skin hazards.

[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift." Avoid general statements such as, "be careful."

	3c. ENERGYSOURCE/CONTACT: Property damage; Pressurized water mains may cause lacerations or broken bones. Pressurized gas mains may explode causing serious injury, or death. Underground electric may cause severe burns, shock, or death.	3b. Wear hearing protection when saw, jackhammer or air compressor are in operation. Otherwise, if sound levels exceed 85 dbA, put on hearing protection. 3c. For air knifing, ensure extention/lance tip reaches the full 5 feet bgs. Air knife should be advanced **AT A MINIMUM** in all four corners of the expected boring location to find any possible arrangement of utilities. 3c. Ensure diameter of soil preclearance hole is at a **MINIMUM 2x** the diameter of any drilling or hard dig equipment that will be entering the hole. 3c. See Complete subsurface clearance protocol for information provided above.
	3d. ERGONOMICS/EXERTION: Muscle strain due to poor body positioning when handling equipment and materials	3d. Use body positioning and lifting techniques that minimizes muscle strain; keep back straight, lift with legs, keep load close to body, and never reach with a load. 3d. Ensure that loads are balanced to reduce the potential for muscle strain. 3d. Two people or a mechanical lifting aid are required when lifting objects over 50 lbs. or when the shape makes the object difficult to lift.
	3e. FALL: Tripping/falling due to uneven terrain, weather conditions, and materials/equipment stored at the Site	3e. Inspect walking path for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions prior to mobilizing equipment. Mob/Demob JSA. 3e. Do not climb over stored materials/equipment; walk around. Practice good housekeeping. 3e. Use established pathways and walk on stable, secure ground. 3e. Equipment and tools will be stored at the lowest point of potential energy and out of the walkway and immediate work area (i.e. tools should not be propped against walls or nearby equipment or vehicles). 3e. Equipment and tools that are not anticipated to be used will be returned to a storage area that is out of the immediate work area. 3e. Ensure power cords and compressed air lines are grouped when used within the work area. 3e. Pre-cleared location will be finished flush to grade as to prevent a slip/trip hazard or coned and taped off.
	3f. CAUGHT: Amputation points associated with the equipment and vacuum hose	3f. Always wear leather gloves when making connections and using hand tools; wear cut-resistant (i.e., Kevlar) gloves when handling cutting tools. 3f. Inspect the equipment prior to use for potential pinch points. 3f. Test all emergency shutdown devices prior to using equipment. 3f. Inspect saw blade for worn surface or missing teeth; switch blade if damaged or blunt. 3f. Ensure all jewelry is removed, loose clothing is secured, and PPE is secured close to the body. 3f. All non-essential personnel shall maintain a 10 foot exclusion zone; position body out of the line-of-fire of equipment. 3f. Drillers and helpers will understand and use the “Show Me Your Hands Policy”.
4. Move drum to staging area using drum cart	**4a. EXPOSURE/CONTACT:** Contamination (e.g., Separate Phase Hydrocarbons (SPH), contaminated groundwater, soil)	4a. Wear Nitrile chemical-resistant gloves under leather or cut proof gloves. 4a. Do not overfill drums. Ensure that the drum lids are attached securely. 4a. All drums will be staged in the designated storage area.
	4b. EXERTION: Muscle strain while maneuvering drums with drum cart/lift gate	4b. See 3d. Do not overfill drums. Use lift gate on back of truck to load and unload drums. Use drum dolly to move drum.
	4c. CAUGHT: Pinch points associated with handling drum lid	4c. Ensure that fingers are not placed under the lid of the drum. Wear leather gloves or cut proof gloves. Use appropriate ratchet while sealing drum lid.
5. Decontaminate equipment.	**5a. EXPOSURE/CONTACT**: To contamination (e.g., Separate Phase Hydrocarbons (SPH), contaminated groundwater, vapors).	5a. Wear chemical-resistant disposable gloves and safety glasses. 5a. Contain decontamination water so that it does not spill. 5a. Use an absorbent pad to clean spills, if necessary. 5a. Spray equipment from side angle, not straight on, to avoid backsplash. 5a. See 3b.
	5b. EXPOSURE: To chemicals in cleaning solution.	5b. See 4a. Review SDS to ensure appropriate precautions are taken and understood.

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JOB SAFETY ANALYSIS	Ctrl. No. GEN-029	DATE: 4/11/2023	☐ NEW ☒ REVISED	PAGE 1 of 2

JSA TYPE CATEGORY	WORK TYPE	WORK ACTIVITY (Description)	
GENERIC	**Preclearing/Sampling**	**Hand Augering**	
DEVELOPMENT TEAM	**POSITION / TITLE**	**REVIEWED BY:**	**POSITION / TITLE**
Sean Owens	Senior Health & Safety Specialist	Brian Hobbs	Corporate Health & Safety Director

REQUIRED AND / OR RECOMMENDED PERSONAL PROTECTIVE EQUIPMENT

☐ LIFE VEST	☐ GOGGLES	☐ AIR PURIFYING RESPIRATOR	☒ GLOVES: Cut Resistant / Leather / Nitrile / Chemical resistant
☒ HARD HAT	☐ FACE SHIELD	☐ SUPPLIED RESPIRATOR	☐ OTHER
☐ LIFELINE / BODY HARNESS	☐ HEARING PROTECTION	☒ PPE CLOTHING: Long sleeve high visibility clothing	
☒ SAFETY GLASSES	☒ SAFETY SHOES: Steel or composite toed		

REQUIRED AND / OR RECOMMENDED EQUIPMENT

Hand Auger Tools (buckets, rods), 5-gallon buckets, hand tools (hammer, etc)

COMMITMENT TO SAFETY- All personnel onsite will actively participate in hazard recognition and mitigation throughout the day by verbalizing SPSAs.

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
1. Drive/walk to hand clearing/hand augering location	**1a. CONTACT:** Property damage and personal injury caused by obstructions/vehicles	1a. Maintain speed limit on-site. 1a. All equipment must be stowed and secured prior to moving. 1a. Drive on established roadways. 1a. Do not back up vehicle without spotter where visibility is limited; use pull-through spots or back into parking spots; use an audible signal (horn/back-up alarm) when backing up vehicles.1c.
	1b. FALL: Personal injury from tripping/falling due to uneven terrain, weather conditions, and materials/equipment stored at portions of the Site	1b. Inspect walking path for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions prior to mobilizing equipment. 1b. Do not climb over stored materials/equipment; walk around. Use established pathways and walk on stable, secure ground. 1b. Use established ramp when descending into/ascending from impoundment areas. 1b. Keep tools and equipment in a designated area. When not in use, tools and equipment must be returned to their proper storage location. Keep work area clear of obstructions.
	1c. EXERTION: Muscle strain/exhaustion while carrying equipment (i.e., hand auger, post-hole digger, shovel, pry bar)	1c. When carrying equipment to/from work area, use proper lifting techniques; keep back straight, lift with legs, keep load close to body, never reach with a load. Ensure that loads are balanced to reduce the potential for muscle strain. Use mechanical assistance or make multiple trips to carry equipment.
	1d. EXPOSURE: Exposure to sun, possibly causing sunburn Biological hazards - bees/wasps, poison oak, thorns, insects, etc.	1d. Wear sunscreen with an SPF of at least 15 whenever 30 minutes or more of exposure is expected. 1d. Inspect area to avoid contact with biological hazards. 1d. Wear cut resistant gloves when handling branches, shrubs, etc. that may lie within the walking path. 1d. Avoid any areas onsite that have poison oak.
2. Secure location	**2a. CONTACT:** Personnel and vehicular traffic may enter the work area.	2a. Delineate the work area with traffic cones and/or caution tape to prevent exposure to traffic and inform others of work activity. 2a. Wear reflective vest and/or fluorescent clothing. 2a. Face the direction of vehicular traffic. Position vehicle to protect worker from traffic. 2a. Communicate work activity with adjacent work areas.
	2b. FALL: Tripping/falling due to uneven terrain, and materials /equipment stored within the work area	2b. Inspect walking path for uneven terrain, weather-related hazards (i.e., ice, puddles, snow, etc.), and obstructions prior to mobilizing equipment to the impoundments. 2b. Equipment and tools will be staged in a convenient, stable, and orderly manner. 2b. Equipment and tools will be stored at the lowest point of potential energy and out of the walkway and immediate work area (i.e. tools should not be propped against walls or nearby equipment or vehicles). 2b. Equipment and tools that are not anticipated to be used will be returned to an appropriate storage area that is out of the immediate work area.

[1] Each Job or Operation consists of a set of tasks / steps. Be sure to list all the steps needed to perform job.
[2] A hazard is a potential danger. Break hazards into six types: Contact - victim is struck by or strikes an object; Caught - victim is caught on, caught in or caught between objects; Fall - victim falls to ground or lower level (includes slips and trips); Exertion - excessive strain or stress / ergonomics / lifting techniques; Exposure - inhalation/skin hazards; Energy Source – electricity, pressure, compression/tension.
[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift." Avoid general statements such as, "be careful."

Assess [1]JOB STEPS	Analyze [2]POTENTIAL HAZARDS	Act [3]CRITICAL ACTIONS
3. Verify pre-clearance protocol; review completed Subsurface Utility Checklist and utility verification site walkthrough.	**3a. ENERGY SOURCE:** Underground utility damage; property damage; personal injury	3a. Confirm that "Call Before You Dig" and local utility companies were contacted prior to hand augering. 3a. Walk the Site to evaluate utility markings and review maps.
4. Augering/advancing borehole	**4a. EXPOSURE:** Contaminated soil/water/vapor **4b. EXERTION:** Muscle strain from lifting, bending, repetitive motion. **4c. CAUGHT:** Personal injury as a result of jewelry/loose clothing caught on equipment, well covers, machinery, hand auger, pry bar etc.. **4d. CONTACT/CAUGHT:** Pinch points, abrasions	4a. Monitor breathing zone with a PID when VOCs area concern. If vapors sustain > 5 ppm, upgrade PPE as per HASP. 4a. Wear chemical-resistant disposable gloves and safety glasses when handling impacted materials. 4a. Place excavated soil on plastic sheeting and store soil waste in designated area. 4a. Work on the upwind side of the boring. 4b. Body positioning and rotating with the auger to reduce strain. Don't twist back. 4c. No form of jewelry should be worn while on-site. 4c. Clothing must be appropriately sized so it is not loose fitting. 4d. Keep head and upper body clear when lifting hand auger, pry bar/post-hole digger. Ensure to not be overly aggressive when using pry bar. 4d. Ensure all jewelry is removed, loose clothing is secured, and PPE is secured close to the body.
5. Lithologic observation and soil sampling	**5a. EXPOSURE:** Contact with contamination (impacted soil and/or lab preservatives)	5a. Wear chemical-resistant disposable gloves to protect hands when handling samples; wear safety glasses when handling any preservatives; use containment material or plastic sheeting to protect surrounding areas. 5a. When collecting soil sample from hand auger, put large zip lock bag over entire auger to prevent spillage of soil on to the ground. 5a. Open sample jars slowly and fill carefully to avoid contact with preservatives.
6. Decontaminate equipment	**6a. EXPOSURE:** Contact with contamination (impacted soil and/or lab preservatives, decontamination solution) **6b. CONTACT/CAUGHT:** pinch points and cuts/abrasions	6a. Wear chemical-resistant disposable gloves and safety glasses. 6a. Use an absorbent pad to clean spills. 6a. Properly dispose of used materials/PPE trash bags. 6b. Keep fingers/hands out of pinch points when dis-assembling hand auger during decontamination.

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[3] Using the first two columns as a guide, decide what actions or procedures are necessary to eliminate or minimize the risk. List the recommended safe operating procedures. Say exactly what needs to be done - such as "use two persons to lift". Avoid general statements such as, "be careful".

APPENDIX B

Safety Data Sheets (SDSs) for Chemicals Used

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

1 Identification of the substance/mixture and of the supplier

1.1 Product identifier

Trade Name: Alconox
Synonyms:
Product number: Alconox

1.2 Application of the substance / the mixture : Cleaning material/Detergent

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer
Alconox, Inc.
30 Glenn Street
White Plains, NY 10603
1-914-948-4040

Supplier
Not Applicable

Emergency telephone number:
ChemTel Inc
North America: 1-800-255-3924
International: 01-813-248-0585

2 Hazards identification

2.1 Classification of the substance or mixture:

In compliance with EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments.

Hazard-determining components of labeling:
Tetrasodium Pyrophosphate
Sodium tripolyphosphate
Sodium Alkylbenzene Sulfonate

2.2 Label elements:

Skin irritation, category 2.
Eye irritation, category 2A.

Hazard pictograms:



Signal word: Warning

Hazard statements:
H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:
P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P321 Specific treatment (see supplemental first aid instructions on this label).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P501 Dispose of contents and container as instructed in Section 13.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

Additional information: None.

Hazard description

Hazards Not Otherwise Classified (HNOC): None

Information concerning particular hazards for humans and environment:

The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.

Classification system:

The classification is according to EC regulation No. 1272/2008, 29CFR1910/1200 and GHS Rev. 3 and amendments, and extended by company and literature data. The classification is in accordance with the latest editions of international substances lists, and is supplemented by information from technical literature and by information provided by the company.

3 Composition/information on ingredients

3.1 Chemical characterization : None

3.2 Description : None

3.3 Hazardous components (percentages by weight)

Identification	Chemical Name	Classification	Wt. %
CAS number: 7758-29-4	Sodium tripolyphosphate	Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	12-28
CAS number: 68081-81-2	Sodium Alkylbenzene Sulfonate	Acute Tox. 4; H303 Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	8-22
CAS number: 7722-88-5	Tetrasodium Pyrophosphate	Skin Irrit. 2 ; H315 Eye Irrit. 2; H319	2-16

3.4 Additional Information : None.

4 First aid measures

4.1 Description of first aid measures

General information: None.

After inhalation:

Maintain an unobstructed airway.

Loosen clothing as necessary and position individual in a comfortable position.

After skin contact:

Wash affected area with soap and water.

Seek medical attention if symptoms develop or persist.

After eye contact:

Rinse/flush exposed eye(s) gently using water for 15-20 minutes.

Remove contact lens(es) if able to do so during rinsing.

Seek medical attention if irritation persists or if concerned.

After swallowing:

Rinse mouth thoroughly.

Seek medical attention if irritation, discomfort, or vomiting persists.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

4.2 Most important symptoms and effects, both acute and delayed

None

4.3 Indication of any immediate medical attention and special treatment needed:

No additional information.

5 Firefighting measures

5.1 Extinguishing media

Suitable extinguishing agents:

Use appropriate fire suppression agents for adjacent combustible materials or sources of ignition.

For safety reasons unsuitable extinguishing agents : None

5.2 Special hazards arising from the substance or mixture :

Thermal decomposition can lead to release of irritating gases and vapors.

5.3 Advice for firefighters

Protective equipment:

Wear protective eye wear, gloves and clothing.
Refer to Section 8.

5.4 Additional information :

Avoid inhaling gases, fumes, dust, mist, vapor and aerosols.
Avoid contact with skin, eyes and clothing.

6 Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures :

Ensure adequate ventilation.
Ensure air handling systems are operational.

6.2 Environmental precautions :

Should not be released into the environment.
Prevent from reaching drains, sewer or waterway.

6.3 Methods and material for containment and cleaning up :

Wear protective eye wear, gloves and clothing.

6.4 Reference to other sections : None

7 Handling and storage

7.1 Precautions for safe handling :

Avoid breathing mist or vapor.
Do not eat, drink, smoke or use personal products when handling chemical substances.

7.2 Conditions for safe storage, including any incompatibilities :

Store in a cool, well-ventilated area.

7.3 Specific end use(s):

No additional information.

Safety Data Sheet

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Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

8 Exposure controls/personal protection





8.1 Control parameters :

7722-88-5, Tetrasodium Pyrophosphate, OSHA TWA 5 mg/m3.

8.2 Exposure controls

Appropriate engineering controls:

Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use or handling.

Respiratory protection:

Not needed under normal conditions.

Protection of skin:

Select glove material impermeable and resistant to the substance.

Eye protection:

Safety goggles or glasses, or appropriate eye protection.

General hygienic measures:

Wash hands before breaks and at the end of work.
Avoid contact with skin, eyes and clothing.

9 Physical and chemical properties

Appearance (physical state, color):	White and cream colored flakes - powder	**Explosion limit lower**: **Explosion limit upper**:	Not determined or not available. Not determined or not available.
Odor:	Not determined or not available.	**Vapor pressure at 20°C**:	Not determined or not available.
Odor threshold:	Not determined or not available.	**Vapor density**:	Not determined or not available.
pH-value:	9.5 (aqueous solution)	**Relative density**:	Not determined or not available.
Melting/Freezing point:	Not determined or not available.	**Solubilities**:	Not determined or not available.
Boiling point/Boiling range:	Not determined or not available.	**Partition coefficient (n-octanol/water)**:	Not determined or not available.
Flash point (closed cup):	Not determined or not available.	**Auto/Self-ignition temperature**:	Not determined or not available.
Evaporation rate:	Not determined or not available.	**Decomposition temperature**:	Not determined or not available.

Safety Data Sheet

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Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

Flammability (solid, gaseous):	Not determined or not available.	**Viscosity**:	a. Kinematic: Not determined or not available. b. Dynamic: Not determined or not available.
Density at 20°C:	Not determined or not available.		

10 Stability and reactivity

10.1 Reactivity : None

10.2 Chemical stability : None

10.3 Possibility hazardous reactions : None

10.4 Conditions to avoid : None

10.5 Incompatible materials : None

10.6 Hazardous decomposition products : None

11 Toxicological information

11.1 Information on toxicological effects :

Acute Toxicity:

Oral:

: LD50 > 5000 mg/kg oral rat - Product .

Chronic Toxicity: No additional information.

Skin corrosion/irritation:

Sodium Alkylbenzene Sulfonate: Causes skin irritation. .

Serious eye damage/irritation:

Sodium Alkylbenzene Sulfonate: Causes serious eye irritation .

Tetrasodium Pyrophosphate: Rabbit - Risk of serious damage to eyes .

Respiratory or skin sensitization: No additional information.

Carcinogenicity: No additional information.

IARC (International Agency for Research on Cancer): None of the ingredients are listed.

NTP (National Toxicology Program): None of the ingredients are listed.

Germ cell mutagenicity: No additional information.

Reproductive toxicity: No additional information.

STOT-single and repeated exposure: No additional information.

Additional toxicological information: No additional information.

12 Ecological information

Safety Data Sheet

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Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

12.1 Toxicity:

Sodium Alkylbenzene Sulfonate: Fish, LC50 1.67 mg/l, 96 hours.
Sodium Alkylbenzene Sulfonate: Aquatic invertebrates, EC50 Daphnia 2.4 mg/l, 48 hours.
Sodium Alkylbenzene Sulfonate: Aquatic Plants, EC50 Algae 29 mg/l, 96 hours.
Tetrasodium Pyrophosphate: Fish, LC50 - other fish - 1,380 mg/l - 96 h.
Tetrasodium Pyrophosphate: Aquatic invertebrates, EC50 - Daphnia magna (Water flea) - 391 mg/l - 48 h.

12.2 Persistence and degradability: No additional information.

12.3 Bioaccumulative potential: No additional information.

12.4 Mobility in soil: No additional information.

General notes: No additional information.

12.5 Results of PBT and vPvB assessment:

PBT: No additional information.

vPvB: No additional information.

12.6 Other adverse effects: No additional information.

13 Disposal considerations

13.1 Waste treatment methods (consult local, regional and national authorities for proper disposal)

Relevant Information:

It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities. (US 40CFR262.11).

14 Transport information

14.1 UN Number: None
ADR, ADN, DOT, IMDG, IATA

14.2 UN Proper shipping name: None
ADR, ADN, DOT, IMDG, IATA

14.3 Transport hazard classes:
ADR, ADN, DOT, IMDG, IATA

Class: None
Label: None
LTD. QTY: None

US DOT
Limited Quantity Exception: None

Bulk:
RQ (if applicable): None
Proper shipping Name: None
Hazard Class: None
Packing Group: None
Marine Pollutant (if applicable): No additional information.

Non Bulk:
RQ (if applicable): None
Proper shipping Name: None
Hazard Class: None
Packing Group: None
Marine Pollutant (if applicable): No additional information.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

Comments: None	**Comments:** None
14.4 Packing group: ADR, ADN, DOT, IMDG, IATA	None
14.5 Environmental hazards :	None
14.6 Special precautions for user:	None
Danger code (Kemler):	None
EMS number:	None
Segregation groups:	None

14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code: Not applicable.

14.8 Transport/Additional information:

Transport category:	None
Tunnel restriction code:	None
UN "Model Regulation":	None

15 Regulatory information

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture.

North American

SARA

Section 313 (specific toxic chemical listings): None of the ingredients are listed.
Section 302 (extremely hazardous substances): None of the ingredients are listed.

CERCLA (Comprehensive Environmental Response, Clean up and Liability Act) Reportable

Spill Quantity: None of the ingredients are listed.

TSCA (Toxic Substances Control Act):

Inventory: All ingredients are listed.
Rules and Orders: Not applicable.

Proposition 65 (California):

Chemicals known to cause cancer: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for females: None of the ingredients are listed.

Chemicals known to cause reproductive toxicity for males: None of the ingredients are listed.

Chemicals known to cause developmental toxicity: None of the ingredients are listed.

Canadian

Canadian Domestic Substances List (DSL):
All ingredients are listed.

EU

REACH Article 57 (SVHC): None of the ingredients are listed.

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

Germany MAK: Not classified.

Asia Pacific

Australia

Australian Inventory of Chemical Substances (AICS): All ingredients are listed.

China

Inventory of Existing Chemical Substances in China (IECSC): All ingredients are listed.

Japan

Inventory of Existing and New Chemical Substances (ENCS): All ingredients are listed.

Korea

Existing Chemicals List (ECL): All ingredients are listed.

New Zealand

New Zealand Inventory of Chemicals (NZOIC): All ingredients are listed.

Philippines

Philippine Inventory of Chemicals and Chemical Substances (PICCS): All ingredients are listed.

Taiwan

Taiwan Chemical Substance Inventory (TSCI): All ingredients are listed.

16 Other information

Abbreviations and Acronyms: None

Summary of Phrases

Hazard statements:

H315 Causes skin irritation.
H319 Causes serious eye irritation.

Precautionary statements:

P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302+P352 If on skin: Wash with soap and water.
P305+P351+P338 If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P321 Specific treatment (see supplemental first aid instructions on this label).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362 Take off contaminated clothing and wash before reuse.
P501 Dispose of contents and container as instructed in Section 13.

Manufacturer Statement:

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

NFPA: 1-0-0

Safety Data Sheet

according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), 29CFR1910/1200 and GHS Rev. 3

Effective date: 12.08.2015 **Revision** : 12.10.2015

Trade Name: Alconox

HMIS: 1-0-0

SAFETY DATA SHEET

according to the (US) Hazard Communication Standard (29 CFR 1910.1200)

Revision Date 01/27/2015 Version 1.2

SECTION 1.Identification

Product identifier

Product number	HX0607
Product name	Hydrochloric Acid 34-37% OmniTrace®

Relevant identified uses of the substance or mixture and uses advised against

Identified uses	Reagent for research and development

Details of the supplier of the safety data sheet

Company	EMD Millipore Corporation | 290 Concord Road, Billerica, MA 01821, United States of America | General Inquiries: +1-978-715-4321 | Monday to Friday, 9:00 AM to 4:00 PM Eastern Time (GMT-5)
Emergency telephone	800-424-9300 CHEMTREC (USA) +1-703-527-3887 CHEMTREC (International) 24 Hours/day; 7 Days/week

SECTION 2. Hazards identification

GHS Classification

Corrosive to Metals, Category 1, H290
Skin corrosion, Category 1B, H314
Serious eye damage, Category 1, H318
Specific target organ systemic toxicity - single exposure, Category 3, Respiratory system, H335

For the full text of the H-Statements mentioned in this Section, see Section 16.

GHS-Labeling

Hazard pictograms



Signal Word
Danger

Hazard Statements
H290 May be corrosive to metals.
H314 Causes severe skin burns and eye damage.
H335 May cause respiratory irritation.

Precautionary Statements
P234 Keep only in original container.
P261 Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray.
P264 Wash skin thoroughly after handling.
P271 Use only outdoors or in a well-ventilated area.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310 Immediately call a POISON CENTER or doctor/ physician.
P321 Specific treatment (see supplemental first aid instructions on this label).
P363 Wash contaminated clothing before reuse.
P390 Absorb spillage to prevent material damage.
P403 + P233 Store in a well-ventilated place. Keep container tightly closed.
P405 Store locked up.
P406 Store in corrosive resistant stainless steel container with a resistant inliner.
P501 Dispose of contents/ container to an approved waste disposal plant.

Other hazards

None known.

SECTION 3. Composition/information on ingredients

Chemical nature Aqueous solution

Hazardous ingredients

Chemical Name (Concentration)
CAS-No.
hydrochloric acid (>= 30 % - < 50 %)
7647-01-0

Exact percentages are being wihtheld as a trade secret.

SECTION 4. First aid measures

Description of first-aid measures

General advice
First aider needs to protect himself.

Inhalation
After inhalation: fresh air. Call in physician.

Skin contact
In case of skin contact: Take off immediately all contaminated clothing. Rinse skin with water/ shower. Call a physician immediately.

Eye contact
After eye contact: rinse out with plenty of water. Immediately call in ophthalmologist.

Ingestion
After swallowing: make victim drink water (two glasses at most), avoid vomiting (risk of perforation!). Call a physician immediately. Do not attempt to neutralize.

Never give anything by mouth to an unconscious person.

Most important symptoms and effects, both acute and delayed
Irritation and corrosion, Cough, Shortness of breath, cardiovascular disorders, Risk of blindness!

Indication of any immediate medical attention and special treatment needed
No information available.

SECTION 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media
Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.

Unsuitable extinguishing media
For this substance/mixture no limitations of extinguishing agents are given.

Special hazards arising from the substance or mixture
Not combustible.
Ambient fire may liberate hazardous vapors.
Fire may cause evolution of:
Hydrogen chloride gas

Advice for firefighters

Special protective equipment for fire-fighters
Stay in danger area only with self-contained breathing apparatus. Prevent skin contact by keeping a safe distance or by wearing suitable protective clothing.

Further information
Suppress (knock down) gases/vapors/mists with a water spray jet. Prevent fire extinguishing water from contaminating surface water or the ground water system.

SECTION 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
Advice for non-emergency personnel: Do not breathe vapors, aerosols. Avoid substance contact. Ensure adequate ventilation. Evacuate the danger area, observe emergency procedures, consult an expert.

Advice for emergency responders: Protective equipment see section 8.

Environmental precautions
Do not empty into drains.

Methods and materials for containment and cleaning up
Cover drains. Collect, bind, and pump off spills.
Observe possible material restrictions (see sections 7 and 10).
Take up with liquid-absorbent and neutralizing material (e.g. Chemizorb® H^+, Art. No. 101595).
Dispose of properly. Clean up affected area.

SECTION 7. Handling and storage

Precautions for safe handling

Observe label precautions.

Conditions for safe storage, including any incompatibilities

Requirements for storage areas and containers

No metal containers.

Tightly closed.

Store at room temperature.

SECTION 8. Exposure controls/personal protection

Exposure limit(s)

Ingredients

Basis	Value	Threshold limits	Remarks
hydrochloric acid 7647-01-0			
ACGIH	Ceiling Limit Value:	2 ppm	
NIOSH/GUIDE	Ceiling Limit Value and Time Period (if specified):	5 ppm 7 mg/m³	
OSHA_TRANS	Ceiling Limit Value:	5 ppm 7 mg/m³	
Z1A	Ceiling Limit Value:	5 ppm 7 mg/m³	

Engineering measures

Technical measures and appropriate working operations should be given priority over the use of personal protective equipment.

Individual protection measures

Protective clothing should be selected specifically for the workplace, depending on concentration and quantity of the hazardous substances handled. The chemical resistance of the protective equipment should be inquired at the respective supplier.

Hygiene measures

Immediately change contaminated clothing. Apply skin- protective barrier cream. Wash hands and face after working with substance.

Eye/face protection

Tightly fitting safety goggles

Hand protection

Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Other protective equipment:

Acid-resistant protective clothing.

Respiratory protection
required when vapors/aerosols are generated.
Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

SECTION 9. Physical and chemical properties

Physical state	liquid
Color	colorless
Odor	stinging
Odor Threshold	0.8 - 5 ppm Gaseous hydrogen chloride (HCl).
pH	< 1 at 68 °F (20 °C)
Solidification point	-30 °C
Boiling point	No information available.
Flash point	Not applicable
Evaporation rate	No information available.
Flammability (solid, gas)	No information available.
Lower explosion limit	Not applicable
Upper explosion limit	Not applicable
Vapor pressure	190 hPa at 68 °F (20 °C)
Relative vapor density	No information available.
Density	ca.1.19 g/cm³ at 68 °F (20 °C)
Relative density	No information available.
Water solubility	at 68 °F (20 °C) soluble
Partition coefficient: n-octanol/water	Not applicable

Autoignition temperature	No information available.
Decomposition temperature	No information available.
Viscosity, dynamic	2.3 mPa.s at 59 °F (15 °C)
Explosive properties	Not classified as explosive.
Oxidizing properties	none
Ignition temperature	Not applicable
Corrosion	May be corrosive to metals.

SECTION 10. Stability and reactivity

Reactivity

Corrosive in contact with metals

Chemical stability

The product is chemically stable under standard ambient conditions (room temperature) .

Possibility of hazardous reactions

Exothermic reaction with:

Amines, potassium permanganate, salts of oxyhalogenic acids, semimetallic oxides, semimetallic hydrogen compounds, Aldehydes, vinylmethyl ether

Risk of ignition or formation of inflammable gases or vapors with:

carbides, lithium silicide, Fluorine

Generates dangerous gases or fumes in contact with:

Aluminum, hydrides, formaldehyde, Metals, strong alkalis, Sulfides

Risk of explosion with:

Alkali metals, conc. sulfuric acid

Conditions to avoid

Heating.

Incompatible materials

Metals, metal alloys
Gives off hydrogen by reaction with metals.

Hazardous decomposition products

in the event of fire: See section 5.

SECTION 11. Toxicological information

Information on toxicological effects

Likely route of exposure
Inhalation, Eye contact, Skin contact

Target Organs
Eyes
Skin
Respiratory system
Cornea

Acute oral toxicity
Symptoms: If ingested, severe burns of the mouth and throat, as well as a danger of perforation of the esophagus and the stomach.

Acute toxicity estimate: 1,892 mg/kg
Calculation method

Acute inhalation toxicity

Symptoms: mucosal irritations, Cough, Shortness of breath, Possible damages:, damage of respiratory tract

Acute toxicity estimate: 6.41 mg/l; 4 h
Calculation method

Skin irritation
Mixture causes burns.

Eye irritation
Mixture causes serious eye damage. Risk of blindness!

Specific target organ systemic toxicity - single exposure
Target Organs: Respiratory system
Mixture may cause respiratory irritation.

Specific target organ systemic toxicity - repeated exposure
The substance or mixture is not classified as specific target organ toxicant, repeated exposure.

Aspiration hazard
Regarding the available data the classification criteria are not fulfilled.

Carcinogenicity

IARC	No ingredient of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
OSHA	No ingredient of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.
NTP	No ingredient of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
ACGIH	No ingredient of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

Further information

After uptake:
After a latency period:
cardiovascular disorders
Handle in accordance with good industrial hygiene and safety practice.

Ingredients

hydrochloric acid
No information available.

SECTION 12. Ecological information

Ecotoxicity

No information available.

Persistence and degradability

No information available.

Bioaccumulative potential

Partition coefficient: n-octanol/water
Not applicable

Mobility in soil

No information available.

Additional ecological information
Forms corrosive mixtures with water even if diluted. Harmful effect due to pH shift.
Discharge into the environment must be avoided.

Ingredients

hydrochloric acid

Substance does not meets the criteria for PBT or vPvB according to Regulation (EC) No 1907/2006, Annex XIII.

SECTION 13. Disposal considerations

The information presented only applies to the material as supplied. The identification based on characteristic(s) or listing may not apply if the material has been used or otherwise contaminated. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste identification and disposal methods in compliance with applicable regulations. Disposal should be in accordance with applicable regional, national and local laws and regulations.

SECTION 14. Transport information

Land transport (DOT)

UN number	UN 1789
Proper shipping name	HYDROCHLORIC ACID
Class	8
Packing group	II
Environmentally hazardous	--

Air transport (IATA)

UN number	UN 1789
Proper shipping name	HYDROCHLORIC ACID
Class	8
Packing group	II
Environmentally hazardous	--
Special precautions for user	no

Sea transport (IMDG)

UN number	UN 1789
Proper shipping name	HYDROCHLORIC ACID
Class	8
Packing group	II
Environmentally hazardous	--
Special precautions for user	yes
EmS	F-A S-B

SECTION 15. Regulatory information

United States of America

SARA 313

The following components are subject to reporting levels established by SARA Title III, Section 313:

Ingredients

hydrochloric acid	7647-01-0	*37 %*

SARA 302

The following components are subject to reporting levels established by SARA Title III, Section 302:

Ingredients

hydrochloric acid	7647-01-0

Clean Water Act

The following Hazardous Substances are listed under the U.S. CleanWater Act, Section 311, Table 116.4A:
Ingredients
hydrochloric acid

The following Hazardous Chemicals are listed under the U.S. CleanWater Act, Section 311, Table 117.3:
Ingredients
hydrochloric acid

DEA List I
Not listed

DEA List II
Listed
Ingredients

hydrochloric acid	7647-01-0

US State Regulations

Massachusetts Right To Know
Ingredients
hydrochloric acid

Pennsylvania Right To Know
Ingredients
hydrochloric acid

New Jersey Right To Know
Ingredients
hydrochloric acid

California Prop 65 Components
This product does not contain any chemicals known to the State of California to cause cancer, birth, or any other reproductive defects.

Notification status

TSCA:	All components of the product are listed in the TSCA-inventory.
DSL:	All components of this product are on the Canadian DSL.
KOREA:	Not in compliance with the inventory

SECTION 16. Other information

Training advice
Provide adequate information, instruction and training for operators.

Labeling

Hazard pictograms



Signal Word
Danger

Hazard Statements
H290 May be corrosive to metals.
H314 Causes severe skin burns and eye damage.
H335 May cause respiratory irritation.

Precautionary Statements
Prevention
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
Response
P301 + P330 + P331 IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308 + P310 IF exposed or concerned: immediately call a POISON CENTER or doctor/ physician.

Full text of H-Statements referred to under sections 2 and 3.

H290	May be corrosive to metals.
H314	Causes severe skin burns and eye damage.
H318	Causes serious eye damage.
H335	May cause respiratory irritation.

Key or legend to abbreviations and acronyms used in the safety data sheet
Used abbreviations and acronyms can be looked up at www.wikipedia.org.

Revision Date01/27/2015

The information contained herein is based on the present state of our knowledge. It characterizes the product with regard to appropriate safety precautions. It does not represent a warranty of any product properties and we assume no liability for any loss or injury which may result from the use of this information. Users should conduct their own investigations to determine the suitability of the information.
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SAFETY DATA SHEET

Helium

Section 1. Identification

GHS product identifier : Helium

Chemical name : Helium

Other means of identification : helium (dot); Helium-4; He; o-Helium; UN 1046,Helium USP

Product type : Gas.

Product use : Synthetic/Analytical chemistry.

Synonym : helium (dot); Helium-4; He; o-Helium; UN 1046,Helium USP

SDS # : 001025

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : GASES UNDER PRESSURE - Compressed gas

GHS label elements

Hazard pictograms :



Signal word : Warning

Hazard statements : Contains gas under pressure; may explode if heated.
May displace oxygen and cause rapid suffocation.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction.

Prevention : Not applicable.

Response : Not applicable.

Storage : Protect from sunlight. Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : Helium

Other means of identification : helium (dot); Helium-4; He; o-Helium; UN 1046,Helium USP

Product code : 001025

CAS number/other identifiers

CAS number : 7440-59-7

Ingredient name	%	CAS number
Helium	100	7440-59-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Section 4. First aid measures

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : No specific data.

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid breathing gas. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Avoid contact with eyes, skin and clothing. Empty containers retain product residue and can be hazardous.

Section 7. Handling and storage

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F). Keep container tightly closed and sealed until ready for use. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Helium	**ACGIH TLV (United States, 3/2019). Oxygen Depletion [Asphyxiant].**

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Section 8. Exposure controls/personal protection

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas. [Compressed gas.]

Color : Colorless.

Odor : Odorless.

Odor threshold : Not available.

pH : Not available.

Melting point : -272.2°C (-458°F)

Boiling point : -268.9°C (-452°F)

Critical temperature : -267.9°C (-450.2°F)

Flash point : [Product does not sustain combustion.]

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : 0.14 (Air = 1) Liquid Density@BP: 7.8 lb/ft3 (125 kg/m3)

Specific Volume (ft ^{3}/lb) : 96.1538

Gas Density (lb/ft ^{3}) : 0.0104

Relative density : Not applicable.

Solubility : Not available.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : 0.28

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Viscosity : Not applicable.

Flow time (ISO 2431) : Not available.

Molecular weight : 4 g/mole

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : No specific data.

Incompatible materials : No specific data.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 10. Stability and reactivity

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Section 11. Toxicological information

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
Helium	0.28	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1046	UN1046	UN1046	UN1046	UN1046
UN proper shipping name	HELIUM, COMPRESSED	HELIUM, COMPRESSED	HELIUM, COMPRESSED	HELIUM, COMPRESSED	HELIUM, COMPRESSED
Transport hazard class(es)	2.2 	2.2 	2.2 	2.2 	2.2 
Packing group	-	-	-	-	-
Environmental hazards	No.	No.	No.	No.	No.

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Additional information

DOT Classification : **Limited quantity** Yes.
Quantity limitation Passenger aircraft/rail: 75 kg. Cargo aircraft: 150 kg.

TDG Classification : Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2).
Explosive Limit and Limited Quantity Index 0.125
Passenger Carrying Road or Rail Index 75

IATA : **Quantity limitation** Passenger and Cargo Aircraft: 75 kg. Cargo Aircraft Only: 150 kg.

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to IMO instruments : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

Section 15. Regulatory information

SARA 311/312

Classification : Refer to Section 2: Hazards Identification of this SDS for classification of substance.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

California Prop. 65

This product does not require a Safe Harbor warning under California Prop. 65.

International regulations

Chemical Weapon Convention List Schedules I, II & III Chemicals

Not listed.

Montreal Protocol

Not listed.

Stockholm Convention on Persistent Organic Pollutants

Not listed.

Rotterdam Convention on Prior Informed Consent (PIC)

Not listed.

UNECE Aarhus Protocol on POPs and Heavy Metals

Not listed.

Inventory list

Australia : This material is listed or exempted.

Canada : This material is listed or exempted.

China : This material is listed or exempted.

Europe : This material is listed or exempted.

Japan : **Japan inventory (ENCS)**: Not determined.
Japan inventory (ISHL): Not determined.

New Zealand : This material is listed or exempted.

Philippines : This material is listed or exempted.

Republic of Korea : This material is listed or exempted.

Taiwan : This material is listed or exempted.

Thailand : Not determined.

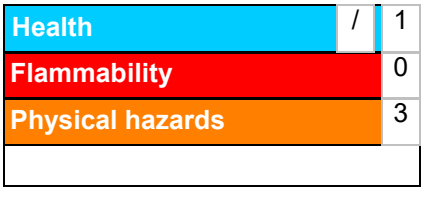
Turkey : Not determined.

United States : This material is active or exempted.

Viet Nam : This material is listed or exempted.

Section 16. Other information

Hazardous Material Information System (U.S.A.)



Section 16. Other information

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

National Fire Protection Association (U.S.A.)



Reprinted with permission from NFPA 704-2001, Identification of the Hazards of Materials for Emergency Response Copyright ©1997, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association, on the referenced subject which is represented only by the standard in its entirety.

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
GASES UNDER PRESSURE - Compressed gas	Expert judgment

History

Date of printing : 1/27/2021

Date of issue/Date of revision : 1/27/2021

Date of previous issue : 4/23/2018

Version : 1.02

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

Flammable Gas Mixture: 1-Butene / Cis-2-Butene / Ethane / Ethylene / Isobutane / Isobutylene (Isobutene) / Isopentane / Methane / N-Butane / N-Pentane / Propane / Propylene / Trans-2-Butene

Section 1. Identification

GHS product identifier : Flammable Gas Mixture: 1-Butene / Cis-2-Butene / Ethane / Ethylene / Isobutane / Isobutylene (Isobutene) / Isopentane / Methane / N-Butane / N-Pentane / Propane / Propylene / Trans-2-Butene

Other means of identification : Not available.

Product use : Synthetic/Analytical chemistry.

SDS # : 010448

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE GASES - Category 1
GASES UNDER PRESSURE - Compressed gas

GHS label elements

Hazard pictograms :



Signal word : Danger

Hazard statements : Extremely flammable gas.
Contains gas under pressure; may explode if heated.
May form explosive mixtures in Air.
May displace oxygen and cause rapid suffocation.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction. Approach suspected leak area with caution.

Prevention : Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.

Response : Leaking gas fire: Do not extinguish, unless leak can be stopped safely. Eliminate all ignition sources if safe to do so.

Storage : Protect from sunlight when ambient temperature exceeds 52°C/125°F. Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : In addition to any other important health or physical hazards, this product may displace oxygen and cause rapid suffocation.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Not available.

CAS number/other identifiers

CAS number : Not applicable.

Product code : 010448

Ingredient name	%	CAS number
Propane	0.0001 - 99	74-98-6
propylene	0.0001 - 99	115-07-1
methane	0.0001 - 50	74-82-8
ethane	0.0001 - 50	74-84-0
Trans-2-Butene	0.0001 - 20	624-64-6
N-Butane	0.0001 - 20	106-97-8
Cis-2-Butene	0.0001 - 20	590-18-1
isobutane	0.0001 - 10	75-28-5
Isobutylene	0.0001 - 10	115-11-7
1-Butene	0.0001 - 5	106-98-9
ethylene	0.0001 - 0.9999	74-85-1
isopentane	0.0001 - 0.9999	78-78-4
n-pentane	0.0001 - 0.9999	109-66-0

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. To avoid the risk of static discharges and gas ignition, soak contaminated clothing thoroughly with water before removing it. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Section 4. First aid measures

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. Extremely flammable gas. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool. If involved in fire, shut off flow immediately if it can be done without risk. If this is impossible, withdraw from area and allow fire to burn. Fight fire from protected location or maximum possible distance. Eliminate all ignition sources if safe to do so.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : Accidental releases pose a serious fire or explosion hazard. No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Section 6. Accidental release measures

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Use spark-proof tools and explosion-proof equipment. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid contact with eyes, skin and clothing. Avoid breathing gas. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Empty containers retain product residue and can be hazardous. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Eliminate all ignition sources. Keep container tightly closed and sealed until ready for use. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Propane	**NIOSH REL (United States, 10/2013).** TWA: 1800 mg/m³ 10 hours. TWA: 1000 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 1800 mg/m³ 8 hours. TWA: 1000 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** TWA: 1800 mg/m³ 8 hours. TWA: 1000 ppm 8 hours.
propylene	**ACGIH TLV (United States, 1/2005).** TWA: 500 ppm 8 hours. Form: All forms **ACGIH TLV (United States, 3/2015).** TWA: 500 ppm 8 hours.
methane	Oxygen Depletion [Asphyxiant]
ethane	Oxygen Depletion [Asphyxiant]
Trans-2-Butene	**ACGIH TLV (United States, 3/2015).** TWA: 250 ppm 8 hours.
N-Butane	**NIOSH REL (United States, 10/2013).** TWA: 1900 mg/m³ 10 hours. TWA: 800 ppm 10 hours. **OSHA PEL 1989 (United States, 3/1989).** TWA: 1900 mg/m³ 8 hours. TWA: 800 ppm 8 hours.

Section 8. Exposure controls/personal protection

	ACGIH TLV (United States, 3/2015). STEL: 1000 ppm 15 minutes.
Cis-2-Butene	**ACGIH TLV (United States, 3/2015).** TWA: 250 ppm 8 hours.
isobutane	**NIOSH REL (United States, 4/2013).** TWA: 1900 mg/m³ 10 hours. TWA: 800 ppm 10 hours. **ACGIH TLV (United States, 6/2013).** STEL: 1000 ppm 15 minutes.
Isobutylene	**ACGIH TLV (United States, 3/2015).** TWA: 250 ppm 8 hours.
1-Butene	**ACGIH TLV (United States, 3/2015).** TWA: 250 ppm 8 hours.
ethylene	**ACGIH TLV (United States, 3/2015).** TWA: 200 ppm 8 hours.
isopentane	**ACGIH TLV (United States, 3/2015).** TWA: 1000 ppm 8 hours.
n-pentane	**ACGIH TLV (United States, 3/2015).** TWA: 1000 ppm 8 hours. **NIOSH REL (United States, 10/2013).** CEIL: 1800 mg/m³ 15 minutes. CEIL: 610 ppm 15 minutes. TWA: 350 mg/m³ 10 hours. TWA: 120 ppm 10 hours. **OSHA PEL (United States, 2/2013).** TWA: 2950 mg/m³ 8 hours. TWA: 1000 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** STEL: 2250 mg/m³ 15 minutes. STEL: 750 ppm 15 minutes. TWA: 1800 mg/m³ 8 hours. TWA: 600 ppm 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Section 8. Exposure controls/personal protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Gas.

Color : Not available.

Melting/freezing point : -105°C (-157°F) This is based on data for the following ingredient: Trans-2-Butene. Weighted average: -175.5°C (-283.9°F)

Critical temperature : Lowest known value: -82.45°C (-116.4°F) (methane).

Odor : Not available.

Odor threshold : Not available.

pH : Not available.

Flash point : Not available.

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Not available.

Vapor pressure : Not available.

Vapor density : Highest known value: 2.1 (Air = 1) (N-Butane). Weighted average: 1.45 (Air = 1)

Gas Density (lb/ft ^{3}) : Weighted average: 0.13

Relative density : Not applicable.

Solubility : Not available.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : Not available.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not applicable.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition.

Incompatible materials : Oxidizers

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
N-Butane	LC50 Inhalation Vapor	Rat	658000 mg/m³	4 hours
isobutane	LC50 Inhalation Vapor	Rat	658000 mg/m³	4 hours
Isobutylene	LC50 Inhalation Vapor	Rat	550000 mg/m³	4 hours
isopentane	LC50 Inhalation Vapor	Rat	280000 mg/m³	4 hours
n-pentane	LC50 Inhalation Vapor	Rat	364 g/m³	4 hours

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Classification

Product/ingredient name	OSHA	IARC	NTP
propylene	-	3	-
ethylene	-	3	-

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Section 11. Toxicological information

Name	Category	Route of exposure	Target organs
ethylene	Category 3	Not applicable.	Narcotic effects
isopentane	Category 3	Not applicable.	Narcotic effects
n-pentane	Category 3	Not applicable.	Narcotic effects

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
Propane	1.09	-	low
propylene	1.77	-	low
methane	1.09	-	low
ethane	1.09	-	low
Trans-2-Butene	2.31	-	low
N-Butane	2.89	-	low
Cis-2-Butene	2.33	-	low
isobutane	2.8	-	low
Isobutylene	2.34	-	low
1-Butene	2.4	-	low
ethylene	1.13	-	low
isopentane	3	171	low
n-pentane	3.45	171	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1954	UN1954	UN1954	UN1954	UN1954
UN proper shipping name	COMPRESSED GAS, FLAMMABLE, N.O.S. (propylene, propane)	COMPRESSED GAS, FLAMMABLE, N.O.S. (propylene, propane)	COMPRESSED GAS, FLAMMABLE, N.O.S. (propylene, propane)	COMPRESSED GAS, FLAMMABLE, N.O.S. (propylene, propane)	COMPRESSED GAS, FLAMMABLE, N.O.S. (propylene, propane)
Transport hazard class(es)	2.1 	2.1 	2.1 	2.1 	2.1 
Packing group	-	-	-	-	-

Section 14. Transport information

Environment	No.	No.	No.	No.	No.
Additional information	-	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2). **Explosive Limit and Limited Quantity Index** 0.125 **ERAP Index** 3000 **Passenger Carrying Ship Index** Forbidden **Passenger Carrying Road or Rail Index** Forbidden	-	-	-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) PAIR**: pentane

TSCA 8(a) CDR Exempt/Partial exemption: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Air Act (CAA) 112 regulated flammable substances: propane; Isobutane; Trans-2-Butene; propylene; N-Butane; methane; isobutylene; ethane; Cis-2-Butene; 1-butene

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Section 15. Regulatory information

Classification : Fire hazard
Sudden release of pressure

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Propane	0.0001 - 99	Yes.	Yes.	No.	No.	No.
propylene	0.0001 - 99	Yes.	Yes.	No.	No.	No.
methane	0.0001 - 50	Yes.	Yes.	No.	No.	No.
ethane	0.0001 - 50	Yes.	Yes.	No.	No.	No.
Trans-2-Butene	0.0001 - 20	Yes.	Yes.	No.	No.	No.
N-Butane	0.0001 - 20	Yes.	Yes.	No.	No.	No.
Cis-2-Butene	0.0001 - 20	Yes.	Yes.	No.	No.	No.
isobutane	0.0001 - 10	Yes.	Yes.	No.	No.	No.
Isobutylene	0.0001 - 10	Yes.	Yes.	No.	No.	No.
1-Butene	0.0001 - 5	Yes.	Yes.	No.	No.	No.
ethylene	0.0001 - 0.9999	Yes.	Yes.	No.	Yes.	No.
isopentane	0.0001 - 0.9999	Yes.	No.	No.	Yes.	No.
n-pentane	0.0001 - 0.9999	Yes.	No.	No.	Yes.	No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	propylene	115-07-1	0.0001 - 99
Supplier notification	propylene	115-07-1	0.0001 - 99

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : The following components are listed: PROPANE; ISOBUTANE; 2-BUTENE-TRANS; PROPYLENE (PROPENE); BUTANE; METHANE; 2-METHYLPROPENE; ETHANE; 2-BUTENE-CIS; 1-BUTENE

New York : None of the components are listed.

New Jersey : The following components are listed: PROPANE; Isobutane; PROPANE, 2-METHYL-; 2-BUTENE-trans; 2-BUTENE, (2E)-; PROPYLENE; 1-PROPENE; BUTANE; METHANE; ISOBUTYLENE; 1-PROPENE, 2-METHYL-; ETHANE; 2-BUTENE-cis; 2-BUTENE, (2Z)-; 1-BUTENE

Pennsylvania : The following components are listed: PROPANE; PROPANE, 2-METHYL-; 2-BUTENE, (E)-; 1-PROPENE; BUTANE; METHANE; 1-PROPENE, 2-METHYL-; ETHANE; 2-BUTENE, (Z)-; 1-BUTENE

International regulations

International lists

National inventory

Australia : All components are listed or exempted.

Canada : All components are listed or exempted.

China : All components are listed or exempted.

Europe : All components are listed or exempted.

Japan : All components are listed or exempted.

Malaysia : Not determined.

New Zealand : All components are listed or exempted.

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : Not determined.

Canada

Section 15. Regulatory information

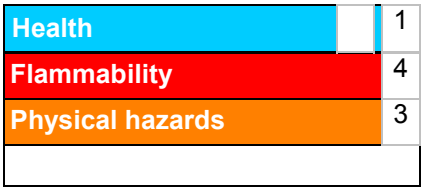
WHMIS (Canada) : Class A: Compressed gas.
Class B-1: Flammable gas.
Class D-2B: Material causing other toxic effects (Toxic).

CEPA Toxic substances: The following components are listed: Methane; Volatile organic compounds
Canadian ARET: None of the components are listed.
Canadian NPRI: The following components are listed: Propane; Butane (all isomers); Butene (all isomers); Propylene; Butane (all isomers); Volatile organic compounds; Butene (all isomers); Volatile organic compounds; Butene (all isomers); Butene (all isomers); Butene (all isomers)
Alberta Designated Substances: None of the components are listed.
Ontario Designated Substances: None of the components are listed.
Quebec Designated Substances: None of the components are listed.

Section 16. Other information

Canada Label requirements : Class A: Compressed gas.
Class B-1: Flammable gas.
Class D-2B: Material causing other toxic effects (Toxic).

Hazardous Material Information System (U.S.A.)



Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)



Reprinted with permission from NFPA 704-2001, Identification of the Hazards of Materials for Emergency Response Copyright ©1997, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association, on the referenced subject which is represented only by the standard in its entirety.

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
Flam. Gas 1, H220 Press. Gas Comp. Gas, H280	On basis of test data On basis of test data

History

Date of printing : 3/21/2016

Date of issue/Date of revision : 3/21/2016

Section 16. Other information

Date of previous issue : No previous validation

Version : 0.01

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Manufactured for

INDUSTRIAL SCIENTIFIC

CORPORATION

1001 Oakdale Road
Oakdale, PA 15071-1500

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TOLL-FREE 800-DETECTS
Fax (412) 788-8353

MATERIAL SAFETY DATA SHEET

Prepared to U.S. OSHA, CMA, ANSI and Canadian WHMIS Standards

1. PRODUCT IDENTIFICATION

CHEMICAL NAME; CLASS: NON-FLAMMABLE GAS MIXTURE

Containing One or More of the Following Components in a Nitrogen Balance Gas: Oxygen, 0.0015-23.5%; Propane, 0-1.1%; n-Pentane, 0-0.75%; n-Hexane; 0-0.48%; Carbon Monoxide, 0.0005-1.0%; Hydrogen Sulfide, 0.001-0.025%

NOTE: MIXTURES COMPRISED OF AN AIR BALANCE GAS CONTAIN BETWEEN 19.5-23.5% OXYGEN.

SYNONYMS: Not Applicable

CHEMICAL FAMILY NAME: Not Applicable

FORMULA: Not Applicable

Document Number: 50016 (Replaces ISC MSDS No.1810-2187, 1810-2343, 1810-3366, 1810-3937 1810-7219, 1810-7599, 1810-6179)

Note: The Material Safety Data Sheet is for this gas mixture supplied in cylinders with 33 cubic feet (935 liters) or less gas capacity (DOT - 39 cylinders). This MSDS has been developed for various gas mixtures with the composition of components within the ranges listed in Section 2 (Composition and Information on Ingredients). Refer to the product label for information on the actual composition of the product.

PRODUCT USE:	Calibration of Monitoring and Research Equipment
SUPPLIER/MANUFACTURER'S NAME:	CALGAZ
ADDRESS:	821 Chesapeake Drive Cambridge, MD 21613
EMERGENCY PHONE:	CHEMTREC: 1-800-424-9300
BUSINESS PHONE:	1-410-228-6400
General MSDS Information	1-713/868-0440
Fax on Demand:	1-800/231-1366

2. COMPOSITION and INFORMATION ON INGREDIENTS

CHEMICAL NAME	CAS #	mole %	EXPOSURE LIMITS IN AIR					
			ACGIHTLV		OSHA		IDLH	OTHER
			TWA ppm	STEL ppm	TWA ppm	STEL ppm	ppm	ppm
Oxygen	7782-44-7	0.0015 - 23.5%	There are no specific exposure limits for Oxygen. Oxygen levels should be maintained above 19.5%.					
Propane	74-98-6	0 - 1.1%	2500	NE	1000	NE	2100	NIOSH REL: 1000 DFG MAK: 1000 ppm
n-Pentane	109-66-0	0 - 0.75%	600	750	1000 600 (Vacated 1989 PEL)	750 (Vacated 1989 PEL)	1500	NIOSH REL: TWA = 120 STEL = 610 (ceiling) 15 minutes DFG MAKs: TWA =1000 PEAK = 2•MAK, 60 min., momentary value
n-Hexane	110-54-3	0 - 0.48%	50	NE	500 50 (Vacated 1989 PEL)	NE	1100	NIOSH REL: 50 DFG MAK: 50
Hydrogen Sulfide	7783-06-4	0.001-0.025 %	10 NIC = 5	15 NIC = 5	10 (Vacated 1989 PEL)	20 (ceiling), 50 (10 min. peak, once per shift) 15 (Vacated 1989 PEL)	100	NIOSH REL: STEL = 10 (ceiling), 10 minutes DFG MAKs: TWA = 10 PEAK = 2•MAK, 10 min., momentary value
Carbon Monoxide	630-08-0	0.0005 - 1.0%	25	NE	50 35 (Vacated 1989 PEL)	200 (ceiling) (Vacated 1989 PEL)	1200	NIOSH RELs: TWA = 35 STEL = 200 ceiling DFG MAKs: TWA = 30 PEAK = 2•MAK, 15 min., average value, 1 hr interval DFG MAK Pregnancy Risk Classification: B
Nitrogen	7727-37-9	Balance	There are no specific exposure limits for Nitrogen. Nitrogen is a simple asphyxiant (SA). Oxygen levels should be maintained above 19.5%.					

NE = Not Established. NIC = Notice of Intended Change See Section 16 for Definitions of Terms Used.

NOTE: ALL WHMIS required information is included in appropriate sections based on the ANSI Z400.1-1998 format. This gas mixture has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW: This gas mixture is a colorless gas which has a rotten-egg odor (due to the presence of Hydrogen Sulfide). The odor cannot be relied on as an adequate warning of the presence of this gas mixture, because olfactory fatigue occurs after over-exposure to Hydrogen Sulfide. Hydrogen Sulfide and Carbon Monoxide (another component of this gas mixture) are toxic to humans in relatively low concentrations. Over-exposure to this gas mixture can cause skin or eye irritation, nausea, dizziness, headaches, collapse, unconsciousness, coma, and death. The Propane, n-Pentane, and n-Hexane components can cause anesthetic or peripheral neuropathy effects. Additionally, releases of this gas mixture may produce oxygen-deficient atmospheres (especially in small confined spaces or other poorly-ventilated environments); individuals in such atmospheres may be asphyxiated.

SYMPTOMS OF OVER-EXPOSURE BY ROUTE OF EXPOSURE: The most significant route of over-exposure for this gas mixture is by inhalation.

INHALATION: Due to the small size of an individual cylinder of this gas mixture, no unusual health effects from over-exposure to the product are anticipated under routine circumstances of use. A significant health hazard associated with this gas mixture is the potential of inhalation of Hydrogen Sulfide, a component of this gas mixture. Such over-exposures may occur if this gas mixture is used in a confined space or other poorly-ventilated area. Over-exposures to Hydrogen Sulfide can cause dizziness, headache, and nausea. Exposure to this component can result in respiratory arrest, coma, or unconsciousness. Continuous inhalation of low concentrations of Hydrogen Sulfide may cause olfactory fatigue, so that the odor is no longer an effective warning of the presence of this gas. A summary of exposure concentrations and observed effects are as follows

CONCENTRATION OF HYDROGEN SULFIDE	OBSERVED EFFECT
0.3-30 ppm	Odor is obvious and unpleasant.
50 ppm	Eye irritation. Dryness and irritation of nose, throat.
Slightly higher than 50 ppm	Irritation of the respiratory system.
100-150 ppm	Temporary loss of smell.
200-250 ppm	Headache, vomiting nausea. Prolonged exposure may lead to lung damage. Exposures of 4-8 hours can be fatal.
300-500	Swifter onset of symptoms. Death occurs in 1-4 hours.
500 ppm	Headache, excitement, staggering, and stomach ache after brief exposure. Death occurs within 0.5 - 1 hour of exposure.
> 600 ppm	Rapid onset of unconsciousness, coma, death.
> 1000 ppm	Immediate respiratory arrest.
NOTE:	This gas mixture contains a maximum of 250 ppm Hydrogen Sulfide. The higher concentration values here are presented to delineate the complete health effects which have been observed for humans after exposure to Hydrogen Sulfide.

HAZARDOUS MATERIAL IDENTIFICATION SYSTEM

HEALTH HAZARD	(BLUE)	3
FLAMMABILITY HAZARD	(RED)	0
PHYSICAL HAZARD	(YELLOW)	0

PROTECTIVE EQUIPMENT

EYES	RESPIRATORY	HANDS	BODY
See Section 8			

For Routine Industrial Use and Handling Applications

Inhalation over-exposures to atmospheres containing more than the Threshold Limit Value of Carbon Monoxide (25 ppm), another component of this gas mixture, can result in serious health consequences. Carbon Monoxide is classified as a chemical asphyxiant, producing a toxic action by combining with the hemoglobin of the blood and replacing the available oxygen. Through this replacement, the body is deprived of the required oxygen, and asphyxiation occurs.

Since the affinity of Carbon Monoxide for hemoglobin is about 200-300 times that of oxygen, only a small amount of Carbon Monoxide will cause a toxic reaction to occur. Carbon Monoxide exposures in excess of 50 ppm will produce symptoms of poisoning if breathed for a sufficiently long time. If this gas mixture is released in a small, poorly ventilated area (i.e. an enclosed or confined space), symptoms which may develop include the following:

CONCENTRATION OF CARBON MONOXIDE	OBSERVED EFFECT
All exposure levels: ..	Over-exposure to Carbon Monoxide can be indicated by the lips and fingernails turning bright red.
200 ppm:	Slight symptoms (i.e. headache) after several hours of exposure.
400 ppm:	Headache and discomfort experienced within 2-3 hours of exposure.
1,000 -2000 ppm:	Within 30 minutes, slight palpitations of the heart occurs. Within 1.5 hours, there is a tendency to stagger.
200-2500 ppm:	Within 2 hours, there is mental confusion, headaches, and nausea. Unconsciousness within 30 minutes.
> 2500 ppm:	Potential for collapse and death before warning symptoms.

Another hazard associated with this gas mixture is the potential for anesthetic and peripheral neuropathy effects after inhalation over-exposures to the Propane, n-Pentane and n-Hexane components of this gas mixture. Specific human over-exposure data are available for n-Pentane and n-Hexane, as follows:

CONCENTRATION OF n-PENTANE	OBSERVED EFFECT
Brief (10 minute) up to 5,000 ppm:	No symptoms.
Higher than 5,000 ppm:	Exhilaration, dizziness and headache can occur.
Long term:	Can cause chronic neurological disorder causing damage to the nerves in the hands and feet (peripheral neuropathy)

CONCENTRATION OF n-HEXANE	OBSERVED EFFECT
Brief (10 minute) at 1,500 ppm:	Irritation of the respiratory tract, nausea and headache.
5000 ppm:	Dizziness and drowsiness can occur.
Long term at 500 ppm:	Can affect the nerves in the arms and legs. Effects include numbing or tingling sensations in the fingers and toes, tiredness, muscle weakness, cramps and spasms in the leg, difficulty in holding objects or walking, abdominal pains, loss of appetite, weight loss. More serious exposures can cause damage to the nerves in the hands and feet (peripheral neuropathy).
Eyes and Vision:	Abnormal color perception and pigment changes in the eyes have been reported among industrial workers exposed to 423-1280 ppm for 5 years or more.
Blood Cells:	Mild forms of anemia have also been associated with exposure to hexane. These are of temporary nature.

Additionally, if mixtures of this gas mixture contain less than 19.5% Oxygen and are released in a small, poorly ventilated area (i.e. an enclosed or confined space), an oxygen-deficient environment may occur. Individuals breathing such an atmosphere may experience symptoms which include headaches, ringing in ears, dizziness, drowsiness, unconsciousness, nausea, vomiting, and depression of all the senses. Under some circumstances of over-exposure, death may occur. The following effects associated with various levels of oxygen are as follows:

CONCENTRATION OF OXYGEN	OBSERVED EFFECT
12-16% Oxygen:	Breathing and pulse rate increased, muscular coordination slightly disturbed.
10-14% Oxygen:	Emotional upset, abnormal fatigue, disturbed respiration.
6-10% Oxygen:	Nausea, vomiting, collapse, or loss of consciousness.
Below 6%:	Convulsive movements, possible respiratory collapse, and death.

SKIN and EYE CONTACT: The Hydrogen Sulfide component of this gas mixture may be irritating to the skin. Inflammation and irritation of the eyes can occur at very low airborne concentration of Hydrogen Sulfide (less than 10 ppm). Exposure over several hours may result in “gas eyes” or “sore eyes” with symptoms of scratchiness, irritation, tearing and burning. Above 50 ppm of Hydrogen Sulfide, there is an intense tearing, blurring of vision, and pain when looking at light. Over-exposed individuals may see rings around bright lights. Most symptoms disappear when exposure ceases. However, in serious cases, the eye can be permanently damaged.

HEALTH EFFECTS OR RISKS FROM EXPOSURE: An Explanation in Lay Terms. Over-exposure to this gas mixture may cause the following health effects:

ACUTE: Due to the small size of the individual cylinder of this gas mixture, no unusual health effects from exposure to the product are anticipated under routine circumstances of use. However, the Hydrogen Sulfide and Carbon Monoxide components of this gas mixture are toxic to humans. Over-exposure to this gas mixture can cause nausea, dizziness, headaches, collapse, unconsciousness, coma, and death. Due to the presence of Hydrogen Sulfide, over-exposures to this gas mixture can also irritate the skin and eyes; severe eye contamination can result in blindness.

Inhalation over-exposures to Propane, n-Pentane, and n-Hexane can cause anesthetic effects and motor neuropathy (i.e. pain and tingling in feet and hands).

3. HAZARD IDENTIFICATION (Continued)

CHRONIC: Abnormal color perception and pigment changes in the eyes have been reported among persons exposed to 420 -1300 ppm of n-Hexane for five years. Additionally, long-term exposure to low levels of n-Hexane or n-Pentane can affect the nerves in the arms and legs. Effects include numbing or tingling sensation, tiredness, cramps, spasms in legs, difficulty holding objects or walking, loss of appetite and weight loss. Pentane isomers, such as n-Pentane, and Propane can cause sensitization of the heart to epinephrine. Refer to Section 11 (Toxicology Information) for additional information on the components of this gas mixture.

TARGET ORGANS: ACUTE: Respiratory system, blood system, central nervous system, cardiovascular system. CHRONIC: Reproductive system, cardiovascular system.

4. FIRST-AID MEASURES

RESCUERS SHOULD NOT ATTEMPT TO RETRIEVE VICTIMS OF EXPOSURE TO THIS GAS MIXTURE WITHOUT ADEQUATE PERSONAL PROTECTIVE EQUIPMENT. At a minimum, Self-Contained Breathing Apparatus must be worn.

No unusual health effects are anticipated after exposure to this gas mixture, due to the small cylinder size. If any adverse symptom develops after over-exposure to this gas mixture, remove victim(s) to fresh air as quickly as possible. Only trained personnel should administer supplemental oxygen and/or cardio-pulmonary resuscitation if necessary.

Victim(s) who experience any adverse effect after over-exposure to this gas mixture must be taken for medical attention. Rescuers should be taken for medical attention if necessary. Take a copy of the label and the MSDS to physician or other health professional with victim(s).

SKIN EXPOSURE: If irritation of the skin develops after exposure to this gas mixture, immediately begin decontamination with running water. Minimum flushing is for 15 minutes. Remove exposed or contaminated clothing, taking care not to contaminate eyes. Victim must seek immediate medical attention.

EYE EXPOSURE: If irritation of the eye develops after exposure to this gas mixture, open victim's eyes while under gentle running water. Use sufficient force to open eyelids. Have victim "roll" eyes. Minimum flushing is for 15 minutes. Seek medical assistance immediately, preferably an ophthalmologist.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing respiratory conditions may be aggravated by over-exposure to this gas mixture. Carbon Monoxide, a component of this gas mixture, can aggravate some diseases of the cardiovascular system, such as coronary artery disease and angina pectoris. Because of the presence of Hydrogen Sulfide, n-Hexane or n-Pentane in this gas mixture, central nervous system conditions, eye disorders, or skin problems may be aggravated by over-exposure to this gas mixture.

RECOMMENDATIONS TO PHYSICIANS: Treat symptoms and eliminate over-exposure. Hyperbaric oxygen is the most efficient antidote to Carbon Monoxide poisoning, the optimum range being 2-2.5 atm. A special mask, or, preferably, a compression chamber to utilize oxygen at these pressures is required. Avoid administering stimulant drugs. Be observant for initial signs of pulmonary edema in the event of severe inhalation over-exposures.

5. FIRE-FIGHTING MEASURES

FLASH POINT: Not applicable.

AUTOIGNITION TEMPERATURE: Not applicable.

FLAMMABLE LIMITS (in air by volume, %):

Lower (LEL): Not applicable.

Upper (UEL): Not applicable.

FIRE EXTINGUISHING MATERIALS: Non-flammable gas mixture. Use extinguishing media appropriate for surrounding fire.

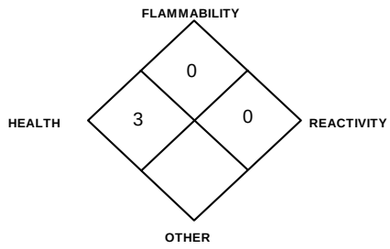
UNUSUAL FIRE AND EXPLOSION HAZARDS: This gas mixture contains toxic gases, Hydrogen Sulfide and Carbon Monoxide, and presents an extreme health hazard to firefighters. This gas mixture is not flammable; however, containers, when involved in fire, may rupture or burst in the heat of the fire.

Explosion Sensitivity to Mechanical Impact: Not Sensitive.

Explosion Sensitivity to Static Discharge: Not Sensitive.

SPECIAL FIRE-FIGHTING PROCEDURES: Structural firefighters must wear Self-Contained Breathing Apparatus and full protective equipment.

NFPA RATING



6. ACCIDENTAL RELEASE MEASURES

LEAK RESPONSE: Due to the small size and content of the cylinder, an accidental release of this gas mixture presents significantly less risk of over-exposure to Hydrogen Sulfide and Carbon Monoxide, the toxic components of this gas mixture, and other safety hazards related to the remaining components of this gas mixture, than a similar release from a larger cylinder. However, as with any chemical release, extreme caution must be used during emergency response procedures. In the event of a release in which the atmosphere is unknown, and in which other chemicals are potentially involved, evacuate immediate area. Such releases should be responded to by trained personnel using pre-planned procedures. Proper protective equipment should be used. In case of a leak, clear the affected area, protect people, and respond with trained personnel.

For emergency disposal, secure the cylinder and slowly discharge the gas to the atmosphere in a well-ventilated area or outdoors. Allow the gas mixture to dissipate. If necessary, monitor the surrounding area (and the original area of the release) for Hydrogen Sulfide, Carbon Monoxide, and Oxygen. Hydrogen Sulfide and Carbon Monoxide level must be below exposure level listed in Section 2 (Composition and Information on Ingredients) and Oxygen levels must be above 19.5% before non-emergency personnel are allowed to re-enter area.

If leaking incidentally from the cylinder, contact your supplier.

7. HANDLING and USE

WORK PRACTICES AND HYGIENE PRACTICES: Be aware of any signs of dizziness or fatigue; exposures to fatal concentrations of this gas mixture could occur without any significant warning symptoms, due to olfactory fatigue or oxygen deficiency. Do not attempt to repair, adjust, or in any other way modify cylinders containing a gas mixture with Hydrogen Sulfide or Carbon Monoxide. If there is a malfunction or another type of operational problem, contact nearest distributor immediately. Eye wash stations/safety showers should be near areas where this gas mixture is used or stored. All work operations should be monitored in such a way that emergency personnel can be immediately contacted in the event of a release. All work practices should minimize releases of Hydrogen Sulfide and Carbon Monoxide-containing gas mixtures.

STORAGE AND HANDLING PRACTICES: Cylinders should be firmly secured to prevent falling or being knocked-over. Cylinders must be protected from the environment, and preferably kept at room temperature (approximately 21°C, 70°F). Cylinders should be stored in dry, well-ventilated areas, away from sources of heat, ignition, and direct sunlight. Protect cylinders against physical damage.

Full and empty cylinders should be segregated. Use a first-in, first-out inventory system to prevent full containers from being stored for long periods of time. These cylinders are not refillable. **WARNING! Do not refill DOT 39 cylinders. To do so may cause personal injury or property damage.**

SPECIAL PRECAUTIONS FOR HANDLING GAS CYLINDERS: WARNING! Compressed gases can present significant safety hazards. During cylinder use, use equipment designed for these specific cylinders. Ensure all lines and equipment are rated for proper service pressure.

PROTECTIVE PRACTICES DURING MAINTENANCE OF CONTAMINATED EQUIPMENT: Follow practices indicated in Section 6 (Accidental Release Measures). Make certain that application equipment is locked and tagged-out safely. Always use product in areas where adequate ventilation is provided.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION

VENTILATION AND ENGINEERING CONTROLS: No special ventilation systems or engineering controls are needed under normal circumstances of use. As with all chemicals, use this gas mixture in well-ventilated areas. If this gas mixture is used in a poorly-ventilated area, install automatic monitoring equipment to detect the levels of Oxygen, Hydrogen Sulfide, and Carbon Monoxide.

RESPIRATORY PROTECTION: No special respiratory protection is required under normal circumstances of use. Use supplied air respiratory protection if Carbon Monoxide levels exceed the exposure levels given in Section 2 (Composition and Information on Ingredients) or if oxygen levels are below 19.5%, or if either level is unknown during emergency response to a release of this gas mixture. If respiratory protection is required for emergency response to this gas mixture, follow the requirements of the Federal OSHA Respiratory Protection Standard (29 CFR 1910.134) or equivalent State standards. The following NIOSH respiratory protection recommendations for Hydrogen Sulfide and Carbon Monoxide are provided for further information.

8. EXPOSURE CONTROLS - PERSONAL PROTECTION (Continued)

NIOSH/OSHA RECOMMENDATIONS FOR HYDROGEN SULFIDE CONCENTRATIONS IN AIR:

Up to 100 ppm: Powered air-purifying respirator with cartridge(s) to protect against hydrogen sulfide; or gas mask with canister to protect against hydrogen sulfide; or SAR; or full-facepiece SCBA.

Emergency or Planned Entry into Unknown Concentration or IDLH Conditions: Positive pressure, full-facepiece SCBA; or positive pressure, full-facepiece SAR with an auxiliary positive pressure SCBA.

Escape: Gas mask with canister to protect against hydrogen sulfide; or escape-type SCBA

NOTE: The IDLH concentration for Hydrogen Sulfide is 100 ppm.

NIOSH/OSHA RECOMMENDATIONS FOR CARBON MONOXIDE CONCENTRATIONS IN AIR:

Up to 350 ppm Supplied Air Respirator (SAR)

Up to 875 ppm Supplied Air Respirator (SAR) operated in a continuous flow mode.

Up to 1200 ppm Gas mask with canister to protect against carbon monoxide; or full-facepiece SCBA; or full-facepiece Supplied Air Respirator (SAR).

Emergency or Planned Entry into Unknown Concentration or IDLH Conditions: Positive pressure, full-facepiece SCBA; or positive pressure, full-facepiece Supplied Air Respirator (SAR) with an auxiliary positive pressure SCBA.

Escape: Gas mask with canister to protect against carbon monoxide; or escape-type SCBA.

NOTE: End of Service Life Indicator (ESLI) required for gas masks.

EYE PROTECTION: Safety glasses. If necessary, refer to U.S. OSHA 29 CFR 1910.133 or appropriate Canadian Standards.

HAND PROTECTION: No special protection is needed under normal circumstances of use. If necessary, refer to U.S. OSHA 29 CFR 1910.138 or appropriate Standards of Canada.

BODY PROTECTION: No special protection is needed under normal circumstances of use. If a hazard of injury to the feet exists due to falling objects, rolling objects, where objects may pierce the soles of the feet or where employee's feet may be exposed to electrical hazards, use foot protection, as described in U.S. OSHA 29 CFR 1910.136.

9. PHYSICAL and CHEMICAL PROPERTIES

The following information is for Nitrogen, the main component of this gas mixture.

GAS DENSITY @ 32°F (0°C) and 1 atm: 0.072 lbs/ ft^3 (1.153 kg/m^3)

FREEZING/MELTING POINT @ 10 psig: -210°C (-345.8°F)

BOILING POINT: -195.8°C (-320.4°F)

SPECIFIC GRAVITY (air = 1) @ 70°F (21.1°C): 0.906

pH: Not applicable.

SOLUBILITY IN WATER vol/vol @ 32°F (0°C) and 1 atm: 0.023

MOLECULAR WEIGHT: 28.01

EVAPORATION RATE (nBuAc = 1): Not applicable.

EXPANSION RATIO: Not applicable.

ODOR THRESHOLD: Not applicable.

SPECIFIC VOLUME (ft^3/lb): 13.8

VAPOR PRESSURE @ 70°F (21.1°C) psig: Not applicable.

COEFFICIENT WATER/OIL DISTRIBUTION: Not applicable.

The following information is for the gas mixture.

APPEARANCE AND COLOR: This gas mixture is a colorless gas which has an rotten egg-like odor, due to the presence of Hydrogen Sulfide.

HOW TO DETECT THIS SUBSTANCE (warning properties): Continuous inhalation of low concentrations of Hydrogen Sulfide (a component of this gas mixture) may cause olfactory fatigue, so that there are no distinct warning properties. In terms of leak detection, fittings and joints can be painted with a soap solution to detect leaks, which will be indicated by a bubble formation. Wet lead acetate paper can be used for leak detection. The paper turns black in the presence of Hydrogen Sulfide. Cadmium chloride solutions can also be used. Cadmium solutions will turn yellow upon contact with Hydrogen Sulfide.

10. STABILITY and REACTIVITY

STABILITY: Normally stable in gaseous state.

DECOMPOSITION PRODUCTS: The thermal decomposition products of Propane, n-Hexane, and n-Pentane include carbon oxides. The decomposition products of Hydrogen Sulfide include water and sulfur oxides. The other components of this gas mixture do not decompose, per se, but can react with other compounds in the heat of a fire.

MATERIALS WITH WHICH SUBSTANCE IS INCOMPATIBLE: Titanium will burn in Nitrogen (the main component of this gas mixture). Lithium reacts slowly with Nitrogen at ambient temperatures. Components of this gas mixture (Hydrogen Sulfide, Propane, n-Pentane, n-Hexane) are also incompatible with strong oxidizers (i.e. chlorine, bromine pentafluoride, oxygen, oxygen difluoride, and nitrogen trifluoride). Carbon Monoxide is mildly corrosive to nickel and iron (especially at high temperatures and pressures). Hydrogen Sulfide is corrosive to most metals, because it reacts with these substances to form metal sulfides.

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Contact with incompatible materials. Cylinders exposed to high temperatures or direct flame can rupture or burst.

11. TOXICOLOGICAL INFORMATION

TOXICITY DATA: The following toxicology data are available for the components of this gas mixture:

NITROGEN: There are no specific toxicology data for Nitrogen. Nitrogen is a simple asphyxiant, which acts to displace oxygen in the

n-PENTANE:

LD_{50} (intravenous, mouse) = 446 mg/kg.

LC_{50} (inhalation, rat) = 364 g/m^3/4 hours

LCLo (inhalation, mouse) = 325 g/m^3/2 hours

n-HEXANE:

Eye, rabbit = 10 mg/ mild

TCLo (inhalation, rat) = 10,000 ppm/7 hr.

TCLo (inhalation, rat) = 5000 ppm/20 hours; teratogenic effects

LD50 (oral, rat) = 28710 mg/kg

LDLo (intraperitoneal, rat) = 9100 mg/kg

LCLo (inhalation, mouse) = 120,000 mg/kg

LD50 (rat, oral): 28,710 mg/kg

ACUTE INHALATION (mouse): 30,000 ppm, narcosis within 30 to 60 minutes; 35,000-40,000 ppm, convulsions and death.

DERMAL (rabbit): 2 to 5 ml/kg for 4 hours resulted in restlessness and discoordination,; death occurred at 5 ml/kg.

HYDROGEN SULFIDE:

LCLo (inhalation, human) = 600 ppm/30 minutes

LDLO (inhalation, man) = 5.7 mg/kg; central nervous system, pulmonary effects

n-HEXANE (continued):

CHRONIC INHALATION (rat): 400-600 ppm, 5 days/week, peripheral neuropathy in 45 days; 850 ppm for 143 days, loss of weight and degeneration of the sciatic nerve. (mouse): 250 ppm, peripheral neuropathy within 7 months; no effects at 100 ppm.

PROPANE:

Long-Term Inhalation: No toxicity or abnormalities were observed when monkeys were exposed to approximately 750 ppm for 90 days. Similar results were obtained when monkeys were exposed to an aerosol spray containing 65% propane and isobutane.

CARBON MONOXIDE:

TCLo (inhalation, mouse) = 65 ppm/24 hours (7-18 preg): rep. effects

TCLo (inhalation, mouse) = 8 pph/1 hour (female 8D post): ter. effects

HYDROGEN SULFIDE (continued):

LCLo (inhalation, human) = 800 ppm/5 minutes

LC_{50} (inhalation, rat) = 444 ppm

CARBON MONOXIDE (continued):

TCLo (inhalation, human) = 600 mg/m^3/10 minutes

LCLo (inhalation, man) = 4000 ppm/30 minutes

TCLo (inhalation, man) = 650 ppm/45 minutes: central nervous system and blood system effects.

LCLo (inhalation, human) = 5000 ppm/5 minutes

LCLo (inhalation, dog) = 4000 ppm/46 minutes

LCLo (inhalation, rabbit) = 4000 ppm

LC_{50} (inhalation, rat) = 1811 ppm/4 hours

LC_{50} (inhalation, guinea pig) = 2450 ppm/4 hours

LC_{50} (inhalation, guinea pig) = 5718 ppm/4 hours

LCLo (inhalation, mammal) = 5000 ppm/5 minutes

LD_{50} (inhalation, wild bird) = 1334 ppm

HYDROGEN SULFIDE (continued):

LC_{50} (inhalation, mouse) = 673 ppm/1 hour

LCLo (inhalation, mammal) = 800 ppm/5 minutes

SUSPECTED CANCER AGENT: The components of this gas mixture are not found on the following lists: FEDERAL OSHA Z LIST, NTP, CAL/OSHA, and IARC; therefore, they are not considered to be, nor suspected to be, cancer-causing agents by these agencies.

IRRITANCY OF PRODUCT: The Hydrogen Sulfide component of this gas mixture, is irritating to the eyes, and may be irritating to the skin.

SENSITIZATION OF PRODUCT: The components of this gas mixture are not known to be skin or respiratory sensitizers. Pentane isomers (i.e. n-Pentane) and Propane can cause cardiac sensitization to epinephrine.

REPRODUCTIVE TOXICITY INFORMATION: Listed below is information concerning the effects of this gas mixture on the human reproductive system.

Mutagenicity: No mutagenicity effects have been described for the components of this gas mixture.

Embryotoxicity: This gas mixture contains components that may cause embryotoxic effects in humans; however, due to the small total amount of the components, embryotoxic effects are not expected to occur.

Teratogenicity: This gas mixture is not expected to cause teratogenic effects in humans due to the small cylinder size and small total amount of all components. The Carbon Monoxide component of this gas mixture which exists up to 1%, can cause teratogenic effects in humans. Severe

11. TOXICOLOGICAL INFORMATION (continued)

exposure to Carbon Monoxide during pregnancy has caused adverse effects and the death of the fetus. In general, maternal symptoms are an indicator of the potential risk to the fetus since Carbon Monoxide is toxic to the mother before it is toxic to the fetus.

Reproductive Toxicity: The components of this gas mixture are not expected to cause adverse reproductive effects in humans.

A mutagen is a chemical which causes permanent changes to genetic material (DNA) such that the changes will propagate through generation lines. An embryotoxin is a chemical which causes damage to a developing embryo (i.e. within the first eight weeks of pregnancy in humans), but the damage does not propagate across generational lines. A teratogen is a chemical which causes damage to a developing fetus, but the damage does not propagate across generational lines. A reproductive toxin is any substance which interferes in any way with the reproductive process.

BIOLOGICAL EXPOSURE INDICES (BEIs): Biological Exposure Indices (BEIs) have been determined for the components of this gas mixture, as follows:

CHEMICAL DETERMINANT	SAMPLING TIME	BEI
CARBON MONOXIDE • Carboxyhemoglobin in blood • Carbon monoxide in end-exhaled air	 • End of shift • End of shift	 • 3.5% of hemoglobin • 20 ppm
n-HEXANE • 2,5-Hexanedione in urine • n-Hexane in end-exhaled air	 • End of shift	 • 5 mg/g creatinine

12. ECOLOGICAL INFORMATION

ENVIRONMENTAL STABILITY: The gas will be dissipated rapidly in well-ventilated areas. The following environmental data are applicable to the components of this gas mixture.

OXYGEN: Water Solubility = 1 volume Oxygen/32 volumes water at 20°C. Log K_{ow} = -0.65

PROPANE: Log K_{ow} = 2.38. Water Solubility = 62.4 ppm, 25°C. Propane is readily degraded by soil bacteria.

PENTANE: Log K_{ow} = 3.39. Water Solubility = 38.5 mg/L. LOG BCF (n-pentane) = calculated, 1.90 and 2.35, respectively. Photolysis, hydrolysis, and bioconcentration are not anticipated to be important fate processes. Biodegradation and soil adsorption are anticipated to be more important processes for this compound.

n-HEXANE: Log K_{ow} = 3.90-4.11. Water Solubility = 9.5 mg/L. Estimated Bioconcentration Factor =2.24 and 2.89. Bioconcentration in aquatic organisms is low. Hexane is volatile. Rapid volatilization from water and soil is anticipated for this compound. Hexane will float in slick on surface of the water

HYDROGEN SULFIDE: Water Solubility = 1 g/242 mL at 20°C.

CARBON MONOXIDE: Water solubility = 3.3 ml/100 cc at 0 °C, 2.3 ml at 20°C.

NITROGEN: Water Solubility = 2.4 volumes Nitrogen/100 volumes water at 0°C; 1.6 volumes Nitrogen/100 volumes water at 20°C.

EFFECT OF MATERIAL ON PLANTS or ANIMALS: No evidence is currently available on this gas mixture's effects on plant and animal life. The Hydrogen Sulfide and Carbon Monoxide components of this gas mixture, can be deadly to exposed animal life, producing symptoms similar to those experienced by humans. This gas mixture may also be harmful to plant life.

EFFECT OF CHEMICAL ON AQUATIC LIFE: No evidence is currently available on the effects of this gas effects on aquatic life. The presence of more than a trace of Carbon Monoxide is a hazard to fish. The following aquatic toxicity data are available for the Hydrogen Sulfide component of this gas mixture.

TLm (Asellussp) = 0.111 mg/L/96 hour
TLm (Cranfgonyx sp) =1.07 mg/L/96 hour
TLm (Gammarrus) = 0.84 mg/L/96 hour
LC_{50} (fly inhalation) = 380 mg/m^3/960 minutes
LC_{50} (fly inhalation) = 1500 mg/m^3/7 minutes
TLm (Lepomis macrochirus, bluegill sunfish) = 0.0478 mg/L/96 hour
TLm (Lepomis macrochirus, bluegill sunfish) = 0.0448 mg/L/96 hour at 21-22 °C
TLm (Pimephlaes promelas, fathead minnow) = 0.0071-0.55 mg/L/96 hour
TLm (Salvenilis foninalis, brook trout) = 0.0216-0.038 mg/L/96 hour at 8-12.5 °C

13. DISPOSAL CONSIDERATIONS

PREPARING WASTES FOR DISPOSAL PREPARING WASTES FOR DISPOSAL: Waste disposal must be in accordance with appropriate Federal, State, and local regulations. Cylinders with undesired residual product may be safely vented outdoors with the proper regulator. For further information, refer to Section 16 (Other Information).

14. TRANSPORTATION INFORMATION

THIS GAS MIXTURE IS HAZARDOUS AS DEFINED BY 49 CFR 172.101 BY THE U.S. DEPARTMENT OF TRANSPORTATION.

PROPER SHIPPING NAME: Compressed gases, n.o.s. (*Oxygen, Nitrogen)*or the gas component with the next highest concentration next to Nitrogen.

HAZARD CLASS NUMBER and DESCRIPTION: 2.2 (Non-Flammable Gas)

UN IDENTIFICATION NUMBER: UN 1956

PACKING GROUP: Not Applicable

DOT LABEL(S) REQUIRED: Class 2.2 (Non-Flammable Gas)

NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2000): 126

MARINE POLLUTANT: The components of this gas mixture are not classified by the DOT as Marine Pollutants (as defined by 49 CFR 172.101, Appendix B).

SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure position, in a well-ventilated vehicle. The transportation of compressed gas cylinders in automobiles or in closed-body vehicles can present serious safety hazards. If transporting these cylinders in vehicles, ensure these cylinders are not exposed to extremely high temperatures (as may occur in an enclosed vehicle on a hot day). Additionally, the vehicle should be well-ventilated during transportation.

Note: DOT 39 Cylinders ship in a strong outer carton (overpack). Pertinent shipping information goes on the outside of the overpack. DOT 39 Cylinders do not have transportation information on the cylinder itself.

TRANSPORT CANADA TRANSPORTATION OF DANGEROUS GOODS REGULATIONS: This gas is considered as Dangerous Goods, per regulations of Transport Canada.

PROPER SHIPPING NAME: Compressed gases, n.o.s. (*Oxygen, Nitrogen)*or the gas component with the next highest concentration next to Nitrogen.

HAZARD CLASS NUMBER and DESCRIPTION: 2.2 (Non-Flammable Gas)

UN IDENTIFICATION NUMBER: UN 1956

PACKING GROUP: Not Applicable

HAZARD LABEL: Class 2.2 (Non-Flammable Gas)

SPECIAL PROVISIONS: None

EXPLOSIVE LIMIT AND LIMITED QUANTITY INDEX: 0.12

ERAP INDEX: None

PASSENGER CARRYING SHIP INDEX: None

PASSENGER CARRYING ROAD VEHICLE OR PASSENGER CARRYING RAILWAY VEHICLE INDEX: 75

NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (2000): 126

NOTE: Shipment of compressed gas cylinders via Public Passenger Road Vehicle is a violation of Canadian law (Transport Canada Transportation of Dangerous Goods Act, 1992).

15. REGULATORY INFORMATION

ADDITIONAL U.S. REGULATIONS:

U.S. SARA REPORTING REQUIREMENTS: This gas is not subject to the reporting requirements of Sections 302, 304 and 313 of Title III of the Superfund Amendments and Reauthorization Act., as follows:

COMPONENT	SARA 302 (40 CFR 355, Appendix A)	SARA 304 (40 CFR Table 302.4)	SARA 313 (40 CFR 372.65)
n-Hexane	NO	YES	YES
Hydrogen Sulfide	YES	YES	YES

15. REGULATORY INFORMATION (Continued)

U.S. SARA THRESHOLD PLANNING QUANTITY: Section 302 EHS TPQ = Hydrogen Sulfide = 500 lbs (227 kg);
U.S. TSCA INVENTORY STATUS: The components of this gas mixture are listed on the TSCA Inventory.
U.S. CERCLA REPORTABLE QUANTITY (RQ): Hexane = 5000 lb (2270 kg); Hydrogen Sulfide = 100 lbs (45.4 lb)
OTHER U.S. FEDERAL REGULATIONS:

- Hydrogen Sulfide, Carbon Monoxide, Propane, n-Pentane and n-Hexane are subject to the reporting requirements of CFR 29 1910.1000.
- Hydrogen Sulfide, Propane and n-Pentane are subject to the reporting requirements of Section 112(r) of the Clean Air Act. The Threshold Quantity for each of these gases is 10,000 pounds and so this mixture will not be affected by the regulation.
- Depending on specific operations involving the use of this gas mixture, the regulations of the Process Safety Management of Highly Hazardous Chemicals may be applicable (29 CFR 1910.119). Hydrogen Sulfide is listed in Appendix A of this regulation. The Threshold Quantity for Hydrogen Sulfide under this regulation is 1500 lbs.
- This gas mixture does not contain any Class I or Class II ozone depleting chemicals (40 CFR part 82).
- Nitrogen, Oxygen and n-Hexane are not listed Regulated Substances, per 40 CFR, Part 68, of the Risk Management for Chemical Releases. Hydrogen Sulfide is listed under this regulation in Table 1 as a Regulated Substance (Toxic Substance), in quantities of 10,000 lbs (4,553 kg) or greater. Carbon Monoxide, Propane and n-Pentane are listed under this regulation in Table 3, as Regulated Substances (Flammable), in quantities of 10,000 lbs (4,553 kg) or greater, and so this mixture will not be affected by the regulation.

U.S. STATE REGULATORY INFORMATION: The components of this gas mixture are covered under the following specific State regulations:

Alaska - Designated Toxic and Hazardous Substances: Carbon Monoxide, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
California - Permissible Exposure Limits for Chemical Contaminants: Carbon Monoxide, Nitrogen, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
Florida - Substance List: Oxygen, Carbon Monoxide, n-Pentane, n-Hexane, Hydrogen Sulfide.
Illinois - Toxic Substance List: Carbon Monoxide, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
Kansas - Section 302/313 List: No.
Massachusetts - Substance List: Oxygen, Carbon Monoxide, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
Michigan - Critical Materials Register: No.
Minnesota - List of Hazardous Substances: Carbon Monoxide, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
Missouri - Employer Information/Toxic Substance List t: n-Pentane, n-Hexane, Propane, Hydrogen Sulfide.
New Jersey - Right to Know Hazardous Substance List: Oxygen, Carbon Monoxide, Nitrogen, Propane, n-Pentane, n-Hexane.
North Dakota - List of Hazardous Chemicals, Reportable Quantities: Hydrogen Sulfide.
Pennsylvania - Hazardous Substance List: Oxygen, Carbon Monoxide, Nitrogen, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
Rhode Island - Hazardous Substance List: Oxygen, Carbon Monoxide, Nitrogen, Propane, n-Pentane, n-Hexane, Hydrogen Sulfide.
Texas - Hazardous Substance List: n-Pentane, n-Hexane, Propane, Hydrogen Sulfide.
West Virginia - Hazardous Substance List: n-Pentane, n-Hexane, Propane, Hydrogen Sulfide.
Wisconsin - Toxic and Hazardous Substances: n-Pentane, n-Hexane, Propane, Hydrogen Sulfide

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65): The Carbon Monoxide component of this gas mixture is on the California Proposition 65 lists as a chemical known to the State of California to cause birth defects or other reproductive harm.
ADDITIONAL CANADIAN REGULATIONS:

CANADIAN DSL/NDSL INVENTORY STATUS: The components of this gas mixture are on the Canadian DSL Inventory.
CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) PRIORITIES SUBSTANCES LISTS: The components of this gas mixture are not on the CEPA Priorities Substances List.
CANADIAN WHMIS CLASSIFICATION: This gas mixture is categorized as a Controlled Product, Hazard Classes A and D2A, as per the Controlled Product Regulations.

16. OTHER INFORMATION

INFORMATION ABOUT DOT-39 NRC (Non-Refillable Cylinder) PRODUCTS

DOT 39 cylinders ship as hazardous materials when full. Once the cylinders are relieved of pressure (empty) they are not considered hazardous material or waste. Residual gas in this type of cylinder is not an issue because toxic gas mixtures are prohibited. Calibration gas mixtures typically packaged in these cylinders are Nonflammable n.o.s., UN 1956. A small percentage of calibration gases packaged in DOT 39 cylinders are flammable or oxidizing gas mixtures.

For disposal of used DOT-39 cylinders, it is acceptable to place them in a landfill if local laws permit. Their disposal is no different than that employed with other DOT containers such as spray paint cans, household aerosols, or disposable cylinders of propane (for camping, torch etc.). When feasible, we recommended recycling for scrap metal content. CALGAZ will do this for any customer that wishes to return cylinders to us prepaid. All that is required is a phone call to make arrangements so we may anticipate arrival. Scrapping cylinders involves some preparation before the metal dealer may accept them. We perform this operation as a service to valued customers who want to participate.

MIXTURES: When two or more gases or liquefied gases are mixed, their hazardous properties may combine to create additional, unexpected hazards. Obtain and evaluate the safety information for each component before you produce the mixture. Consult an Industrial Hygienist or other trained person when you make your safety evaluation of the end product. Remember, gases and liquids have properties which can cause serious injury or death.

Further information about the handling of compressed gases can be found in the following pamphlets published by: Compressed Gas Association Inc. (CGA), 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102. Telephone: (703) 412-0900.

P-1 *"Safe Handling of Compressed Gases in Containers"*
AV-1 *"Safe Handling and Storage of Compressed Gases"*
"Handbook of Compressed Gases"

PREPARED BY: CHEMICAL SAFETY ASSOCIATES, Inc.
PO Box 3519, La Mesa, CA 91944-3519
619/670-0609

Fax on Demand: 1-800/231-1366

AIR LIQUIDE™

This Material Safety Data Sheet is offered pursuant to OSHA's Hazard Communication Standard, 29 CFR, 1910.1200. Other government regulations must be reviewed for applicability to this gas mixture. To the best of CALGAZ knowledge, the information contained herein is reliable and accurate as of this date; however, accuracy, suitability or completeness are not guaranteed and no warranties of any type, either express or implied, are provided. The information contained herein relates only to this specific product. If this gas mixture is combined with other materials, all component properties must be considered. Data may be changed from time to time. Be sure to consult the latest edition.

Heat Illness Prevention Program

HEAT ILLNESS
PREVENTION PROGRAM

CORPORATE HEALTH AND SAFETY DIRECTOR	:	**Brian Hobbs, CIH, CSP**
EFFECTIVE DATE	:	**10/2019**
REVISION DATE	:	**03/2024**
REVISION NUMBER	:	**3**

TABLE OF CONTENTS

1. PURPOSE 1
2. SCOPE AND APPLICABILITY 1
3. ROLES AND RESPONSIBILITIES 1
4. HAZARD IDENTIFICATION AND ASSESSMENT 2
5. TRAINING 2
6. DRINKING WATER 3
7. ACCESS TO SHADE 4
8. MONITORING AND SCHEDULING 5
9. ACCLIMATIZATION AND NEW EMPLOYEE PROCEDURES 5
10. HEAT WAVE AND EXTREME HEAT PROCEDURES 5
11. EMERGENCY RESPONSE PROCEDURES 6
12. HEAT-RELATED ILLNESSES 6
13. OTHER HEAT CONTROLS 8

1. PURPOSE

Roux Associates, Inc. and its affiliated **companies**, Roux Environmental Engineering and Geology, D.P.C, and Remedial Engineering (collectively, "Roux") has established this heat illness prevention program to assist in preventing workplace accidents, injuries, and illnesses associated with temperature extremes. Roux is committed to taking every precaution to protect employees who might be exposed to heat stress, including establishing safe work practices, heat illness prevention controls, and emergency preparedness, which will be detailed in this plan.

2. SCOPE AND APPLICABILITY

Roux's Heat Illness Prevention Program applies to all employees who may be exposed to heat stress in the field.

3. ROLES AND RESPONSIBILITIES

The Heat Illness Prevention Program Administrator for Roux is the Corporate Health and Safety Director (CHSD), Brian Hobbs, CIH, CSP. The daily administration of the program is delegated to the Operations Manager (OM) and Office Health and Safety Manager (OHSM). The CHSD has the authority, responsibility, and overall accountability for the comprehensive implementation of this program.

All managers and supervisors shall implement and maintain the heat illness prevention program in work areas where there is a potential for heat stress.

Management Responsibilities

Management (i.e., Project Managers, Project Principals, OM) must provide the following to promote compliance and foster a good safety culture:

- Comply with applicable standards.
- Inform employees of the provisions of the heat illness prevention program and ensure understanding.
- Provide sufficient water, shade, rest areas, and other heat illness controls for employees.
- Assist with establishing work practices to minimize heat stress risks, such as acclimatization, required rest periods, employee monitoring, and strategic scheduling.
- Encourage employees to report hazardous conditions or heat illness symptoms.
- Provide training to any employee who could possibly be exposed to the risk of heat illness.

Employee Responsibilities

Employees are expected to actively participate in the organization's heat illness prevention program, which includes the following responsibilities:

- Receive appropriate training with regard to heat stress.
- Understand core concepts of heat illness prevention and follow guidelines to mitigate risks.
- Recognize the signs and symptoms of heat illness and immediately report them.
- Cooperate with workplace inspections and incident investigations.

Effective Communication

All Roux employees shall be accountable for ensuring there is effective communication with both the field team and their subcontractors. Communication between Roux employees project leads (e.g., Project Principal, Project Managers) and subcontractors (if applicable) will be established and maintained so that employees can quickly

contact should there be a change in condition or someone at the Site exhibits signs/symptoms of heat stress. These types of incidents would follow Roux's Incident Investigation and Reporting Management Program 2.12 and Roux's Injury Illness Prevention Program 2.22.

4. HAZARD IDENTIFICATION AND ASSESSMENT

Prior to scheduled fieldwork, the project team shall ensure a hazard assessment is conducted as it relates to heat stress. This will include a determination of how much heat and exertion employees are likely to be exposed to based on the work activity.

Factors that can increase heat stress include the following:

- Temperatures at the work site;
- Humidity;
- A lack of air movement or exchange;
- The amount of time employees spend working in the heat;
- The time of day work takes place;
- Sources of radiant heat (e.g., sunlight, fire, or hot furnace);
- Work activities that produce heat (e.g., welding);
- Physical contact with warm or hot objects or liquids;
- The clothing and PPE employees are required to wear; and/or
- Physically strenuous work.

Results of the hazard analysis should be used to determine appropriate controls for mitigating heat stress, whenever possible, for planning acclimatization, and for developing work schedules that rotate workers to limit employee exposure. Typically, the Site Supervisor (SS) or Site Health and Safety Officer (SHSO) shall conduct worksite observations to ensure all employees follow heat illness prevention procedures and that hazards are sufficiently controlled. However, all employees should be continuously evaluating work site conditions and be able to recognize heat stressors in order to prevent heat illnesses.

5. TRAINING

All Roux employees shall be trained on the topics listed below prior to beginning work, which may potentially expose workers to heat stress.

Training Topics

- The environmental, behavioral, and personal risk factors for heat illness, such as radiant heat sources, exertion, clothing and PPE, and use of alcohol or drugs.
- Types of heat illnesses, common symptoms, and appropriate emergency response for each.
- The knowledge that mild symptoms may quickly become more severe or life-threatening.
- The importance of immediately reporting any signs or symptoms of heat illness to the supervisor.
- The employer's responsibility to provide shade, water, access to first aid, and cool-down rests during work and the employee's freedom to exercise their rights under this standard without fear of retaliation.

- The employer's heat stress plan and its procedures:
  - Procedures for employees who are newly assigned to work in high-heat areas.
  - The organization's acclimatization methods, as applicable.
  - Heatwave procedures.
  - Heat illness and emergency response, including contact information.
- The importance of frequent consumption of water and the taking of rest breaks.
- How heat illness prevention applies to employees' specific tasks.

Increasing Training Effectiveness:

- The SS/SHSO will hold daily tailgates with the field team to go over daily work tasks and basic safety information including Job Safety Analysis (JSA) review as well as incorporate elements such as current weather and effects on the work activities for the day.
- If a heat wave or high heat is anticipated, OHSMs and/or OMs will provide communications to Roux employees prior to their shifts and remind them of any special high heat procedures.

6. DRINKING WATER

Employees shall be given access to potable drinking water. Access to water will be provided as near as possible to where employees are working, and there shall be enough locations so employees will have sufficient water. Water should be fresh and pure, free of taste or smell that would discourage employees from drinking, comfortably cool, and obtained from an approved source.

The recommendation is that during warm or hot weather, employees drink four 8-ounce glasses of water, or a total of one quart per hour, throughout the entire work shift. Easy access to sufficient potable drinking water throughout the work shift encourages employees to drink.

During a heat wave, water shall be replenished more often to keep available and cool. Water containers (and all spouts and levers) must be kept clean. If able, provide single-use drinking cups with appropriate waste receptacles. Accessible sanitation facilities shall also be maintained at work Sites as appropriate.

SS/SHSO is responsible for the following:

- Drink sufficient water before, during, and after work shifts to maintain hydration.
- Encourage frequent drinking of small amounts of water throughout the shift. In high-heat environments, remind field staff and subcontractors that drinking extra water may be necessary.
- Discourage the choice of drinks with caffeine or sugar that may possibly dehydrate employees instead of water. Also, discourage the drinking of alcohol.
- Monitor the water supply.
- If employees become dehydrated and are unable to alleviate symptoms with the steps below, get them immediate medical attention.

Field Staff/Subcontractors are responsible for the following:

- Drink sufficient water before, during, and after work shifts to maintain hydration. Drink up to 4 cups of water per hour, especially during hot weather.
- Be aware that in high-heat situations, you may need to drink more water.

- Monitor yourself and others for signs of dehydration. If you feel dehydrated:
  - Follow Roux's Incident Notification Flowchart;
  - Rest in the shaded resting area; and
  - Drink water in small amounts, but frequently.

7. ACCESS TO SHADE

Access to shaded areas will be provided to Roux staff, as needed. Employees are encouraged to use these areas when they feel overheated. Roux's SS/SHSO shall oversee the proper implementation of shaded areas and will communicate these locations on a daily basis with the Field Team.

Depending on the Site, shaded areas can include the following:

- Pop-up Tents
- Canopies
- Umbrellas
- Structures mechanically ventilated or open to air movement
  - Garage
- Conex-mounted RV canopies
- Full and thick tree canopies that block direct sunlight
- Buildings
- Enclosed areas only if they provide cooling comparable to shade in open-air
  - Vehicles with air conditioning

Shaded Area Requirements

The shade shall be strong enough to cool employees down and other shadows should not be visible in the shade. The shade will be provided by Roux when the air temperature exceeds 80°F. If the temperature is less than 80°F, shade will be available and provided upon request. The SS/SHSO will monitor conditions to determine when the air will exceed (and is exceeding) 80°F. For most Sites, air will be monitored hourly and shade will be set up immediately if 80°F is exceeded.

Shade shall be located as close as practical to areas where employees are working and is easily accessible. These areas will be considered safe and free from other hazards. Shaded areas should be large enough to accommodate all employees who are on a break, resting, or recovering without crowding. Should natural vegetation be used for shade, the SS/SHSO will evaluate shade for effectiveness.

Field Staff Responsibilities

Field Staff should take ordinary rest breaks in the shaded areas and monitor themselves for signs of heat stress, and go to the shaded area when they need to cool down. Any issues or problems with shaded areas should be reported to the SS/SHSO for the Site.

If shaded areas are used for a preventative cool-down, the SS/SHSO will ensure the affected employees will remain in the shade until they begin to feel better. The SS/SHSO will continue to monitor the employees and ask them if

they are experiencing symptoms of a heat illness. Employees shall not be sent back to work before symptoms have ended and at a minimum at least 10 minutes of rest.

8. MONITORING AND SCHEDULING

Monitoring

The SS/SHSO and Field Team will continue to monitor themselves and others for signs of heat illness. The SS/SHSO will monitor when the air temperature exceeds 80°F. Throughout the summer, weather and temperature will be monitored at least two weeks ahead, and the work schedule will be planned to accommodate the expected weather.

Scheduling

Scheduling accommodations may include:

- Working during cooler hours of the day
- Working at night
- Stopping work early
- Rescheduling work activities
- Increasing frequency of breaks

In general, strenuous work activities shall be rescheduled to the coolest parts of the day.

Special precautions are required for temperatures above 80°F, 95°F, and heat waves. These precautions are provided in the sections below.

9. ACCLIMATIZATION AND NEW EMPLOYEE PROCEDURES

Roux requires employees to be acclimatized in order for them to better tolerate heat in the workplace. Acclimatization is the physical process of adapting to a different thermal environment, allowing a better toleration of heat. Acclimatization procedures require gradual exposure that gives the employee time to adjust to each level of exposure. Acclimatization is essential for new employees but is necessary for all employees when the temperature significantly changes. Heat stress is much more likely if these procedures are not followed.

The SS/SHSO is responsible for observing new employees during their first 14 days of employment in high-heat areas.

Re-acclimatization is necessary if employees are absent from high-heat environments for a week or more or the temperature increases significantly.

10. HEATWAVE AND EXTREME HEAT PROCEDURES

Heat Wave Procedures

A heat wave is defined as consistent temperatures over 80°F or if the temperature is 10° higher than the average daily temperatures in the preceding 5 days.

SS/SHSO and Project Management (e.g., PP, PM) shall closely observe and monitor employees during a heat wave. The Field Teams should institute a ratio of one SS to 20 or fewer employees, a mandatory buddy system, or

a consistent practice for supervisors to check on employees. Pre-shift meetings to review high-heat procedures with employees will be carried out to emphasize work-rest schedules, drinking water, shade, etc.

Extreme Heat Procedures

When work-site temperatures equal or exceed 95°F, the employer will enact extreme heat procedures:

- Employees will be closely observed by the SS/SHSO for signs of heat illness. New employees will be supervised for acclimatization.
- Effective communication and monitoring will be assured through the use of periodic check-ins with the SS/SHSO via phone. Communications between employees and Project Management (e.g., PP/PM) will be established and maintained. Mandatory 10-minute break periods are required for every two hours worked. SS/SHSO must enforce this rule.
- Pre-shift safety tailgate meetings will occur to review procedures and to remind employees to drink water and take cool-down rests if needed. SS/SHSO shall remind employees to rest and drink water. Employees should drink more water than usual.

11. EMERGENCY RESPONSE PROCEDURES

Roux is dedicated to providing prompt appropriate care for all employees who report or show symptoms of heat illness. If an employee shows signs of heat illness, they will be monitored and shall not be left alone or sent home without being offered first aid or emergency medical services. If on-Site personnel require any medical treatment, the following steps will be taken:

1. Notify Roux's Project and Corporate Management Team for any work-related injury and/or illness occurrence, and communicate with the contracted Occupational Health Care Management Provider, AllOne Health (AOH), immediately following the notifications provided above.
2. Based on discussions with the Project Team, Corporate Management, and the AOH evaluation, if medical attention beyond onsite First Aid is warranted, transport the injured / ill person (IP) to the Urgent Care Center, or notify the Fire Department or Ambulance Emergency service and request an ambulance or transport the victim to the hospital, and continue communications with Corporate Management Team. An Urgent Care/Hospital Route map with locations and directions is provided within Site Specific Health and Safety Plans.
3. First aid medical support will be provided by onsite personnel trained and certified in First Aid, Cardio Pulmonary Resuscitation (CPR), Automatic External Defibrillation (AED), and Blood-Borne Pathogens (BBP) Awareness, until relieved by emergency medical services (EMS).
4. The SHSO and Project Manager will perform a Loss Investigation (LI) and the Project Team will complete the final Loss Report.

12. HEAT-RELATED ILLNESSES

Heat Stress

Heat stress is a significant potential hazard and can be associated with heavy physical activity and/or the use of personal protective equipment (PPE) in hot-weather environments. For these reasons, the company will provide potable drinking water and access to shade or other areas of relief (i.e., air-conditioned vehicles and work trailers). Supervisors, prior to supervising personnel in the field as well as all personnel involved with the fieldwork of a project, are trained in this HASP that includes preventing heat-related illnesses and the below procedures in response to heat-related symptoms and illness. Since much of our work is dependent upon environmental factors beyond our control, we must closely monitor air temperature and humidity and be aware of avoiding radiant heat sources and providing as much air circulation as possible wherever we work. Physical factors that need to be evaluated as part of our Job Safety Analysis (JSA) reviews include the level of physical activity and duration of work

and the type (i.e., color, weight breathability) of the clothing we select. In addition, personal factors such as age, weight, fitness, drug/alcohol use, and prior history of heat-related illness need to be considered.

Heat cramps are brought on by prolonged exposure to heat. As an individual sweats, water and salts are lost by the body, resulting in painful muscle cramps. The signs and symptoms of heat stress are as follows:

- Severe muscle cramps, usually in the legs and abdomen;
- Exhaustion, often to the point of collapse; and
- Dizziness or periods of faintness.

First aid treatment includes, but is not limited to, shade, rest, and fluid replacement. Typically, the individual should recover within one-half hour while being monitored constantly. If the individual has not improved substantially within 30 minutes and the body temperature has not decreased, the individual should be transported to a hospital for medical attention.

Heat Exhaustion

Heat exhaustion may occur in a healthy individual who has been exposed to excessive heat while working or exercising. The circulatory system of the individual fails as blood collects near the skin to rid the body of excess heat through transference. The signs and symptoms of heat exhaustion are as follows:

- Rapid and shallow breathing;
- Weak pulse;
- Cold and clammy skin with heavy perspiration;
- Skin appears pale;
- Fatigue and weakness;
- Dizziness; and
- Elevated body temperature.

First aid treatment includes, but is not limited to, cooling the victim, elevating the feet, and replacing fluids. If the individual is not substantially improved within 30 minutes and the body temperature has not decreased, the individual should be transported to the hospital for medical attention.

Heat Stroke

Heat stroke occurs when an individual is exposed to excessive heat and stops sweating. This condition is classified as a MEDICAL EMERGENCY requiring immediate cooling of the victim and transport to a medical facility. The signs and symptoms of heat stroke are as follows:

- Dry, hot red skin;
- Body temperature approaching or above 105 degrees F;
- Confusion, altered mental state, slurred speech;
- Seizures;
- Large (dilated) pupils; and
- Loss of consciousness – the individual may go into a coma.

First aid treatment requires immediate cooling and transportation to a medical facility. Heat stress is a significant hazard if any type of protective equipment (semi-permeable or impermeable) that prevents evaporative cooling is worn in hot-weather environments.

13. OTHER HEAT CONTROLS

Clothing and PPE

Employees should choose clothing that is reflective, light-colored, lightweight, loose-fitting, and breathable. Clothing should cover the exposed parts of the body. In direct sun, hard hats with a brim or bill may be helpful. Should specialized cooling garments be applicable, please consult with your OM/OHSM/CHSD.

Managing Employee Risk Factors

It is recommended that employees are aware of how their health can affect their risk of heat stress. The following increases ones risk for a heat related illness:

- A poor level of physical fitness
- Obesity
- Chronic or acute illnesses
- Conditions such as diabetes, heart disease, or high blood pressure
- Certain medications, such as diuretics
- Age (60+)

Employees should:

- Maintain their health outside of work
- Be aware of the effects of medications
- Drink adequate amounts of water
- Eat light, cool meals during work shifts and save heavy meals until after the shift is over
- Do not skip meals: food helps replace electrolytes when sweating
- Take breaks as needed
- Do not consume alcohol prior to working in a hot environment

APPENDIX D

Personal Protective Equipment (PPE) Management Program

PERSONAL PROTECTIVE EQUIPMENT
MANAGEMENT PROGRAM

CORPORATE HEALTH AND SAFETY DIRECTOR	:	**Brian Hobbs, CIH, CSP**
EFFECTIVE DATE	:	**01/2019**
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TABLE OF CONTENTS

1. PURPOSE 1
2. SCOPE AND APPLICABILITY 1
3. PROCEDURES 1
3.1 Introduction 1
3.1.1 Training 1
3.2 Types of PPE 2
3.2.1 PPE Inspection, Cleaning Maintenance, and Storage 2
3.2.1.1 PPE Inspection 2
3.2.1.2 PPE Cleaning and Maintenance 2
3.2.1.3 PPE Storage 3
3.3 Fitting, Donning and Doffing PPE 3
3.4 Controlling Hazards Associated with PPE Use 4
3.5 PPE Selection 5
3.6 Protective Clothing Selection Criteria 5
3.6.1 Chemicals Present 5
3.6.2 Concentration of the Chemical(s) 5
3.6.3 Physical State 6
3.6.4 Length of Exposure 6
3.6.5 Abrasion 6
3.6.6 Dexterity 6
3.6.7 Ability to Decontaminate 6
3.6.8 Climactic Conditions 7
3.6.9 Work Load 7
3.6.10 Types of Protective Materials 7
3.7 Protection Levels 7
3.7.1 Level A Protection 7
3.7.2 Level B Protection 9
3.7.3 Level C Protection 10
3.7.4 Level D Protection 12
3.7.5 Level E Protection 12
3.7.6 Additional Considerations 13
3.8 Decontamination of PPE 13
3.8.1 Site-Specific Decontamination Plans 14
3.8.2 Emergency Decontamination of PPE 14
3.8.3 Protection of Decontamination Line Assistants 15
3.8.4 Procedures to Minimize PPE Contamination 15
3.8.5 PPE Disposal 16

1. PURPOSE

Roux Associates, Inc. and its affiliated companies, Roux Environmental Engineering and Geology, D.P.C., and Remedial Engineering (collectively, "Roux") has instituted the following program to establish guidelines for the selection of personal protective equipment (PPE) for use by Roux personnel performing field activities in hazardous environments. PPE is not meant to be a substitute for engineering, work practice, and/or administrative controls, but PPE should be used in conjunction with these controls to protect employees in the workplace. Clothing, body coverings, and other accessories designed to prevent worker exposure to workplace hazards are all types of PPE. To ensure adequate PPE employee-owned PPE is evaluated on a case-by-case basis to insure its adequacy, maintenance and sanitation.

2. SCOPE AND APPLICABILITY

These guidelines apply to all PPE selection decisions to be made in implementing the Roux program. The foundations for this program are the numerous Occupational Health and Safety Administration (OSHA) standards related to PPE cited in 29 CFR 1910 Subpart I, 29 CFR 1926 Subpart E, and the hazardous environment work employee protection requirements under the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) standard at 29 CFR 1910.120 and 1926.65. To ensure hazard assessments are documented, the levels of protection, types of protection, and tasks requiring protection are covered in site-specific Health and Safety Plans (HASPs) and Job Safety Analyses (JSAs).

3. PROCEDURES

Due to the varied nature of site activities and the different potential hazards associated with different sites, several aspects must be considered when selecting PPE. The following text describes PPE selection logic and provides guidelines and requirements for the appropriate selection and use of PPE.

3.1 Introduction

To harm the body, chemicals must first gain entrance. The intact skin and respiratory tract are usually the first body tissues that are exposed to chemical contaminants. These tissues provide barriers to some chemicals but, in many cases, are damaged themselves or are highly permeable by certain chemical compounds. PPE, therefore, is used to minimize or eliminate chemical compounds from coming into contact with these first barrier tissues.

Proper PPE selection is essential in preventing exposures. The Project Manager (PM) or health and safety personnel making the selection will have to consider several factors. The level of protection, type, and kind of equipment selected depends on the hazardous conditions. In some cases, additional selection factors include cost, availability, compatibility with other equipment, and performance. All these factors must be accurately assessed before work can be safely carried out.

3.1.1 Training

Training shall be provided to all field-based employees in properly using and caring for PPE. Training shall include, but not be limited to, the initial 40-hour HAZWOPER training, annual 8-hour HAZWOPER refresher training, and site-specific PPE training. The training program includes when PPE is necessary, what types of PPE are required; how to don, doff, adjust, and wear PPE; the limitations of PPE; the proper care, maintenance, useful life, signs of PPE failure and emergency procedures to follow in the event of PPE failure and disposal of PPE. In addition, retraining shall be conducted when workplace changes require a change in PPE when an employee demonstrates a lack of knowledge or improper use of PPE is identified.

3.2 Types of PPE

The type and selection of PPE must meet certain general criteria and requirements as required under OSHA 29 CFR 1910.132 (General Industry) and 1926.95 (Construction). In addition to these general requirements, specific requirements and specifications exist for some types of PPE that form the basis of the protective clothing scheme. All manufacturer's recommendations for PPE care and use shall be followed. All PPE shall be maintained in a sanitary and reliable condition. Additionally, proper fit and size shall be evaluated to ensure adequate employee protection. Should PPE become defective, it shall be immediately removed from service and discarded.

The following is a list of the common types of specific PPE and the specific requirements for the PPE type, where applicable:

1. Hard Hats - Regulated by 29 CFR 1910.135 and 1926.100; and specified in ANSI Z89.1.
2. Face Shields and Safety Glasses - Regulated by 29 CFR 1910.133 and 1926.102; and specified in ANSI Z87.1.
3. Respiratory Protection - Regulated by 29 CFR 1910.134 and 1926.103.
4. Hand Protection - Regulated by 29 CFR 1910.138
5. Foot Protection - Regulated by 29 CFR 1910.136 and 1926.96; and specified in ANSI Z41.1.
6. Protective Clothing (e.g., fully encapsulated suits, aprons) - Specified in NFPA 1991/1992/1994.

3.2.1 PPE Inspection, Cleaning Maintenance, and Storage

The Office Health and Safety Manager (OHSM) or their designee is responsible for procuring PPE, in accordance with this management program. Single-use/disposable PPE should be purchased and used whenever practicable.

3.2.1.1 PPE Inspection

Roux employees must inspect PPE regularly, before and after each use, to check for defects and damage. Garments and other PPE in central storage must be inspected at least annually or as recommended by the manufacturer by the OHSM, Equipment Manager and/or their designee. Defective or damaged equipment must be tagged as out-of-service, immediately removed from the work site and discarded.

3.2.1.2 PPE Cleaning and Maintenance

All Roux employees are responsible for routine cleaning of their assigned PPE. Decontamination of PPE is addressed within Roux's Site Control and Decontamination Program as well as specified within site-specific health and safety plans. As appropriate, Roux employees should be issued single-use PPE when practicable to minimize the requirement for decontamination. When performing routine cleaning of reusable PPE:

- Always follow the manufacturer's recommendations to avoid damaging the PPE. For example, some cleaning solutions compromise the integrity of protective helmets' shells.
- Clean and maintain PPE according to the manufacturer's recommendations. Before being re-issued, PPE should be thoroughly sanitized.
- Disassemble, wash, and sanitize reusable respirators after each use, refer to Roux's Respiratory Protection Management Program.

Employees are not authorized to repair PPE without prior approval from the Health and Safety Department. Reusable PPE may require maintenance by the manufacturer to maintain integrity and certification. Many

manufacturers specify which repairs, if performed by the end-user, will void product warranty, therefore Roux employees are not typically authorized to perform such maintenance or repairs.

3.2.1.3 PPE Storage

Certain equipment failures can be directly attributed to improper storage. The OHSM or Equipment Manager (or another designated person) is responsible for implementing procedures for appropriate PPE storage, for equipment that is centrally stored. Both central storage and dedicated PPE provided to employees should be stored using the following:

- Store goggles and safety glasses in protective cases.
- Store PPE (such as helmets, boots, etc.) in clean, dust-proof containers or bags out of direct sunlight.
- PPE should ideally be stored under climate-controlled conditions. PPE, stocked gear bags, and/or go-kits should not be stored in hot, cold, or other extreme environmental conditions, and they should not be stored in vehicles (government-owned or rentals) for even short periods of time. Do not store helmets on the rear window shelf of a vehicle.
- Store different kinds of clothing and gloves separately to prevent errors in selection.
- Hang or fold protective clothing in accordance with manufacturers' recommendations.
- Never store contaminated PPE near new protective clothing or street clothing. Potentially contaminated, reusable clothing must be stored (usually bagged) away from new PPE, in a well-ventilated area, with good air flow around each item, until the garment is decontaminated or disposed.
- See Roux's Respiratory Protection Management Program for detailed procedures on storing respirators.

3.3 Fitting, Donning and Doffing PPE

Roux shall provide appropriately sized PPE for Roux employees. Improper fitting such as tight-fitting garments, can tear, especially at the knees, crotch, shoulders, back, and elbows due to movement. Protective clothing that is too large can easily snag and/or limit a user's dexterity. The Roux PM shall ensure site/project-specific PPE is kept in a sufficient stock of appropriately sized PPE (e.g., Level C ensembles). The OHSM, Equipment Manager and/or their designee shall ensure a sufficient stock of appropriately sized PPE is maintained in central storage locations.

The Site Supervisor (SS)/Site Health and Safety Officer (SHSO) is responsible for ensuring that site-specific procedures for donning and doffing PPE are incorporated into site-specific HASPs. Donning and doffing procedures may differ depending on the type of PPE and clothing (e.g., Level D, Modified Level D, Level C) utilized. Figures 1-4, provide examples of procedures that can be used to don and doff Levels A through D and are provided as a reference. Site-specific conditions may warrant adjustments to such procedures. Consult the CHSD for additional information.

Site-specific donning and doffing procedures should include the use of an assistant where necessary. Donning and doffing certain types of PPE without assistance could risk PPE failure or damage. Care must be taken to prevent the spread of contaminants on the PPE. Decontamination procedures should limit the potential for cross contamination and may include gross decontamination of outer boots, gloves, and suits as necessary to prevent tracking of contaminants into the contamination reduction zone (CRZ) and clean zone(s).

3.4 Controlling Hazards Associated with PPE Use

PPE use can pose potential health and safety hazards, which range from minor discomfort to life-threatening height stroke. The magnitude of the potential hazard can vary and will depend on various factors, including an individual's fitness level, the type of PPE worn, the work demands, individual work practices, duration of work and environmental conditions. The use of PPE can also lead to reduced efficiency and work performance.

Among hazards associated with PPE use, heat stress emerges as a prevalent and significant hazard. Particularly, the use of substantial and/or impermeable attire, such as heavy coveralls, Tyvek suits, splash suits, or Level A or B suits, alongside strenuous work, amplifies the risk of heat stress. Regular monitoring for indications of heat stress is imperative for workers operating in such conditions. Roux's Heat Illness Prevention Program lays out requirements for signs and symptoms as well as preventative measures to mitigate the potential for heat illness. In addition, cold environments can pose adverse risk, such examples include use of non-insulated steel-toe safety shoes in frigid conditions which has the potential to increase the risk of frostbite, while safety gloves worn for chemical protection may inadequately insulate hands from the cold.

It is the responsibility of Project Teams to integrate site-specific protocols to manage PPE hazards into such site-specific HASPs. These protocols can encompass considerations like work/rest ratios, crew rotations, and other accommodations for exceptionally demanding conditions.

The following measures are recommended for controlling hazards posed by PPE use:

- Prioritize through the hierarchy of controls with a focus on elimination, substitution, engineering, work practice and administrative control implementation rather than sole reliance on PPE. PPE shall be considered the last line of worker protection.
- Workers should maintain physical fitness to be able to withstand the potential physical strain of PPE use. A physically fit individual will endure less physiological strain, manifesting in a lower heart rate, reduced body temperature (indicating diminished retained body heat), more effective sweating, slightly lower oxygen consumption, and carbon dioxide production. Furthermore, acclimatization to extreme environmental conditions, such as high temperatures, can influence work performance and physical capacity.
- Understand the symptoms of PPE failure. Workers encountering any of these symptoms while donning PPE should promptly notify their onsite SHSO and/or SS:
    - Perception of odors when wearing a respirator
    - Skin irritation
    - Acute discomfort
    - Difficulty breathing
    - Unusual fatigue
    - Dizziness
    - Inability to see, hear, or speak clearly
    - Uncomfortable restriction of movement
    - Rapid pulse, nausea, or chest pain
- Implement a buddy system. Especially in situations where there is a need for increased level of protection (e.g. Level A-C) workers should work in pairs or teams, and are instructed to monitor the integrity of their team/partners gear and remain alert for symptoms of PPE failure.

3.5 PPE Selection

For site-specific work, the Project Manager in consultation with the Health and Safety Department has overall responsibility for coordinating the selection and distribution of PPE to field staff and for ensuring that the selected PPE is appropriate for the site-specific hazards. Generally speaking Roux employees are not engaged in emergency response or perform work at uncontrolled hazardous waste sites, if the case the CHSD shall be made aware of the work and consult with the Project Team on appropriate PPE selection. Most work falls under environmental sampling of low concentration water/soil/perimeter air. Therefore work is carried out in Level D PPE. Upgrades would be based on more information as it becomes available. The United States Environmental Protection Agency (EPA) has created Guidelines for PPE Ensemble Selection to assist workers in selecting PPE ensembles for specific activities and tasks and determining which ensembles and air monitoring equipment should be used to address specific chemicals. Guidelines to Ensembles for Specific Activities/Tasks Where Chemical Exposure is Possible is provided as a reference as Appendix A.

3.6 Protective Clothing Selection Criteria

3.6.1 Chemicals Present

The most important factor in selecting PPE is the determination of what chemicals the employee may be exposed to. The number of chemicals on field investigations may range from a few to several hundred. The exact chemicals or group of chemicals present at the site (certain groups tend to require similar protection) can be determined by collecting and analyzing air, soil, water, or other site media samples. When data are lacking, research into the hazardous materials used or stored at the site can be used to infer potential chemical exposures on the site.

The most appropriate clothing shall be selected once the known or suspected chemicals have been identified and considered based on the type of work to be performed.

Protective garments are made of several different substances for protection against specific chemicals. There is no universal protective material. All will decompose, permeate, or otherwise fail to protect under given circumstances. Fortunately, most manufacturers make guides to using their products (i.e., Dupont's Tyvek™ Permeation Guide). These guides are usually for gloves and coveralls and typically provide information regarding chemical degradation rates (failure of the material to maintain structural integrity when in contact with the chemical) and may provide information on the permeation rate (whether or not the material allows the chemical to pass through). When permeation tables are available, they shall be used with degradation tables to determine the most appropriate protective material for the specific chemical hazard(s).

During most site work, chemicals are usually in mixed combinations, and the protective materials are not in continuous contact with pure chemicals for long periods; therefore, the selected material may be adequate for the particular chemical of most concern and type of work being performed, yet not the "best" protecting material for all site chemicals and activities. Selection shall depend upon the most hazardous chemicals based on their hazards and concentrations. Sometimes, layering (i.e., using several layers of protective materials) affords the best protection.

3.6.2 Concentration of the Chemical(s)

One of the major criteria for selecting protective material is the concentration of the chemical(s) in air, liquid, and solid state. Airborne and liquid chemical concentrations should be compared to the OSHA standards and American Conference of Governmental Industrial Hygienists (ACGIH) and National Institute for Occupational Safety and Health (NIOSH) guidelines to determine the level of skin or other absorptive

surface (e.g., eyes) protection needed. While these standards are not designed specifically for skin exposed directly to the liquid, they may provide skin designations indicative of chemicals known to have significant skin or dermal absorption effects. For example, airborne levels of PCBs on-site may be low because they are not very volatile, so the inhalation hazard may be minimal; however, PCB-containing liquid coming in direct contact with the skin may cause overexposure. Thus, PCBs have been assigned a skin designation in the OSHA and ACGIH exposure limit tables.

3.6.3 Physical State

The characteristics of a chemical may range from nontoxic to highly toxic, depending on its physical state. Inorganic lead in soil would not be considered toxic to site personnel unless it became airborne since it is generally not absorbed through the intact skin. However, organic lead in a liquid could be readily absorbed through the skin. Soil is frequently contaminated with hazardous materials. Concentrations will vary from a few parts per million to nearly one hundred percent by volume. The degree of hazard depends on the type of soil and concentration of the chemical. Generally speaking, "dry" soils that have not become airborne do not pose a hazard to site personnel if they take minimal precautions, such as wearing lightweight gloves.

3.6.4 Length of Exposure

The length of time a material is exposed to a chemical increases the probability of a breakthrough. Determinations of actual breakthrough times for short-term exposures indicate that several materials that would be considered inadequate under long-term exposures can be used. Different materials that would be considered inadequate under long-term exposures can be used. It should be kept in mind that during the manufacturer’s permeation testing, a pure (100% composition) liquid is usually placed in direct contact with the material, producing a worst-case situation.

3.6.5 Abrasion

When selecting protective clothing, the job the employee is engaged in must be taken into consideration. Persons moving drums or performing other manual tasks may require added protection for their hands, lower chest, and thighs. Using leather gloves and a heavy apron over other normal protective clothing will help prevent damage to the normal PPE and thus reduce worker exposures.

3.6.6 Dexterity

Although protection from skin and inhalation hazards is the primary concern when selecting PPE, the ability to perform the assigned task must be maintained. For example, personnel cannot be expected to perform work that requires fine dexterity if they must wear thick gloves. Therefore, the PPE selection process must consider the task being performed and provide PPE alternatives or techniques that maintain dexterity while still protecting the worker (e.g., wearing tight latex gloves over more bulky hand protection to increase dexterity).

3.6.7 Ability to Decontaminate

If disposable clothing cannot be used, the ability to decontaminate the materials selected must be taken into consideration. Once a chemical makes contact with the material, the PPE must be cleaned before reusing it. If the chemical has completely permeated the material, the clothing cannot be adequately decontaminated, and the material should be discarded.

3.6.8 Climactic Conditions

The human body works best with few restraints from clothing. Protective clothing adds a body burden by increasing weight, restricting movement, and preventing the body's natural cooling process. In severe situations, a modified work program must be used.

Some materials act differently when they are very hot and very cold. For example, PVC becomes almost brittle in frigid temperatures. If there are any questions about the stability of the protective materials under different conditions, the manufacturer should be contacted before using PPE in the field.

3.6.9 Work Load

Like climactic conditions, the type of work activity may affect work duration and personnel's ability to perform certain tasks. Similarly, the amount of protective materials a person wears will affect their ability to perform certain tasks. For example, a person in a total encapsulating suit, even at 72˚F, cannot work for more than a short period of time without requiring a break.

The work schedule should be adjusted to maintain the health of the employees. Modified work practices may include allowing more time for individual job tasks and implementing work/rest cycles per NIOSH and ACGIH thermal stress recommendations. Special consideration should be given to the selection of clothing that protects the worker and adds the least burden when personnel are required to perform strenuous tasks. Excessive bodily stress frequently represents the most significant hazard encountered during fieldwork.

3.6.10 Types of Protective Materials

1. Cellulose or Paper: suitable for nuisance dust and coarse fibers.
2. Natural and Synthetic Fibers
    a. Tyvek™: suitable small-sized hazardous particles, including lead, asbestos, and mold.
    b. Tychem™: is suitable for a variety of hazards, from light liquid splashes to heavy exposures to industrial chemicals and agents.
    c. Nomex™: is suitable for flame-resistance, radiation resistance, acids, alkalis, fluorocarbon refrigerants (CFCs), and non-polar solvents.
3. Elastomers
    a. Polyethylene: suitable for polar substances and solvents.
    b. Saran™ : suitable for flame-resistance, acids, alkalis, oils, and organic solvents.
    c. Polyvinyl Chloride (PVC): suitable for alcohols, oils, inorganic acids, alkalis, and salts.
    d. Neoprene: suitable for polar/non-polar substances, petroleum mixtures, and ≤ 200 F heat resistance.
    e. Butyl Rubber: suitable for polar substances and solvents.
    f. Viton: suitable for non-polar substances, petroleum mixtures, and ≤ 200 F heat resistance.
    g. Nitrile: suitable for polar/non-polar substances and petroleum mixtures.

3.7 Protection Levels

3.7.1 Level A Protection

Level A protection (a fully encapsulated suit) is used when skin hazards exist or when no known data positively rule out skin and other absorption hazards. Per the Roux Respiratory Protection Management

Program, Roux employees are not authorized to enter an IDLH atmosphere; therefore, the program does not allow supplied air respirators (SARs) or self-contained breathing apparatus (SCBA). At no time will Level A work be performed without the consent of the CHSD and OM.

The following conditions warrant the use of Level A protection:

- Hazardous substances have been identified and require the highest level of protection for skin, eyes, and the respiratory system;
- The atmosphere contains less than 19.5% oxygen or an atmosphere immediately dangerous to life and health (IDLH) that have not been ruled out;
- Site operations involve a high potential for splash, skin immersion, or exposure to suspected skin hazards;
- Direct-reading instruments indicate high levels of unidentified but potentially hazardous vapors or gases in the air (e.g., Total atmospheric readings on the Photoionization Detector (PID), Flame Ionization Detector (FID), and similar instruments indicate 500 to 1,000 ppm of unidentified substances); and
- Direct-reading instruments are not available to test the air and suspected highly toxic substances may be present.

It may be necessary to base the decision to use Level A protection on indirect evidence. Other conditions that may indicate the need for Level A protection include:

- Confined spaces;
- Sites containing known skin hazards;
- Sites with no established history to rule out skin and other absorption hazards;
- Site exhibiting signs of acute mammalian toxicity (e.g., dead animals, illnesses associated with past entry into the site by humans);
- Sites at which sealed drums of unknown materials must be opened;
- Visible indicators such as leaking containers or smoking chemical fires; and
- Extremely hazardous substances (e.g., cyanide compounds, concentrated pesticides, Department of Transportation Poison "A" materials, suspected carcinogens, and infectious substances) are known or suspected to be present, and skin contact is possible.

Table 1: Recommended Level A Ensemble Components			
Component	**Type**	**Manufacturer / Recommended Material**	**Notes**
Respirator	Positive-pressure full- facepiece SCBA or positive-pressure supplied-air respirator with escape SCBA[1]	NIOSH approved respirator	See Roux's Respiratory Protection Program. Roux employees are not approved to utilize Supplied Air (SAR) and/or Self-contained breathing apparatus (SCBA).
Suit	Totally encapsulated chemical- and vapor-protective suit	DuPont® Tychem™ or Responder CSM™	Other material types may be substituted based on known contaminants.
Inner Gloves	Light weight	Nitrile, Neoprene, PVC, or Viton®	Other material types may be substituted based on known contaminants.
Outer Gloves	Integral part of suit	See Appendix A for additional information	Confirm chemical performance rating for suspected contaminants. Glove material may have different performance ratings than suit material. All fully-encapsulating suit materials must be compatible with substances involved.
Inner Boot	Integral Part of Suit	-	-
Outer Boot	HazMat boot[2]	–	Confirm chemical performance rating of outer boot for suspected contaminants. Provides slip/abrasion resistance.
Hard Hat	Standard[3]	-	-

[1] Must be NIOSH approved.
[2] Must meet NFPA 1991/NFPA 1994 requirements depending on the site hazard assessment.
[3] Must comply with the applicable ANSI standard.

3.7.2 Level B Protection

Level B protection is utilized when the highest level of respiratory protection is needed, but hazardous material exposure to the few unprotected areas of the body is unlikely. At no time will Level B work be performed by Roux personnel without the consent of the CHSD and OM.

The following conditions suggest a need for Level B protection:

- The type and atmospheric concentration of toxic substances have been identified, and they require the highest level of respiratory protection;

- IDLH atmospheres where the substance or concentration in the air does not present a severe skin hazard;
- The type and concentrations of toxic substances do not meet the selection criteria permitting the use of air-purifying respirators and
- It is highly unlikely that the work being done will generate high concentrations of vapors, gases, particulates, or splashes of materials that will affect personnel's skin.

Table 2: Recommended Level B Ensemble Components

Component	Type	Manufacturer / Recommended Material	Notes
Respirator	Positive-pressure full- facepiece SCBA or positive-pressure supplied-air respirator with escape SCBA[1]	NIOSH approved respirator	See Roux's Respiratory Protection Program. Roux employees are not approved to utilize Supplied Air (SAR) and/or Self-contained breathing apparatus (SCBA).
Suit	Chemical-resistant clothing (liquid-splash protective suit with integral boot and hood)[2]	DuPont® Tychem® CPF 3	Other material types may be substituted based on known contaminants.
Inner Gloves	Light/medium weight	Nitrile, Neoprene, PVC, Viton®, or PE/EVAL	Other material types may be substituted based on known contaminants.
Outer Gloves	Medium/heavy weight	Butyl MIL-G12223, Nitrile, Neoprene, PVC, Viton®, PE/EVAL, or heavy weight Nitrile or Neoprene	Confirm chemical performance rating. Other material types may be substituted based on known contaminants.
Inner Boot	Safety work boot	–	Other boot types may be substituted based on known contaminants and physical hazards. Puncture resistant shanks may be required.
Outer Boot	Heavy weight Latex booties or outer boots[2]	Latex booties are used to protect suit for light duty applications. NFPA-rated outer boots may be required based on anticipated site conditions and tasks.	Other outer boot coverings may be substituted based on known contaminants/anticipated tasks.
Hard Hat	Standard[3]	-	-

[1] Must be NIOSH approved.
[2] Must meet NFPA 1991/NFPA 1994 requirements depending on the site hazard assessment.
[3] Must comply with the applicable ANSI standard.

3.7.3 Level C Protection

Level C protection is utilized when skin and respiratory hazards are well defined, and the criteria for using negative pressure respirators have been fulfilled (i.e., known contaminants and contaminant concentrations, acceptable oxygen levels, approved filter/cartridge available, known cartridge service

life, etc.). Level C protection may require an emergency escape respirator during specific initial entry and site reconnaissance situations or when applicable after that.

Table 3: Recommended Level C Ensemble Components

Component	Type	Manufacturer / Recommended Material	Notes
Respirator	Full-face air-purifying respirator with appropriate cartridge[1]	NIOSH approved respirator	See Roux's Respiratory Protection Program for information about the brand, model, acceptable configurations, and specific care instructions for the standard issue respirator. Half-faced respirators may be donned if hazard assessment warrants.
Suit	Puncture/tear resistant suit material with boot and hood[2]	DuPont® Tychem® CPF 2/CPF 3 or Saranex	Other material types may be substituted based on known contaminants, if considered more appropriate.
Inner Gloves	Light weight	Nitrile, Neoprene	Other material types like Neoprene, PVC, Viton®, or PE/EVAL may be substituted based on known contaminants, if considered more appropriate.
Outer Gloves	Medium/heavy weight	Butyl, Nitrile, or other work glove	Confirm chemical performance rating. Other material types may be substituted based on known contaminants, if considered more appropriate.
Inner Boot	Safety work boot	–	Other boot types may be substituted based on known contaminants and physical hazards. Puncture resistant shanks may be required.
Outer Boot	Heavy weight Latex booties or outer boots[2]	Latex booties are used to protect suit for light duty applications. NFPA rated outer boots may be required based on anticipated site conditions and tasks.	Other outer boot coverings may be substituted based on known contaminants.
Hard Hat	Standard[3]	-	-
Eye Protection	Safety glasses/goggles[3,4]	-	-

1 Must be NIOSH approved.
2 Must meet NFPA 1991/NFPA 1994 requirements depending on the site hazard assessment.
3 Must comply with the applicable ANSI standard.
4 In the case a ½ face respirator is worn eye protection is required.

3.7.4 Level D Protection

Level D is the basic work uniform. Level D is worn when the atmosphere contains no known hazard. Work functions preclude splashes, immersion, potential for inhalation, or direct contact with hazard chemicals. For most Roux field jobs Level D is the standard minimum level of protection worn.

Table 4: Recommended Level D Ensemble Components

Component	Type	Manufacturer / Recommended Material	Notes
Respirator	None	-	-
Suit	Coveralls, street clothes, or disposable Tyvek suit	–	Other types may be substituted as appropriate.
Inner Gloves	N/A		
Outer Gloves	As appropriate for physical hazards and for comfort	–	-
Boot	Safety work boot	–	Roux's standard safety boot is 6", steel/composite safety toe, and electrical hazard (EH) rated.
Outer Boot Covering	As appropriate	–	–
Hard Hat	Standard[3]	-	-
Eye Protection	Safety glasses/goggles[3]	-	-
High Visibility Clothing	High Visibility Vest /Jacket[3]	-	ANSI Class 2 Safety Vests/Jackets are the standard. Class 3 Safety vests/jackets shall be worn in worksites with 50+ MPH traffic.
Hearing Protection	Ear muffs/plugs	-	Workers exposed to excessive noise shall don hearing protection. Refer to Roux's Hearing Conservation Program for more information.

[1] Must be NIOSH approved.
[2] Must meet NFPA 1991/NFPA 1994 requirements depending on the site hazard assessment.
[3] Must comply with the applicable ANSI standard.

3.7.5 Level E Protection

Level E protection is used when radioactivity above 10 millirems per hour (mrems/hr) is detected at the site. Personal protective equipment for Level E includes:

- Coveralls;
- Air purifying respirator (i.e., P100 or equivalent);
- Time limits on exposure;
- Appropriate dermal protection for the type of radiation present, and

- Radiation dosimetry and ambient monitoring.

3.7.6 Additional Considerations

Fieldwork will contain a variety of situations due to chemicals in various concentrations and combinations. These situations may be partially ameliorated by following the work practices listed below:

1. Foot protection is needed on every site. If the ground to be worked on is contaminated with liquid, and it is necessary to walk in the chemicals, some sort of protective shoe coverings or "booties" can be worn over the boots. Shoe coverings should be designed with soles to help prevent slips. Using disposable shoe coverings when contacting liquid contamination can on and reduce overall decontamination requirements. If non-liquids are to be encountered, a Tyvek™ bootie could be used. The advantage of booties is questionable if the ground contains any sharp objects. Boots should be worn with either cotton or wool socks to help absorb perspiration.
2. If the site requires hard hats, chin straps should be used if a person will be stooping over where his/her hat may fall off. Respirator straps should not be placed over the hard hats, as this will affect the respirator's fit.

   Some types of protective materials conduct heat and cold readily. In cold conditions, natural material clothing should be worn under protective clothing. Protective clothing should be removed before allowing a person "to get warm." Applying heat, such as with a space heater, to the outside of the protective clothing may drive contaminant permeation. In hot weather, under clothing will absorb sweat. It is recommended that workers use all cotton undergarments.
3. Body protection should be worn and taped to prevent anything from running into the top of the boot. Gloves should be worn and taped to prevent substances from entering the top of the glove. Duct tape is preferred, but masking tape can be used. When aprons are used, they should be taped across the back for added protection. However, this should be done so that the person has mobility.
4. Atmospheric conditions such as precipitation, temperature, wind direction, humidity, wind velocity, and pressure determine the behavior of contaminants in air or the potential for volatile materials to become airborne. These parameters should be considered in determining the need for and the level of protection.
5. A program must be established for periodic air monitoring during site operations. Without an air monitoring program, any changes to air quality would go undetected and might jeopardize on-site personnel. Monitoring can be done with various types of air pumps and filtering devices, followed by laboratory analysis of the filtration media, personnel dosimeters, and periodic walk-throughs by personnel carrying real-time direct-reading survey instruments.
6. For operations in the exclusion zone, different levels of protection may be selected, and various types of chemical-resistant clothing may be worn. This selection should be based on the job function, reason for being in the area, and the potential for skin contact with, or inhalation of, the chemicals present.
7. Escape masks must be readily available when levels of respiratory protection do not include an SCBA and the possibility of an IDLH atmosphere exists. The use and placement of escape masks should be made on a case-by-case basis. Escape masks should be strategically located at the site in areas with higher potential for vapors, gases, or particulates.

3.8 Decontamination of PPE

Roux prefers the use of single use PPE to minimize the requirement for significant decontamination. The following procedures shall be considered should a field project require the need for decontamination of PPE. Roux has also developed a Site Control and Decontamination Management Program.

3.8.1 Site-Specific Decontamination Plans

The Project Manager (or another authorized individual) is responsible for formulating the site-specific PPE decontamination plan as an integral part of the Health and Safety Plan (HASP). The SHSO/SS' responsibilities include ensuring the plan's implementation and adapting it as site conditions evolve. Refer to Roux's Site Control and Decontamination Management program for additional requirements.

The decontamination plan, often created in conjunction with PPE selection, must be established prior to workers entering potentially contaminated areas. The plan should address the following key aspects:

- Decontamination Hazard Evaluation and Risk Assessment: Assessing risks associated with decontamination processes.
- PPE for Decontamination Line Assistants: Specifying appropriate PPE for personnel involved in decontamination.
- Roles and Responsibilities During Decontamination: Defining tasks and duties during the decontamination process.
- Layout and Quantity of Decontamination Stations: Determining the number and arrangement of decontamination stations, along with the designated PPE decontamination procedures at each station.
- Decontamination Equipment: Identifying the necessary equipment for effective decontamination.
- Decontamination Methods: Describing the methods and protocols for decontaminating personnel and equipment.
- Preventing Contamination of Clean Areas: Outlining procedures to prevent contamination of uncontaminated zones.
- Minimizing Contact with Contaminants During CPC Removal: Providing guidelines to reduce wearer exposure during the removal of Chemical Protective Clothing (CPC).
- Disposal Procedures for Inadequately Decontaminated Clothing and Equipment: Ensuring proper disposal practices for items that have not been adequately decontaminated.

The initial decontamination plan, which is developed in conjunction with the initial site hazard assessment, should be based on worst-case assumptions about the extent and type of contamination.

3.8.2 Emergency Decontamination of PPE

The designated SHSO/SS (or another authorized individual) assumes responsibility for addressing emergency decontamination within the site-specific Health and Safety Plan (HASP). Emergency decontamination may become necessary due to events such as fires, explosions, sudden violent storms, or medical emergencies. The emergency decontamination plan must clearly delineate emergency egress routes, as well as procedures for both decontamination and egress.

Some key points to consider regarding emergency decontamination.

- Immediate Notification: The SHSO/SS (or their designated counterpart) must be promptly informed of any circumstances requiring emergency decontamination. Additionally, they are accountable for tracking all personnel during the process.
- Urgent Medical Treatment: If urgent medical attention is necessary, decontamination of PPE may be delayed until the victim's condition stabilizes.
- Balancing Priorities: When feasible, decontamination should occur without hindering essential first aid. However, if a worker is exposed to an extremely toxic or corrosive substance, immediate decontamination is crucial to prevent severe injury or fatality.

- Heat-Related Illness: In cases of heat-related illness, protective clothing must be promptly removed (refer to Roux's Heat Illness Prevention Program).

Emergency Facilities:

- For workers potentially exposed to corrosive materials, quick drenching or flushing facilities must be provided in accordance with 29 CFR 1910.151(c) and 1926.50(g).
- Similarly, if workers face other hazards (such as splash or dust) that could harm the eyes or body, readily accessible wash stations are essential. These stations should be properly located and maintained, including regular water changes, as per the manufacturer's instructions.

3.8.3 Protection of Decontamination Line Assistants

Should work require a decontamination corridor the following shall be used as guidance. The SHSO/SS (or other designated person) must for ensuring that decontamination line assistants receive appropriate PPE and addressing their protection within the site-specific HASP. Key zones—namely, the Exclusion Zone (EZ), Contamination Reduction Zone (CRZ), and Clean Support Zone—must be clearly marked both in the field and within the site-specific HASP. The following should be considered when preparing for protection of decontamination line assistants.

1. Task Hazard Analysis: A thorough analysis must be conducted for line assistants to determine the optimal PPE level required. Factors influencing this decision include:
    - Expected or Visible Contamination on Responders
    - Type of Contaminant and associated respiratory and skin hazards
    - Total Vapor/Gas Concentrations in the CRZ
    - Presence of Particulates and specific inorganic or organic vapors in the CRZ
    - Results of Wipe Tests (refer to Section 5.4)
    - Slope and Configuration of the CRZ
2. PPE Levels: Depending on the situation:
    - Line assistants may need to wear the same PPE level as workers in the EZ.
    - Alternatively, line assistants may be adequately protected by using PPE one level lower (e.g., wearing Level C protection while decontaminating workers who are wearing Level B)."

3.8.4 Procedures to Minimize PPE Contamination

Proper work practices and procedures should be implemented at sites to minimize the potential for contact with chemicals of concern while onsite. The following guidance should be considered when developing site specific procedures:

- Opt for single-use Personal Protective Equipment (PPE) when feasible to minimize decontamination needs.
- Ensure complete sealing of PPE closures and interfaces, including pockets, zippers, and other potential openings.
- Position gloves and boots underneath the sleeves and pant legs of outerwear to reduce exposure.
- Place hoods outside the collar if they are not already attached.
- Utilize disposable outerwear and equipment when suitable to facilitate easy disposal and reduce decontamination efforts.
- Secure all junctions with tape to block contaminants from entering gloves, boots, jackets, and suits.

- Adopt work practices that limit contact with hazardous substances, such as avoiding unnecessary exposure.
- Employ remote techniques for sampling, handling, and opening containers, like using drum grapples and pneumatic impact wrenches.
- Store monitoring and sampling devices in bags designed with openings for sample ports and sensors.
- Cover contaminant sources with plastic sheeting or overpacks to shield PPE from contamination.

3.8.5 PPE Disposal

The PM in coordination with the field team shall ensure the safe disposal of all wastes generated from PPE use. PPE must be placed in appropriate containers, labeled, and prepared for disposal separately from other forms of waste. Refer to Roux's General Waste Corporate Management Program for further guidance.

APPENDIX A
EPA's
GUIDELINES TO ENSEMBLES FOR SPECIFIC ACTIVITIES/TASKS
WHERE CHEMICAL EXPOSURE IS POSSIBLE

GUIDELINES TO ENSEMBLES FOR SPECIFIC ACTIVITIES/TASKS
WHERE CHEMICAL EXPOSURE IS POSSIBLE

IMPORTANT: READ FOOTNOTES AND ASSUMPTIONS/JUSTIFICATIONS PRIOR TO USING TABLE

Notes:

1. This table is for use by trained environmental professionals only. To use this table:
   a. Scan the activity description to find activities (bolded) that most closely matches those you plan to engage in.
   b. Review Hazard/Conditions section to make sure the hazards of the planned activity match those listed. Note the Required Work Practices and be ready to follow them.
   c. For those activities most likely to be conducted as part the response, select Targeted Minimum PPE (Personal Protective Equipment).
   d. Necessary equipment needs to be available and used unless other information becomes available which necessitates an upgrade or allows a downgrade in the protection level. The work area must be continuously re-evaluated to ensure workers have the proper safety equipment.
   e. When working in hazardous environments, workers must always be aware of their surroundings. In addition to this Table, workers entering these environments need to use "common sense" prior to proceeding.
2. These ensembles focus on chemical protection and may not be adequate for all hazards. This Table can be used as a starting point but does not circumvent proper evaluation by an industrial hygienist in appropriate situations. See Table 2 for more specific chemical agents.
3. Suits, gloves, boots listed in the Minimum PPE column will not be appropriate for all activities, hazards and conditions. The listings should be used as a guide only. Confirm PPE compatibility with specific chemical contaminants.
4. A comprehensive Task Hazard Analysis must be performed prior to final selection of ensembles/PPE material types.
5. Hardhat (Class A or C), safety glasses/other eye protection are typically required but may not be specified here. In noisy environments (above 85dB) hearing protection is required. In areas where there is traffic, heavy machinery, or other hazards involving worker visibility problems a Class 2 High Visibility Vest must be worn. Activities requiring vests include natural disaster responses, demolitions, and excavations.
6. PPE makes and models referenced in these tables are only suggestions. Other comparable, adequate makes and models may be used.

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Emergency Response and/or Initial Entry/Assessment – Low Hazard Expected (Sites/Facilities): • Air and Radiation Monitoring Sweep • Visual Assessment • Note Taking • Photo-documentation	• Suspected low hazard based on site history/visual evidence. • No CBRN suspected. • No visible/suspected vapors. • No potential for IDLH atmosphere. • Unknown physical hazards. • Some site background information. • No intrusive work expected. • Low potential for chemical splash/contact (based on expected tasks/ known conditions). • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Level B** (Downgrade/upgrade based on knowledge of contaminants and monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs) **Respirator: Scott or MSA Full Face** **Suit Type:** [I]Tychem CPF-3 (with boot, hood)/ChemTape **Inner Glove:** [II]Nitrile (6 mil min recommended) **Outer Glove:** [II]Neoprene, Nitrile, (28 mil min recommended) **Outer Steel Toe Boot:** [IV]Tingley HazProof Model 82330 **or** **Steel Toe Boot Cover**: [V]Latex HazMaster Booty and rely on suit boot material for permeation protection. **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON**: Dry or soap & water

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Emergency Response and/or Initial Entry/Assessment of Unknown – Potential Moderate Hazard (Sites/Facilities): • Air and Radiation Monitoring Sweep • Visual Assessment • Note Taking • Photo-documentation	• Possible high hazard chemicals based on site history/visual evidence (spills, corrosion, industrial practices, etc.). • No CBRN suspected. • No visible/suspected vapors. • **No** reasonable potential for **IDLH** atmosphere. • Unknown physical hazards. • Little/ no site background information. • No intrusive work expected. • Low potential for chemical splash/contact. • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Level B** (Downgrade/upgrade based on knowledge of contaminants and monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs) **Respirator: Scott or MSA Full Face** **Suit Type:** [I]Tychem Responder (with boot, hood)/ChemTape **Inner Glove:** [II]Nitrile (6 mil min recommended) **Outer Glove:** [II]Neoprene, Nitrile, (28 mil min recommended) **Outer Steel Toe Boot:** [IV]Tingley HazProof Model 82330 **or** **Steel Toe Boot Cover**: [V]Latex HazMaster Booty and rely on suit boot material for permeation protection. **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON**: Dry or soap & water

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Emergency Response and/or Initial Entry/Assessment of Unknown - Suspected High Hazard (Sites/Facilities): • Air and Radiation Monitoring Sweep • Visual Assessment • Note Taking • Photo-documentation	• Potential for high hazard chemicals/ IDLH based on site history/visual evidence (visible/expected reactions, spills, vapors, fumes, smoke, known releases, etc.). • No CBRN suspected. • Potential for chemical reactions. • Unknown physical hazards. • Little/ no site background information or information suggesting high hazard. • Intrusive work possible. • Potential for chemical splash/contact. • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Level A** (Downgrade/upgrade (Trelleborg, etc.) based on knowledge of contaminants and monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs) **Respirator: Scott or MSA Full Face** **Suit Type:** Encapsulating [I]Tychem Responder/Responder CSM (with boot, hood, gloves)/ChemTape **Inner Glove:** [II]Nitrile (6 mil min recommended) **Outer Glove:** [II]Neoprene, Nitrile, (28 mil min recommended) **Outer Steel Toe/Steel Shank Boot:** [IV]Tingley HazProof Model 82330 and rely on suit boot material for permeation protection. (ASTM F-2413/ANSI Z41) **DECON**: Dry or soap & water: water source for emergency DECON; other DECON agents on hand.

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Drum/Tank Sampling • Container opening • Continuous air monitoring • Product sampling	• Unknown chemicals. • No CBRN. • Potential splash hazard. • Physical hazard controls in place. • Assumes no initial hazardous atmosphere. • Ensure availability of water source for emergency DECON/shower/eyewash. • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Level B** (Upgrade/Downgrade based on knowledge of contaminants and monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs) **Respirator: Scott or MSA Full Face** **Suit Type:** [I]Tychem Responder (with boot, hood)/ChemTape **Inner Glove:** [II]Nitrile, Neoprene, Viton, PVC **Outer Glove:** [II]Heavy Duty Butyl, Nitrile, **Other:** ANSI Approved Splash Shield **Outer Steel Toe Boot:** [IV]Tingley HazProof Model 82330 **or** **Steel Toe Boot Cover**: [V]Latex HazMaster Booty and rely on suit boot material for permeation protection. **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON or soap and water; water source for emergency DECON and eyewash suggested.

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Hazardous Categorization Testing (**HAZCAT**) • Opening sample containers in controlled environment • Working with small sample quantities in well ventilated area • Conducting HAZCAT testing with appropriate lab equipment	• Assumes known chemical classes and site situation/background. • No CBRN suspected. • Assumes immediate suit removal if contaminated and frequent glove changes. • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Level B** (Upgrade/Downgrade based on knowledge of contaminants and monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs) **Respirator: Scott or MSA Full Face** **Suit Type:** [I]Tychem CPF4 (with hood, boot) **Inner Glove:** [II]Nitrile **Outer Glove:** [II]Viton or 4-H (use surgie over the 4-H for dexterity) **Outer Steel Toe Boot:** [IV]Tingley HazProof Model 82330 **or** **Steel Toe Boot Cover**: [V]Latex HazMaster Booty and rely on suit boot material for permeation protection. **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry or soap and water; water source for emergency DECON and eyewash suggested

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Oil Spill Response/Recovery Operations – Fresh Product: • Recovery operations (vac truck, skimmers, boom deployment where direct contact expected) • Product sampling • Continuous air monitoring at/near source of spill	• Crude oil/diesel/kerosene/gasoline spill. • Assumes fresh/ongoing spill, close proximity to source. • Assumes early phase while evaporation of light organics, benzene/other aromatics is still occurring (24-48 hours or if spill is on-going). • Assumes down-wind location. • Continuous air monitoring required for %LEL, Organics, $\%O_2$ (and H_2S as necessary for sour crude). • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Modified Level C:** 1/2 face respirator w/safety glasses/goggles as needed for splash protection. Downgrade as appropriate based on air monitoring. **Respirator: Scott or MSA ½ Face** **Respirator Cartridge:** [III] Multi-Phase Cartridge (Scott 642 Multi-purpose; MSA with/GME P-100 or equivalent). **Suit Type:** [I]Tychem CPF4 w/boot [jet fuel use Tychem BR] **Inner Glove:** [II]Neoprene (for protection at DECON line only, not for prolonged contact) **Outer Glove:** [II]Viton-Butyl Rubber (assumes potential for direct contact with fresh material – based on benzene/aromatic constituents) SEE NEXT ROW FOR WEATHERED PRODUCT. **Outer Steel Toe Boot:** [IV]Tingley HazProof Model 82330 **or** **Steel Toe Boot Cover**: [V]Latex HazMaster Booty and rely on suit boot material for permeation protection. **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON/ Soap and water as feasible

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Oil Spill Response Assessment/Recovery – Weathered Product • Shoreline clean-up assessment (SCAT) • Environmental sampling/weathered product sampling • Recovery Operations for weathered material • Assessment via boat/on or near water – use appropriate flotation device with ensemble.	• Crude oil/diesel/kerosene/gasoline spill. • Assumes weathered oil (over 24-48 hours, depending on spilled material and ambient temperatures). • Assumes operations are remote from source of spill. • Assumes no other potential for airborne aromatics/benzene/flammable vapors.	**Modified Level D** (Upgrade/Downgrade based on potential for contact and air monitoring with FID/PID, LEL/O_2 Meter. **If contact with material suspected, use following:** **Suit Type:** [I]Tychem F w/boot [jet fuel-Tychem BR] (Tychem SL may be an option for weathered crude/diesel – see manufacturer's information) **Inner Glove:** [II]Nitrile **Outer Glove:** [II]Nitrile (Best Nitri-solv 727) **Outer Boot Cover:** [V]Latex HazMaster Booty **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON/Soap and water as feasible

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Demolition/Excavation Operations: • Heavy equipment operation • Excavation/Trenching • Continuous air monitoring when soil is disturbed or demolition activities conducted. • Fuel Oil underground tank removal. • Drum Excavation activities EXCLUDED.	• Demolition activities generating potentially hazardous particulates (asbestos, lead, silica, etc.). • Excavation activities that could expose soil contaminated with low levels of known hazardous chemicals to the surrounding area /in the trench/ excavation. • No potential for IDLH atmosphere. • Site background information available. • Known physical hazards. • Workers will have minimal/ no contact with contaminants (i.e., operators in a cab, inspectors/ observers at a safe distance). • Continuous air monitoring required in trench for %LEL, Toxics, and $\%O_2$ when workers are in trench and for particulate when activities generating particulate are conducted. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Modified Level C:** 1/2 face respirator w/safety glasses. Downgrade or upgrade as appropriate based on air monitoring. **Respirator: Scott or MSA ½ Face** **Respirator Cartridge:** [III] Multi-Phase Cartridge (Scott 642 Multi-purpose P-100; MSA with/GME P-100 or equivalent). **Suit Type:** [I]Proshield Next Gen **Inner Glove:** NA **Outer Glove:** Leather **Outer Steel Toe Boot: NA** **Steel Toe Boot Cover**: [V]Latex HazMaster Booty (if chemical in soil is possible) **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON/ Soap and water as feasible

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Natural Disaster Response (Hurricane, Tornado, Flood, Earthquake) - Orphan Container Recovery: • Routine hand collection/pick-up of small containers from debris piles/lines • Land based operations - conducted on foot **Note:** Physical Hazards may necessitate PPE modifications.	• Unknown materials – confident identification based on visual observations. • **Required Work practice:** re-evaluate prior to moving suspicious containers. Air monitoring and PPE upgrade may be required. • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Modified Level D:** Upgrade/downgrade based on suspicious containers (not easily identified visually) and air monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs **Suit Type:** [I]Tychem CPF-3 w/boot **Inner Glove:** [II]Nitrile **Outer Glove:** [II]Nitrile (Best Nitri-solv 727) or Leather **Outer Boot Cover:** [V]Latex HazMaster Booty **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON/Soap and water as feasible
Natural Disaster Response (Hurricane, Tornado, Flood, Earthquake) - Orphan Container Recovery: • Routine Drum recovery from debris lines/piles/ other – conducted on land **Note:** Physical Hazards may necessitate PPE modifications.	• Unknown materials – confident identification based on visual observations. • **Required Work practice:** re-evaluate prior to moving suspicious containers. Air monitoring and PPE upgrade may be required. • **Required Work Practice:** Immediate PPE Change-out (i.e., gloves, etc.) upon contact with chemicals. • **Required Work Practice:** Must follow standard air monitoring protocol.	**Modified Level D:** Upgrade/downgrade based on suspicious containers (not easily identified visually) and air monitoring with PID/FID, radiation detector, LEL/O_2 per HASP/ SOSGs **Suit Type:** [I]Tychem CPF-3 w/boot **Inner Glove:** [II]Nitrile **Outer Glove:** [II]Nitrile (Best Nitri-solv 727) or Leather **Outer Boot Cover** [V]Latex HazMaster Booty **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON/Soap and water as feasible

Activity Description	Hazards/Conditions	Targeted Minimum PPE
Natural Disaster Response (Hurricane, Tornado, Flood, Earthquake) – Flood water sampling: • Water Sampling of flood waters where potential for contact with hands/feet is high **Note:** Physical Hazards may necessitate PPE modifications.	• Unknown contaminants • Potential for pathogens suspected • Low potential for acute exposure to hazardous chemicals • Assumes open air/well ventilated areas **Required Work Practice:** Monitor all poorly ventilated areas in appropriate PPE/Respiratory Protection for organic vapors (PID & FID), %LEL/flammable atmospheres, H_2S prior to entry	**Modified Level D:** Upgrade based on more information as it becomes available. **Suit Type:** [I]Proshield Next Gen **Inner Glove:** [II]Nitrile **Outer Glove:** [II]Nitrile (Best Nitri-solv 727) **Outer Boot**: Waders (butyl, neoprene) as needed. **Steel Toe/Steel Shank Boots:** ASTM F-2413/ANSI Z41 **DECON:** Dry DECON/Soap and water as feasible
Environmental Sampling (Low Concentration Water/Soil/Perimeter Air): • Multi-media Sampling • Documentation (written/photo) • Inspection of clean-up operations	• Known Chemical Contaminants. • Airborne concentrations well below PELs. • Minimal chance of skin exposure to chemicals. • Insects possible.	**Level D:** Upgrade based on more information as it becomes available. **Suit Type:** [I]Proshield 1 (if ticks, etc. maybe a problem) **Inner Glove:** [II]Nitrile **Outer Glove:** NA **Outer Boot:** NA **Steel Toe Boots:** ASTM F-2413/ANSI Z41 **DECON:** NA

i. Tychem and Proshield suits can be purchased from Safeware: 800-331-6707, http://www.safewareinc.com , (see also LSS, http://www.labsafety.com, Dupont: 1-800-931-3456, http://www2.dupont.com/Personal_Protection/en_US/index.html)

ii. Nitrile Inner/Outer Gloves; Viton; Butyl Rubber; 4-H (polymeric) can be purchased from Safeware: 800-331-6707, http://ww.safewareinc.com ; Airgas: 1-866-718-0685, http://www.airgas.com (see also North Safety, http://www.northsafety.com); Best Gloves, http://www.bestglove.com ; Lab Safety Supply (LSS), http://www.labsafety.com; Airbill, http://www.airbill.com)

iii. Multi-Phase Cartridge (Scott 642 Multi-purpose; MSA with/GME P-100 or equivalent) can be purchased from LSS: 1-800-356-0673, http://www.labsafety.com (see also Safeware, http://www.safewareinc.com; Scott Safety, http://www.scotthealthsafety.com/; MSA, http://www.msanet.com/)

iv. Tingley HazProof Overboots or similar can be purchased from LSS: 1-800-356-0673, http://www.labsafety.com; National Safety, Inc.: 1-800-213-7092, http://www.nationalsafetyinc.com

v. Latex Hazmaster Booties, Nuke Boot or similar can be purchased from Safeware: 800-331-6707, http://www.safewareinc.com; Airbill: 1-215-632-2000, http://www.airbill.com; (see also Airgas, http://www.airgas.com; LSS, http://www.labsafety.com

APPENDIX E

Subsurface Utility Clearance Management Program

SUBSURFACE UTILITY CLEARANCE MANAGEMENT PROGRAM

CORPORATE HEALTH AND SAFETY DIRECTOR	:	**Brian Hobbs, CIH, CSP**
EFFECTIVE DATE	:	**01/2019**
REVIEW DATE	:	**03/2024**
REVISION NUMBER	:	**4**

TABLE OF CONTENTS

1. PURPOSE 1
2. SCOPE AND APPLICABILITY 1
3. PROCEDURES 1
3.1 Before Intrusive Activities/Job Planning Process 1
3.1.1 Project Kick-Off Meeting 2
3.2 Utility Mark Out 2
3.3 Site Visit/Utility Walkthrough 3
3.3.1 Project Management-Field Personnel 4
3.3.2 Utility Markings 4
3.4 Preferred Methods of Clearing the Subsurface (Pre-Clearing) 6
3.4.1 Guidance for Tools and Equipment 6
3.5 During Intrusive Activities 7
3.5.1 Concrete/Paving Surface Removal 7
3.5.2 Pre-Clearance Procedures 7
3.6 Stop Work Authority 8
3.7 Reporting Utility Incidents 8

APPENDICES

Appendix A – Roux Subsurface Utility Clearance Checklist/ Utility Verification/Site Walkthrough Record

Appendix B – Private Utility Technology Applications and Considerations

1. PURPOSE

Roux Associates, Inc. and its affiliated companies, Roux Environmental Engineering and Geology, D.P.C., and Remedial Engineering (collectively, "Roux") has instituted the following program for completing proper utility mark-outs and for conducting subsurface clearance activities. This establishes a method to ensure, to the greatest extent possible, that utilities have been identified and contact and/or damage to underground utilities and other subsurface structures will be avoided. For the purpose of this program, a structure is defined as any underground feature that may present a potential source(s) of energy, such as, but not limited to, utility vaults, bunkers, piping, electrical boxes, wires, conduits, culverts, utility lines, underground tanks, and ducts.

2. SCOPE AND APPLICABILITY

The Subsurface Utility Clearance Management Program applies to all Roux employees, its contractors, and subcontractors. Employees are expected to follow this program for all intrusive work involving Roux or other personnel (e.g., contractors/subcontractors) working for Roux unless the client's requirements are more stringent. Intrusive work activities can include, but are not limited to, digging or scraping the ground surface, including, but not limited to, excavation; test pitting or trenching; soil vapor sampling or the installation of soil borings, soil vapor monitoring points and wells, or monitoring wells; and drilling within concrete slabs on grade.

Deviation from the program, regardless of the specific work activity or location, must be pre-approved based on the client's site knowledge, experience, site conditions, and additional documentation on the site. Any exceptions shall be documented through the Roux Subsurface Utility Clearance Variance Form located within the Roux Health & Safety Online Application or through OKTA. Approval is required by the Project Principal (PP) and the Operations Manager (OM) in consultation with the Office Health and Safety Manager (OHSM) or Corporate Health and Safety Director (CHSD) prior to mobilization. Depending on the work location, more stringent federal, state, local, or client requirements may apply. It is the responsibility of the Project Team to identify such requirements prior to mobilization.

3. PROCEDURES

3.1 Before Intrusive Activities/Job Planning Process

Prior to intrusive work at a site, the Project Manager (PM) shall ensure that the notification of the State One Call or equivalent service (Nationwide-811) is completed a minimum of 48-72 hours (One-Call State Law Directory) before intrusive work activities (this timeline excludes Saturdays, Sundays, Legal Holidays and 811 observed holidays). This notification is required by law for all states. State-specific/local laws related to utility location may vary. The project team is responsible for understanding requirements that may affect their work site.

Obtain, review, and field verify relevant historical site data that may include: as-builts/site plans; easement/right-of-way information; historical aerial photos/development plans; local/state permitting records; previous site investigation/boring logs; and/or interviews with site representative/client. Interviews with site or client personnel should ask the following:

- Employee(s) Name and Relationship with the site;
- Types of utilities, including structure and location of utilities on-site;
- Depth of known utilities; and

- Any other relevant information as it pertains to the site.

Prior to intrusive work activities, information pertaining to the site should be included in Roux's Subsurface Utility Clearance Checklist and Utility Verification/Site Walkthrough forms. This form is located within the Roux Health & Safety Online Application or through OKTA.

If there is the potential for unexploded ordinances or munitions, consultation with your OM and CHSD is required prior to site operations.

3.1.1 Project Kick-Off Meeting

During the project kick-off meeting for intrusive activities, the PM will review the Roux Subsurface Utility Clearance Checklist, Utility Verification / Site Walkthrough Record (Appendix A) and the below bullet points with the project field team:

- Confirm that the State One Call or equivalent is received and that the ticket number is confirmed, reviewed, and valid for the time of work. If intrusive work activities are not conducted during this valid time period, the One Call ticket must be renewed, and the site must be remarked;
- Review the work scope to be performed with the site owner/tenant to determine if it may impact any utilities;
- Determine the need for utility owner companies to be contacted or to have their representatives on site;
- Where mark-outs terminate at the property boundary, consider the use of private utility locating / (e.g., Radio Frequency Detection, Electromagnetic Induction), Ground Penetrating Radar (GPR) , and other applicable geophysical inspection services. The use of private utility locating firms, however, does not eliminate the legal requirement for the subcontractor (e.g., driller, excavation firm) to submit a request for Public Utility Mark-outs. Also, the information provided by the service may be inaccurate and unable to locate subsurface utilities and structures in urban areas, landfills, urban fill areas, below-reinforced slabs, etc. They should not be relied upon as the only means of performing utility clearance;
    - A mark-out is defined as the process of contracting with a competent and qualified company to confirm the presence or absence of underground utilities and structures. This process will clearly mark out and delineate identified utilities so that intrusive work activities can be performed without causing disturbance or damage to the subsurface utilities and structures. After utility mark-outs are completed, soft Digging must completed prior to intrusive work. Section 3.4 Preferred Methods of Clearing the Subsurface (Pre-Clearing) outlines requirements for pre-clearing techniques in order of preference.
- Documented description of the dig site, which is included in the project's Health and Safety Plan (HASP), and one call report will be maintained in the field and distributed amongst Roux personnel, its contractors, and subcontractors; and
- Documentation of the actual placement of mark outs in the field shall be collected using dated pictures, videos, and/or sketches with distance from markings to fixed objects. All documentation shall be maintained within the project file.

3.2 Utility Mark Out

- Ensure the Mark-out / Stake-out Request Information Sheet (or one-call report) is complete and accurate for the site, including address and cross streets, and review for missing utilities. Ensure ticket life is still valid for work.

  - Note: utility mark-out organizations do not have contracts with all utilities, and it is often necessary to contact certain utilities separately, such as the local water and sewer authorities, local transportation departments, and railroad operators. In the event the Project Teams anticipate subsurface work will impact public utilities, railroad operations, or public roadways, coordination with the utility owners/operators is required.

- Have written confirmation prior to mobilizing to the site that the Project Team or Roux personnel performing the intrusive activity has correctly completed the mark-out notification process, including requesting mark-outs, waiting for mark-outs to be applied to ground surfaces at the site, and receiving written confirmation of findings (via fax or email) from utility operators for all known or suspected utilities in the proposed area of intrusive activity, and provided utility owner written confirmation to Roux personnel for review and project files documentation.
- Do not begin any intrusive activity until all utility mark-outs have been completed (i.e., Did all utilities mark-out the site?) and any unresolved mark-out issues are finalized. Perform a site walk to review the existing utilities and determine if the utility locators have located said utilities.

  (Note: The Tolerance Zone is defined as three feet from the outside edge of any subsurface structure.)
- For non-subscribing utility owners or if public one-call service is not available, perform due diligence and request further information regarding utility type, construction details, location, and burial depth directly from public service providers/utility owners. Request utility mark-out by each public service provider/utility owner as applicable. Confirm contact and response by each public utility owner on the Subsurface Utility Clearance Checklist.
- If utilizing a Private Mark out, ensure the contractor has a plan regarding what types of technology will be used based on Table 1 in Appendix B: Private Utility Technology Applications and Considerations. If possible, it is recommended that multiple technologies be used to sweep each location/work area. Use a tracer wire to locate the utility (when tracer wires are present). Record the results of the private utility mark-out on the Utility Verification/Site Walkthrough Record form.

3.3 Site Visit/Utility Walkthrough

Before mobilization with the subcontractor or during the pre-work safety tailgate with the subcontractor, perform a site walkthrough after utility mark-outs have been completed to determine whether additional potential hazards are present and look for visible signs of utilities that may be present. Outlined below are considerations regarding a site walk before intrusive activities. Before initiating any intrusive work, verify that the utilities marked on-site align with the information provided in the One Call response notification/ticket and with site plans and documents. If any discrepancies arise, address them promptly to ensure accuracy and do not start intrusive work until they are rectified.

- Identify overhead utilities that may impede equipment mobilization or work zones to ensure adequate Occupational Safety and Health Administration (OSHA) clearance distance(s), as specified within the site-specific Health and Safety Plan (HASP) and 29 CFR 1926.1408 Table A.

The presence of any of the following may indicate potential subsurface structures:

- Locations of buildings, equipment, and features like area lights, signs, sprinkler systems, phones, drains, natural gas meters, manholes, etc.;
- Warning tape, which is often a sign of underground services;
- Material like pea gravel, sand, or other non-native materials can indicate the presence of tanks or lines or any deviations from the established native soil or backfill conditions;

- Red concrete, which is often used for electrical duct banks;
- Evidence of damaged utilities, such as piping materials, insulation, or odors present in the work area; and
- Other utilities, including fire hydrants, electrical transformers, pipeline markers, valve covers, steam lines, valve box covers, clean-outs, etc.

By observing the path between the main service line and the connection point (e.g., a utility meter at the exterior of the site building), it may be possible to determine the likely routing of on-site utilities. However, this method should not be relied upon solely, and proper risk mitigation strategies should be in place before proceeding with any ground disturbance activities. Look outside your work zone for other potential utilities that may cross through your work zone.

For sites with potential underground storage tanks present (UST), the following guidance applies:

- Identify if the product piping is either rigid or flexible.
- Conduct a visual examination of the tank field, observation wells, dispensers, vent stacks, and UST fill points to determine their location.
- Locate and become familiar with the emergency shutoff button/switch, if present.
- Determine the orientation, arrangement, and location of the tanks, as well as their size and capacity, through the examination of visible features at grade, such as fill ports and extractor covers, and by consulting any available as-built drawings.

Before commencing any subsurface intrusive work, field staff should thoroughly address any discrepancies in utility company mark-outs or the absence of mark-outs.

3.3.1 Project Management-Field Personnel

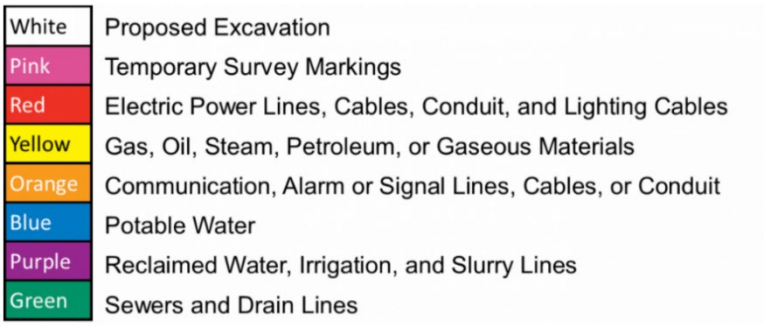
Whenever possible, it is advisable to assign the same project personnel to both utility location and clearance tasks as well as intrusive activities. This continuity ensures that site knowledge and utility information gathered during the clearance phase remain up-to-date. Having this historical perspective helps minimize the risk potential of utility strikes.

In cases where maintaining the same personnel throughout the project isn't feasible, a thorough knowledge transfer regarding site utilities, locations, clearance results, and proposed intrusive activities becomes essential. The PM must ensure that there is a successful handoff of information when there is a change in field personnel.

3.3.2 Utility Markings

The utility marking color code includes various uniform colors. The following APWA uniform color code (ANSI Z535.1) is provided below. While certain government agencies or large industrial facilities may use additional colors, Roux's policy is to consider any unlisted paint marking or pin flag color as a subsurface utility marking unless proven otherwise.

If utilities or subsurface anomalies are identified but their type or classification remains uncertain, it is advised to employ pink paint or pin flag (Temporary Survey Marking) for marking. Once the utility type is definitively established, the pink marks should be updated to accurately represent the correct type of utility.

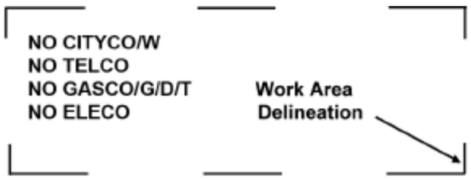


Understanding the markings left by locators during the 811 process is crucial for avoiding utility-related issues. Typically, these markings are done when Roux staff members are not physically present on-site. To enhance understanding/accuracy, it is advisable for staff to be present during the 811 process or engage in conversations with locators, both public and private, while on-site. Additionally, utility marks must adhere to the proper standards outlined in the Uniform Color Code.

Common Abbreviations

Source: Common Ground Alliance

Facility Identifier		**Underground Construction Descriptions**		**Infrastructure Materials**	
CH	Chemical	C	Conduit	ABS	Acrylonitrile - Butadiene - Styrene
E	Electric	CDR	Corridor	ACP	Asbestos Cement Pipe
FO	Fiber Optic	D	Distribution Facility	CL	Cast Iron
G	Gas	DB	Direct Buried	CMC	Cement Mortar Coated
LPG	Liquefied Petroleum	DE	Dead End	CML	Cement Mortar Lined
PP	Petroleum Products	JT	Joint Trench	CPP	Corrugated Plastic Pipe
RR	Railroad Signal	HP	High Pressure	CMP	Corrugated Metal Pipe
S	Sewer	HH	Hand Hole	CU	Copper
SD	Storm Drain	MH	Manhole	CWD	Creosote Wood Duct
SS	Storm Sewer	PB	Pull Box	HDPE	High Density Polyethylene
SL	Street Lighting	R	Radius	MTD	Multiple Tile Duct
STM	Steam	STR	Structure (vaults, junction inlets, lift station)	PLA	Plastic (conduit or pipe)
SP	Slurry System	T	Transmission Facility	RCB	Reinforced Concrete Box
TEL	Telephone			RCP	Reinforced Concrete Pipe
TS	Traffic Signal			RF	Reinforced Fiberglass
TV	Television			SCCP	Steel Cylinder Concrete Pipe
W	Water			STL	Steel
W	Reclaimed Water "Purple"			VCP	Vertrified Clay Pipe



3.4 Preferred Methods of Clearing the Subsurface (Pre-Clearing)

At least one of the methods listed below shall be carried out during pre-clearing activities. The Project Team is responsible for evaluating risks associated with the Scope of Work to determine which method is selected. If none of the following pre-clearing activities are performed, a Subsurface Utility Clearance Variance must be submitted to the OM. This Subsurface Utility Clearance Variance must provide clear lines of evidence that there are no utilities present within the intrusive work zone. Examples include demolition permits of the site, utility closure documents indicating no live utilities on-site, as-builts, site history, etc.

The following approaches shall be considered and implemented based on the Scope of Work.

- ***Soft Digging***
  - This is the preferred method of utility clearance when clearing higher-risk utilities. Soil should be cleared through the use of a vacuum truck/equivalent, an accompanying air knife (preferred), or a water lance to break up and loosen the soil for removal with the vacuum.
- ***Hand Digging***
  - Soil should be broken up and removed using a shovel or other appropriate hand tools without excessive force. Limit the use of dig bars or other tools that, if used incorrectly, can significantly damage utilities.
- ***Hand Augering***
  - The hand auger must be turned slowly using even hand pressure without excessive force. Rounded edge augers are preferred. Hand augers should not be used in pea stone/pea gravel where utilities may be present and could potentially be damaged by the hand auger. The abrupt absence of soil recovery in a hand auger could indicate utilities as pea gravel or sand may have spilled out of the auger (exception: native soil conditions that typically result in poor hand auger recoveries). If any resistance is encountered while operating the hand auger for pre-clearance, the equipment will be removed, and the exploratory test hole will be visually inspected by onsite personnel for any obstructions or indications of subsurface structures.

3.4.1 Guidance for Tools and Equipment

Personnel performing pre-clearance activities shall keep tools and equipment in safe working order and be properly inspected before use. If tools or equipment are broken, they will be tagged and removed from service. The following specify additional guidelines regarding tools and equipment:

- Hand-digging tools must have a non-conductive handle, such as fiberglass, wood, or composite, or fully insulated handles and potential contact surfaces.
- Blades on shovels and post-hole diggers should have rounded or blunt edges.
- Pick axes or pointed spades should not be used for physical clearance.
- Crowbars, pinch-bars, or pry bars should not be used to break hardened soil or backfill except when authorized by the Site Supervisor (SS). This should only be used to loosen materials like bricks or larger stones.

- Electric-powered equipment must have ground fault protection.
- Should there be refusal or difficulty with advancing hand tools, the contractor shall stop work and notify the Roux SS or Site Health and Safety Officer (SHSO) immediately.

3.5 During Intrusive Activities

3.5.1 Concrete/Paving Surface Removal

Remove any surface coverings (i.e., pavement, brush, debris, etc.) to ensure workers have clear visibility of the work area and subsurface conditions. Avoid mechanical jackhammering over known lines unless they are de-energized, locked-out/tagged-out, and potential repairs are planned or if the utility has been completely disconnected prior. When cutting or coring, go only as far as needed to penetrate the surface cover. When removing a large surface area, begin at the perimeter of the removal zone. This initial step helps identify any utilities passing through the work zone. For extensive areas, using a concrete saw might not be practical. Instead, heavy equipment is often employed. During this process, a designated spotter should guide the heavy equipment. Their role is to watch for warning signs of utilities. It's crucial that the heavy equipment does not have "teeth" that could potentially pass through the surface and damage utilities.

3.5.2 Pre-Clearance Procedures

Install pre-clearance exploratory test holes using one of the techniques, as outlined in Section 3.4, for the first 5-ft below land surface (BLS) at each location before conducting intrusive mechanized activities. Should utilities be located at a greater depth than 5-ft BLS consult with the OM, OHSM and CHSD regarding adjustments to the pre-clearance requirements to go greater than 5-ft BLS. Some Clients may require greater than 5-ft BLS for pre-clearance test holes; Project teams should be aware of such Client requirements prior to work.

Pre-clearance exploratory test holes should be defined in the SOW/proposal provided to the client to prevent project delays and to allow adequate time for the PM and PP to evaluate alternative approaches for the project. Alternative approaches will need to be pre-approved by the OM through a Subsurface Utility Clearance Variance.

Both single-point and three-point clearance are acceptable as long as the following criteria are met below. For single-point clearance, the exploratory test hole is advanced at the exact location of the proposed borehole. If three-point clearance is performed, it must be done in a triangular pattern around the proposed borehole and in a configuration that would not allow utilities to enter the borehole.

- The size of the pre-clearance exploratory test hole should be, at a minimum, twice the diameter of any downhole tool or boring device.
- For direct push applications (CPT, Geoprobe®, etc.), the borehole clearance diameter shall be at least 125% of the diameter of the largest tool being pushed through the subsurface (e.g., tip, rod, sampler, etc.), to the minimum required depth.
- For excavations, all utilities need to be marked and then exposed by soft-digging or by hand following the protocols in this program. Pre-clearing for excavations may be performed by the "moat" technique (i.e., soft Digging around the perimeter). In these cases, dig in small lifts (<12" for first 5 feet) using a dedicated spotter.)
- For Tolerance Zone work, unless otherwise agreed upon with the Utility Operator, work within the tolerance zone requires verification by means of pre-clearance test holes specified in Section 3.4 to expose the utility. Once structures have been verified, a minimum clearance of three feet must be maintained between the utility and any powered equipment. If considered a high-risk utility, additional requirements may be necessary and required by the Operator of the utility. Consultation with the OM and CHSD may be appropriate.

The PM, field team lead, or personnel performing oversight is to:

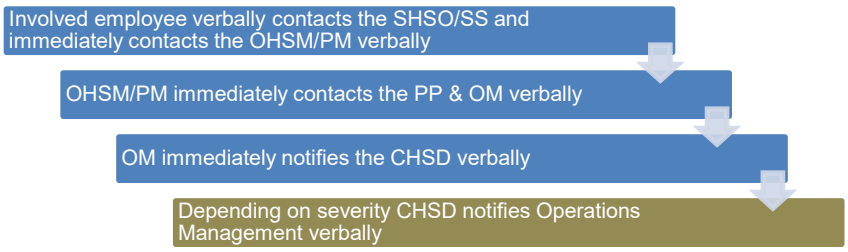
- Ensure the mark-out remains valid. (In certain states, there are limits regarding the duration of time after the mark-out was applied to the ground surface work can be started or interrupted.) Additionally, the mark-outs must be maintained, documented, and in many cases, refreshed periodically to be considered valid. This will be accomplished through calls to the one call center.
- Ensure intrusive activities are only performed within the safe boundaries of the mark-out as detailed in the One-Call Report.
- Halt all work if intrusive activities have resulted in the discovery of an unmarked utility. Roux personnel shall notify the facility owner/operator and the one call center. All incidents such as this will be reported as per Roux Incident Investigation and Reporting Management Program.
- Halt all work if intrusive activities must take place outside of the safe boundaries of a mark-out and only proceed after new mark-outs and subsurface utility clearance are performed.
- Halt the intrusive activities and immediately consult with the PP if an unmarked utility is encountered.
- Complete any loss reports associated with subsurface utility strikes as necessary.
- If a utility cannot be found as marked, Roux personnel shall notify the facility owner/operator directly or through the one-call center. If the facility operator is not responsive, then the one-call center must be notified. Following notification, the excavation/mechanical intrusive work may continue unless otherwise specified in state law.
- Contractors/subcontractors must contact the one-call center to refresh the ticket when the excavation continues past the life of the ticket. State law dictates ticket life. Project teams must be aware of their state-specific requirements.

3.6 Stop Work Authority

Each Roux employee has Stop Work Authority that he or she will execute upon determination of any imminent safety hazard, emergency situation, or other potentially dangerous situation, such as hazardous weather conditions. This Stop Work Authority includes subsurface clearance issues such as the adequacy of a mark-out or identification during intrusive operations of an unexpected underground utility. Authorization to proceed with work will be issued by the PM/PP in consultation with the OHSM after such action is reviewed and resolved. The PM will initiate and execute all management notifications and contact emergency facilities and personnel when this action is appropriate.

3.7 Reporting Utility Incidents

Roux field personnel engaged in any utility strike (e.g., subsurface/aboveground) must promptly stop work, shutdown any equipment and get to a safe location at the Site. Then notify the PM to discuss the incident. In case of injuries, field personnel must call 911 or the local emergency services number and then inform the PM. Additional notifications shall follow Roux's Incident Notification Process. Depending on the utility strike additional notifications shall be made to utility operators and/or clients/site contacts.



Appendix A
Roux Subsurface Utility Clearance Checklist

Appendix A

Roux Subsurface Utility Clearance Checklist/Utility Verification/Site Walkthrough Record

Roux Subsurface Utility Clearance Checklist ***Date of Revision: 3/2024***

Work site set-up and work execution

ACTIVITY	Yes	No	N/A	COMMENTS INCLUDING JUSTIFICATION IF RESPONSE IS NO OR NOT APPLICABLE
Daily site safety meeting conducted, SPSAs performed, JSAs reviewed, appropriate work permits obtained (if applicable).				
HASP is available and reviewed by site workers / visitors.				
Subsurface Utility Clearance Procedure has been reviewed with all site workers.				
Mechanical intrusive work activities may not be performed at any location without authorization from the Roux Site Supervisor (SS). Clearance activities may not be performed at any location unless the SS is physically present.				
Work area secured; traffic control established as needed. Emergency shut-off switch located. Fire extinguishers / other safety equipment available as needed.				
Utility mark-outs (public / private) clear and visible. Provide Excavator's Stake-Out Reference Number / Request Date / Time.				
Tolerance zone work identified. Intrusive work activities cannot be performed in areas that are in direct conflict with any markings made by public or private locators.				
Unless the PP & OM authorizes it, all boreholes and test pit locations must be physically cleared before using mechanized equipment. Required minimum physical clearance depths and diameters are as follows: • Physically clear to a depth of 5 feet bls. • The size of the pre-clearance exploratory test hole must be, at a minimum, twice the diameter of any downhole tool or boring device. • For direct push applications (CPT, Geoprobe®, etc.) the borehole clearance diameter shall be at least 125% to the diameter of the largest tool being pushed through the subsurface (e.g., tip, rod, sampler, etc.).				
Work execution plan reviewed and adhered to (ground disturbance methods, clearance depths, any special utility protection requirements, or any other execution requirements; especially for Tolerance Zone work).				

Mechanical intrusive work is prohibited within 3-feet distance in all directions from subsurface structures that will be intentionally exposed during pre-clearance. Any removal of material within 3-feet of the subsurface structure may only proceed by hand using non-conductive tools/compressed air if authorized by state law and the owner/operator of the utility.				
All equipment onsite must maintain the appropriate horizontal distance from any point on the equipment to the nearest overhead electrical power line. Refer to site-specific HASP and local/utility company requirements.				
Verbal endorsement received from Roux PM and OM for any required field deviations to work execution plan.				

Key Reminders for Execution

The Subsurface Utility Clearance Protocol should be referenced to determine all requirements while executing subsurface work. The bullet points below are intended as general reminders only and should not be relied upon solely.

- The size of the pre-clearance exploratory test hole must be at a minimum twice the diameter of any downhole tool or boring device to minimum required depth of 5 feet bls.
- For direct push applications (CPT, Geoprobe®, etc.) the borehole clearance diameter shall be at least 125% of the diameter of the largest tool being pushed through the subsurface (e.g., tip, rod, sampler, etc.), to the minimum required depth of 5 feet bls.
- The tolerance zone is defined as three feet plus half of the diameter or half of the greatest dimension (for elliptical sewers, duct banks, and other non-cylindrical utilities) of a utility and three feet from the outside of any subsurface structure.
- For excavations, all utilities need to be marked and then exposed by hand, following the protocols in this program. Pre-clearing for excavations may be performed by the “moat” technique (i.e., soft digging around the perimeter). In these cases, dig in small lifts (<12” for first five feet) using a dedicated spotter.) For Tolerance Zone work, unless otherwise agreed upon with the Utility Operator, work within the tolerance zone requires verification by means of hand-dug test holes to expose the utility. Once structures have been verified, a minimum clearance of three feet must be maintained between the utility and any powered equipment.

Utility Verification/Site Walkthrough Record

Employee Name:_____

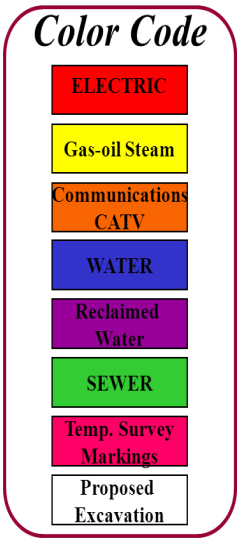
Date: _____

Instructions: For each utility suspected at the job site, indicate the location on the job site, approximate burial depth, and means of detecting the utility. Leave blank if that utility is not believed to be present.

Utility	Description of Utility Location Identified Onsite	Approx. Depth (bls)	Method / Instrumentation used to determine Utility Location	Utility Owner Response (Date/Time)	Mark Out Indicates (Clear / Conflict)
Electrical Lines					
Gas Lines					
Pipelines					
Steam Lines					
Water Lines					
Sanitary and Stormwater Sewer lines					
Pressured Air-Lines					
Tank Vent Lines					
Fiber Optic Lines					
Underground Storage Tanks					
Phone Lines/ Other					

* bls - below land surface

Site Sketch Showing Utilities:



Other Comments / Findings:

Completed by: _____

Signature: _____ Date: _____

Appendix B
Private Utility Technology Applications and Considerations

Appendix B – Private Utility Technology Applications and Considerations

Technology ⇒ Utility/Object ⇓	Radio Frequency Electro-Magnetic Detector (connection to utility, or induction without connection)	Radio Frequency Electro-Magnetic Detector (passive sweep)	Ground Penetrating Radar (GPR)⊙	Acoustic Plastic Pipe Locator	Beacon, Sonde or Conductive Rodder Insertion	EM-61 (time domain electromagnetics) Ξ	
Power/Instrument Line (Energized/Signaled) □	❋ G	G	G	R	R	G	
Power Line (Non-energized) □	❋ G	R	G	R	R	G	
Sewer/Water Line (Metallic) □	❋ G	Y	G	Y	G	G	
Sewer/Water Line (Non-metallic)	R	R	G	G	❋ G	R	
Instrument / Telecomm Lines (Non-energized)	❋ G	R	G	R	R	Y Only if metallic	
Hydrocarbon Transmission Line (Pipeline)◆ □	❋ G	R	G	R	R	G	
Metallic/Non-Metallic Line (with Tracer Wire)	❋ G	Y	G	Y	Y	G metallic	Y non-metallic
Metallic/Non-Metallic Line (without Tracer Wire)	G metallic	R non-metallic	R	❋ G	Y	Y	G metallic	R non-metallic
Metal or Fiberglass UST	R	R	❋ G	R	R	G metallic	R non-metallic

Additional Considerations

Technology ⇒ Variable ⇓	Radio Frequency Electro-Magnetic Detector	Ground Penetrating Radar (GPR)⊙	Acoustic Pipe Locator	Beacon, Sonde, or Conductive Rodder Insertion	EM-61 Ξ
Moist Soil	G	Y	G	G	G
Dry Soil	Y	G	Y	G	G
Clay	Y	R	G	G	G
Concrete w/Rebar	R	Y	G	G	R
Long Horizontal Profile	G	G	G	G	G
Short Horizontal but Deep Vertical Profile	Y	G	R	R	G
Access to Line✚	G	N/A	G	G	G
No Access to Line✚	G (induction or passive)	G	R	R	G
	R (direct connect)				G
Ferrous Metal	G	G	G	G	G
Non-ferrous Metal	Y	G	G	G	G
Adjacent or crossing conductive utility(ies)	Y	N/A	N/A	N/A	Y

Each site will be unique. Do not use this table as the sole criteria for technology selection. Use it as a starting point to assess available, applicable technology(s).

❋ Indicates best technology for given object. Site structures, rebar in concrete, shallow groundwater tables, perched storm water, etc. can significantly affect performance and reliability of any electro/magnetic method. Other utilities which cross or are adjacent to the target line can cause the EM signal to bleed or jump to the other utility line.

□ Metallic lines that have power running through them or can be connected to a tracer signal generator.

◆ Natural gas pipeline locating technicians must be trained/certified (in the U.S. requires DOT and Office of Pipeline Safety standards, other regions may have similar certification or requirements).

⊙ Most sensitive to interpretation. The skill, training and experience of operator are critical.

Ξ Emerging technology with limited availability.

✚ Access: induce unique electronic signature, apply acoustical impulse or insert conductive rodder/beacon/sonde.

Green Generally, an applicable technology **Yellow** May or may not be applicable **Red** Not generally applicable

APPENDIX F

Heavy Equipment Exclusion Zone Policy

HEAVY EQUIPMENT EXCLUSION ZONE MANAGEMENT PROGRAM

CORPORATE HEALTH AND SAFETY DIRECTOR	**:**	**Brian Hobbs, CIH, CSP**
EFFECTIVE DATE	**:**	**01/2019**
REVIEWED DATE	**:**	**03/2024**
REVISION NUMBER	**:**	**3**

TABLE OF CONTENTS

1. PURPOSE 1
2. SCOPE AND APPLICABILITY 1
3. PROCEDURES 1
   3.1 Exceptions 2
4. TRAINING 2
5. STOP WORK AUTHORITY 2

1. PURPOSE

The Exclusion Zone Management Program aims to establish the minimum clearance distance that must be maintained between workers and heavy equipment while equipment is in operation (i.e., engaged or moving). The intent is to have no personnel or equipment entering the Exclusion Zone while the equipment is in operation or moving to ensure that Roux and Subcontractor employees are unnecessarily exposed to the hazards of the equipment.

2. SCOPE AND APPLICABILITY

This Management Program applies to all Roux Associates, Inc. and its affiliated companies, Roux Environmental Engineering and Geology, D.P.C., and Remedial Engineering (collectively, "Roux") employees and their subcontractors performing fieldwork and are potentially exposed to heavy equipment. Heavy equipment includes, but is not necessarily limited to, excavation equipment, drill rigs, vacuum trucks, forklifts, lull telehandlers, man lifts, bobcats, delivery trucks, etc.

3. PROCEDURES

As specified in the following sections of this program, Exclusion Zones must be established and maintained during activities involving the movement/operation of heavy equipment. The Exclusion Zone requirements apply to all personnel on the site but are primarily focused on personnel required to work near the equipment. The exclusion zone is in effect when heavy equipment is moving or engaged (e.g., movement of an arm or bucket of an excavator, rotation of an auger, lifting of a load with a forklift, raising/lowering of a man lift, etc.).

1. The Exclusion Zone must meet the following minimum requirements:
   - A minimum distance of 10 feet from all heavy equipment and loads being moved by the equipment;
   - Greater than the swing/reach radius of any moving part on the heavy equipment (i.e., for large equipment, this may mean an exclusion zone distance larger than 20 feet);
   - Greater than the fall zone of equipment and their contents; and
   - Greater than the tip-over distance of the heavy equipment.

   The size of the Exclusion Zone will need to be determined on a task-specific basis considering the size of the heavy equipment in use and the task being performed. Prior to all heavy equipment operations, the Exclusion Zone(s) distance must be specifically identified in the Job Planning Process and incorporated in the pre-job tailgate meeting with the subcontractor(s), including any updates to our Job Safety Analysis (JSA).
2. The spotter (or another authorized individual) is responsible for enforcing the Exclusion Zone and not conducting any other task. The spotter should be positioned immediately outside of the Exclusion Zone within a clear line of sight of the equipment operator. The spotter must signal the operator to stop work if anyone or anything has the potential to enter or compromise the Exclusion Zone. The operator should stop work if the spotter is not within their line of sight. If a spotter must be within the Exclusion Zone, they must be in a designated area outside the swing/tip radius, fall zone, line of fire of lifted loads, etc. If multiple pieces of equipment are being used, one spotter may be adequate so long as there is a clear line of sight and the spotter can control the zone(s). Radios would be required since hand signals would not be adequate if two pieces of equipment are in operation at the same time in the Exclusion Zone.

3. If an individual must enter the Exclusion Zone, the designated Spotter must signal the Equipment Operator to stop the equipment. Once the equipment is no longer moving (e.g., movement of an arm of an excavator is STOPPED, lifting of a load with a forklift STOPPED, raising/lowering of a man lift is STOPPED, etc.), the operator must bring the boom/arm to the ground ensuring a “Zero Energy State” and DISENGAGE THE CONTROLS and STOP and SIGNAL BY “SHOWING HIS HANDS.” This signal will indicate that it is safe for the person to enter the limits of the Exclusion Zone to perform the required activity. The equipment must remain completely stopped/disengaged until all personnel exited the Exclusion Zone's boundaries and the designated Spotter has signaled by “SHOWING HIS HANDS” to the Equipment Operator that it is safe to resume operations.
4. When entering the limits of the Exclusion Zone, personnel must, at a minimum:
    - Establish eye contact with the operator and approach the heavy equipment in a manner that is in direct line of sight to the Equipment Operator;
    - Never walk under any suspended loads or raised booms/arms of the heavy equipment; and
    - Identify a travel path free of Slip/Trip/Fall hazards.
5. The Exclusion Zone should be delineated using cones with orange snow fences or solid poles between the cones, barrels, tape, or other measures. For work in rights-of-way, rigid barriers, such as Jersey barriers or temporary chain link fences, should be used. For certain types of widespread or moving/mobile equipment operations, such delineation may not be practicable around equipment or individual work areas. In such instances, it is expected that the entire operation will be within a larger secure work area or that additional means will be utilized to ensure the security of the work zone.

All subcontractors who provide heavy equipment operations to field projects must implement a program that meets or exceeds the expectations described above as well as any additional requirements that may be required on a client or site-specific basis. Logistics involving heavy equipment should be understood and discussed prior to the field event during the job planning phase.

3.1 Exceptions

It is recognized that certain heavy equipment activities may require personnel to work within the limits of the Exclusion Zone as specified in this program. Such activities may include certain excavation clearance tasks, drill crew activities, or construction tasks. However, any such activity must be pre-planned, emphasizing limiting the amount and potential exposure of any activity required within the zone. The critical safety steps to mitigate the hazards associated with working within the Exclusion Zone must be defined in the JSA and potentially other project-specific plans (i.e., critical lift plans, etc.), and approved by the Roux Project Principal (PP), Office Health and Safety Manager (OHSM) and client representative, if required, prior to implementation.

4. TRAINING

Many Roux projects have different requirements that are client-specific or site-specific in nature. However, all Roux employees are provided initial training, as well as annually thereafter, on our Heavy Equipment Exclusion zone policy.

5. STOP WORK AUTHORITY

All Roux employees and their subcontractors have stop-work authority. Upon initial hire, all Roux employees are provided initial safety orientation, including stop work authority. All Roux employees and subcontractors are encouraged to stop work whenever any task or operation presents unreasonable risk or employees are

unsure how to carry out work safely. This includes upon observing any questionable safety-related behavior or condition, they are to stop work immediately and discuss the behavior or condition with the individual(s) involved. Upon stopping work, the following actions will be taken:

- Notify the affected parties to include the Project Manager (PM) and Site Health and Safety Officer (SHSO);
- Work to correct the situation or not proceed until the situation is corrected by the PM or SHSO;
- Resume work only when told to proceed by either the PM or SHSO;
- The SHSO will document the Stop-Work intervention in the field logbook;
- Stop-Work interventions will be reported to the PP for review to ensure the interventions are closed; and
- The PP will share learnings from the interventions, as appropriate, throughout the firm, to demonstrate the importance of the Stop-Work interventions.

Please note: Any form of retribution or intimidation directed at any individual or company for exercising their right to issue a stop work authority will not be tolerated.

APPENDIX G

Resumes of Key Personnel

PROFESSIONAL PROFILE



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EDUCATION
BS, Geology, Binghamton University, 2005

PROFESSIONAL LICENSES
Professional Geologist, New York, 2017

Jessica L. Taylor, PG

Principal Hydrogeologist

EXPERIENCE SUMMARY
Nineteen years of experience: Principal, Senior, Project, and Staff Hydrogeologist, Roux, Islandia, New York; Staff Hydrogeologist and Intern at GSC | Kleinfelder.

TECHNICAL SPECIALTIES
Project Management and Field Management for large-scale soil excavation and remediation projects, including site assessment, remediation implementation, and construction activities. Negotiation with NYSDEC Brownfield Clean-up Program (BCP) and NYCOER E-Designation/Voluntary Clean-up Program. Coordination and management of large-scale demolition and renovation support. Performance of sampling and direction of field sampling teams for the following media: soil, groundwater, surface water, soil vapor, sludge, and sediment. Soil characterization, coordination with construction management teams, disposal brokers, and facilities for cost-effective disposal of contaminated and clean soils from complex, large-scale projects.

REPRESENTATIVE PROJECTS

- **Project Principal, Remediation of two Parcels as part of the NYSDEC Brownfield Cleanup Program, Inwood, Manhattan, New York.** This project included due diligence environmental assessment and investigation of a former grocery store and retail gasoline filling station/auto repair, development of NYSDEC-approved Remedial Investigation Work Plan and Remedial Action Work Plan, and remediation during construction an affordable housing development. Acted on behalf of developer to provide soil classification data and vet disposal facilities and manage registration and disposal of unknown USTs.
- **Project Principal, Large Redevelopment Project including Four Buildings with NYCOER E-Designations for Hazardous Materials, Brooklyn, New York.** The project encompasses 22 acres including the Barclays Center. Project responsibilities include coordination and oversight of in situ waste characterization sampling, excavation, and proper disposal of 500,000 CY of soil. Included sampling, classification, and coordination with construction managers and soil disposal facilities for disposal of soil impacted by petroleum contamination and TCLP hazardous levels of lead and corrosivity. Designed soil delineation sampling programs to limit boundaries of more contaminated soils to reduce disposal costs. Responsible for implementing and managing remediation work at several NYSDEC spill sites within the project footprint, including in situ chemical oxidation, UST removal, and soil excavation. Agency support for NYSDEC, NYCDEP, NYCOER, MTA (LIRR/NYCT), and ESDC.
- **Project Principal Providing Technical Guidance to Construction Management Team during the Excavation of NYSDEC Brownfield Cleanup Program Project, Yonkers, New York.** Coordinated with development team, their consultant, soil brokers, and disposal facilities to determine appropriate facilities and manage costs during disposal of approximately 30,000 tons of soil contaminated with TCSA-level PCBs, hazardous lead, and elevated VOCs triggering UHCs.
- **Project Principal, Remediation of Two Parcels as part of the NYSDEC Brownfield Cleanup Program, Hunter's Point South, Queens, New York.** This project included due diligence environmental assessment and investigation, development of NYSDEC-approved Remedial Investigation Work Plan and Remedial Action Work Plan, and remediation during construction of two mixed-use, affordable housing developments. Acted on behalf of developer to evaluate Change Order Request by contractor for disposal of soil with elevated PAHs and hazardous levels of lead. Designed delineation sampling program to limit costs associated with disposal of contaminated soil.

- **Project Principal, Remediation of a 0.66-acre Parcel in as part of a NYSDEC Brownfield Cleanup Program, Brooklyn, New York.** This project included due diligence environmental assessment and investigation, development of NYSDEC-approved RIWP and RAWP including an active sub-slab depressurization system, and remediation during construction of mixed- use affordable housing developments including full cellar. Also required coordination with NYCHPD and NYCDEP to meet regulatory requirements for funding. Continued support during the Site Management phase includes preparation of Periodic Review Reports and quarterly sampling and monitoring of an active sub-slab depressurization system.
- **Project Principal, Management of NYCOER E-Designation for Hazardous Materials during Excavation and Construction of a Hotel/Residential Building, Manhattanville, New York.** Responsibilities included negotiation with NYCOER to limit additional sampling required for Remedial Investigation, and soil management including performing in situ waste characterization, coordination with soil brokers, and oversight of disposal of 16,000 CY of soil.
- **Project Principal, Real Estate Acquisition Due Diligence for Industrial Properties, Queens and The Bronx, New York.** Prepared Phase I ESAs and designed and implemented Phase II ESAs to meet financing requirements while coordinating with selling parties. Provided technical and strategic support, including remedial cost estimates during short due diligence periods.
- **Project Principal, Redevelopment of Four Properties for a Supportive Housing Development with NYCOER to Address NYCDEP E-Designations, Brooklyn, New York.** Coordination with NYCOER to implement remedial investigation and develop RAP as part of the NYC VCP.
- **Senior Project Manager, Environmental Management of Asbestos Remediation during the Renovation of Nassau Coliseum, Uniondale, New York.** Responsible for coordinating inspections and delineation of ACM, preparing budgetary estimates, and bid support for full abatement. Also includes management of decommissioning and replacement of existing emergency generator UST.
- **Project Manager, Commercial Redevelopment Site, The Bronx.** Project work includes in situ waste characterization, management and coordination of excavation, community air monitoring, and development of NYCDEP-approved RAP.
- **Client Liaison and Full-time On-site Construction Manager, Redevelopment Site, Rego Park, New York.** Collection of 500 in situ waste characterization soil samples, oversight of 250,000 cubic yards of soil excavation and remediation, development of post-remediation sampling plan, and organization of waste manifests and hazardous waste documents to ensure proper disposal. Coordination of daily site activities with multiple construction contractors and other involved parties on behalf of client. Oversight and confirmatory soil sampling for on-site treatment of 75,000 cubic yards of hazardous lead-contaminated soil.
- **Project and Field Manager, Phase I and Phase II ESAs on a Portfolio of Retail Gasoline Stations, New York and New Jersey.** Responsibilities included drilling and sampling oversight and health and safety management, as well as writing Phase II ESA reports for over 40 sites.
- **Field Manager, Remediation System Installation, Brooklyn, New York.** Responsibilities included daily oversight of contractors excavating soil and installing piping within streets and sidewalks. Ensured compliance with client-specific Health and Safety Completed daily health and safety meeting and reports and attended weekly construction progress meetings.
- **Field Manager, Quarterly Groundwater Sampling Rounds at a Former Pesticides Manufacturing Facility, Dayton, New Jersey.** Responsibilities include direction of multiple sampling teams and coordination with subcontractors.
- **Field Manager, Site Investigation Activities at a Redevelopment Site, Staten Island, New York.** Responsible for oversight of subcontractor performing soil borings and soil and groundwater sampling.
- **Field Manager, Groundwater Monitoring Rounds at Former Oil and Fuel Distribution Terminals, Staten Island, Westchester, Glen Cove, and Oceanside, New York.** Activities include system operations and maintenance, supervision of multiple field personnel, performing water levels gauging, and collection of groundwater samples from site monitoring wells using a variety of equipment.
- **Field Manager, Site Investigation at a Former Chemical Manufacturer, Brooklyn, New York.** Responsibilities included oversight of subcontractor installation of monitoring wells, collection of soil and groundwater samples, and logging soil lithology.
- **Field Manager, Annual Groundwater Sampling at a Chemical Manufacturing Superfund Site, Delaware.** Involves the oversight and supervision of multiple teams of personnel for a weeklong gauging and sampling round.
- **Field Manager, Underground Storage Tank Closure, Queens, New York.** Provided health and safety supervision, collection of soil and groundwater samples, and oversight of subcontractor closure activities on behalf of client.
- **Field Manager, Long-term Remediation Project for the City of New York.** Includes quarterly groundwater sampling and soil vapor sampling as part of an NYSDEC-approved work plan, as well as oversight of soil sampling as part of subsurface investigations. Creation of tables and figures based on investigation results and as part of periodic reports submitted to NYSDEC.

- **Field Manager, Off-site Investigation at a Former Chemical Production Facility in Rensselaer, New York.** Investigation included the installation of piezometers, monitoring wells, and soil gas and environmental health and safety oversight.
- **Project and Field Manager, Implementation of a Phase II ESA Large Ongoing Redevelopment Project, New York.** Responsibilities included coordination and oversight of drilling, sampling, and excavation of soil. Drilling methods included sonic rotary, Geoprobe, hollow-stem auger, and air hammer/split spoon sampling. Includes oversight of Phase II ESA and waste characterization activities, coordination with laboratory contacts, as well as synthesis of lithology logs for over 100 soil borings. Project includes completion of Phase II ESAs (sampling of soil, groundwater, and soil gas) for over 50 properties.
- **Project and Field Manager, Brooklyn, New York.** Responsible for implementing and managing remediation work at several NYSDEC spill sites within the footprint of a large redevelopment project. Responsibilities included management and oversight of in situ chemical oxidation for treatment of petroleum-impacted groundwater.
- **Field Manager, Redevelopment Site, New Jersey.** Collection of waste characterization soil samples, post excavation confirmatory sampling, and groundwater off-site discharge sampling.

PROFESSIONAL TRAININGS

OSHA 40-Hour HAZWOPER Training, 2005

OSHA 10-Hour Construction Safety Training, 2008

PROFESSIONAL PROFILE



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EDUCATION
BS, Marine Science, Coastal Carolina University, 2011
MS, Environmental Studies, College of Charleston, 2013

PROFESSIONAL TRAININGS
OSHA 40-hour HAZWOPER Training
OSHA NYC Site Safety Training (SST) Certified
OSHA 8-hour HAZWOPER Refresher Training, Certificate Current
NYCOER Gold Certified Professional

Levi Curnutte

Senior Scientist I

EXPERIENCE SUMMARY
Eleven years of experience: Staff Scientist, Project Scientist, and Senior Scientist I at Roux, Islandia, New York.

TECHNICAL SPECIALTIES
Design, implementation, and management of remedial investigations and remedial actions for real estate and industrial sites in regulatory programs, including United States Environmental Protection Agency Federal Superfund (CERCLA), New York State Department of Environmental Conservation (NYSDEC) Brownfields Cleanup Program (BCP), New York City Office of Environmental Remediation (NYCOER) E-Designation and Voluntary Cleanup Programs, New York City Department of Environmental Protection (NYCDEP), and New York State Spills Program; management of due diligence Phase I & II Environmental Site Assessments; and management of large-scale soil excavation projects including soil waste characterization implementation and construction management, located primarily in the tri-state and surrounding areas. Strategic consulting for multi-party sites in various federal and state regulatory programs. Technical and regulatory expertise focused on petroleum, industrial, and real estate site transfers.

REPRESENTATIVE PROJECTS

- Project Manager for a large ongoing redevelopment project in Brooklyn, New York, including the Barclays Center and the relocation of a nine-acre 100-year-old active rail yard. Project included management of four buildings with NYCOER “E” designations and the implementation of Remedial Action Work Plans (RAWPs), in situ soil characterization sampling, non-hazardous soil disposal, underground storage tank (UST) removals and NYSDEC spill remediation at multiple sites, and Site Management Plan (SMP) O&M task implementation. Achieved an NYCOER Notice of Satisfactions for four properties. Agency support for NYSDEC, NYCDEP, NYCOER, MTA (LIRR/NYCT), and ESDC.
- Project Manager providing support for all soil and groundwater disturbances during development of a large 12.5-acre college campus located on Roosevelt Island, New York, New York. Management tasks included Agency support for NYCDEP and NYSDEC, CAMP and SWPPP implementation, soil characterization for reuse and disposal, UST removal adhering to NYSDEC regulations, asbestos abatement coordination, and submission of a NYCDEP Remedial Closure Report. Received NYCDEP letters of completion for all remedial activity requirements set forth for the site.
- Project Manager and Client Representative providing strategic and technical oversight for a portfolio of 10 multi-party sites across Federal Superfund (7), NJ Site Remediation Program (2), and NYS Brownfield Cleanup Program (1) projects. Responsibilities include managing annual budgets exceeding $1M, coordinating technical subcontractors, collaborating with PRPs, legal teams, and regulators, and driving portfolio strategies focused on liability reduction and risk transfer. Expertise includes identifying liability drivers, developing closure strategies, optimizing remedial and lifecycle costs, evaluating settlement and cash-out opportunities, managing project financials, and advocating for client interests among performing parties.
- Project Manager for remediation of a 1-acre parcel in the Sunset Park section of Brooklyn, New York. Site was issued RCRA Consent Decree violations and entered the NYSDEC BCP to satisfy violations and remediation requirements.

This project included preparation of BCP Application submission, robust due-diligence environmental assessment and investigation, and development of NYSDEC-approved Remedial Investigation, Interim Remedial Measures, and Remedial Action Work Plans as well as Beneficial Use Determination (BUD) Application. Remedial actions included removal of hazardous and non-hazardous waste, in situ chemical oxidation (ISCO) application for groundwater remediation, UST removal and NYSDEC spill remediation, and sub-slab depressurization system (SSDS) installation. Redevelopment consisted of industrial office space and a large parking garage for use as commercial vehicle fleet storage and maintenance.

- Project Manager for post-closure SMP O&M tasks and Field Manager for RAWP implementation at a NYSDEC BCP site in the Williamsburg neighborhood of Brooklyn, New York, completing extensive remediation of chlorinated VOC-impacted soil and groundwater to accommodate development of a mix-used building and underground parking garage. Primary contaminants of concern were PCE and TCE. Project responsibilities included management of zero-valent iron injections (ZVI) for a permeable reactive barrier (PRB), installation of SSDS, waterproofing/vapor barrier inspections, groundwater monitoring and sampling, CAMP, coordination and tracking of hazardous and non-hazardous waste, and providing contractor work zone health and safety recommendations/oversight in accordance with OSHA guidance. Key contributor in the submissions of the Periodic, Annual, and Final Engineering Reports submitted to NYSDEC leading to Certificate of Completion. Project received by the NYC Brownfield Partnership's 2017 Big Apple Brownfield Award for Innovation. Project lead for maintaining compliance with ongoing SMP O&M and reporting requirements.
- Project Manager for six separate sites with NYCOER "E" designations that are part of a large 21-acre affordable redevelopment project in Brownsville neighborhood of Brooklyn, New York. All sites are under NYCOER regulation, with one site enrolled in the VCP. Project management includes NYCOER enrollment, design and implementation of remedial investigations and assessments, design, and implementation of Remedial Action Work Plans, in situ soil characterization sampling and soil removal (including hazardous soil), opening of a NYSDEC Spill and closure, and UST removal adhering to NYSDEC regulations which resulted in obtaining a Notice of Satisfaction for all six sites.
- Project Manager for former Manufactured Gas Plant (MGP) site in Gowanus neighborhood of Brooklyn, New York. Under NYSDEC regulation, O&M responsibilities include coordination of monitoring of recovery wells known to be former and current producers of coal tar (DNAPL), DNAPL recovery and disposal, and associated reporting.
- Project Manager for an 85-acre commercial site within the NYCOER Voluntary Cleanup Program (VCP) undergoing a 500K sq. ft. mall expansion. Project involved the construction of an adjacent building to the existing mall and a new above-grade parking structure. Manager for RAWP implementation and production of multiple Remedial Action Reports leading to two NYCOER Notices of Satisfactions for the client to date.
- Project Manager for remediation of two parcels in Queens, New York, as part of NYSDEC BCP containing petroleum compounds and hazardous concentrations of heavy metals. This project included preparation of BCP Application submission, due-diligence environmental assessment and investigation, in situ waste characterization design and implementation, development of NYSDEC-approved Remedial Investigation Work Plans and RAWPs, and future remediation during construction of two mixed-use, affordable housing developments. Also required coordination with NYCHPD and NYCDEP to meet regulatory requirements for funding.
- Project Manager for an affordable housing redevelopment site in NYSDEC BCP in Brooklyn, New York. The Site was formally used by Brooklyn Water Works and an automobile repair facility in which contaminants of concern are petroleum compounds in soil and chlorinated solvents in soil gas. Project management roles include BCP Application submission, due-diligence assessment, and investigation activities, in situ waste characterization design and implementation, development of NYSDEC-approved Remedial Investigation and Remedial Action Work Plans. A Track 1 Cleanup was completed for the site.
- Project Manager for remedial investigation of a previously abandoned oil-water separator located at a NYSDEC-regulated 175-acre former petroleum refinery and terminal in Brooklyn, New York, to delineate residual contamination. Responsibilities included the management of all field tasks, site management, property owner and tenant coordination, and investigation report.
- Project Manager for ongoing long-term O&M support and Field Manager for RAWP implementation at a NYSDEC BCP site in the Brownsville neighborhood of Brooklyn, New York. Previous use as a dry cleaner left residual contamination of PCE and TCE in soil and groundwater. Field management of remediation of chlorinated VOC-impacted soil and groundwater including source excavation and tracking of hazardous and non-hazardous waste, potassium permanganate ($KMnO_4$) injections for groundwater treatment, installation of soil vapor extraction wells, groundwater monitoring and sampling, and CAMP.

- Field Manager of subset of field operations for a large-scale, high-profile investigation of 500 residential and sensitive-use properties located throughout Los Angeles County. As a result of lengthy aerial depositions of emissions originating from a former battery recycling facility in Vernon, California, soil was analyzed in situ for lead contamination on a real-time basis through the use of X-ray fluorescence (XRF) instruments. Helped coordinate and perform the rapid assessment of soils by multiple teams while under heavy scrutiny by the press, regulators, and homeowners.

PUBLICATIONS

Climate Change and Bemisia tabaci (Hemiptera: Aleyrodidae): Impacts of Temperature and Carbon Dioxide on Life History. Curnutte, L., Simmons, A. M., and S. Abd-Rabou. Ann. Ent. Soc. Amer. 107(5): 933-943. 2014.

PROFESSIONAL PROFILE



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EDUCATION

BA, Biological Sciences,
Binghamton University State University of New York, 2022
MS, Biological Sciences,
Binghamton University State University of New York, 2023

PROFESSIONAL TRAININGS

OSHA 40-Hour HAZWOPER Training, 2023
OSHA 30-Hour Construction Safety Training, 2023
NYC Site Safety Training, 2023

Benjamin Weintraub

Staff Scientist II

EXPERIENCE SUMMARY

Three years of experience: Staff Scientist II, Roux, Islandia, New York.

TECHNICAL SPECIALTIES

Community Air Monitoring Program (CAMP); telemetry; noise monitoring; groundwater, soil, and soil vapor sampling; soil boring logs (gINT); petroleum recovery; subcontractor oversight; waste characterizations; remedial investigations; Health and Safety Plan (HASP) writing; Phase I investigation reporting; Phase II field manager and report writing; litigation support; wetland delineation; habitat mapping; GIS and groundwater contour mapping.

REPRESENTATIVE PROJECTS

- **Field Manager, Environmental Oversight During Excavation, Controlled Rock Blasting, and the Construction of a Sewer Bypass System, NYC Department of Design and Construction Site, The Bronx, New York.** Duties include construction activity documentation, daily site reporting, maintaining truck log, and contractor coordination.
- **Project Manager, Overnight Travel Quarterly Groundwater Sampling Event, Former Aerospace Components Manufacturer RCRA Site, Connecticut.** Responsible for coordination with field staff, equipment and sample bottle preparation, and annual report production that incorporates groundwater contour map generation based on field gauging data.
- **Field Staff, Port Facility Development Project, Developing Baseline Data to Support the Suitability of Potential Mitigation Site, Staten Island, New York.** Responsibilities include habitat mapping and the performance of wetland delineation using GIS mapping via a GNSS receiver.
- **Field Staff, Managing Driller Subcontractors Operating a Geoprobe Drill During Waste Characterization, Automobile Storage Facility, Staten Island, New York; Remedial Investigation, Derelict Golf Course, White Plains, New York.** Each project encompassed over 100 soil borings, hundreds of soil samples, and traversing across dozens of acres of challenging terrain. Project scale required excellent organization and coordination over multiple weeks to carry out scope.
- **Field Lead, Overseeing Groundwater Sampling Teams, Managing Individual Workload and Project Organization, Former Petroleum Refinery and Storage Facility, Brooklyn, New York.** Work was conducted using peristaltic and bladder pumps at a two-week annual sampling event and for yearly system performance.
- **Assistant to the Project Manager, Monthly Invoice Preparation for Eight Sites, Electric Utility Service Provider, Manhattan and Queens, New York.**
- **Field Lead, Multiday Phase II, Former Parking Garage Cellar with Two Subcontractor Drill Teams, New York, New York.** Responsibilities included safely directing a gas Geoprobe in an enclosed space while performing groundwater, soil vapor, and soil sampling.
- **Field Staff, General Construction Oversight, New York, New York.** Conducted CAMP during intrusive subsurface work to monitor airborne dust and volatile organic compound concentrations throughout the boroughs of Manhattan, Queens, Brooklyn, and the Bronx. Ensured soil export trucks are safely loaded and sent to a project standards approved facility.

- **Field Lead, Wildlife Management Program, Former Fibers Facility, Virginia.** The Site includes 350-acres of forest, 12-acres of grassland, and 16-acres of wetlands. Supported bat surveys, bird box inspections, species identification through grass and meadow transects and tree surveys. Involved overnight travel.
- **Expert Witness Support, Litigation Case Involving Insurance Dispute Over Costs Incurred Over Remediation of Two Dozen Mining Facilities in Canada.** Responsibilities included review and organization of over a hundred pages of documents, advisement of the Expert Witness, and task delineation to other staff.

APPENDIX C

Community Air Monitoring Plan

New York State Department of Health (NYSDOH)
Generic Community Air Monitoring Plan (CAMP)

Overview

A Community Air Monitoring Plan (CAMP) requires real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at contaminated sites. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., offsite receptors including residences and businesses and onsite workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the CAMP helps to confirm that work activities did not spread contamination offsite through the air.

The generic CAMP presented below will be sufficient to cover many, if not most sites. Specific requirements should be reviewed for each situation in consultation with NYSDOH to ensure proper applicability. In some cases, a separate site-specific CAMP or supplement may be required. Depending upon the nature of contamination, chemical-specific monitoring with appropriately sensitive methods may be required. Depending upon the proximity of potentially exposed individuals, more stringent monitoring or response levels than those presented below may be required. Special requirements will be necessary for work within 20 feet of potentially exposed individuals or structures and for indoor work with co-located residences or facilities. These requirements should be determined in consultation with NYSDOH.

Reliance on the CAMP should not preclude simple, common-sense measures to keep VOCs, dust, and odors at a minimum around the work areas.

Community Air Monitoring Plan

Depending upon the nature of known or potential contaminants at each site, real-time air monitoring for VOCs and/or particulate levels at the perimeter of the exclusion zone or work area will be necessary. Most sites will involve VOC and particulate monitoring; sites known to be contaminated with heavy metals alone may only require particulate monitoring. If radiological contamination is a concern, additional monitoring requirements may be necessary per consultation with appropriate DEC/NYSDOH staff.

Continuous monitoring will be required for all ground intrusive activities and during the demolition of contaminated or potentially contaminated structures. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, test pitting or trenching, and the installation of soil borings or monitoring wells.

Periodic monitoring for VOCs will be required during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from existing monitoring wells. “Periodic” monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at wells on the curb of a busy urban street, in the midst of a public park, or adjacent to a school or residence.

VOC Monitoring, Response Levels, and Actions

VOCs must be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone) on a continuous basis or as otherwise specified. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions, particularly if wind direction changes. The monitoring work should be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. The equipment should be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment should be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

1. If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.
2. If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.
3. If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown.
4. All 15-minute readings must be recorded and be available for State (DEC and NYSDOH) personnel to review. Instantaneous readings, if any, used for decision purposes should also be recorded.

Particulate Monitoring, Response Levels, and Actions

Particulate concentrations should be monitored continuously at the upwind and downwind perimeters of the exclusion zone at temporary particulate monitoring stations. The particulate monitoring should be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. The equipment must be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration should be visually assessed during all work activities.

1. If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 150 mcg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.
2. If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work must be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.
3. All readings must be recorded and be available for State (DEC and NYSDOH) and County Health personnel to review.