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Mr. Ronnie Lee, P.E.
NYSDEC
Division of Environmental Remediation
Remedial Bureau B
625 Broadway
Albany, New York 12233-7017

Subject:
Consolidated Edison Company of New York, Inc.
Parcel C, Hunt Point Former MGP Site, Bronx, New York August 13, 2024
NYSDEC #203112
Revised Off-Site Supplemental Remedial Investigation Work Plan

Dear Mr. Lee:

On behalf of Consolidated Edison Company of NY, Inc. (Con Edison), this revised Off-Site Supplemental Remedial Investigation Work Plan (Work Plan) has been prepared by Ramboll Americas Engineering Solutions, Inc. (Ramboll) to support off-Site supplemental remedial investigation (SRI) activities for the Parcel C area of the Hunts Point former Manufactured Gas Plant located at in Bronx, New York (MGP; the "Site").

This Work Plan is a revision to the Work Plan that was originally submitted as an addendum to the New York State Department of Environmental Conservation (NYSDEC) approved Off-Site Characterization Work Plan dated November 6, 2012 (Arcadis 2012) and is being provided to propose a revision to the sampling scope and updated guidance to be followed during this investigation.

Background

The Site is an approximately 160-acre tract of land located within the Hunts Point peninsula at the confluence of the Bronx and East Rivers. For investigation purposes, portions of the Site have been divided into parcels (Parcels A through F). The Site also contains the Sultana and Citarella property, located south of Parcel C; the Krasdale Foods property, located between Parcels D and F; and The City of New York Department of Sanitation marine transfer station, located on the southern portion of the Site (**Figure 1**). Various investigations and remediation of Parcels A through F and the Krasdale Foods property have been completed and are documented in the RIR (Arcadis 2014). An overview of Parcel C, the subject of this Work Plan, is provided below.

The following reports related to Parcel C were reviewed as part of the summary provided below:

- *Hunts Point Cooperative Market Redevelopment Plan, Response Plan for the Operating Unit Portion of Parcel C, Bronx, New York, Final Revised* (LMS 2001)

- *Hunts Point Food Distribution Center Redevelopment Plan, Sections of the Redevelopment Plan for the Operable Unit 1 Portion of Parcel C, Bronx, New York, Final Revised* (Henningson, Durham & Richardson Architecture and Engineering P.C. [HDR] 2009)

Two subsurface investigations were completed in 1997 and 1999 on Parcel C under the NYSDEC Voluntary Cleanup Program (VCP). The 1997 investigation consisted of the completion of five soil borings to a depth of 6 to 10 feet below ground surface (bgs) and the installation of one monitoring well screened across the water table. The 1999 investigation consisted of the completion of four test trenches and five test pits to the water table, one soil boring to 40 feet bgs, as well as the collection and analysis of soil and groundwater samples.

A coal layer was encountered across most of Parcel C from the surface to 2 to 4 feet bgs, with greatest thickness near the center of the site. Occasional coal tar/tar boils (1 to 4 feet in diameter) were also observed at the surface, and occasionally at 3 to 4 feet bgs. Areas of “soft ground” were also encountered during the 1999 investigation but were not investigated, as the areas could not support the excavator. In addition, petroleum-impacted soils were noted in the southern portion of the parcel. Groundwater conditions at Parcel C exhibited no evidence of product, including dense non-aqueous phase liquid (DNAPL).

An occasional sheen on groundwater was noted during completion of the trenches and, during the 1999 investigation, a sheen was also noted on the East River at low tide approximately 20 feet offshore (Arcadis 2014). The sheen was observed adjacent to a former outfall in the bulkhead. A test boring was installed in line with the observed sheen to identify any source areas or conduits for this sheen. No visual evidence of impacts was observed throughout the boring. Several unidentified former utilities were noted during the trenching. These utilities appeared to be steel, or iron pipes buried at relatively shallow depths and were thought to be remnants of the former MGP. Two pipes observed in the southern portion of the trenches included an 8-inch diameter adjacent to a 4-inch diameter pipe. Both pipes appeared to be in good condition and were encountered in the southern end of the trenches, perpendicular to the bulkhead. A single concrete pipe was also found and was estimated to be about 4 feet in diameter. The pipe was perpendicular to the bulkhead and appeared to be a possible storm water drainage pipe. A fourth pipe was discovered in the southern end of the trenches. The pipe was 3 feet in diameter and appeared to be concrete and intact with no materials noted to be exiting from it.

Following the investigation, HDR prepared a Response Plan for Parcel C for the NYSDEC, dated March 2001 and revised November 2001. The Response Plan compiled historical background information, site investigation data, and site development plans for the purposes of evaluating the chosen remedy. The Response Plan was approved by both the NYSDEC and New York State Department of Health.

Since the investigations described above, Parcel C and surrounding areas have been redeveloped. The redeveloped property has historically been referred to as the Anheuser Busch (AB) Parcel, which includes Parcel C as well as an area to the south which was formerly a Con Edison easement (**Figure 1**). This area has historically been referred to as the non-VCP AB Parcel and has not previously been investigated under the VCP; however, it is included under the Site Management Plan for the Parcel C. The northern and eastern perimeters are occupied by the future Greenway Park as part of the South Bronx Greenway Master Plan. An easement for the Iroquois Pipeline occupies the southernmost portion of Parcel C. Henceforth in this Work Plan, the AB Parcel will be referred to as Parcel C, based on the historical context for the proposed SRI activities discussed above.

The majority of the Parcel C was redeveloped to a slab on-grade warehouse occupied by AB. The Parcel C remedy, incorporated during redevelopment, included installation of a passive sub-slab depressurization system under the building, engineered cap, and 1 foot of imported fill in landscaped areas. In addition, to raise the surface elevation of the parcel 4 to 5 feet out of the Federal Emergency Management Agency flood zone, approximately 14,000 cubic yards (cy) of excavated soils generated during the bulkhead rehabilitation project on Parcel B, as well as an additional 26,000 cy of excavated soils from other areas of the project, were used as fill material on Parcel C. As part of the redevelopment project, the bulkhead was rehabilitated. Coal tar-impacted soils encountered on the landward side of the former bulkhead were removed during the rehabilitation project and properly disposed.

The Site (#V00554) was transitioned from the VCA to an Order on Consent (CO 020180516-519) on July 25, 2018 and assigned a new ID number (#203112).

2013 Remedial Investigation Activities

The 2012 Off-Site Characterization Work Plan was submitted by Con Edison to assess the potential presence and extent of MGP-related impacts in the off-site areas of the Hunts Point former MGP (Arcadis 2012). The off-site RI was completed in 2013 with activities consisting of field reconnaissance of the shoreline and a sediment investigation consisting of the advancement of sediment cores and sediment sampling and analyses (Arcadis 2014). The shoreline reconnaissance was conducted to identify outfalls and/or preferential pathways from the upland to the rivers. An unknown 60-inch concrete outfall, Outfall 4, was identified along the shoreline of Parcel C.

A reported in the 2014 RIR, eighty-one cores were advanced within the Bronx and East Rivers within three investigation areas: northern, central, and southern. Anthropogenic materials were observed within sediment cores across the investigation area that included degraded coal fragments, pyrite/coal pieces, debris, glass fragments, and wood pieces/chips/fragments. During the field investigation, DNAPL, significant sheening, or evidence of purifier waste, was not observed in any of the cores. Sheens, primarily in trace to little amounts within the sediment pore spaces were observed in the sediment. Subsequent forensic evaluations concluded that the sheens were primarily associated with petroleum hydrocarbons from weathered heavy and mid-distillate oils. In addition to identifying petroleum hydrocarbons, the forensic evaluation also identified the presence of pyrogenic materials (e.g., coal tar products, such as, but not limited to, MGP residuals, creosote, asphalt sealcoat). Sheens were only observed on the water surface during the retrieval of sediment core SD-07B located near Outfall 4. The SD-07B and Outfall 4 locations are presented on both **Figure 2**.

Based on the results of the off-Site RI activities, the potential migration and extent of MGP-related impacts to/in sediments off-Site of the Hunts Point former MGP were sufficiently characterized, with the exception of the area adjacent to Parcel C where sheen was observed during coring at location SD-07B adjacent to Outfall 4. The SRI activities to further characterize Parcel C are described below.

Proposed Site Investigation Activities

These SRI activities will be conducted to evaluate the potential presence or ongoing migration of MGP-related impacts from Parcel C to the sediments in the area at and around SD-07B, Outfall 4, and in an area where sheen was historically observed in the river. The potential presence of preferential pathways on Parcel C, such as current/former buried utility lines will be evaluated.

SRI activities will generally consist of the following:

- Conducting a site reconnaissance to confirm current Site conditions.
- Completing a subsurface geophysical survey to locate subsurface utilities and/or potential preferential pathways.
- Completing a closed-circuit television inspection of the piping associated with Outfall 4, to the extent possible (and other piping as appropriate).
- Advancing soil borings along the piping associated with Outfall 4, and adjacent to river boring SD-07B, and the area where sheen was historically observed in the river.
- If applicable, convert soil boring locations into temporary well points followed by the installation of permanent recovery wells if deemed necessary.

Implementation of SRI related activities and procedures summarized below will be consistent and in compliance with the methods presented in the following documents:

- Field Sampling Plan: Detailed descriptions of sampling methods and techniques for the activities listed above, including field guidance documents, are provided in the Field Sampling Plan (FSP; **Appendix A**).
- Quality Assurance Project Plan: Sampling procedures that will be used for samples collected during the SRI, along with the applicable quality assurance/quality control requirements are provided in the Quality Assurance Project Plan (QAPP; **Appendix B**).

  A NYSDEC guidance document entitled *Sampling, Analysis, And Assessment of Per- And Polyfluoroalkyl Substances (PFAS)*, dated April 2023, require that all work plans submitted to NYSDEC pursuant to one of the remedial programs under Part 375 shall include PFAS sampling and analysis procedures that conform to the guidelines provided in the guidance document (NYSDEC 2023). This Work Plan and subsequent attachments have been revised to be compliant with this guidance document.

- Community Air Monitoring Plan: The procedures for conducting real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter the Site's designated work area are provided in the Community Air

Monitoring Plan (CAMP; **Appendix C**).

Per the NYSDEC requests from the October 2023 NYSDEC email, the attached CAMP for this Work Plan has been updated to incorporate requirements for work within 20-feet of potentially exposed individuals or structures and special requirements for indoor work with co-located residences or facilities. However, as part of the SRI activities discussed above, no work within 20-feet of potentially exposed individuals and structures or indoor work is proposed or anticipated for this work outlined in this Work Plan and subsequent appendices.

- Health and Safety Plan: A site-specific Health and Safety Plan (HASP) is provided as **Appendix D**.

Any deviation from the activities discussed below will be communicated to Con Edison's Project Manager and the NYSDEC's Project Manager and will be documented in the field book.

Site Reconnaissance

Prior to commencement of activities described below, Ramboll will conduct a site reconnaissance of Parcel C adjacent to Outfall 4 (**Figure 2**). The paved area including the bulkhead will be inspected for the presence of storm drains, indications of underground piping or other potential preferential pathways, surface drainage pathways, and evidence of historical surface releases, if any. Pertinent observations from the site reconnaissance will be used to refine the limits of the geophysical survey and the locations of soil borings, both described below.

Geophysical Survey

A geophysical survey will be conducted to locate subsurface utilities that could potentially serve as a preferential pathway for the migration of MGP-related compounds from Parcel C to sediments in the East River. The area of the geophysical survey is shown on **Figure 2.** This boundary includes the area adjacent (upgradient) to previously completed sediment boring SD-07B, the area adjacent (upgradient) to Outfall 4, piping previously identified near Outfall 4, and includes areas adjacent to where coal tar was historically observed in the subsurface and the historical sheen observed in the river. The area of the geophysical survey boundary may be expanded to investigate any utilities found. Ground penetrating radar, electromagnetic induction, and magnetometer survey methods will be used to complete the survey. Following completion of the field survey, a detailed map will be prepared presenting the findings. The results of the geophysical survey will also be used to assist with the utility clearance required for the installation of soil borings described below.

Closed Circuit Television Inspection

Following completion of the geophysical survey, a television video inspection of the piping for Outfall 4 will be conducted, as well as a video inspection of other relevant piping located during the geophysical survey as feasible. The television video inspection will be used to evaluate the integrity of the piping. Specifically, the pipes will be inspected for signs of leaks, or other indications that the condition of the piping has been compromised.

Soil Boring Installation

A total of eight soil borings (SB-01 through SB-08) will be completed by a NY-licensed driller to evaluate subsurface conditions inland (upgradient) of SD-07B, Outfall 4, and areas where a sheen was historically observed in the river. The proposed soil boring locations are shown on **Figure 2**. Soil borings may be added or re-located based on observations during the geophysical survey and CCTV inspection. The rationale for each of the eight boring locations is summarized below in Table 1-1:

Table 1-1
Soil Boring Location Rationale

Sampling Location ID	Rationale
SB-01	Evaluate the presence, if any, of DNAPL or other visual impacts where coal tar was historically observed and adjacent (upgradient) of the area where sheen was historically observed in the river.
SB-02	
SB-03	Evaluate the presence, if any, of DNAPL or other visual impacts adjacent (upgradient) to Outfall 4.
SB-04	
SB-05	Evaluate the presence, if any, of DNAPL or other visual impacts adjacent (upgradient) of SD-07B, where sheen was generated during collection of the sediment core.
SB-06	
SB-07	
SB-08	Evaluate the presence, if any, of DNAPL or other visual impacts adjacent to the piping previously identified near Outfall 4.

Proposed soil boring locations will be subject to review and approval by the property owner as well as cleared by geophysical survey. Any changes to the proposed boring locations will be communicated to NYSDEC's Project Manager prior to the commencement of drilling.

Each soil boring will be completed using hollow-stem auger, rotary sonic (rotasonic), or direct-push methods in accordance with the protocols presented in the FSP. The drilling method will be selected by Con Edison following the completion of the geophysical survey and evaluation of results. Given that the Site's elevation was raised up to five feet during redevelopment, unidentified subsurface utilities may be present at depths down to approximately ten feet below ground surface (bgs). At the soil boring locations, vacuum operated soft-dig excavator (VacTron or equivalent) will be used by the driller to excavate small diameter holes (approximately two feet by two feet in diameter) to ten feet bgs. If the soft-dig excavator cannot dig to 10-feet bgs, the drilling location will be re-located.

During drilling activities, air monitoring will take place in accordance with the CAMP (**Appendix C**). Recordings will be documented and kept on-Site for the duration of SRI activities.

It is estimated that the native soils will be encountered at approximately 15 to 28 feet bgs (Arcadis 2014). Beginning at 10 feet bgs, soil samples will be collected continuously from each soil boring by advancing a 5-foot-long Macro Core liner. All proposed soil borings will be advanced to the top of competent bedrock or refusal, whichever is shallower. Retrieved soil core intervals will be visually characterized, screened with a photoionization detector (PID), and have observations recorded on borings logs. Observations including the presence of potential DNAPL, coal tar, or other visual / olfactory impacts will be documented.

Following completion of the soil borings, the borehole will be tremie-grouted to the ground surface using a cement-bentonite grout. Soil borings completed in a paved area will be repaired with an asphalt patch or concrete, as appropriate. Drilling cuttings that are not observed to be impacted will be placed in the borehole. If impacted drill cuttings are observed, they will be containerized in 55-gallon steel drums.

Soil Sampling

If the presence of DNAPL, coal tar, or other visual / olfactory impacts are observed, soil samples will be collected from the interval(s) where impacts are present and analyzed for the groups of constituents:

- Volatile organic compounds (VOCs) via United States Environmental Protection Agency (USEPA) method 8260D
- Semi-VOCs (including forensic polycyclic aromatic hydrocarbon [PAHs]) via USEPA method 8270E
- Metals via USEPA method 6010D
- Forensic total petroleum hydrocarbon (TPH) via USEPA method 8015B

Additionally, per the *NYDEC Sampling, Analysis, And Assessment of Per- And Polyfluoroalkyl Substances (PFAS)* guidance document, dated April 2023, soil samples will also be analyzed for PFAS via USEPA method 1633. Analytical reporting limits and laboratory sampling requirements are included in Table 1 of the QAPP (**Appendix B**).

Soil samples analyzed for PFAS will be collected in accordance with Appendix B of the *NYDEC Sampling, Analysis, And Assessment of Per- And Polyfluoroalkyl Substances (PFAS)* guidance document, dated April 2023. Field staff will review and comply with Ramboll's PFAS Sampling Field Guidance procedures (Appendix C of the FSP) to ensure field clothing, PPE, sun/biological protection, and personnel hygiene prior to and during sampling is PFAS free.

Sampling equipment will be pre-cleaned using a twostep decontamination process starting with Alconox, and then followed with a rinse using laboratory provided PFAS-free water. The laboratory will provide documentation that sources of water and containers used for decontamination are PFAS free.

If conditions are identified where soil sampling is required, a precleaned stainless steel sampling spoon will be used to obtain the sample. Once the soil sample is obtained, it will be deposited into a stainless-steel bowl for mixing prior to filling the laboratory provided PFAS-free sample containers. The soil sample will be placed directly into the bowl and mixed thoroughly by rolling the material into the middle until the material is homogenized. Once the mixing of the material is complete, the soil sample will be placed in the applicable container. Details regarding the type of PFAS-free sampling containers and laboratory sampling handling requirements for PFAS are provided in Table 1 of the QAPP (**Appendix B**).

Temporary and Permeant Monitoring Well Installation

If DNAPL is encountered at a soil boring location, a 1-inch diameter Schedule 40 polyvinyl chloride pipe (PVC) temporary well point will be installed by the driller, with the screen (slot size 0.25mm) interval overlapping the depth of the observed DNAPL. The temporary well will be prepacked in a stainless-steel mesh outer component (slot size 0.028mm). The temporary well will be gauged 48 hours after installation to evaluate whether measurable DNAPL accumulates. Any DNAPL that accumulates in the temporary wells will be removed and containerized in 55-gallon steel drums. Following DNAPL removal, the temporary well will be gauged again five days later.

If DNAPL is observed to have accumulated at a measurable and extractable amount during the second gauging event, a permanent monitoring well will be installed at that location to determine the potential mobility of the DNAPL. The permanent monitoring wells will be constructed of 4-inch diameter Schedule 40 PVC with a 0.010-inch 10-foot screened interval and will be completed flush with the ground surface. The locations and well construction details would be provided to NYSDEC for consultation prior to well installation.

Investigation-Derived Waste Management

The investigation-derived waste (IDW), which could include soil cuttings, extracted DNAPL, and rinsate water, will be sampled and analyzed for full Toxic Characteristic Leaching Procedure (TCLP) analysis (volatile organic compounds [VOCs], semi-VOCs, pesticides, herbicides), cyanide, ignitability, reactivity, corrosivity, polychlorinated biphenyls (PCBs), and PFAS for characterization. Rinsate water generated from both heavy and standard equipment decontamination will also be containerized in separate labeled steel open-top 55-gallon steel drums. IDW samples will be collected in accordance with the QAPP and applicable disposal facility requirements.

The drums will be staged in a secure designated location until they are able to be appropriately transported off-Site and disposed by a Con Edison approved transporter and disposal facility.

Investigation Support Activities

Supporting activities will be conducted in accordance with the field guidance documents in the FSP (**Appendix A**). These activities may include the following:

- Equipment decontamination
- Investigation-derived waste management
- Surveying
- Health and safety
- Community air monitoring

Reporting

The results of the investigation will be included in an Off-Site SRI Report. The Off-Site SRI Report will evaluate the information collected in the context of the existing conceptual site model (CSM) and will be updated as appropriate. The Off-Site SRI Report text will be supported by boring logs, tables, and figures illustrating RI findings, as appropriate. The Off-Site SRI Report will include proposed next steps with respect the results of the investigation.

References

ARCADIS. 2012. *Off-Site Characterization Work Plan*. Hunts Point Former Manufactured Gas Plant. Bronx, New York, NY. Prepared for Consolidated Edison Company of New York, Inc. April.

ARCADIS. 2014. *Off-Site Remedial Investigation Report*. Hunts Point Former Manufactured Gas Plant. Bronx, New York, NY. Prepared for Consolidated Edison Company of New York, Inc. November.

HDR. 2009. *Hunts Point Food Distribution Center Redevelopment Plan, Sections of the Redevelopment Plan for the Operable Unit 1 Portion of Parcel C.* Bronx, New York, Final Revised.

LMS. 2001. *Hunts Point Cooperative Market Redevelopment Plan, Response Plan for the Operating Unit Portion of Parcel C.* Bronx, New York, Final Revised.

NYSDEC. 2023. *Sampling, Analysis, And Assessment of Per- And Polyfluoroalkyl Substances (PFAS)*. April.

Attachments

Figures

Figure 1: Site Plan
Figure 2: Proposed Soil Boring Locations

Tables (in-report)

Table 1-1: Soil Boring Location Rationale

Appendices

Appendix A: Field Sampling Plan
Appendix B: Quality Assurance Project Plan
Appendix C: Community Air Monitoring Plan
Appendix D: Healthy and Safety Plan

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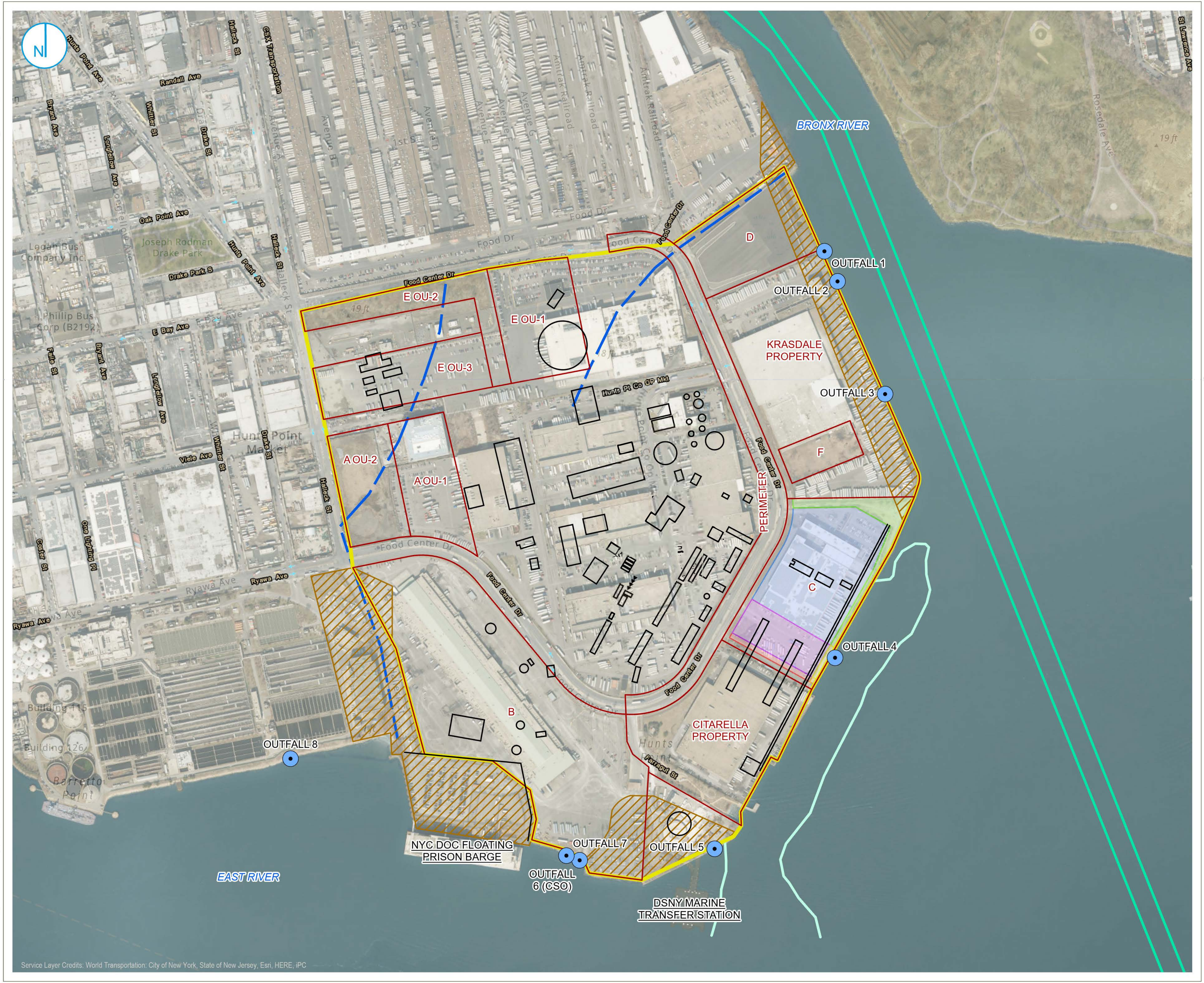
Please feel free to contact me at (718) 204-4331 should you have any questions or comments on the proposed Work Plan.

Sincerely,

Melissa Abt

Melissa Abt
Project Manager – EH&S, Remediation
Consolidated Edison Company of NY, Inc.

cc:
Mihir Chokshi – Con Ed



● CURRENT/FORMER OUTFALL

- - - FORMER SUFACE DRAINGE FEATURE

— BRONX RIVER FEDERAL NAVIGATION CHANNEL

— DREDGED CHANNEL

— FORMER SITE FEATURE

▨ FILLED LAND (1947-1975)

▭ EXTENT OF FORMER MANUFACTURED GAS PLANT

▭ PARCEL BOUNDARY

▭ ANHEUSER-BUSCH REDEVLOPMENT PARCEL

▭ IROQUOIS PIPELINE VOLUNTARY CLEANUP PROGRAM (VCP) PORTION OF ANHEUSER-BUSCH PARCEL

▭ NON-VCP PORTION OF ANHEUSER-BUSCH PARCEL

▭ GREENWAY REDEVLOPMENT PARCEL

▭ IROQUOIS PIPELINE VCP PORTION OF GREENWAY

▭ NON-VCP PORTION OF GREENWAY

NOTE

ALL SITE FEATURES ARE ADAPTED FROM FIGURE 1 - SITE PLAN (ARCADIS, JULY 2014), AND SHOULD BE CONSIDERED APPROXIMATE

0 250 500 Feet

SITE PLAN

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
FORMER HUNTS POINT MANUFACTURED GAS PLANT
BRONX, NEW YORK

Figure 01

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY

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PROJECT: 1940106769 | DATED: 3/28/2024 | DESIGNER: KAUFMADR

C:\Users\kaufmadr\OneDrive - Ramboll\Desktop\Ramboll\GIS\Projects\HuntsPoint\Pro\HuntsPoint.aprx\Proposed Borings

Service Layer Credits: Bing Maps Aerial: © 2024 Microsoft Corporation © 2024 Maxar ©CNES (2024) Distribution Airbus DS

PROJECT: 1940106769 | DATED: 8/13/2024 | DESIGNER: KAUFMADR

▲ PROPOSED BORING LOCATION
■ SEDIMENT CORE SAMPLE LOCATION
⊙ OUTFALL
- - HISTORICAL SITE FEATURE

NOTES
1. ALL SITE FEATURES ARE APPROXIMATE
2. SEDIMENT CORE SAMPLE SD-07B WAS COLLECTED ON NOVEMBER 30, 2012; ANALYTICAL RESULTS ARE PRESENTED IN THE REMEDIAL INVESTIGATION REPORT, DATED APRIL 17, 2014

0 30 60 Feet

PROPOSED BORING LOCATIONS

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
FORMER HUNTS POINT
MANUFACTURED GAS PLANT
BRONX, NEW YORK

FIGURE 02

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.
A RAMBOLL COMPANY

Appendix A
Field Sampling Plan

Field Sampling Plan

Hunts Point Former MGP - Parcel C

Recipient:	**Con Edison of NY**
Document type:	**Field Sampling Plan**
Version:	**1**
Date:	**April 2024**

Contents

Appendices

1. Introduction

On behalf of Consolidated Edison Company of NY, Inc. (Con Edison), this Field Sampling Plan (FSP) has been prepared by Ramboll Americas Engineering Solutions, Inc. (Ramboll) to support off-Site supplemental remedial investigation (SRI) activities for the Parcel C area at the Hunts Point former Manufactured Gas Plant (MGP; the "Site").

This FSP summarizes the field procedures, methods, and field guidance documents (FGDs) to be referenced during the implementation of the off-Site SRI activities with Parcel C. The FSP is intended to be used in conjunction with the Quality Assurance Project Plan (QAPP), Community Air Monitoring Plan (CAMP), and site-specific Health and Safety Plan (HASP) associated with the revised Off-Site RI Work Plan addendum (Work Plan) in which this FSP is attached.

1.1 Project Organization

On behalf of Con Edison, Ramboll has overall responsibility for the off-Site characterization field activities. Project direction will be provided by Con Edison, with oversight by the New York State Department of Environmental Conservation (NYSDEC). Off-Site characterization field activities will require support from various members of the project team. A summary of key project personnel is summarized below. A description of the responsibilities of each member of this team is described further in the QAPP (Appendix B of the Work Plan).

Company/ Organization	Title	Name	Phone Number	Email
NYSDEC	Case Manager	Ronnie E. Lee	518-402-9615	Ronnie.lee@dec.ny.gov
Con Edison	Project Manager	Melissa Abt	718-201-4331	AbtM@coned.com
Ramboll	Project Officer	Timothy Olean	508-395-6960	tim.olean@ramboll.com
	Project Manager	William Moore	973-820-1044	william.moore@ramboll.com
	Field Manager	Matt Miller	609-951-9003	mmmiller@ramboll.com
	Ramboll QA Officer	Kristin Drucquer	405-905-4772	kdrucquer@ramboll.com
	Field Personnel	TBD	TBD	TBD

2. Field Guidance Procedures

This FSP includes field guidance documents (FGDs) associated with the following field activities:

- Field Reconnaissance and Geophysical Survey
- Soil Boring Installation, Soil Characterization, and Soil Sampling
- Temporary and Monitoring Well Installation and Gauging
- Equipment Decontamination

Details concerning the specific implementation and scope of these field activities are discussed in the Work Plan in which this FSP is attached.

2.1 Site Reconnaissance and Geophysical Survey

Prior to commencement of field activities, Ramboll will conduct a site reconnaissance of Parcel C. Pertinent observations from the site reconnaissance will be used to refine the limits of the geophysical survey and the locations of proposed soil borings.

A geophysical survey will be conducted by a qualified subcontractor, with direction and oversight by Ramboll, to identify subsurface utilities that could potentially serve as preferential pathways for the migration of MGP-related compounds. Following the geophysical survey, the subcontractor will perform a video-inspection using an in-line CCTV of Outfall 4.

Activities related to the geophysical survey will be completed in accordance with Ramboll’s Subsurface Utility Clearance Safe Work Practice procedures, which is provided as Attachment 8 of the HASP.

Documentation of field activities, observations, and records will be completed in accordance with Ramboll’s Field Records and Notes Field Guidance procedures, which is provided as **Appendix A**.

2.2 Soil Boring Installation and Characterization

Each soil boring will be completed using hollow-stem auger, rotary sonic (rotasonic), or direct-push methods. At each of the soil boring locations, vacuum operated soft-dig excavator (VacTron or equivalent) will be used by the driller to excavate small diameter holes (approximately two feet by two feet in diameter) to 10 feet bgs.

All proposed soil borings will be advanced to the top of competent bedrock or refusal, whichever is shallower. Activities, documentation, and logging related to the soil characterization will be completed in accordance with Ramboll’s Soil Classification Field Guidance procedures, which is provided as **Appendix B**.

2.3 Soil Sampling

Soil samples analyzed for VOCs, SVOCs, metals, and TPH will be collected in accordance with *NYSDEC’s DER-10 - Technical Guidance for Site Investigation and Remediation* and Ramboll’s Subsurface Soil Sampling – Direct Push Technology Field Guidance procedures, which is provided as **Appendix C**.

Soil samples analyzed for PFAS will be collected in accordance with Appendix B of the *NYDEC Sampling, Analysis, And Assessment of Per- And Polyfluoroalkyl Substances (PFAS)* guidance document, dated April 2023. Field staff will review and comply with Ramboll's PFAS Sampling Field Guidance procedures, which is provided in **Appendix D**.

Sample handling, shipping, and documentation will be completed in accordance with Ramboll's Sample Naming, Labeling, Handling, Shipping, and Chain of Custody Field Guidance procedures, which is provided as **Appendix E.**

Details regarding the laboratory analytical methods, SOPs, and sampling precautions for PFAS are discussed further in the QAPP.

2.4 Temporary or Monitoring Well Installation

If DNAPL is encountered at a soil boring location, a temporary well point will be installed by the driller, with the screen interval overlapping the depth of the observed DNAPL. Free Product gauging activities, if needed, will be performed in accordance with Ramboll's Groundwater and Free Product Level Measurements Field Guidance procedures, which is provided as **Appendix F**.

If DNAPL is observed to have accumulated during the second gauging event, a permanent monitoring well will be installed by a licensed driller at that location to determine the potential mobility of the DNAPL. The drilling contractor will install and develop each monitoring well in accordance with NYSDEC's *DER-10 - Technical Guidance for Site Investigation and Remediation* and Ramboll's Permanent Well Overburden Well Installation Field Guidance procedures, which is provided as **Appendix G**.

2.5 Decontamination

During investigation activities, heavy equipment (drill rig, augers, etc.) will be decontaminated by the subcontracted NY-licensed drillers if DNAPL is observed within any of the soil boring locations. If soil samples are required, the heavy equipment will be decontaminated by manually scrubbing with an Alconox and PFAS-free water solution rinse prior to moving to another boring location. Additionally, non-disposable standard equipment will be decontaminated with an Alconox and PFAS-free water solution prior to the beginning of investigation. Standard equipment decontamination activities will be completed in accordance with Ramboll's PFAS Sampling and Sampling Equipment Decontamination Field Guidance procedures, which is provided as **Appendix D** and **Appendix H**, respectively.

FIELD GUIDANCE DOCUMENT NO. 1.01

FIELD RECORDS AND NOTES

RAMBOLL ENVIRON

FIELD GUIDANCE DOCUMENT NO. 1.01

FIELD RECORDS AND NOTES

Prepared By:	Clem Ockay Sharon Burkett Jason Swankert Jinjun Wang
Peer Reviewed By:	Michael Potts Jose Sananes Stan Popelar Jessica Donovan Nestor Soler
Approved By:	J. Mark Nielsen
Applicable To:	All North American offices
Effective Date:	February 21, 2014
Revision Date:	July 12, 2016
Revision Notes:	1. Revised company name and format.
Documents Used as Reference During Preparation:	

CONTENTS

ATTACHMENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines established by Ramboll Environ for recording and maintaining field notes associated with field activities, site visits, and sampling efforts.

Although this FGD provides guidelines for recording information, it should be understood that for certain projects more specific procedures may be applicable, including state-specific or regulatory program-specific guidelines, requirements or procedures. Specific requirements for these types of projects and activities will be reviewed by the Ramboll Environ Principal-in-Charge / Project Director (PIC) and Project Manager (PM) and any additional requirements will be defined in a project-specific Work Plan, sampling plan and/or project-specific FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans but rather a general reference for developing project specific requirements.

It should be noted that this FGD does not supersede Ramboll Environ Health and Safety procedures or Site-Specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. All Ramboll Environ employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP, followed by procedures recommended in this FGD. The Ramboll Environ PIC and PM shall ensure that all project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information is maintained in the project file. The signatures of the PIC and PM indicate approval of the methods and precautions outlined in the HASP.

2. EQUIPMENT/MATERIALS

Equipment and materials necessary to conform to this FGD include:

- Bound Notebook – lined high-grade 50 percent rag paper with a hard-cover and water-resistant surface (e.g., “Rite-in-the-Rain”). Soft-bound field books are acceptable for limited duration projects.
- All Weather Pens or (weather permitting) other indelible ballpoint pens with black or blue ink.
- Watch (or other time keeping device).

Based on the field activity and project, the following also may be needed:

- Field Log Forms (preferably produced on “Rite-in-the-Rain” water-resistant paper).
- Ruler/Straight Edge.
- Stop-Watch.
- Calculator.
- Laptop Computer.
- Lookup tables for well volume calculation, tank size estimation, etc.

- Clipboard/field case.
- Gallon-size or larger plastic zip top bag or other clear plastic to cover note book and forms in wet weather.

In some cases, such as those involving long-term construction management activities, project specific daily reports, may be produced from the field notes and maintained electronically in portable document format (pdf). An example of Ramboll Environ's daily report form is provided in **Attachment A**.

3. PROCEDURES REFERENCED

The following FGDs and Standard Practice Instruction (SPI) are related to this FGD and should be referenced, as needed:

- **SPI 27**, Utility Clearance.
- All field sampling and installation FGD categories.

The list above is not intended to be all inclusive. Other SPIs and FGDs may need to be referenced based on the specific requirements of the site-specific sampling plan (e.g., field screening FGDs, FGDs for sampling, etc.).

4. PROCEDURES

4.1 General Information

Information from all pertinent field activities, site visits, and sampling efforts should be recorded in a field book during each day of field activities. The following information should be considered when recording field notes:

- Field notes should present a complete record of the field activities observed. The author of the field notes, project manager (PM) or others may need to refer to the field notes at a later date to confirm facts and/or field interpretations. Thus, the notes should be complete enough to enable reviewers to reconstruct the field activities and observations.
- Field books are part of the official project record, and could become legal records; therefore, a separate bound field book should be used for each project.
- Records should be kept in ink (waterproof ink, when necessary). Indelible ballpoint pens with black or blue ink should be used. Felt tip or red pens, erasable ink, and pencil are unacceptable being neither permanent nor archival.
- When an entry to the field book needs to be corrected, a single line should be drawn through the error, initialed and dated. Never erase or obliterate any field notes.
- The ownership information should be provided inside the front cover of the field book as follows: "If found, please return to Ramboll Environ." Include the office address and general phone number as well as case/project number and name. This increases the chances of the notebook being returned if lost.

- Generally, each page of the notes should be initialed or signed by the author (or authors). If multiple individuals are involved in activities at the site or for projects involving long-term construction management activities, multiple logbooks may be maintained.
- Pages left intentionally blank should be marked with an "X" and labeled "left intentionally blank".
- Blank spaces at the bottom of a field book page should be stricken across the page.
- Data entries should be recorded in the field book immediately upon obtaining the data. Avoid making temporary notes in other locations for later transfer to the field book, as this increases the potential for transcription errors or loss of data.
- If using field forms to record data, note in the field book which forms are being used and the number of forms. All pages of forms should be numbered sequentially and cross-referenced in the field book. Each page of the forms should be signed and dated. Finally, ensure that forms are securely filed in the project file upon return to the office each day.
- Scan and/or photocopy the field notes regularly (at least weekly if long-term field work is ongoing).
- Descriptions of activities should be objective, <u>not</u> subjective.
- Descriptions should be consistent with the level of certainty of the observation, for example record "odor <u>like</u> gasoline," rather than a definitive note such as gasoline odor.
- Explain any deviations or omissions from the work specified in the work plan, especially when such deviations result in measurements/samples not being collected, or additional measurements/samples being collected.
- Avoid writing extraneous commentary in the field book.

4.2 Organization of Field Notes

- Field notes should generally be kept in chronological order throughout the day.
- Use military time (e.g., 0900 for 9:00 am or 1645 for 4:45 pm).
- Start each new day on a new page.
- Sign and date your notes at the end of each day and draw a line through any remaining blank lines. Initial each page.
- If collecting a large number of samples, prepare a summary at the end of each day including a list of samples collected and reference to the chain-of-custody form or airbill number, as appropriate.
- To help easily locate information for subsequent reference and report preparation, consider including a sketch and designating a separate page or pages for certain items such as:
  - Photograph Log
  - Water Level Measurements

  - Groundwater purging/sampling information and related field measurements for each well
  - Drum Log that would include drum number (which corresponds to number presented on each drum), date filled, contents, percent full and location on site. Note that drums should not be given numbers such as D001, D002, etc., as these designations could be confused with hazardous waste codes.
- Refer to sampling plans or if unavailable or deviating from a plan, include sketches of sampling locations or photograph locations/directions to reflect actual locations.

4.3 Daily Entries

At a minimum, daily entries in a field book should include:

- Pagination and date on each page of the notes.
- Date and time of starting work.
- Names of all field people on-site and their titles (field supervisor, etc.).
- Record of the daily “tailgate” health and safety briefing, including attendees and their affiliation and a list of topics discussed. Note that detailed information can be included on a form in the HASP but the meeting should be documented in the field book as well.
- Names and affiliations of all contractors, subcontractors, clients, agency representatives and visitors.
- Visitors to the site – when they came, when they left, who they represent, and purpose for their visit on-site.
- Subcontractor (if used). Include company name, names of any personnel and their role (e.g., driller’s helper).
- General weather conditions – add additional notes if weather changes during the day (i.e., starts/stops raining, snowing, changes in temperature).
- General purpose of proposed work effort (e.g. “to collect groundwater samples from all on-site monitoring wells”). Do not add information on the legal strategies or implications of the work unless specifically directed to do so by the PM or PIC.
- Description of work area including direction of and information on photographs taken.
- Location of work area including map references (include a sketch map in field book).
- Detail of work effort, particularly any deviation from the sampling plan or standard operating procedures, including why the deviation was made and responsible person who approved the deviation.
- Objective field observations.
- Field measurements (e.g., pH, PID readings).
- Field analysis results (results from any field test kits used).
- Type of equipment used in sampling, type and model of PID, pH meter, other meters, etc. and calibration information (e.g., calibrated OVM Model 580B PID using 100 ppm isobutylene).

- Personnel and equipment decontamination procedures (describe the method once and state that it will always be used unless otherwise noted. Then note when there are deviations and the reason for each deviation.)
- Records of conversations/decisions made with others in the field such as the PM, on-site personnel, or regulatory personnel.

In addition to the General Information and Daily Entries (**Sections 4.1 and 4.3** above), specific details for each type of work should be included in the field notes as indicated on the FGD corresponding to the activity performed. Typical field activities for Ramboll Environ personnel fall into the following major categories of field activities:

- Drilling of Soil Borings.
- Soil and Sediment Sample Collection.
- Monitoring Well Installation and Development.
- Surface water and Groundwater Sampling.
- Oversight of Remedial Activities.
- Vapor Intrusion Sampling/Soil Gas Sampling.
- Indoor Air/Ambient Air Sampling.

4.4 Utility Clearance

In accordance with Standard Practice Instruction (SPI) 27, where available, public and private utility clearance is required for all work that will involve ground disturbance. For each field activity that includes ground disturbance, certain information must be recorded in the field book as discussed below and in SPI 27. In addition, the subsurface clearance form included in the health & safety plan should be completed.

4.4.1 Public Utility Locating

- If a subcontractor contacted the One-Call Service to request a public utility location, obtain the file/ticket number issued by the One-Call Service from the subcontractor.
- Verify and record completion and closure of the ticket before proceeding with work.
- Include a sketch map of the work area and/or entire site and show locations of marked and suspected utilities in relation to the work area. If appropriate, photograph the area before ground disturbance.

4.4.2 Private Utility Locating

- A private utility locator is typically a subcontractor to Ramboll Environ. Record the name of the company and individuals performing this service.
- Record utility clearance findings as above for the public locate.

4.4.3 Site Reconnaissance

- After a site reconnaissance is performed to identify possible utilities in the area, record pertinent information regarding site reconnaissance findings in the field notebook.

4.4.4 Documenting a Health and Safety or Utility Incident

- After attending to emergency needs, document all pertinent information in the field book including notifications made and details of the incident such as personnel and equipment involved, and measurements as appropriate.
- Include a description of each photograph in your field book including the information outlined in **Section 4.6** (Photographs).

4.5 Oversight of Remedial Activities

While record keeping requirements for remedial or construction projects must remain consistent with the procedures of this FGD, additional information may need to be tracked and recorded. Discuss the specific requirements with the PM or PIC prior to going to the field to understand the context of the oversight role and what types of information may be critical to the oversight. In some cases, such as those involving long-term construction management activities, in addition to field books, project specific daily reports, such as that included in Attachment A, should be completed and maintained electronically in portable document format (pdf).

4.6 Photographs

If photographs are taken, the following information should be recorded in the field book for each photograph:

- Date and time.
- Name of site and field task.
- General orientation and description of the subject.
- Location on-site.
- Sequential number of the photograph and roll number if using film. Image number if using a digital camera.
- When appropriate, include a person or object for scale (a coin, tape measure, vehicle, etc.).

If taking a large number of photographs, designate one or more pages of the field book as a photo-log and record photograph information in that log format. In addition, include a sketch of the relative photograph locations and directions. Upload photographs to the networked files for that project. For film photographs, label the outside envelope from the photos and negatives clearly with case/project number, names, dates, etc.

5. PRECAUTIONS

All field activities require recording sufficiently detailed information throughout the implementation of field work. However, certain precautions should be taken to ensure safety while recording the required information. It is important to always remain alert and aware of your surroundings.

- Avoid walking while recording information. Sites may have excavations, equipment, debris and other obstacles that pose slip, trip or fall hazards.
- Step away from roadways and high traffic areas before commencing note-taking. Do not assume that drivers can see you standing on the shoulder of a road, especially in bad weather. Many workplace traffic accidents involve distracted drivers hitting a worker standing/working on the shoulder of a roadway. Wear a safety vest or brightly colored (yellow or orange) clothing and remain alert at all times.
- Stand a safe distance away from the driller or excavator when taking notes. Be aware that the operator may not be able to see you, equipment/cable accidents can happen very quickly, and you need to be alert and ready to move.

6. RECORDKEEPING

Field books should be managed in accordance with Ramboll Environ’s Document Retention Policy and project-specific requirements. For ongoing projects, field notes should be copied periodically (at least weekly), including a digital copy saved to the project folder on the office’s secure network. Upon upload, a network link to the digitized field notes should be provided to the Project Manager (PM). When an individual field book is complete, the book should be submitted to the administrative staff for final cataloging and filing. The field books should be stored in the Project File.

If additional details or modifications are necessary after completion of field activities, such changes should be made in contrasting color ink and signed and dated. Upon completion of the work, the field book should be kept in a secure location on company property (i.e. local office) with previous field books from the designated project.

00WSITESOP\PRIN_WP\41894v1

ATTACHMENT A
SAMPLE PROJECT-SPECIFIC DAILY REPORT

RAMBOLL ENVIRON

DAILY FIELD LOG

Project No.	00-WSITESOP	**Report No.**	087
Project Name	Sediment Remediation	**Date**	October 22, 2012
Location	123 Main St., One City, One State	**Weather**	Sunny, 71°F Wind: 8 mph W Precipitation: 0.00 inches

Contractors	**Visitors**
Contractor Environmental Services (CES) – (61) Ramboll Environ (John Doe, Jane Doe, John Roe, Jane Roe)	Lift Crane (1) Rise Crane (2)

Equipment On Site

WA380 Loaders (2); DSC Booster Pumps (3); Godwin Pumps (2); Dozers (3); 20’ Sea Containers (3); Fusion Welder (2); Light Plant (1); 2,000-gal fuel tank (3); Tugboat (1); PC490 Excavator (1); PC220 Excavator (1); PC300 Excavator (1); Cap Spreader Barges (2); JCB Forklift (1); Crane Mats (19); Tender Boat (3); Work Boat w/ Crane Mount (1); 750 lb Danforth Anchors (18); Slurry Mix Tanks (2); Hopper Feed Tanks (2); CAT 330 Excavator (1); Kubota RTV (2); Stacking Conveyor (3); Roller (1); Scows (2); Site Truck (1); Clamshell & Conventional Buckets (1); Pontoon Boat (1); 500-gal Fuel Tank (1); 500-gal Gasoline Tank (1); 20 cy dumpster (1); 30’x80’ Deck barges (2); 10’x40’ Section Barges (6); 125 Kva Generator (1); Portable toilets (5); Manitowac 222 Crane (1); Fence Panels (22); 21,000 gal-Frac Tank (1); 500-gal Towable Water Tank (1); 10’x20’ Section Barges (4); small scows (2); 70 Kva Genset (1); Telebelt Conveyor (1); 135’x50’ Deck barge (1); 140’x48’ Deck barge (1); Crawler crane (1); WITTE 1409 deck barge (1).

Imported/Exported Material

No material was delivered to the site or to the dock facility today.

Activities

Ramboll Environ and CES on 24-hour operation from 07:00 on Monday.

06:00 John Doe on-site (beginning of shift).

06:30 Jane Doe on-site (beginning of shift).

- At 07:00, CES conducted safety meeting.
- At 8:00 CES began armor material placement in Cap Area 17 (mechanical placement using the PC 490 excavator).
- At 08:30 CES and Ramboll Environ began filter thickness verification in Cap Area 29b.
    - CES retrieved 8-inch verification pans #29-18, 29-21, and 29-22.

Activities

  - Ramboll Environ measured and documented filter thickness placed.
  - A summary of the cap verification measurements is provided in the attached table.
- At 09:40 the hydraulic filter malfunctioned on the crane barge. The crane barge was towed to the dock for repair at 12:00.

12:00 John Roe on-site (beginning of shift).

- During daytime operations, Ramboll Environ and CES continued inspections of SESC measures. No issues were observed.
- During daytime operations, Ramboll Environ continued to monitor cap material delivery pipes over the bulkhead to ensure adequate clearance is maintained at the bulkhead. No issues were observed.
- At 14:00 repairs to the crane barge were completed and the crane barge returned to Cap Area 29b to continue filter thickness verification.
  - CES retrieved 8-inch verification pan #29-25.
  - Ramboll Environ measured and documented filter thickness placed.
  - A summary of the cap verification measurements is provided in the attached table.
- At 14:20 a small hydraulic leak (less than a quart) was observed on the PC 490 and CES used absorbent pads to clean it up. The leak originated from a hydraulic hose sections that CES did not have a replacement for. No additional mechanical placement was completed for the rest of the day.
- At 14:45 Ramboll Environ and CES began sand thickness verification in Cap Area 25.
  - CES advanced a push core at location #BS-25-229 for sand thickness verification.
  - Ramboll Environ measured and documented sand thickness placed.
  - A summary of the cap verification measurements is provided in the attached table.
- At 15:35 CES towed the WITTE 1409 deck barge to dock for reloading of material and replaced it with the WITTE 1403 barge which was loaded with sand, filter material (ASTM 57), and armor material (ASTM 4).
- At 15:37 Ramboll Environ and CES began sand thickness verification in Cap Area 23.
  - CES advanced a push core at locations #23-1, 23-2, and QA-23-1.
  - Ramboll Environ measured and documented sand thickness placed.
  - A summary of the cap verification measurements is provided in the attached table.
- At 15:50 CES began placement of 1-inch armor stone in Cap Area 6a.

16:00 John Doe off-site (end of shift).

- At 16:15 Ramboll Environ and CES began armor thickness verification in Cap Area 6a.
  - CES retrieved a 6-inch verification pan at BH #2.
  - Ramboll Environ measured and documented armor thickness placed.
  - A summary of the cap verification measurements is provided in the attached table.
- At 16:30 CES completed armor placement in Telebelt Setup Location 1 (which includes Cap Areas 6a and 13b) and began repositioning the Telebelt system to Setup Location 2 (placement area includes Cap Areas 6a and 13a).

17:00 Jane Doe off-site (end of shift).

- At 17:15 CES made repairs to the safety latch for the crane hook on the crane barge.
- At 18:42 CES began placement of sand in Cap Area 6a and 13a. Placement was halted from 19:50 to 21:17 for the shift change.

Activities

- At 21:40 sand placement was completed in Cap Area 6a and 13a and CES removed incidental debris from the adjoining portion of the cap area south of the active area.

20:00 Jane Roe on-site (beginning of shift)

- From 21:45 to 22:30 Ramboll Environron and CES continued sand thickness verification in Cap Areas 6a and 13.
  - CES advanced cores at locations #6-8, #6-14, #13-37, and #13-69.
  - Ramboll Environ measured and documented sand thickness placed.
  - A summary of the cap verification measurements is provided in the attached table.
  - CES placed 8-inch layer thickness verification pans at locations #6-8 and #6-14.
- At 22:45 CES continued placement of sand in Cap Area 13a (mechanical placement using Telebelt).

23:20 John Roe off-site (end of shift)

- From 23:35 to 23:50 Ramboll Environ and CES placed 8-inch layer thickness verification pans in Cap Area 29b at locations #29-30 and 29-31.

Activities

Photo 1: Mechanical placement of armor in Cap Area 17.

Photo 2: Filter thickness verification in Cap Area 29B.

Activities

Photo 3: Armor thickness verification in Cap Area 6A.

Photo 4: Placement of sand using Telebelt in Cap Areas 6 and 13.

RAMBOLL ENVIRON

DAILY FIELD LOG

CAP Verification Thickness, Sediment Remediation, 123 Main St., One City, One State

Date	Time	Cap Area	Lane ID	Pan ID	Type (Full Depth, Intermediate, Core, Manual, Vibra-core)	Sand Thickness (in)	Filter Thickness (in)	Armor Thickness (in)	Verification Thickness (in)	Consent Order Total Thickness	Maximum Allowable Total Thickness	Comments
10/22/2012	9:01	29B	218	29-18	Intermediate		2			6	12	
10/22/2012	9:15	29B	221	29-22	Intermediate		3			6	12	
10/22/2012	9:23	29B	219/220	29-21	Intermediate		<1			6	12	Filter stone was piled to less than 1 inch in only one corner of the pan.
10/22/2012	14:22	29B	222	29-25	Intermediate	<1				6	12	
10/22/2012	14:47	25	229	BS-25-229	Core	9				6	12	
10/22/2012	15:30	23		23-2	Core	11				18	30	
10/22/2012	16:15	6A		BH 2	Intermediate	11	7.6	>6		18	30	
10/22/2012	16:32	23		QA-23-1	Core	9.25				18	30	
10/22/2012	21:55	6A		6-8	Core	3.5				6	16	
10/22/2012	22:05	13A	100	13-37	Core	5				12	19	
10/22/2012	22:10	13A	99	QA-13	Core	3				12	19	

Note: The measurements for pans shifted from their target location (possibly the result of barge/boat interference) may not be representative and will be subject to review for thickness verification purposes.

By: John Doe, Ramboll Environ

FIELD GUIDANCE DOCUMENT NO. 5.01

SOIL CLASSIFICATION

FIELD GUIDANCE DOCUMENT NO. 5.01

SOIL CL SOIL CLASSIFICATION

Prepared By:	James Moran
Peer Reviewed By:	Jose Sananes Adam Duskocy Robert Patchett Jonathan Johnson Safaa Dergham Sarah Stoneking Carol Serlin Nestor Soler
Approved By:	J. Mark Nielsen
Applicable To:	All North American offices
Effective Date:	November 16, 2015
Revision Notes:	1. Revised descriptions in Table 5 (12/7/2015)
Documents Used as Reference During Preparation:	ASTM D1586 - 11 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils; ASTM D 2487-00 Standard Practice for Classification of Soils for Engineering Purposes; ASTM D 2488-00 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure); New Jersey Department of Environmental Protection, 2005. Field Sampling Procedures Manual; Ontario Ministry of Environment and Energy Standards Development Branch. “Guidance on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario Version 1.1”. December, 1996; and, Ontario Ministry of Environment Regulation 153/04 as amended by Ontario Regulation 511/09, 2011.

CONTENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines established by Ramboll Environ US Corporation (Ramboll Environ) for the field classification and description of soils using manual tests for geologically logging soil borings. Soil types and properties may vary significantly at a site and accurate soil(s) identification and geologic logging is an essential element of the site characterization process. A standardized classification and description procedure for soil logging is provides for consistency across phases of field work, as well as across sites as it provides for a clear, accurate, and complete summary of subsurface field conditions observed during the implementation of soil investigation activities. Consistent soil classification is imperative as it allows the use of logs created by one or multiple field staff in developing accurate conceptual site models developed to support characterization of the nature and extent of contamination, performing hydrogeological modeling, conducting site specific risk evaluations, evaluating the feasibility of remedial alternatives, and/or preparing remedial design specifications. Accurate soil classification is also necessary for estimating engineering properties of materials.

The visual identification techniques detailed herein are generally consistent with the Unified Soil Classification System (USCS). The USCS is based on grain size and response to physical manipulation at various water contents to define plasticity and texture. This system is commonly used for classifying soils encountered in boreholes, test pits and surface sampling. As a matter of background, this soil logging system was initially developed by Arthur Casagrande in the 1940s. The Airfield Classification System, as it was then known, was adopted with minor modifications by the United States Bureau of Reclamation and the United States Corps of Engineers in 1952. In 1969, the American Society for Testing and Materials (ASTM) adopted the system and it is currently designated as D-2488-09a.

Although this FGD provides guidelines for field classifying and describing soils for preparation of soil boring logs, it should be understood that more specific procedures may be applicable for certain projects, including state-specific or regulatory program-specific guidelines or requirements. Detailed classification criteria are summarized in the FGD, however, all of these criteria may not have to be applied to every project. Specific requirements will be reviewed by the Ramboll Environ Principal-in-Charge (PIC) and/or Project Manager (PM) and any additional requirements will be defined in a project-specific Work Plan, sampling plan and/or project-specific FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans but rather a general reference for developing project specific requirements.

This FGD does not supersede Ramboll Environ Health and Safety procedures or Site-Specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. All Ramboll Environ employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP, followed by procedures recommended in this FGD. The Ramboll Environ PIC and PM shall ensure that all project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information is maintained in the project file. The signatures of the PIC and PM indicate approval of the methods and precautions outlined in the HASP.

2. EQUIPMENT/MATERIALS

A general checklist of equipment that may be required for typical soil classification procedures is provided below. Note that soil logging procedures are covered under **FGD 5.09**. This checklist only suggests general materials and equipment that may be necessary for a project or task and should not be considered an exhaustive compilation. More specialized equipment or materials may be required when describing soils in the field in conjunction with soil sample collection, completion of field soil boring logs, or installation of wells.

- Field notebook or pertinent field log forms and all-weather or permanent pens as outlined in FGD 1.01 - Field Notes and Records.
- Measuring Tape.
- Knife (for cleaning exposed soil surfaces).
- Plastic sheeting.
- Magnifying Glass.
- Digital Camera.
- Water.

Based on the field activity and project, the following may also be needed:

- Munsell Soil Color Book.
- Field sieves.
- Geotechnical Gauge (as manufactured by W. F. McCollough or equivalent).

3. PROCEDURES REFERENCED

The following FGDs are related to this FGD and should be reviewed prior to mobilization, as needed:

- FGD 1.01 - Field Notes and Records,
- FGD 2.02 - Site Preparation, Inspection and Housekeeping, and
- FGD 5.09 - Soil Boring Log Preparation.

The list above is not intended to be all inclusive. Other FGDs and Standard Practice Instruction may need to be referenced based on the specific requirements of the site-specific work plan/sampling plan (e.g., field screening FGDs, FGDs for sampling of media, etc.).

4. PROCEDURES

4.1 General Information

Information regarding all activities related to the classification of soil samples should be recorded in the Field Notebook or on a Soil Boring Log form (a comprehensive example is provided as Attachment A in FGD 5.09). The Field Notes or Soil Boring Log form should be populated concurrently with soil classification activities, and the person completing the log should pay close attention to the drilling activities when boreholes are advanced (refer to FGD 5.09 - Soil Boring Field Log Preparation).

Most generally, the primary soil grain size can be identified by assigning a group symbol and name or, in the case of soils with properties that do not distinctly place it into a single group, borderline symbols and names. For accurate description and identification of soils, the following key physical properties should be field-determined and recorded in the following order:

- Color including color variations within the same sample.
- Soil particle size identification name (synonymous with ASTM D2488-09a Group Name) with appropriate particle size modifiers. It is suggested that percentage by volume of each particle size be recorded).
- Soil description modifiers (as appropriate for the scope of work – discuss with the project manager ahead of time) including:
  - For coarse grained materials:
    - Gradation.
    - Grain shape and angularity.
    - Cementation.
    - Range of grain or particle sizes (sorting).
    - Maximum particle size.
    - Relative density (of sands).
  - For fine grained materials:
    - Consistency.
    - Dry strength.
    - Dilatancy.
    - Toughness and plasticity.
- Moisture content.
- Relative density or consistency.
- Signs of potential contamination (discoloration, odor, staining, etc.).
- Other general observations (micaceous, calcification, presence of shells, roots, iron-oxide staining, etc.).

4.2 Field Determination of the Soil Identification Name

Soils are generally subdivided into three types: coarse-grained soils, fine-grained soils and organic soils. Coarse-grained soils (also referenced as granular or non-cohesive) include gravel and sand. Fine-grained soils (also known as cohesive soils) include silts and clays. Soils that do not behave like a coarse- or fine-grained material and that have a high content of decaying vegetative matter are considered organic soils. Soil types are further subdivided into soil groups in accordance with the USCS.

4.2.1 Predominant Soil Classification

USCS soil identification is based on the portion of the soil sample that will pass a 3-inch sieve. The larger than 3-inch particles (i.e., cobbles and boulders) must be removed, manually for a loose sample or accounted for in an intact sample, before classifying the soil. The percentages by volume of cobbles and boulders or other debris should be estimated and recorded, and description of these materials recorded. Of the fraction of soil smaller than 3-inches, estimate and note the percentage of the gravel, sand and fines using the procedures outlined herein. The percentages shall be estimated to the closest 5% and the percentages of gravel, sand and fines must add up to 100%. If one of the components is present but not in sufficient quantity to be considered 5% of the smaller than 3-inch portion, indicate its presence by the term “trace” (e.g., fine to medium gravel with trace fines). A trace is not to be considered in the total of 100% for the components.

The following procedures outline how to determine the predominant soil type in the material

- Spread a representative soil sample on a flat surface.
- Determine whether or not the predominant size fraction is discernible with the naked eye or using the Geotechnical Gauge (also refer to **Table 1** below).
  - If the material contains less than 50% fines (i.e., clay, silt) it is considered a coarse-grained soil. Procedures and definitions for describing and identifying properties of coarse grained soils are presented in **Section 4.2.2**.
  - If the soil contains greater than 50% fines, it is a fine grained soil. Procedures and definitions for describing and identifying properties of fine grained soils are presented in **Section 4.2.3**.

If the material has a high content (greater than 50%) of decaying vegetative matter and does not behave like a silt or clay, it is classified as an organic soil (refer to **Section 4.2.4**). Soils containing moderate amounts of organic matter that still retain the properties of silts and clays should be described as fine-grained soils.

Table 1: Soil Types and Particle Sizes

Principal Soil Type	Descriptive Term	Size	U.S. Standard Sieve	Familiar Example Range
Coarse-grained (individual grains can be seen with the naked eye - see Section 4.2.2)	Boulder	Greater than 305 mm	Greater than 12 in.	Bigger than a basketball
	Cobble	76 to 305 mm	3 to 12 in.	Fist sized to basketball
	Coarse gravel	19 to 76 mm	3/4-in. to 3 in.	Thumb to fist sized
	Fine gravel	5 to 19 mm	#4 to 3/4-in.	Pea to thumb sized
	Coarse sand	2 to 5 mm	#10 to #4	Rock salt to pea sized
	Medium sand	0.4 to 2 mm	#40 to #10	Sugar to rock salt
	Fine sand	0.074 to 0.4 mm	#200 to #40	Fine sugar to table salt
Fine-grained (individual grains not visible - see Section 4.2.3)	Silt or clay	Microscopic	Passing No. 200	Flour sized and smaller
Organic (see Section 4.2.4)	Peat or muck	Microscopic	--	Decaying vegetable matter

Once the predominant soil type has been defined, proceed to the corresponding subsection for further guidance.

4.2.2 Coarse-grained Soils

If the soil has been determined to be predominantly coarse-grained, further examination is required to determine the grain size distribution, the grain shape, and the density of the in situ deposits (if applicable) so the materials can be classified into groups in accordance with the USCS. The procedure for field classifying coarse-grained soils is described below.

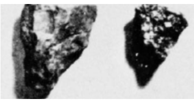
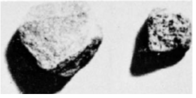
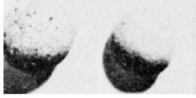
- Define the soil type based on the most prevalent particle size as follows:
  - The soil is gravel if the percentage of gravel is estimated to be more than the percentage of sand.
  - The soil is sand if the percentage of sand is estimated to be equal to or more than the percentage of gravel.
- Describe the gradation of coarse-grained soils as well graded, poorly graded or gap graded (note for geologists: this may be contrary to the terms well sorted or poorly sorted). A summary of the descriptive gradation of coarse-grained soils is provided in **Table 2**.

Table 2: Description of Gradation of Coarse-Grained Soils

Description	Meaning
Well graded/Poorly sorted	A good representation of all grain sizes is present.
Uniformly or poorly graded/sorted	All grains are approximately the same size.
Gap graded/Well sorted	Intermediate grain sizes are absent.
Note: Source ASTM D2488	

- If particles are sufficiently large, describe the particles according to a characteristic shape, which may vary from angular to rounded to flat or elongated. Appropriate descriptive terms are listed in **Table 3**.

Table 3: Description of Grain Shape of Coarse-Grained Soils

Descriptive Term	Criteria	Example
Angular	Irregular with sharp edges such as freshly broken rock	
Subangular	Irregular with smooth edges	
Subrounded	Irregular but smooth like a lump of molding clay	
Rounded	Marble- or egg-shaped; very smooth	
Flaky	Sheet of paper or flake of mica	
Flat	Ratio of width to thickness greater than 3	
Elongated	Ratio of length to width greater than 3	
Note: Adapted from ASTM D2488		

- Describe the cementation of intact coarse-grained soils as weak, moderate or strong, in accordance with the criteria defined in **Table 4**.

Table 4: Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure
Note: Source ASTM D2488	

- If the coarse-grained material is determined to be sand, describe its relative density in accordance with the criteria defined in **Table 5** based on blow counts. If you have not collected blow counts using standard ASTM procedures, it is recommended that you either not include density descriptions or clearly indicate in the field notes that the estimated density is not based on standard penetration tests (SPTs).

Table 5: Criteria for Describing Relative Density

Description	Uncorrected SPT N-Value (blows/foot)
Very Loose	4
Loose	4 to 10
Medium Dense	10-30
Dense	30-50
Very Dense	50 or greater
Note: SPT: Standard Penetration Test (ASTM D1586)	

4.2.3 Fine-grained Soils

If the soil has been determined to be predominantly fine-grained, manual tests need to be performed to classify the fine-grained material because the soil grains cannot be seen with the naked eye. One of the primary means of classifying fine-grained soil is to determine its plasticity. Plasticity generally increases with clay content so, for the purpose of field classification, one can estimate whether the fine fraction of a soil stratum is primarily silt or clay by determining the relative plasticity of the soil. Note, however, that this is a generalization which may lead to erroneous classification of plastic silts as clays.

An additional field test is to wet the soil and rub it between your fingers. If the soil feels gritty, the fines likely include a significant proportion of silt; if the soil feels smooth and can be spread into a thin ribbon without breaking, the soil likely contains a greater percentage of clay. Similar to estimates of plasticity, this is a generalization. If the distinction between silt and clay is important on a project, a sample should be submitted to a soils laboratory for a hydrometer analysis (ASTM D422) to accurately classify the fine-fraction of the soil. The primary field tests for classifying fine-grained soils are consistency, dry strength, dilatancy (mobility of pore water), toughness, and plasticity. However, these field tests may not be required for all projects (refer to the project-specific Work Plan or Sampling Plan). The field-manual procedures are described below.

- Prior to manual testing a sample, remove particles that are medium sand-size and larger.
- Materials that had to be removed from the samples to perform the test should be described.

To perform the consistency test, push thumb onto a relatively undisturbed portion of the soil sample and describe the density/consistency of soils as very soft, soft, firm, hard or very hard, in accordance with the criteria in **Table 6**.

Table 6: Field Criteria for Describing Consistency

Description	Criteria	Uncorrected SPT N-Value (blows/foot)
Very Soft	Thumb will penetrate soil more than 1-inch	Less than 2
Soft	Thumb will penetrate soil approximately 1-inch	2 to 4
Firm	Thumb will indent soil approximately ¼-inch	4 to 15
Hard	Thumb will not indent soil but readily indented with thumbnail	15 to 30
Very Hard	Thumbnail will not indent soil	Greater than 30
Note: Adapted from ASTM D2488		

- To perform the dry strength test, select enough soil to mold material into a ball measuring approximately 1-inch in diameter.
  - Mold the material until it has the consistency of putty, adding water if necessary.
  - From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½-inch in diameter. If the test specimen contains natural dry lumps, those that are about ½-inch in diameter may be used in place of the molded balls.
  - Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 140°F.
  - Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in **Table 7**.

  - Upon completion of the test, if the specimen is easy to crush it is probably a silt and if it is hard to crush it is probably a clay.

Table 7: Criteria For Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling.
Low	The dry specimen crumbles into a powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between thumb and a hard surface.
Note: Source ASTM D2488	

- To perform the dilatancy test, select enough soil to mold material into a ball about ½-inch in diameter.
  - Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
  - Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula.
  - Shake horizontally, tapping the underside of the hand vigorously with the palm of other hand several times. Note the reaction of water appearing on the surface of the soil.
  - Squeeze the sample by closing the hand or pinching the soil between the fingers and note the reaction as none, slow, or rapid in accordance with the criteria in **Table 8**. The reaction is the speed with which water appears while shaking, and disappears while squeezing.
  - Upon completion of the test, if the specimen has a glassy, wet look it is probably a silt and if it has a dry look it is probably a clay.

Table 8: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear, or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.
Note: Source ASTM D2488	

- To perform the toughness test, the test specimen used in the dilatancy test is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8-inch. If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.
  - Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8-inch. The thread will crumble at a diameter of 1⁄8-inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread as none, low, medium, high, or very high in accordance with the criteria in **Table 7**.
  - After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in the **Table 9**.
  - Upon completion of the test if a thread cannot be rolled it is probably a silt and if the specimen can be rolled into a thin thread it is probably a clay. Note: some silts are plastic (i.e., able to be rolled into a thread) so this generalization should be confirmed by other tests.

Table 9: Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.
Note: Source ASTM D2488	

- On the basis of the observations made during the toughness test above, describe the plasticity of the material in accordance with the criteria provided in **Table 10**.

Table 10: Criteria for Describing Plasticity

Description	Criteria
Non-plastic	A 1/8 inch thread cannot be rolled at any moisture content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.
Note: Source ASTM D2488	

4.2.4 Organic Soils

If the material does not behave like a silt or clay and has a high content of decaying vegetative matter, it is classified as an organic soil and not subjected to the identification procedures detailed in the FGD. Following are some typical attributes of organic soil:

- Organic soils are composed primarily of vegetative matter in various stages of decomposition and have a fibrous to amorphous texture.
- Organic soil is usually dark brown or black and may have an organic odor.
- Often organic soil will change color (e.g., black to brown) when exposed to air. Some organic soil will lighten in color significantly when air-dried.
- Organic soil normally will not have a high toughness or plasticity.

Organic soils can be broadly grouped into two categories:

- Topsoil: a surficial organic soil layer that may contain organic matter. Note that topsoil may be encountered below the surface if buried by geological processes or man-made fill.
- Peat: an organic soil composed primarily of plant remains in various stages of decomposition. There are no standardized criteria for describing peat, however, It is generally described in terms of its degree of decomposition and strength:
  - Firm - the soil matrix is comprised of fibers that are compressed into a layer.
  - Spongy - the soil is very compressible and has an open structure.

  - Plastic - the soil can be molded like a clay and smears on surfaces.
  - Fibrous - the plant remains are recognizable and have retained some strength.
  - Amorphous - plant remains are not recognizable.

4.2.5 Soil Name Designation

The basic name of a soil should be consistent with the ASTM D2488-09 Group Name, based on visual estimates of gradation and plasticity, and should be capitalized. The acceptable soil names for coarse and fine grained soils are those listed in **Figures 1, 2 and 3**. Note that, if the soil appears to be fill material (e.g., fragments of brick, glass, slag, etc.), the soil grain sizes should be described, but the soil type should be identified as “FILL” rather than using one of the other two letter identifiers.

- As detailed in **Figure 1**, for coarse grained materials,
  - If the percentage fines is less than or equal to 5%, the coarse-grained material is considered to be “clean” and the following USCS symbols are applicable:
    - GW for well graded gravel;
    - SW for well graded sand;
    - GP for poorly graded or gap-graded gravel; and
    - SP for poorly graded or gap-graded sand.
  - If the percentage fines is more than or equal to 15%, the coarse-grained material is considered to be “with fines” and the following USCS symbols are applicable:
    - GC if the predominant soil type is gravel and the fines are determined to be clayey;
    - SC if the predominant soil type is sand and the fines are determined to be clayey;
    - GM if the predominant soil type is gravel and the fines are determined to be silty; and
    - SM if the predominant soil type is sand and the fines are determined to be silty.
  - If the percentage fines is more than 5% or less than 15%, dual USCS symbols are applicable. The first group symbol would correspond to the “clean” coarse-grained material designation and the second group symbol would correspond to the “coarse-grained material “with fines: designation (e.g., poorly graded SAND with silt would be SP-SM). If dual USCS cannot be assigned, the soil should be only described in terms of the percentage of each soil group (e.g., 85% sand and 15 % silt).

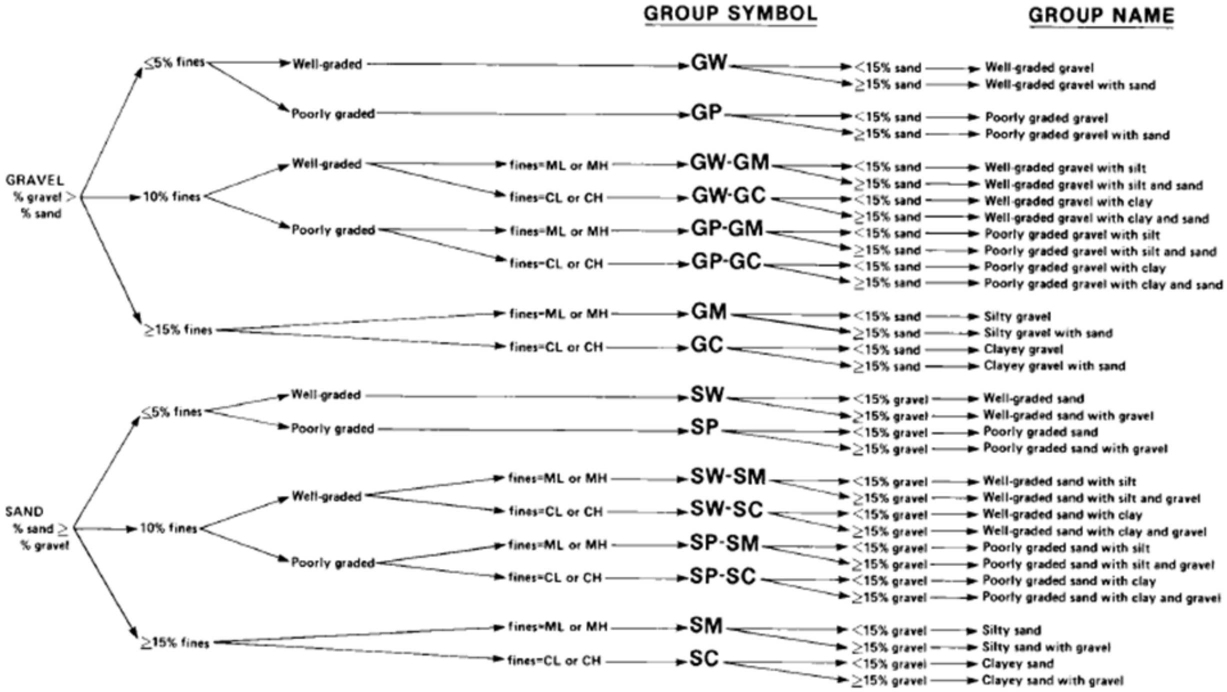


Figure 1:

Flow Chart for Identifying Coarse-Grained Soil (Source ASTM D2488-09)

- For fine grained inorganic materials,
  - On the basis of the manual tests, identify the inorganic fine grained soils in accordance with the criteria provided in **Table 11**.
  - Expand the group name description as detailed in **Figure 2** based on the percent sand or gravel that the fine-grained material contains.

Table 11: Identification of Inorganic Fine-Grained Soils from Manual Tests

USCS Symbol	Soil Description	Dry Strength	Dilatancy	Toughness and Plasticity
ML	Silt	None to low	Slow to rapid	Low or thread cannot be formed
CL	Lean clay	Medium to high	None to slow	Medium
MH	Elastic silt	Low to medium	None to slow	Low to medium
CH	Fat clay	High to very high	None	High

Note:

Source ASTM D2488

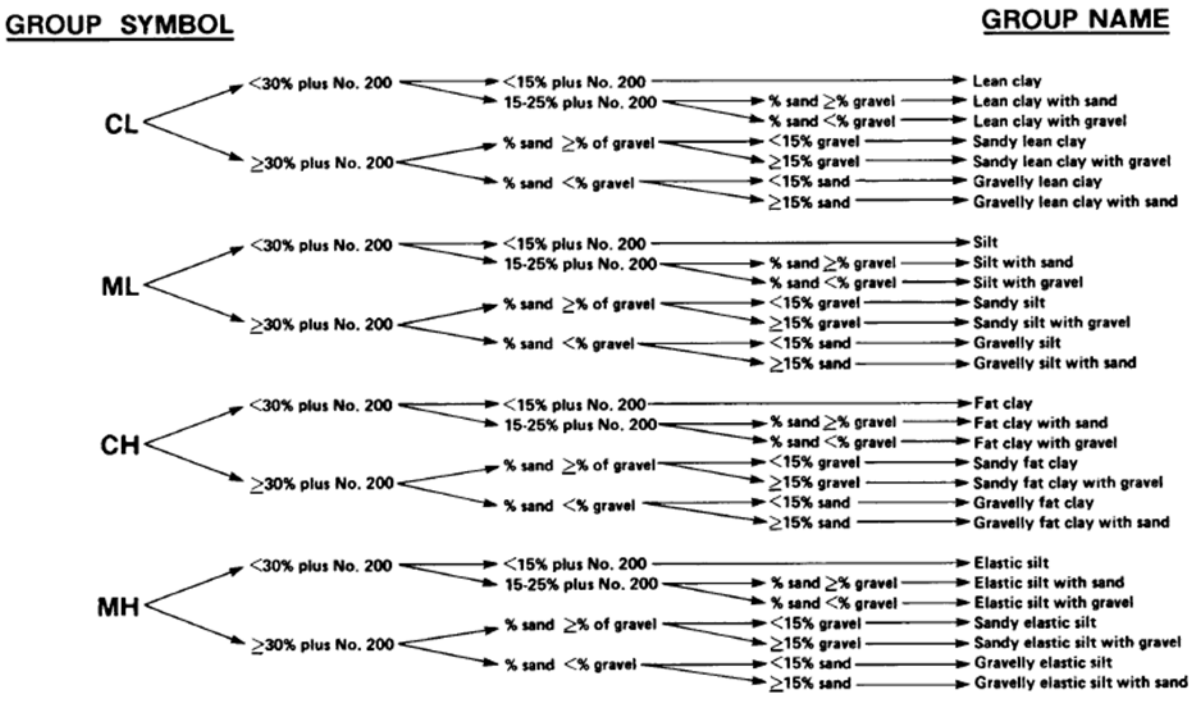


Figure 2:

Flow Chart for Identifying Inorganic Fine-Grained Soil (Source ASTM D2488-09)

If the soil contains enough organic particles to influence the soil properties the soil should be identified as an organic soil (OL/OH), expanding the group name description as detailed in **Figure 3** based on the percent sand or gravel that the organic material contains.

- It is not necessary to characterize organic soils using the full identification procedures for fine grained materials as detailed above in **Section 4.2.3**.
- Organic soils shall be identified as top soil or peat (PT).
- However, description of the other relevant observable properties of the organic soils should be given (color, odor, moisture content).

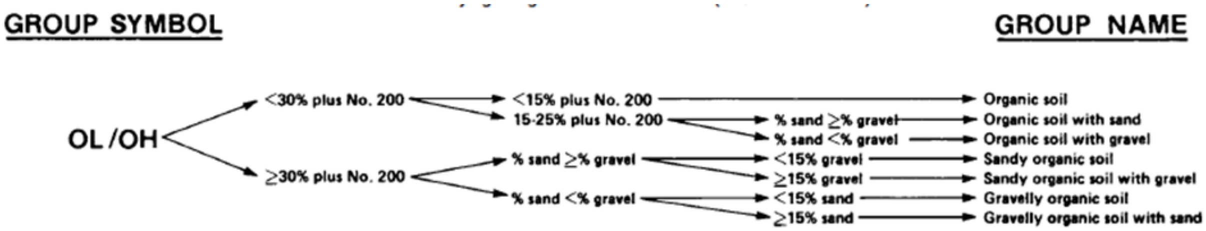


Figure 3:

Flow Chart for Identifying Organic Fine-Grained Soil (Source ASTM D2488-09)

In designating soil names and descriptions, it is customary to list the primary grain size first, followed by modifiers and secondary grain sizes. Common modifiers include:

- Trace: Particles are estimated to be less than 5% by volume.
- Few: 5 to 10% by volume.
- Little: 15 to 25% by volume.
- Some: 30 to 45% by volume.
- Mostly: 50 to 100% by volume.

4.3 Color

Color is probably the most obvious feature of soil and is an important soil property that should be included in its description. An experienced observer can often relate soil color to specific chemical, physical and/or biological properties of the soils in that area. Some broad generalizations are also possible. For example, inorganic soils typically have clean, bright colors (e.g., light gray, olive green, brown, red, yellow, white), whereas organic soils have dark or drab shades (e.g., dark gray, dark brown, black). Red colors may indicate the presence of free iron oxides common in well-oxidized soil and white or pinkish colors may be indicative of silica, calcium carbonate or aluminum compounds. Materials of similar geologic origin could also be identified based on color.

Mottling or spots or streaks of a particular color within a predominant background color is indicative of soil that has experienced a variety of conditions that affect the soil color. Thus, mottling in soil is a clue that should be evaluated in terms of depositional environments, groundwater fluctuations, or contaminant transport. Mottling is described in terms of three basic characteristics:

- Abundance (few, common, many),
- Contrast (faint, distinct, prominent), and
- Size (fine, medium, coarse).

In expressing color, it is customary to list the dominant color first, followed by a description of abundance, contrast, and size of the other colors in the mottled pattern. When describing the color of a soil:

- Color should be described as accurately as possible using the Geotechnical Gauge. For example, rather than “brown,” consider gray-brown, brownish-orange, tan, dark brown, etc. If use of a Munsell color chart is required, both the code and associated color should be listed. Note, however, that it is generally not necessary to get overly-specific in naming a particular shade.
- Note whether the sample contains layers, patches or mottling of varying colors, and describe all of the representative colors.
- Indicate whether the color represents dry conditions.

It is customary to use the color description of the soil in lower case before the soil name and appropriate modifiers.

4.4 Moisture

Soil moisture is an important indicator of soil conditions and should be included in the description of a soil. For example, visible or free water from a soil sample can infer the proximity of the water table or perched water zones. Soil moisture conditions should be described using the criteria provided in **Table 12**.

Table 12: Criteria for Describing Soil Moisture

Description	Criteria	Granular Soil	Cohesive Soils
Dry	Absence of moisture, dusty, dry to the touch	Soil runs freely though hands	Hard, powdery or friable
Moist	Moisture present but no free water	Soil particles will begin to adhere	Soil has weakened structure but free water does not form when handling
Wet	Visible free water; usually soil is at or below water table	Color darkens, soil particles will adhere and free water is present	Color darkens, soil has weakened structure and/or free water forms when handling
Note: Adapted from ASTM D2488			

It is customary to describe the soil's moisture in lower case and within parenthesis following the soil name and appropriate modifiers.

4.5 Visual Indications of Potential Contamination

During environmental sampling, visual indications of potential contamination (e.g., discoloration) and/or the presence of anthropogenic materials (e.g., glass, wood, brick, plastic, slag, gravel fill, etc.) may be encountered. Record observations of any potential field evidence of environmental impacts and/or the presence of anthropogenic materials in the soil description. Anthropogenic materials are commonly used as fill and could indicate a non-native source of contamination. Notable observations of potentially contaminated soils include: staining, sheens, unusual discolorations, unusual crystals, and odors. When describing visual indications of contamination, describe how they are present, such as a sheen, staining along joints or root casts, residual or free-phase product seeping from the sample; however, do not attempt to infer what chemical may be present. For larger investigation projects with well-defined contaminants of concern and release mechanisms, it is advisable to prepare guidelines for screening and describing contaminated soils.

Soils having a significant amount of organic matter typically have a distinctive, pungent musty odor of decaying vegetation. In addition, soils impacted with organic contamination may exhibit unusual odors; some contaminants that may give a noticeable odor include petroleum hydrocarbons, solvents, ammonia, mineral spirits, turpentine, phenols and cresol, and organic pesticides. Odors may generally be described using the criteria provided in **Table 13** and descriptions of the odor characteristics (e.g., rotten egg odor, sweet chemical odor); however, do not attempt to infer the specific chemical that may be present. If field activities are being conducted as part of a litigation project or potential litigation project, always check with the PIC/PM prior to including descriptors for odors as it may be preferable to simply note the presence of an odor without classifying it as strong, slight, etc.

Table 13: Criteria for Describing Odor

Description	Criteria
Strong	Distinct or sharp odor is noticed
Moderate to Slight	Less distinct to faint odor
None	No detectable odor is noted
Note: Adapted from USEPA EPA/600/4-91/029	

When inspecting soils for signs of contamination, adhere to the requirements of the HASP and, before monitoring soil odors, the sample should be screened with field screening equipment. Under no circumstance should odors be vigorously inhaled from any soils as they could contain potential biological or chemical hazards.

It is customary to describe the signs of potential contamination in lower case and within parenthesis following the soil name and appropriate modifiers.

4.6 Example Soil Descriptions

In summary, a soil is identified by assigning a group symbol and name with a description of the following key physical properties:

- USCS soil name (synonymous with ASTM D2488-09a Group Name) with appropriate modifiers,
- Color,
- Moisture content,
- Relative density or consistency, and
- Field evidence of potential contamination.

The above-noted naming convention generally follows the format described by the USCS classification system as described in ASTM D2488-09a. For reference purposes, examples of soil descriptions are provided in **Table 14**.

Table 14: Example Soil Classification

Detailed Field Observations	Basic Field Observations	Soil Classification
About 70% fine, hard round dark gray (N3) sand, 10% fine sub-angular, hard gray (N5) gravel, and 20% light gray (N7) silt low dry strength, slow dilatancy and no plasticity; trace of reddish brown silty clay; SPT-N = 8; wet, maximum size fine sand	70% fine gray sand, 10% fine gravel, and 20% light gray silt with trace of reddish brown silty clay (wet, loose)	Dark gray silty fine SAND (SM) with trace of reddish brown silty clay (wet, loose) Or Dark gray (N3) silty fine SAND (SM) with trace of reddish brown (10R3/6) silty clay (wet, loose)
About 65% fine to coarse, hard subangular reddish brown (10R3/6) sand, and 20% fine sub-angular, hard gray gravel with 15% coal fragments and cinders; SPT-N = 35; moist, maximum size 1- inch		Reddish brown well graded SAND (SW) with little sub-angular fine gravel and little fill (coal fragments, cinders) (moist, dense) Or Reddish brown (10R3/6) well graded SAND (SW) with little sub-angular fine gravel and little fill (coal fragments, cinders) (moist, dense)
Dark brown (10YR3/3) to dark gray (N3) spongy fibrous organic soil, many fine roots, trace of fine to coarse sand; SPT-N = 2; wet, very soft to soft, maximum size 5 mm; Discolored, moderate sweet chemical smell		Dark brown to dark gray peat (PT) with trace of fine to coarse sand (wet, very soft to soft) (discolored, moderate sweet chemical smell) Or Dark brown (10YR3/3) to dark gray (N3) peat (PT) with trace of fine to coarse sand (wet, soft) (discolored, moderate sweet chemical smell)
About 30% coarse, hard angular yellowish red (10YR6/8) sand with weak cementation, 5% fine sub-angular, hard brown (10YR5/3) gravel, and 65% greenish gray (5G6/1) silt, firm, medium dry strength, slow dilatancy and medium plasticity; SPT-N = 16; wet, maximum size ½-inch. Strong petroleum odor and black staining		Greenish gray elastic SILT with some yellowish red (10YR6/8) angular coarse sand a few sub-angular brown gravel (wet, firm) (stained, strong petroleum odor) Or Greenish gray (5G6/1) elastic SILT (MH) with some yellowish red (10YR6/8) angular coarse sand a few sub-angular brown (10YR5/3) gravel (wet, firm) (stained, strong petroleum odor)

5. PRECAUTIONS AND OTHER CONSIDERATIONS

Accurate soil classification requires the collection of sufficiently detailed information throughout the logging process. Certain precautions should be taken to while recording the required information.

- Sunglasses should not be worn when describing soil colors.
- Note that samples from split-spoons and small-diameter core tools are not always representative of coarse-grained strata. Be sure to check driller's logs (when available) and soil cuttings for boulders, cobbles, gravels or other materials that may be encountered during advancement of the boring.
- Fill may be encountered during site characterization activities. Fill material can be determined from historical information or from the identification of man-made materials, such as concrete, brick, glass, plastic, cinders, and/or wood. If the soil boring being described is determined to be fill material, "fill" should be included in the soil description. Materials designated as "fill" should still be classified according to the USCS analysis methods provided above. Additional descriptors should be added if the materials making up the fill can be explicitly identified.
- If there are odor or color descriptors that are significant to a project (e.g., prussian blue at an MGP site or solvent-like odors at petroleum site), these should be discussed with the PIC/PM and understood prior to implementing field activities.

6. RECORDKEEPING

This FGD specifically pertains to recordkeeping during soil sampling projects. All information should be recorded in accordance with FGD 1.01 (Field Notes and Records) and FGD 5.09 (Soil Boring Field Log). In general, draft field forms should be scanned and saved electronically immediately following the completion of the soil sampling activities. Following review of draft documents by the PIC and/or PM, field forms should be finalized and final versions may be included in project reports, if necessary. Draft and final versions of the field form should be managed in accordance with Ramboll Environ's Document Retention Policy and project-specific requirements, and copies should be maintained in the project file.

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FIELD GUIDANCE DOCUMENT NO. 5.07

SUBSURFACE SOIL SAMPLING –
DIRECT PUSH TECHNOLOGY (DPT)

FIELD GUIDANCE DOCUMENT NO. 5.07

SUBSURFACE SOIL SAMPLING – DIRECT PUSH TECHNOLOGY (DPT)

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CONTENTS

ATTACHMENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines for use by Ramboll employees operating in the United States and Canada for collection of subsurface soil samples using direct push technologies (DPT). DPT is commonly used for soil sample collection at sites where there is an advantage to using a drill rig with a smaller footprint that can quickly penetrate soils while reducing the generation of investigation derived waste (IDW) (EPA, 2005). Subsurface soil sampling via DPT may be conducted as part of environmental investigations or remedial actions to:

- Collect soil samples for biological, chemical and/or geotechnical testing[1] and assess hydrogeological conditions including, but not limited to, sampling to support source identification, characterize nature and extent of contamination in soils, assess background conditions, and conduct confirmatory sampling; and
- Allow visual, odor, and volatile vapor screening of subsurface soils.

This FGD provides guidance for subsurface soil sampling using DPT associated with typical field activities and projects, however, it should be understood that for certain projects other sampling procedures or alternative methods may be required, including methods specified by state-specific or regulatory program-specific guidelines, requirements or procedures. Site-specific and state/regulatory requirements will be reviewed by the Ramboll Principal-in-Charge / Project Director (PIC / PD) and/or Project Manager (PM), and additional requirements will be defined in the project-specific Work Plan, Field Sampling Plan, Quality Assurance Project Plan (QAPP) and/or FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans but rather a reference for developing project specific procedures.

This FGD does not supersede Ramboll health and safety procedures or site-specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. Ramboll employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP followed by approved site-specific procedures, which may include those in this FGD. The Ramboll PIC/PD and/or PM shall verify that project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information are maintained in the project file for the duration of the project or as established by applicable Ramboll document handling and retention policies. The signatures of the PIC/PD and/or PM indicate approval of the methods and precautions outlined in the site-specific HASP.

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[1] Note that direct push sampling does not allow collection of undisturbed samples required for certain geotechnical testing (e.g., strength, consolidation, hydraulic conductivity).

2. EQUIPMENT AND MATERIALS

A general list of equipment that may be necessary for typical subsurface soil sampling using DPT is provided below. This list provides an overall summary of general equipment which may be required for soil sampling using DPT but should not be considered exhaustive. Additional equipment may be specified in the project-specific Work Plan and/or HASP.

- Site information (e.g., maps, contact numbers, keys or lock codes for gates or access points, previous field logs).
- The DPT rig, and other drilling equipment, such as rods, samplers, liners (e.g., PVC, polyethylene, acrylic, Lexan), and caps, which should be supplied by the drilling contractor (refer to **Attachment A** for brief descriptions of commonly used samplers).
- Appropriate tools for adjusting samplers and opening liners (dual longitudinal liner ripping blade, hacksaw (with clean blades), pliers, wrench, etc.), which should be supplied by the drilling contractor.
- Pin flags or wooden stakes, or in paved areas, spray paint or nails with flagging tape, to mark sample location(s). Care should be taken not to use materials that may interfere with sampling/analytical results. Refer to **FGD 1.04** (Documenting Sampling Locations).
- Plastic sheeting.
- Folding worktable, half-pipe, or half-sheet of corrugated roofing plastic to hold and keep the samplers organized.
- Soils classification guidance chart as outlined on **FGD 5.01** (Soil Classification).
- Color chart (e.g., Munsell) as outlined on **FGD 5.01** (Soil Classification).
- Measuring tape (both long-weighted cloth type and small measuring type, preferably marked in tenths and hundredths of a foot) for measuring sample recovery and subsample intervals.
- Spatula, knife or spoon (typically stainless steel) used for splitting soil cores and collecting soil samples.
- Mixing bowl/bucket and spoons (typically stainless steel unless metal analysis will be performed) for composite sample preparation.
- Laboratory supplied certified-clean sample containers (appropriate for various analyses to be performed), as may be required in the Work Plan.
  - If soil samples are to be analyzed for Volatile Organic Compounds (VOCs) refer to **FGD 5.05** (Soil Sampling for VOC Analysis) for additional equipment requirements.
  - If soil samples are to be analyzed or screened for Non-aqueous Phase Liquid (NAPL) refer to **FGD 5.11** (Soil Sampling - NAPL Dye Tests) and/or **FGD 5.12** (Soil Sampling - NAPL Ultraviolet Light Tests) for additional equipment requirements.
  - If soil samples are to be analyzed for Polychlorinated biphenyl (PCBs) refer to **FGD 5.16** (Soil Sampling for PCB Analysis) for additional equipment requirements.
  - If soil samples are to be analyzed for poly and perfluoralkyl substances (PFAS), refer to **FGD 1.07** (PFAS Sampling).

- Sample shipment containers, labels, chain of custody forms and packing materials for sampling containers as outlined in **FGD 1.02** (Sample Handling, Shipping, and Chain of Custody).
- Trash Bags - used to dispose of gloves and other non-hazardous waste generated during sampling (refer to **FGD 15.01**, Waste Handling).
- Decontamination supplies (refer to **FGD 14.01**, Sampling Equipment Decontamination).
- Appropriate waste container and labelling materials – used to dispose of IDW and/or decontamination wastes (refer to **FGD 15.01**, Waste Handling).
- Field screening equipment (e.g., PID, XRF) as required by the site-specific Work Plan, Field Sampling Plan, QAPP and/or the site-specific HASP.
- Zip-loc® bags and/or glass jars and aluminum foil (used for field screening purposes).
- Personal Protective Equipment (PPE) in accordance with the site-specific HASP, including protective gloves which must always be worn when handling and using sample equipment.
- Field notebook and test boring and well construction field log forms (if required), and all-weather or permanent pens as outlined in **FGD 1.01** (Field Notes and Records).
- Mobile phone and camera.
- For long-term drilling projects, setting up a field station is recommended. The field station might include portable chair(s), worktable, canopy, and a first aid station/kit.

3. PROCEDURES REFERENCED

In addition to the reference and guidance documents cited above, the following Safe Work Practices (SWPs) and FGDs are related to this FGD and should be reviewed prior to mobilization, as needed:

- **SWP** Subsurface Utility Clearance
- **FGD 1.01,** Field Notes and Records
- **FGD 1.02**, Sample Handling, Shipping and Chain of Custody
- **FGD 1.03**, Data Management
- **FGD 1.04**, Documenting Sampling Locations
- **FGD 1.05**, Field Quality Control Samples
- **FGD 1.07**, PFAS Sampling
- **FGD 2.02**, Site Preparation, Inspection and Housekeeping
- **FGD 4.06**, Equipment Calibration
- **FGD 5.01**, Soil Classification
- **FGD 5.04**, Surface Soil Sampling
- **FGD 5.05**, Soil Sampling for VOC Analysis

- **FGD 5.06**, Field Analysis of Soils using Portable X-Ray Fluorescence
- **FGD 5.09**, Soil Boring Log Preparation
- **FGD 5.10**, Borehole Decommissioning
- **FGD 5.11**, Soil Sampling - NAPL Dye Tests
- **FGD 5.12**, Soil Sampling - NAPL Ultraviolet Light Tests
- **FGD 5.16**, Soil Sampling for PCB Analysis
- **FGD 5.19,** Incremental Composite Sampling (Soils/Sediments)
- **FGD 6.06**, Temporary Overburden Well Installation and Sampling
- **FGD 14.01**, Sampling Equipment Decontamination
- **FGD 14.02**, Heavy Equipment Decontamination
- **FGD 15.01**, Waste Handling

The list above is not intended to be all inclusive. Other SWPs and FGDs may need to be referenced based on the specific requirements of the site-specific Work Plan, Field Sampling Plan, and/or QAPP (e.g., field screening FGDs, FGDs for sampling of other media, etc.).

4. PROCEDURES

4.1 Planning and Design Considerations

Strategic decisions including, but not limited to, the selection of the direct push drill rig (e.g., access limitations), and the potential need to adjust boring locations (e.g., subsurface utilities), will be approved by the PIC/PD and/or PM before the initiation of associated field activities and will be documented in the Work Plan, Field Sampling Plan, and/or QAPP. The Work Plan, Field Sampling Plan, and/or QAPP will be designed for the collection of quality data to meet the objectives of the sampling program and will include information such as the number of borings, depth, number of samples per boring, and the laboratory analyses to be performed on each sample as well as quality assurance/quality control (QA/QC) requirements. The Work Plan, Field Sampling Plan, and/or QAPP will generally provide for some discretion in the field, depending on encountered conditions; however, any significant departure from prescribed sampling activities should be discussed with and approved by the PIC/PD and/or PM.

When planning a DPT sampling event, the following should be considered:

- *Type of Direct Push Rig*. DPT uses hydraulically powered rigs that utilize both hydraulic force and percussion to advance soil sampling equipment into the subsurface. Some direct push rigs are also equipped with a rotational drive that will allow the use of augers. Direct push rigs can be mounted on pickup trucks, skid loaders, tracked carriers, skids or other vehicles. The type and size of the direct push rig and associated equipment will depend on project -specific needs such as the boring depth and access limitations. The type of direct push rig and associated equipment should be specified in the work plan and discussed with the drilling contractor prior to mobilization.

- *Sampling Locations*. Consideration for placement of sampling locations should be given to the objectives of the sampling effort. However, accessibility and potential hazards (e.g., subsurface utilities, overhead clearance [including utilities, ceilings or other obstructions] traffic, surface stability, soil strength), and need to precut surfaces (e.g., asphalt or concrete) should be considered when selecting sampling locations as they could limit DPT equipment use and/or require additional controls (e.g., traffic control, clearing of vegetation, temporary mats for protection of landscaping, or delicate surfaces).
- *Sampler Type*. DPT samples can be collected using either single barrel or double tube configurations (refer to **Attachment A** for brief descriptions of commonly used DPT samplers). The dual tube system is preferable as it provides a casing that isolates the media to be sampled from the formation, thereby preventing potential cross-contamination or potential sloughing of the borehole walls. A single barrel sampler may be suitable for discrete shallow (i.e., less than 10 feet) sampling in the unsaturated zone provided that the barrel sampler is used in a sealed or closed configuration. The sampler barrel is typically five feet in length.
- *Subsurface Soils*. DPT is most suitable for sampling cohesive overburden soils that contain a low percentage of gravel and are not dense or highly compacted, or contain cobbles or weathered rock. In cases where soils to be sampled may lack cohesiveness and may fall out of the sampler, core catchers at the leading end of the sampler may help retain the sample until retrieval at the surface.
- *Liner Type*. DPT soil sampling uses a liner to facilitate sample retrieval from the barrel. Liner materials include brass, stainless steel, cellulose acetate butyrate, polyethylene terephthalate glycol, polyvinyl chloride, and Teflon. Potential interferences between the liner materials and the contaminants of concern must be evaluated when selecting the liner materials. When low reporting limits are required, use of the more inert liner materials (e.g., stainless steel) is recommended.
- *Liner Dimensions*. Liners vary in diameter (from about 1 to 3 inches) and length (from about 2 to 5 feet). Metal liners can also be obtained in shorter lengths (2-6 inches) to allow ready collection of discrete intervals. Selection of the liner dimensions should consider: (a) volume requirements for sample analyses; (b) quantity of samples and sampling intervals (ideally the sampler would be positioned at the top of the interval on interest); and (c) enhanced recovery (typically larger diameter borings will be less affected by presence of small subsurface obstructions like pebbles).
- *Borehole backfilling approach.* Factors to be considered in selecting the approach for backfilling the borehole include potential contamination of drill cuttings, local permit regulations and guidance, and client specific requirements. DPT boreholes can be backfilled using several methods, including retraction grouting with a tremie tube and a bentonite and/or Portland cement grout, gravity filling with bentonite and/or Portland cement grout, filling with hydrated bentonite pellets, or backfilling with drill cuttings.

4.2 Pre-Field Work Preparation Guidelines

Before initiating field activities, field staff should review and complete pertinent tasks identified in **FGD 2.02** (Site Preparation, Inspection and Housekeeping). In addition, to the extent that non-dedicated sampling equipment is to be used (e.g., spatula, knife or spoon, mixing bowls), such sampling equipment should be decontaminated before collection of each sample to minimize potential cross-contamination between samples, as described in **FGD 14.01** (Sampling Equipment Decontamination), the project-specific Work Plan, Field Sampling Plan and/or QAPP. Used disposable sampling equipment should be considered IDW and should be managed in accordance with **FGD 15.01** (Waste Handling), following the sampling event.

At a minimum, the following tasks should be completed (as applicable) as field staff prepare for implementation of the work:

- Coordinate and obtain permission for site access;
- Review and sign the site-specific HASP;
- Review applicable permits and permit conditions that may affect site work including backfill requirements, air, dust or sound monitoring, agency notifications, and restricted operating hours;
- If work is being conducted under agency supervision, make appropriate advance notifications to advise of the start of work;
- Confirm soil boring/sampling locations;
- Complete subsurface clearance activities (refer to **SWP** Subsurface Utility Clearance);
- Review project-specific Work Plan, Field Sampling Plan, and/or QAPP, where applicable;
- Review and discuss with the PIC/PD and/or PM the proposed Work Plan, Field Sampling Plan or sampling strategy;
- Identify the type of sampler and drilling equipment required for project-specific tasks and review the standard instruction manual provided by the manufacturer of the specific sampling equipment being used for sampling;
- Contact the drilling contractor to verify scope and confirm sampling equipment is available and appropriately decontaminated prior to mobilization;
- Contact the laboratory to provide advance notice when sample delivery is anticipated; and
- Verify that all equipment/materials and sampleware required to complete the work have been packed prior to mobilization.

Prior to the commencement of the field effort, Ramboll oversight personnel should inspect, test, and/or calibrate equipment that will be used to take field measurements (refer to **FGD 4.06**, Equipment Calibration). To increase productivity in the field, it is recommended that prior to mobilization the laboratory-provided sampleware quantities are checked, sample containers are pre-labeled (refer to **FGD 1.02**, Sample Handling, Shipping and Chain of Custody) and non-dedicated sampling equipment is decontaminated and packaged (refer to **FGD 14.01,** Sampling Equipment Decontamination).

4.3 Direct Push Sampling Guidelines

The following provides a recommended list of practices for soil sampling using DPT.

- Where applicable, contact the identified key site personnel upon arrival to the Site and visually assess proposed work areas and decide where containerized soil cuttings and other IDW should be staged and stored.
- Review the physical location of each soil boring with the driller before initiating subsurface work. Verify that the proposed locations have been cleared in accordance with **SWP** Subsurface Utility Clearance and that the drill rig can operate safely while maintaining minimum clearance from overhead power lines, or damaging other property (e.g., equipment, fences, etc.).
- Inspect the backfill material provided by the drillers to verify it complies with potential permit requirements.
- Discuss the following with the driller:
  - Expected depth and diameter of the borings;
  - Amount and depth of the soil samples to be collected;
  - Approximate anticipated depth of groundwater;
  - Borehole backfilling procedure and materials;
  - Staging locations for soil cuttings and other IDW;
  - Location for conducting equipment decontamination; and
  - Surface materials and the need to predrill or core prior to DPT. If the surface material is asphalt, the direct push drill rig tooling may be able to penetrate the asphalt (verify with driller prior to initiating field work). However, if the surface is covered with concrete, a concrete corer or saw may be required to provide access to the subsurface.
- Prior to start of the DPT sampling, set up the sample processing/field station area, which may include placing plastic sheeting on the ground surface to prevent potential contamination of underlying soil/asphalt/concrete, setting up a worktable, core cradle, or corrugated sheets to hold the samplers, and installing a canopy.
- Although equipment will be decontaminated between uses to further limit potential cross-contamination between sampling locations, sampling should progress from suspected areas of lowest to highest concentration.
- The driller will advance the DPT sampler to the target sampling depth (refer to **Attachment A** for brief descriptions of commonly used DPT samplers). The sampler will be advanced using hydraulic pressure and percussion hammering on the driving head of the sampling assembly at a constant rate. The sampler will be advanced to a depth that is equal to its length (typically 24-inch inner sampling barrel), or less if sampler refusal is encountered (i.e., limited or no advancement of the sampler, altering the robe alignment or bending of the rod). Refusal can result from tip resistance (i.e., distinct unconsolidated deposits overlying bedrock or presence of cobbles in the subsurface), sleeve friction (i.e., the interaction of the sampler with cohesive soils, which can "grab" the outside of the sampler and limit depth penetration), subsurface heterogeneity, or

operator error (e.g., advancing the probe off vertical, which will cause the probe to bend).

- During direct push sampling, Ramboll personnel should:
  - Maintain a safe distance from the drill rig and maintain eye contact with the operator if approaching the drill rig.
  - Monitor ambient air in the work area as required by the site-specific Work Plan or Field Sampling Plan and the site-specific HASP.
  - Communicate with the operator regarding observed changes in subsurface conditions during drilling (e.g., increased or decreased resistance to DPT, groundwater first encountered) and depths where these occur.
- Have the drilling contractor retrieves the sampler from the borehole, place the sampler on the sample processing work area, and remove the liner from the sample barrel.
- Upon delivery, Ramboll personnel will
  - Don a pair of new clean nitrile gloves immediately prior to handling each core.
  - If the liner will be used as a sample container, use a decontaminated (refer to **FGD 14.01,** Sampling Equipment Decontamination) tool to cut the portion of the liner that will be used for the sample, and cover it with liner caps, which should be taped to the liner to prevent sample loss (Teflon or other tape without potential VOC-containing adhesives for VOC samples). Then cut the remainder of the liner as described below.
  - If the liner will not be used as the sample container, cut it lengthwise on either side with a decontaminated (refer to **FGD 14.01,** Sampling Equipment Decontamination) tool to separate the halves and allow for sample screening and collection. If sampling for VOCs is being performed, do not cut the liner until immediately prior to field screen/sample to minimize VOC loss.
- Once the liner is open, Ramboll personnel should:
  - Place a measuring tape alongside the liner, photo-document the core, and measure and record the soil recovery in the core. If poor soil recovery is experienced or anticipated, then evaluate the possible causes for poor recovery. Consider (a) advancing the core to the top of the desired sample interval and then advancing the core to obtain the desired interval; (b) using a catcher; (c) extending the sampler to a cohesive layer, if present; (d) using a larger split spoon barrel; and/or (e) advancing a second adjacent soil boring to target the necessary interval. Alternatively, review and discuss with the PIC/PD and/or PM other sampling approaches.
  - When the sample recovery is less than 100%, the recorded retrieved interval corresponds to the top of the target sampling interval. For example, if recovering 18 inches from the 10 to 12 feet below ground surface (bgs) sampling interval, the sampling interval recorded is 10 to 11.5 feet bgs. Exceptions may include presence of slough in the top of the sampler, when sampling compressible soils (e.g., peat), or if a rock temporarily prevents sample collection. If any of these conditions are

  observed during drilling, discuss appropriate recording of the sample recovery with the PIC/PD and/or PM.

  - Use a decontaminated (refer to **FGD 14.01,** Sampling Equipment Decontamination) spatula, knife or spoon to split the soil cores and to expose soil for sampling, field screening, and photo-documentation.
  - Screen the soil with field instruments (e.g., PID, XRF) as required by the site-specific Work Plan, Field Sampling Plan, and/or QAPP and in accordance with instrument manufacturer recommendations and pertinent FGDs.
  - Classify the soil in accordance with **FGD 5.01** (Soil and Rock Classification) and document related drilling activities in accordance with **FGD 5.09** (Field Soil Boring Log Preparation).
  - If soil samples are to be field tested for the presence of NAPL refer to **FGD 5.11** (Soil Sampling - NAPL Dye Tests) and/or **FGD 5.12** (Soil Sampling - NAPL Ultraviolet Light Tests).
  - Don a new pair of clean nitrile gloves immediately prior to collecting samples that will be sent for laboratory analyses.
  - Collect samples as required by the site-specific Work Plan, Field Sampling Plan, and/or QAPP as follows:
    - If soil samples are to be analyzed for VOCs collect these samples first in accordance with **FGD 5.05** (Soil Sampling for VOC Analysis).
    - Homogenize sample in accordance with the homogenization procedures provided in **Section 4.4**.
    - If soil samples are to be analyzed for PCBs refer to **FGD 5.16** (Soil Sampling for PCB Analysis).
    - If soil samples are to be analyzed for PFAS, refer to **FGD 1.07** (PFAS Sampling).
    - If multiple samples are to be collected from a single liner, don a pair of new clean nitrile gloves and use a decontaminated (refer to **FGD 14.01,** Sampling Equipment Decontamination) spatula, knife or spoon to collect and prepare each sample.
  - Transfer the sample to appropriate sample container(s) provided by the analytical laboratory, label and seal the sample containers, and store in an ice-filled insulated cooler pending transport to the analytical laboratory, or the laboratory courier in accordance with sample container guidelines in **Section 4.5** and sample transport and storage guidelines in **Section 4.6** and **FGD 1.02** (Sample Handling, Shipping, and Chain of Custody).

- If multiple samples are to be collected, decontaminate non-dedicated, non-disposable sampling equipment between sampling locations as described in the **FGD 14.01** (Sampling Equipment Decontamination), the project-specific Work Plan, Field Sampling Plan and/or QAPP.
- If the Work Plan or Sampling Plan requires continuous sampling, have the driller advance the sampler to a depth equal to the base of the last sample interval. If sampling is

discontinuous, have the driller advance the sampler to just above the next sample target depth.

- Upon completion of the drilling and soil sampling activities:
  - The boring shall be backfilled as required in the project-specific Work Plan, Field Sampling Plan, and/or permit(s).
  - If surfaces are to be restored (e.g., pavement, concrete, vegetation), reconstruct the surface and match to adjoining grades in accordance with the project-specific Work Plan and/or Field Sampling Plan.
  - Document the sampling location in accordance with **FGD 1.04** (Documenting Sampling Locations) and place a stake or flag at the sampling location for future reference if these do not interfere with site activities (e.g., in a parking lot or driveway).
- If required by the project-specific Work Plan or Field Sampling Plan, decontaminate the drilling rig and equipment prior to demobilization from the Site in accordance with **FGD 14.02** (Heavy Equipment Decontamination).
- If dedicated, disposable sampling equipment was used during the sampling event, it should be considered IDW and should be managed in accordance with **FGD 15.01** (Waste Handling) following the collection sampling event.

4.4 Sample Homogenization Procedures

Homogenization refers to the complete mixing of materials to obtain uniform color and consistency throughout the sample prior to analyses. Homogenization is typically performed on discrete samples (e.g., several intervals within a sampling location or several sampling locations within a specific sampling interval) to create composite samples. Compositing may be performed either in the field or at the laboratory. Homogenization should not be performed for samples designated for VOC analysis (refer to **FGD 5.05,** Soil Sampling for VOC Analysis).

- Place samples to be homogenized into a large, decontaminated (refer to **FGD 14.01**, Sampling Equipment Decontamination) or dedicated container constructed of inert material (e.g., glass, Teflon, or stainless steel) appropriate for the analyses requested.
- Prior to homogenization, remove large, unrepresentative materials such as twigs, leaves, stones, wood chips, and debris and document this encountered material in the field log.
- Mix materials as quickly and efficiently as possible using a decontaminated (refer to **FGD 14.01**, Sampling Equipment Decontamination) glass, high density polyethylene, or stainless-steel spoon until textural, color, and moisture homogeneity are achieved.
- When mixing large amounts of materials, mechanical mixers can be used as long as they are made of stainless steel, and have been decontaminated (refer to **FGD 14.01**, Sampling Equipment Decontamination).

4.5 Sample Containers

As outlined in **FGD 1.02** (Sample Handling, Shipping and Chain of Custody), equipment and sample containers that will come into contact with collected soil samples should be constructed of inert materials that will not affect the concentration of constituents in the sample (i.e., stainless steel or Lexan®). The level of care that needs to be taken with the materials used will depend on the level and types of constituents associated with the sample and the quality assurance needs and study goals. This should be outlined in the project-specific Work Plan, Field Sampling Plan and/or QAPP.

When the liners will not be used for sample collection, the laboratory will provide appropriate sample containers appropriate for each predetermined sample analysis. The sample volume is a function of the analytical requirements and will be specified in the Work Plan, Field Sampling Plan and/or QAPP. If possible, jars should be filled to capacity allowing no headspace (unless samples are to be stored frozen in which case some head space is required to allow for sample expansion). If samples are to be analyzed for VOCs, they should be collected in a manner that minimizes disturbance of the sample (refer to **FGD 5.05**, Soil Sampling for VOC Analysis).

4.6 Sample Transport and Storage

Sample containers shall be handled as outlined in **FGD 1.02** (Sample Handling, Shipping and Chain of Custody). Samples should be kept in an ice-filled transport container during fieldwork and covered to limit light penetration.

If the liners will be used for sample collection, they should be properly capped/sealed at both ends and stored to minimize sample disturbance.

4.7 QA/QC

Follow QA/QC procedures described in the project-specific Work Plan, Field Sampling Plan and/or QAPP throughout the sample collection, processing, handling, and analysis process. In their absence, the QA/QC guidelines of **FGD 1.05** (Field Quality Control Samples) should be reviewed.

5. PRECAUTIONS AND OTHER CONSIDERATIONS

Field activities require recording sufficiently detailed information throughout the implementation of field work. Certain precautions should be taken to work safely while collecting soil samples via DPT. Additionally, implementation of the work may face some difficulties, including the following:

- Direct push drilling is only suitable in unconsolidated shallow sediments. If the lithology at the site contains large amounts of gravel/cobbles, dense clay, caliche or bedrock, alternative drilling techniques may have to be considered.
- Only drillers licensed in the State where the work is being performed should be subcontracted to perform the work, if applicable. Most states have specific licensing requirements.

- In some States or local jurisdictions, drilling permits are to be procured by the driller and/or consultant prior to mobilization. In addition, boring logs and other documentation may need to be submitted to the permitting entity by the driller and/or consultant after completion of the drilling and sampling. Local Ramboll offices should be consulted to determine if specific reporting requirements apply. If the driller obtains the drilling permits, Ramboll should obtain copies of the required permits prior to mobilization. When applicable, Ramboll should also obtain copies of the driller's soil boring records after completion.
- Prior to mobilization, identify the location of soil borings and evaluate the need for security, barricading, and/or traffic control (e.g., when borings are located near the right of way).
- It is important to always remain alert and aware of your surroundings. Sampling using a direct push rig involves the use of heavy equipment, and is subject to hazards posed by equipment, vehicle traffic, industrial machinery, hazardous chemicals and contaminants, and/or other physical, mechanical, and chemical hazards.
- Stand a safe distance away from the direct push rig when taking notes. Be aware that the operator may not be able to see you, equipment accidents can happen very quickly, and you need to be alert and ready to move. Be sure to wear a high-visibility vest or clothing.
- Keep direct push equipment out of high-traffic areas and properly stored when not in use to limit trip, spill and fall hazards onsite. Use marking tools when necessary to flag or mark off possibly dangerous areas.
- If the borehole cannot be completed by the end of the day, leave the drill rig over the borehole. Where not possible (e.g., public right of way), cover the borehole and secure the area to prevent accidents and unauthorized access.
- At sites with certain contaminants and/or subsurface conditions, potentially toxic and/or explosive gases may migrate from the borehole to the surface. Field staff should perform air monitoring and confirm that PPE is used in accordance with the site-specific HASP.
- When working out of sight of the general public or when site employees are in potentially hazardous areas (e.g., wooded habitats), field staff should use the "buddy system" and ensure that the project-specific HASP includes safety measures and procedures for work in isolated areas.
- When the liners are removed from the sampler tubes, <u>it is important to track the proper orientation of the sample</u> and to precisely and liberally mark the depths (e.g., top of run, labeled footage marks along the length of the sample, total depth of run) at which the sample was collected. Different liner cap colors can be used to distinguish the top from the bottom of the core or the orientation can be marked on the exterior of the liner with a permanent marker. When, say a six-inch sample is cut out of a sample run from a 5-foot sleeve, the remaining sleeve portions should be sufficiently labeled so that the boring can continue to be properly logged and to avoid confusion.
- If the Work Plan or Field Sampling Plan specifies analyses requiring field preservation, be sure to avoid direct contact with laboratory-provided preservative chemicals.

- The sample processing area should minimize exposure to ambient factors (e.g., atmospheric air, wind-blown dust, vehicular exhaust).
- Background soil samples should be kept isolated from samples collected from potentially contaminated soil samples and IDW. When possible, sampling should progress from areas of lowest to highest suspected concentrations.
- When possible, designated roles should be established so that the soil sampling and logging is performed by the same person and the recording and documentation is completed by the same person throughout the sampling process.
- When backfilling boreholes below the water table, bentonite pellets or coated bentonite chips are generally easier to place than standard bentonite chips because pellets do not hydrate as quickly, hence pellets or coated bentonite chips are the preferred method for small backfill jobs where significant confining zones have not been breached. Note, however, that some pellet coatings have been known to contain acetone, which may interfere with groundwater VOC analysis. If used, samples of the coated bentonite pellets may be collected and held for future analysis if acetone is detected in the groundwater sample.

6. RECORDKEEPING

Document sampling locations in accordance with **FGD 1.04** (Documenting Sampling Locations) and record information related to soil sampling in accordance with **FGD 1.01** (Field Notes and Records) and **FGD 1.03** (Data Management). In addition, for each soil boring a soil boring log with the recorded information should be prepared and saved in the project file (refer to **FGD 5.09** – Soil Boring Logs).

ATTACHMENT A
DIRECT PUSH SAMPLING EQUIPMENT

Direct push technology (DPT) sampling involves “pushing” a hollow lined barrel into the subsurface using a combination of equipment weight and high frequency percussive or hydraulic methods. Since DPT compresses and/or rearranges soil particles to allow the barrel to advance, there is no need to remove soil thereby minimizing soil cuttings requiring offsite disposal. The depths that can be achieved by DPT sampling are dependent on the soil type, the size of the sampler, and the weight and power of the DPT rig. DPT sampling is most suitable for sand, silt and clay with some gravel. DPT technology may have difficulty penetrating dense or hard soil, hard-packed saturated sand, and soil with cobbles or boulders.

DPT devices may be driven by manual, mechanical, or hydraulic methods, and may be truck-mounted or stand-alone. A DPT tool string includes the sample collection tool and extension rods for advancement and retrieval of the sample tool. There are three types of rod systems:

A. The Large Bore DPT soil sampling system consists of a single string of rods that connect the sampling tool to the rig and is used as a discrete interval sampler. The large bore sampling system consists of a head assembly, a barrel, liner, a piston rod, a cutting shoe, and a piston tip. While it is being driven, the sampler remains closed by a piston tip that is held in placed by a reverse-threaded stop pin at the tailing end of the sampler. Once at the top of the target sampling interval, the stop pin is removed with an extension rod lowered through the drill stem. The sampler is then driven to the target depth, and the drill stem and sampler are removed from the borehole to retrieve the sample.

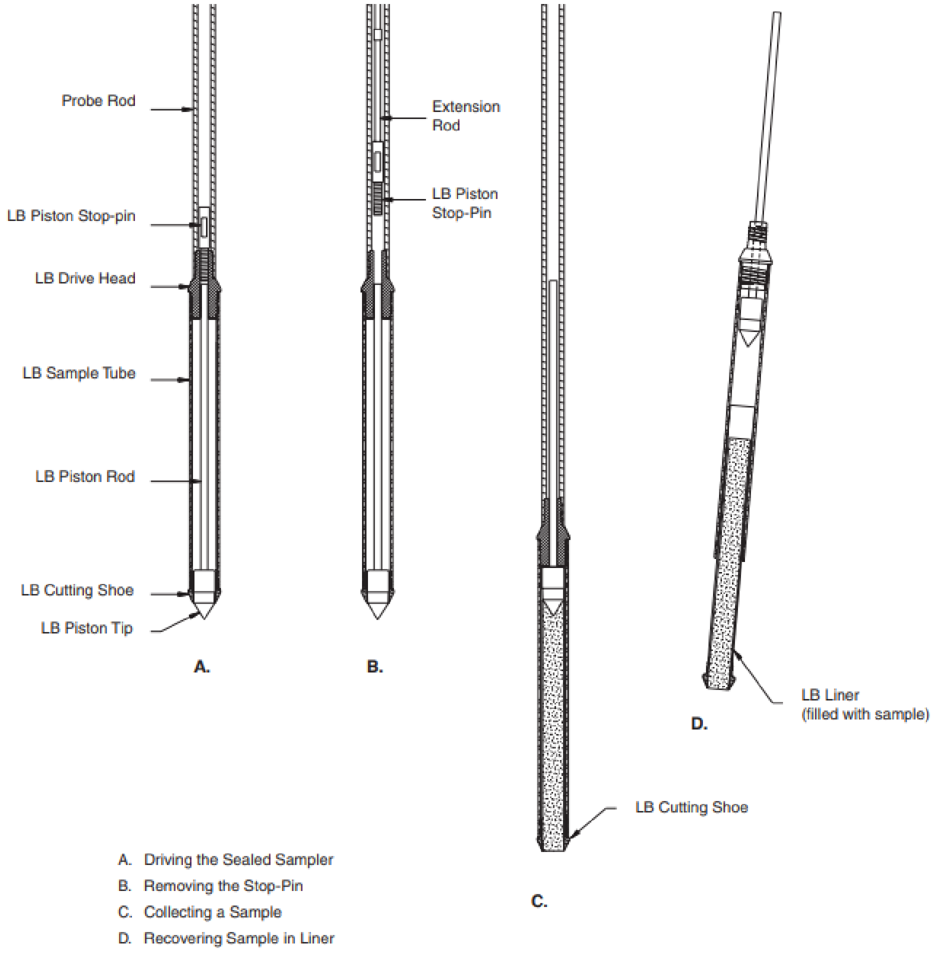


Figure 1: Large Bore DPT System (Source: Geoprobe)

B. Single tube DPT soil sampling consists of a single string of rods that connect the sampling tool to the rig and can be used as an open tube sampler or closed point sampler assembly. The open tube sampling system consists of a head assembly, a barrel, liner and a cutting shoe. The cutting shoe is affixed to the liner, which is inserted and threaded into the barrel. The drive head is threaded the opposite end of the barrel. In this configuration, coring starts at the ground surface with a sampler that is open at the leading end. The sampler is driven to the target depth in the subsurface using the DPT rig, and when retrieved, the entire string is removed from the borehole. To collect samples from greater depths when soils are stable, a new sampler is reintroduced into the open borehole and the process repeated. In unstable soils that cause borehole wall collapse, the single tube sampler can be equipped with a closed point assembly. The closed point assembly also allows collection of targeted interval samples at depth.

A closed point assembly can be inserted into the single tube DPT soil sampler. This assembly fits firmly into the cutting shoe and is held in place by center rods that prevents soil from entering the sampler as it is advanced to the bottom of an existing hole, allowing collection of a representative sample at the target depth. The barrel and closed point string are driven to the target sampling depth, after which the closed point string is retrieved leaving the barrel and open tube sampling system in-place. The sampler is driven to the target depth in the subsurface using the DPT rig, after which the entire string is removed from the borehole to retrieve the sample.

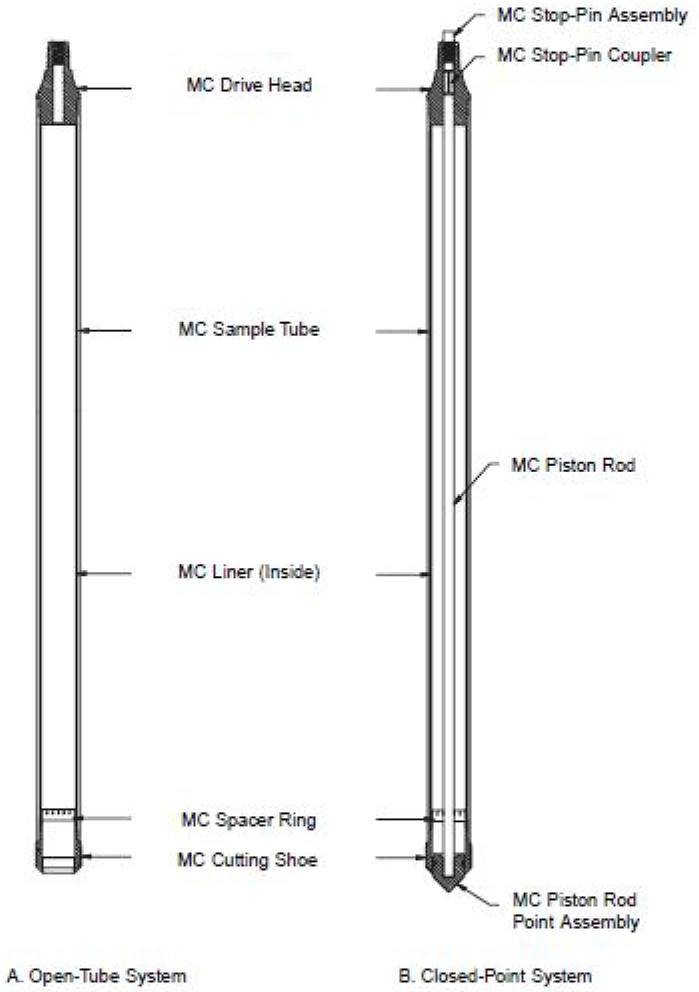
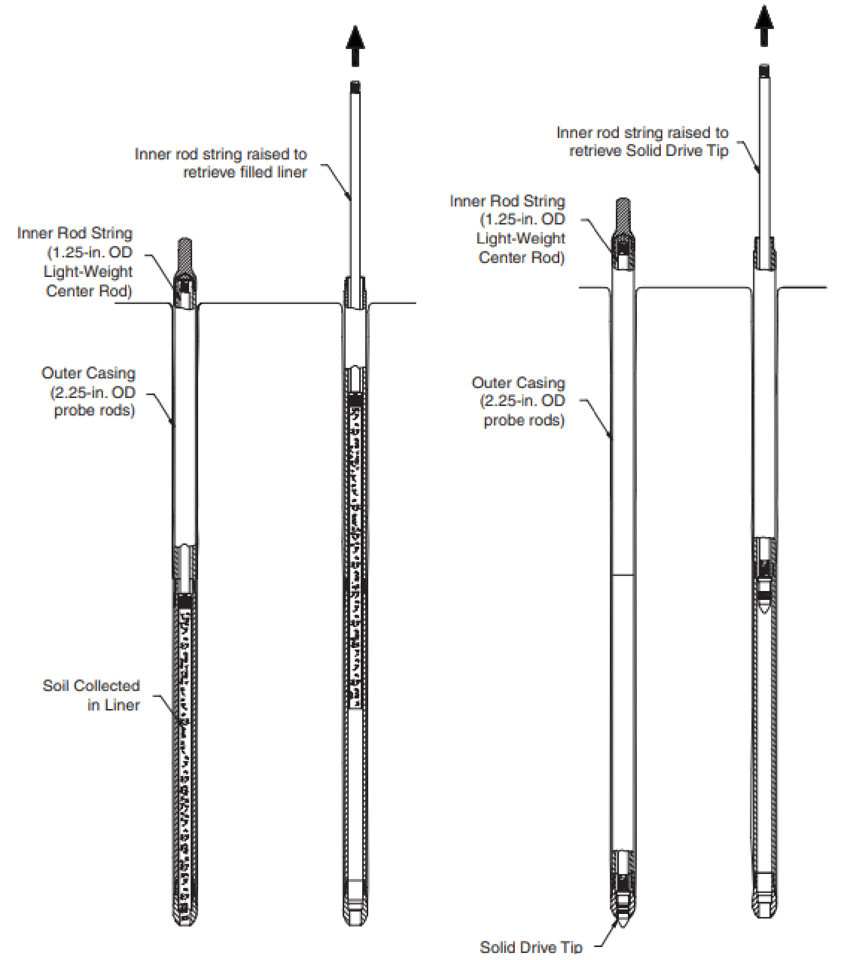


Figure 2: Single Tube DPT System (Source: Geoprobe)

C. The dual tube DPT soil sampling system allows sampling of subsurface soils from within a sealed outer casing. It uses an outer casing that remains in place during sample retrieval and an inner rod and liner string for sample collection. A cutting shoe is installed at the leading end of the outer casing probe rod. The inner string assembly (i.e., inner rod and sample liner) is installed within the outer casing. If the first sampling interval is not the ground surface, a solid drive tip (discrete point) is used on the leading end of the inner rod string instead of a sample liner to seals the assembly as it is driven into the subsurface. The dual tube system with the discrete point is then driven to the top of the target sampling interval, at which point the inner string is retrieved, and the discrete point is removed from the drive head and replaced with a liner. The inner rod with the liner is then inserted into the outer casing, which is extended with an additional casing. A drive cushion is then placed on top of the inner rod and a drive cap placed over the entire assembly. The whole string is driven to the target sampling depth, after which the inner rods and liner with sample are retrieved from the outer casing.



(a) Outer Casing Driven with Liner (b) Outer Casing Driven with Solid Drive Tip

Figure 3: Dual Tube DPT System (Source: Geoprobe)

FIELD GUIDANCE DOCUMENT NO. 1.02

SAMPLE NAMING, LABELING, HANDLING, SHIPPING AND CHAIN OF CUSTODY

RAMBOLL ENVIRON

FIELD GUIDANCE DOCUMENT NO. 1.02

SAMPLE NAMING, LABELING, HANDLING, SHIPPING AND CHAIN OF CUSTODY

Prepared By:	Chris Buzgo Taryn Correll Melanie Charles
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Applicable To:	All North American offices
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Revision Notes:	1. Revised company name and format.
Documents Used as Reference During Preparation:	US EPA Region 4, 2007. *Sample and Evidence Management*.

CONTENTS

ATTACHMENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines and procedures established by Ramboll Environ for sample management including identification, labeling, handling/packaging, chain-of-custody, and transport. A sampling event could be dismissed if sample containers are broken in transport, samples are improperly labeled and unable to be reconciled, or chain-of-custody practices are not followed. Therefore, proper sample management is essential to the production of data of reliable quality that can be used for decision-making.

Although this FGD provides guidelines for managing samples from the time of collection through transfer to the laboratory for analysis, it should be understood that for certain projects more specific procedures may be applicable, including state-specific or regulatory program-specific guidelines, requirements or procedures.

Similarly, these guidelines may not be applicable to ongoing projects with a previously established sample nomenclature that does not correspond to the naming conventions outlined in this FGD, which may be important to adhere to for the sake of continuity and consistency. Specific requirements for these types of projects and activities will be reviewed by the Ramboll Environ Principal-in-Charge / Project Director (PIC) and Project Manager (PM) and any additional requirements will be defined in a project-specific Work Plan, sampling plan and/or project-specific FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans but rather a general reference for developing project specific requirements. In addition, PICs and PMs are encouraged to provide additional direction or training to junior scientists and engineers for the implementation of the procedures outlined in this FGD.

Procedures discussed herein are primarily for the most common types of sampling conducted – soil, water, sediment, soil vapor, and/or air. Other types of sampling events (e.g., sampling of concrete, biota, etc.) may require additional steps to those described in this FGD. For media that are not as commonly sampled, this FGD should be reviewed in the context of project-specific sampling requirements, and modified as applicable.

It should be noted that this FGD does not supersede Ramboll Environ Health and Safety procedures or Site-Specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail.

2. EQUIPMENT / MATERIALS

Equipment and materials necessary to conform to this FGD include:

2.1 Sample Labeling / Chain-of-Custody

- Paper towels.
- Laboratory Sample Label.
- Bound Field Notebook – lined high-grade 50 percent rag paper with a hard-cover and water-resistant surface (e.g., “Rite-in-the-Rain”) or appropriate field forms.
- All Weather Pens or (weather permitting) other indelible ballpoint pens with black or blue ink.
- Watch (or other time keeping device).
- Clear tape.
- Laboratory Chain-of-Custody (COC) Forms.
- Gallon-size or larger plastic zip top bags or other clear plastic to insert the COC form.

2.2 Sample Packaging / Transport

- Coolers (or original Summa canister shipping container for air or soil vapor sampling).
- Ice.
- Ice scoop.
- Gallon-size or larger plastic zip top bags or other clear plastic to fill with ice.
- Quart and gallon-size plastic zip top bags for sample containers (solids or aqueous).
- Padding (bubble wrap, Styrofoam packing material, etc.).
- Packing tape.
- Scissors.
- Custody seals.
- Black indelible ink pen.
- Post-it notes.
- Tape, zip tie, or other items to attach COC to coolers/sample shipping containers.
- Shipping air bill (FedEx pre-filled forms with Ramboll Environ’s account info are available).

3. PROCEDURES REFERENCED

- All field sampling FGD categories.
- **FGD 1.01**, Field Notes and Records.
- **FGD 1.03**, Data Management.

4. PROCEDURES

After collection, samples will be managed in conformance with the provisions outlined in the following sections. After sample shipment, copies of the final signed COC should be kept in the project file. A completed COC (inclusive of signatures from the laboratory), which should be provided with the laboratory data deliverables, should also be kept in the project file. An example completed COC is included in **Attachment A**.

In general, a standard sample naming convention should be used. The sample identification scheme should ensure that samples, including quality control samples (e.g., trip blanks), will be uniquely identified between events. Thus, in developing the sample identification scheme, historical data and reports should be reviewed to establish a location identification scheme which ensures that locations will be uniquely identified.

4.1 Sample Identification

Every sample collected must be associated with a unique identifier. Prior to mobilization, field personnel should confirm with the PM or PIC the sample name format to be used since there may be occasions when the standard sample identification (ID) format detailed in this FGD is not applicable. For example, an ongoing project with a previously established sample nomenclature that does not correspond to the naming conventions outlined in this FGD, which may be important to adhere to for the sake of continuity and consistency. Similarly, field personnel should confirm with the laboratory any limitations on the number of characters that can be used to identify a sample (a partial list of the analytical laboratories typically used by Ramboll Environ is provided in Attachment B of **FGD 1.03**, Data Management). In the absence of project specific instructions, the following scheme, which limits the sample ID to 18 characters, is recommended.

The recommended sample name or ID will consist of an alphanumeric describer that will identify the site name, sample type, sample location, sample depth (if applicable), and sample collection date using the following convention:

- The first three identifiers in the sample name will consist of a three-letter acronym for the study site (e.g., samples collected from an ABC Industries site might have ABC as the first three identifiers in the sample ID) or alternatively, if the name of the study site is too long or the borings are being advanced on properties adjacent to the study site, the first three identifiers could also be RE (short for Ramboll Environ).
- Following the site name portion of the sample ID will be a dash and one of the following modifier designating the type of sample:
  - Outdoor Air – OA;
  - Duplicate Sample – DS;
  - Effluent – EF;
  - Indoor Air – IA;
  - Influent – IN;
  - Injection Well – IW;

  - Midfluent – MD;
  - Monitoring Well (permanent) – MW;
  - Monitoring Well (temporary) – TW;
  - Hydropunch HP;
  - Piezometer – PZ;
  - Production Well – PW;
  - Recovery or Extraction Well – RW or EW;
  - Rinse Blanks – RB;
  - Sediment Sample – SE;
  - Soil Boring – SB;
  - Soil Vapor (i.e., outside of a building) – SV;
  - Sub-Slab Soil Vapor – SSV;
  - Surface Soil – SS;
  - Surface Water – SW;
  - Trip Blank – TB;
  - Waste Characterization – WC; or
  - Investigation-Derived Waste - IDW.

- Following the sample location code will be a two or three digit numeric designation indicating a unique location for that type of sample. For example, a soil sample collected from boring number 3 would have a sample type code of SB and a two digit numeric designation of 03. Thus, samples from this location would be referred to as SB03 or SB003, rather than SB3).
- For aqueous media (i.e., groundwater, surface water, QA/QC samples), and soil vapor sampling (i.e., indoor air, ambient air, soil vapor) the depth code will be followed by a six digit numeric code indicating the date the sample was collected (yymmdd). Non-aqueous samples such as soil and sediment samples will utilize a four digit acronym designating the top of the sampling interval in feet (e.g., 07.5 representing a sample collected from 7.5 feet below the ground surface or 10.5 representing a sample collected from 10.5 feet below the ground surface).
- Field duplicates will be labeled as ordinary field samples with a unique identification number. Duplicate samples should not be identifiable by sample ID alone so as to reduce the potential for bias and allow the laboratory to analyze them as “blind” quality control samples. Thus, in the event that multiple samples are collected on the same day from the same location (i.e., a duplicate sample), the designation “DS” (duplicate sample) will be used in place of the parent sample’s sample type code and a sequential numeric designation will be assigned in place of the numeric location code. This sequential numeric designation will be “01” for the first duplicate sample collected that day, “02” for the second duplicate sample collected that day (from another sample location, media, etc.), and so on. Subsequent duplicate samples collected on multi-day

sampling events should be numbered sequentially (e.g., -“03” from the previous day’s sampling).Since obvious links between the parent and duplicate samples in the Sample ID are to be avoided, it is very important to document in the field logbook or field notes which sample is the parent sample to each duplicate.

- Additional sample volumes collected for matrix spike (MS) and matrix spike duplicate (MSD) analysis will be noted on the COC forms, and no special designations will be used in the sample container labels.

For aqueous media (i.e., groundwater, surface water, QA/QC samples), the sample location code can also be followed by a single-letter acronym designating the well depth (e.g., bedrock (B), deep (D), intermediate (I) or shallow (S)) or the approximate depth the sample was collected.

Following are some sample name examples:

- A shallow soil sample collected from 3.5 feet collected from soil boring location 12 at ABC Industries on March 22, 2012 would be designated as “ABC-SB012-03.5”. The complete depth sample range would be recorded in the field logbook or field notes.
- Groundwater samples collected from three different intervals at temporary well point location 3 at ABC Industries on March 22, 2012 could be designated as “ABC-TW003S-120322,” “ABC-TW003I-120322,” and “ABC-TW003D-120322” depending on the requirements of the project-specific Work Plan, sampling plan and/or project-specific FGDs.
- Paired indoor air and sub-slab soil vapor samples collected from location 3 at ABC Industries on March 22, 2012 would be designated as “ABC-IA03-120322” and “ABC-SSV03-120322”, respectively.
- A duplicate of the groundwater sample collected from temporary well point location 3 at ABC Industries on March 22, 2012 (see example above), which is the second duplicate sample collected that day, would be designated as “ABC-DS02-120322”. Document in the field logbook or field notes which sample is the parent sample to each duplicate.

4.2 Sample Labeling

Sample labels shall be attached or otherwise adhered to all sample containers. If multiple containers comprise a sample, the label should identify the container number relative to the total number of containers (e.g., 3/4 or 3 of 4). The following procedures should be followed when labeling samples:

- Properly label samples immediately before or immediately following sample collection. Record the following information on each label in indelible black or blue ink (non-Sharpie):
  - Project/Site name;
  - Sample location/sample ID;
  - Sampling date;
  - Sampling time (except for Quality Assurance/Quality Control “QA/QC” samples);

  - Analyses to be performed;
  - Preservative;
  - Ramboll Environ as the company name; and
  - Sampler initials.
- Wipe sample containers clean of any debris/water to allow the label to be attached.
- Double-check the label information to make sure it is correct. Remove the backing from the label and apply the label to the sample container. Cover label with clear tape.
- Bag the sample and place it in the designated sample cooler. Make sure there is plenty of ice in the cooler at all times. Maintain the samples at 4±2°C from the time of sample collection until delivery to the laboratory.
- Summa canisters and regulators should be returned to their original shipping container (e.g., typically cardboard boxes).
- Sampling information, including the QA/QC sampling time, should be reflected in the field notebook or on field forms, along with the following information:
  - The location of the sample in relation to reference points.
  - Field screening measurements (e.g., photoionization detector [PID] readings), when appropriate.
  - Whether the sample is a QC sample (e.g., split sample, field duplicate, or rinse sample).
  - Any unusual or pertinent observations (oily sheen on groundwater sample, odors).
  - For soil vapor samples record the summa canister and corresponding regulator serial numbers, building interior and outdoor temperatures, sample start and stop times, negative pressure start and stop readings, summa canister size, and atmospheric pressure.

4.3 Sample Packaging

While samples should be kept in the sampling cooler(s) at 4±2°C from the time of collection, it is not always feasible during sampling to pack samples as required for transport to the laboratory. At the end of the sampling day, sample packaging for transport to the laboratory should be conducted in an organized and clean area (free of potential cross-contaminants). The following procedure should be followed to prepare the sample(s) and cooler(s) for transport:

- Gather coolers/sample shipping containers, ice, zip-lock bags, and padding, as appropriate.
- Containerize ice in zip-lock bags (double bag) and place a layer of ice bags on the bottom of the cooler.
- Place a layer of padding on top of the ice bags and then begin placing the properly labeled samples in the cooler. Do not bulk pack – be sure to provide padding between sample bottles.

- Once the layer of padded sample containers is full (but not over-packed), place another layer of padding material on top of the sample containers.
- An additional layer of double-bagged ice can be added on top of the padding layer for additional cooling.
- Use multiple coolers if one cooler does not provide sufficient capacity to hold all samples along with appropriate amounts of padding and ice. It is preferable to use more coolers and more padding rather than over-packing and crowding the samples, as sample integrity may be compromised during transport.
- Confirm that each cooler used contains a temperature blank.
- Confirm that a trip blank has been included with the samples if the sampling plan and analyses (e.g., volatile organic compounds [VOCs]) call for use of a trip blank. Ensure that all samples to be analyzed for VOCs are placed in the same cooler as the associated trip blank. If necessary, use more than one trip blank.
- Close coolers/shipping containers and group them together for transport.

4.4 Sample Chain-of-Custody

Sample Chain-of-Custody (COC) forms shall be filled out as soon as practicable after collection of the samples, but can also be cross-checked during the packaging of the samples for transport to confirm that all samples/blanks have been accounted for on the COC. COCs are legal documents and should be filled out carefully and accurately. An example completed COC is included in **Attachment A**.

- The following information should be provided when completing the COC (use indelible black or blue ink ball-point):
  - Project Manager Name and Contact information for report submittal.
  - Sampler’s name.
  - Analyses Turn-Around Time (typically standard unless otherwise directed).
  - Project/Site name and location (municipality/state). Try to use a consistent Project/Site Name when re-visiting a site for multiple sampling events.
  - Regulatory Program.
  - Sample ID for each sample.
  - Sample collection date and time for each sample.
  - Sample matrix for each sample.
  - Number of sample containers for each sample.
  - Analyses requested for each sample.
  - Sample matrix and air sample volume, if appropriate.
  - Sample preservation method.
  - Indicate whether samples are field filtered or require filtering in the laboratory.

  - Special instructions or notes to the laboratory (for example, expedited turnaround or holding samples for analysis pending results of other samples).
  - Signatory information when relinquishing samples (signature, company, date and time of recipient and sample releaser) – see below.
  - Note Delivery Service (e.g., laboratory courier or Federal Express) and air bill Number (if applicable).
  - For vapor samples, record the summa canister and regulator serial numbers, building interior and outdoor temperatures, sample start and stop times, negative pressure start and stop readings, summa canister size, and atmospheric pressure, if required by the laboratory, a project-specific Work Plan, sampling plan and/or project-specific FGDs.
- If a minor mistake is made when filling out the COC, cross out the error with a single line and write your initials and date next to the error. Major errors in transcription require that a new COC form be completed to ensure legibility of information on the original and carbon copy pages of the COC form.
- The use of quotation marks or other terms to indicate repetitive information within a column should be avoided. If several entries in a row are repetitive, place a continuous vertical arrow through the cells from the first entry to the next different entry.
- If additional instructions or information is necessary to provide to the laboratory, provide these details on the COC (usually within the “remarks” section) – do not enclose additional pages of instructions.
- If more than one COC form is necessary to accommodate all of the samples being transported to the laboratory use consecutive numbers to identify the additional COC forms (i.e., Page 1 of ___, Page 2 of ___, etc.).

4.5 Sample Transport

Maintaining the chain-of-custody is just as important during sample transport as it is during sampling activities. Note that a sample is considered to be in custody if:

- It is in the actual possession of an investigator (sampler);
- It is in the view of an investigator (sampler), after being in their physical possession;
- It was in the physical possession of an investigator (sampler) and then they secured it to prevent tampering; and/or
- It is placed in a designated secure area.

Option 1

The preferred method of transporting the collected samples under chain-of-custody to the laboratory is for the sampler/field personnel to hand-deliver the cooler(s)/container(s) of samples to the laboratory. When this transport method is possible, the following procedure must be followed:

- Once you have finished completing the COC, place it in a zip-lock bag without signing the “relinquished by”/”received by” (or equivalent) signatory boxes. Keep this outside of, but with, the packaged cooler(s).
- Place two (2) custody seals on opposite corners of each packaged sample cooler (across the opening) and sign/date each custody seal.
- Transport the properly packed and padded cooler(s) and the COC to the laboratory.
- The sampler/field staff must meet with the laboratory representative that accepts sample drop-offs (it is unacceptable to leave samples at a front desk or anywhere without having a laboratory representative sign off on receipt).
- Upon meeting the laboratory representative, sign your name on the COC in the “relinquished by” signatory block. Write the current date and time next to your signature.
- The laboratory representative will then sign their name in the “received by” signatory block using the same date and time. The samples are no longer under the sampler/field staff’s custody and chain-of-custody will continue with the laboratory throughout analysis of the samples.
- The laboratory representative will provide you with one of the carbon copies of the COC, which you should maintain with the project files/field logbooks.

Option 2

The second most preferred method of transporting samples to the laboratory is to arrange a laboratory courier pick-up at the site at the end of the sampling day. The arrangements should be made with the laboratory in advance (usually during the ordering of sampling containers) to plan when and where the laboratory courier service will meet the field staff at the site. When this transport method is used, the following procedure must be followed:

- Once you have finished completing the COC, place it in a zip-lock bag without signing the “relinquished by”/”received by” (or equivalent) signatory boxes. Keep this outside of, but with, the packaged cooler(s).
- Take the properly packaged cooler(s) and COC and meet with the laboratory courier service representative at the predetermined time and location at the site.
- Upon meeting the laboratory courier representative, sign your name on the COC in the “relinquished by” signatory block. Write the current date and time next to your signature.
- Place two (2) custody seals on opposite corners of each packaged sample cooler (across the opening) and sign/date each custody seal.
- The laboratory courier representative will then sign their name in the “received by” signatory block using the same date and time. The samples are no longer under the sampler/field staff’s custody and chain-of-custody will continue with the laboratory courier service and the laboratory throughout transport and analysis of the samples.
- The laboratory courier representative will provide you with one of the carbon copies of the COC, which you should maintain with the project files/field logbooks.

Option 3

If it is not possible for the field staff to drop off the samples at the laboratory or a laboratory courier service to pick up the samples on the same day of collection at the project site, arrangements can be made for the laboratory courier service to pick up the samples the following day at the Ramboll Environ office (assuming next day pick up is consistent with the stipulated hold time for all samples). The courier pickup arrangements should be made with the laboratory in advance (usually during the ordering of sampling containers), if possible. When this third transport method is used, the following procedure must be followed:

- Once you have finished completing the COC, place it in a zip-lock bag without signing the “relinquished by”/”received by” (or equivalent) signatory boxes. Keep this outside of, but with, the packaged cooler(s).
- Place two (2) custody seals on opposite corners of each packaged sample cooler (across the opening) and sign/date each custody seal.
- Transport the properly packaged coolers/shipping containers and COC from the site back to the Ramboll Environ office.
- Place the properly packaged coolers/shipping containers in the field room (a locked, secure space).
- Remove the COC from the zip-lock bag and sign your name on the COC in the “relinquished by” signatory block. Write the current date and time next to your signature.
- Do not write anything else or sign anywhere else in the “relinquished by” or “received by” signatory spaces.
- Place a post-it note on the COC that indicates the number of coolers/shipping containers (if more than one) that should accompany that COC. Return the COC to the zip-lock bag.
- Leave the COC with the coolers in a fashion that will ensure the COC does not get separated from the coolers. For example, the COC could be taped to the cooler/shipping container; a zip-tie could be placed through the zip-lock bag and attached to the handle of a cooler, etc.
- If there are multiple cooler/shipping containers that will be left with the one COC, place notes or some other indicator on each of the coolers to denote which coolers/shipping containers belong to the same group.
- Leave coolers/shipping containers and COC in secure field room, ensuring that the door to the field room is locked behind you.
- For sampling events that require leaving more than one cooler/shipping container in the field room with the COC, the sampler should notify and send photo-documentation of the sample locations to office personnel (those that might possibly get called when the laboratory courier arrives for pick-up the following day) to alert them to the group of coolers/shipping containers and any marks/notes placed on the coolers to group them together.
- When the pre-arranged laboratory courier pickup occurs, it is possible that another field staff member (other than the original sampler) will receive the call to transfer the

samples to the laboratory courier. Whoever receives a call to meet with the laboratory courier should meet the courier at the field room if the original sampler is not able to.

- The Ramboll Environ staff member meeting the courier should review the COC/post-it note to confirm how many coolers/shipping containers should be included in the grouping. This staff member should also confirm that the correct number of coolers/shipping containers are grouped together with the COC. If the staff member is unsure or has any questions about what coolers correspond to the COC, the staff member should call the original sampler.
- Once the staff member has confirmed that all the coolers/shipping containers are accounted for with the COC, they should remove the COC from the zip-lock bag.
- The staff member then signs the “received by” signatory block next to the original sampler’s signature. The staff member should put the date and time next to their signature that was used by the original sampler on the previous day. For example, if Sampler A signed the COC at 17:55 on 3/22/12 and Staff Member B met with the courier the following day, Staff Member B signs the COC as “received by” on the same line as Sampler A signed “relinquished by” and Staff Member B also puts the date and time of their signature as 17:55 and 3/22/12. This accounts for the samples being in a secured Ramboll Environ space after the original sampler placed them there (i.e., in Ramboll Environ’s custody) and Staff Member B signs off at the same time/date as the original sampler because they are acting as a representative of Ramboll Environ.
- The staff member then signs off on the second line in the “relinquished by” signatory block and writes the CURRENT date and time (current as of when the courier is there for pick-up).
- The laboratory courier representative will then sign in the “received by” block on the second line and will use the same current date/time. At this time, the samples are no longer under Ramboll Environ’s custody and the chain-of-custody will continue with the laboratory courier and the laboratory through transport and analysis of the samples.
- The laboratory courier representative will provide you with one of the carbon copies of the COC, which you should maintain with the project files/field logbooks.

Option 4

Some sampling events may take place at sites that are not in the same general geographic region or that require analyses that are only performed at laboratories that are not located within driving distance. In these cases, samples may need to shipped to the laboratory from the project site (or the Ramboll Environ office). Due to the variations in out-of-state laboratories and transportation requirements based on preservatives and sample material, a specific plan for sample transport should be discussed between the sampling field team and the project’s PM or PIC to ensure that all laboratory and Federal/State transportation requirements are met. In general, the following steps should be considered when planning sample transport using a shipping service (e.g., FedEx, UPS, etc.):

- Package samples with more padding than would normally be used in field vehicle/ laboratory courier road transport.
- Consider the amount of ice required to keep samples cool for the duration of the trip to the laboratory.

- Samplers should sign the “relinquished by” signatory block of the COC with the date and time when they drop off the samples for shipment. Then place the COC in a zip-lock bag and place it in the cooler to be shipped. Place signed custody seals on the cooler and then secure the cooler closed with tape around the entire seal of the opening and then around the cooler (perpendicular to the opening) to ensure the cooler is secure during shipping.
- Consider the preservatives used with the samples. Based on United States Environmental Protection Agency (USEPA) research and subsequent negotiation with the US Department of Transportation (USDOT), environmental samples do not need to be declared as “hazardous materials” when they (or the preservative used with them) fall below a certain weight percent limit for certain acids/bases. The concentration of constituents expected in samples and preservatives should be compared to regulations to see if special hazardous materials handling applies.
- Consider USDOT, International Air Transport Association (IATA), and any other Federal/State transportation regulations governing the shipment of hazardous materials or dangerous goods.
- Shipping papers need to be retained with the COC, and sampling staff must confirm tracking to receipt by lab. The sampler must verify that all of the containers shipped arrived at the lab.

5. PRECAUTIONS

All field activities require recording sufficiently detailed information throughout the implementation of field work. However, certain precautions should be taken to ensure safety while preparing samples for shipment and recording the required information.

- It is important to always remain alert and aware of your surroundings and wear a high visibility safety vest. Activities associated with the labeling and preparation of samples for shipment should be performed away from active work areas or traffic areas, preferably in a field office or on the back of a field truck.
- To prevent laboratory bias in analysis of QA/QC samples (e.g., field duplicates), do not name or assign times to quality control samples with a similar sample ID as the parent sample. Since the duplicate sample’s sample ID will not have a direct indication of what parent sample it is related to, the parent and quality control sample information should be recorded in field logbooks or forms.
- Should samples need to be preserved over longer time periods (e.g., weekend), replenish ice in the cooler as needed to ensure that the samples are preserved at 4±2°C until delivery to the laboratory. Avoid placing samples in refrigerators or freezers.
- Consider potential for hazardous materials within sample media or sample preservatives. Consult Federal and State regulations to determine if special hazardous materials handling procedures must be followed on a project by project basis.

6. RECORDKEEPING

Record all information related to the release of samples in accordance with **FGD 1.01**, Field Notes and Records. After the COC is signed, by both the releaser and receiver of samples and the samples are transferred, obtain a copy of the signed COC. A completed COC (inclusive of signatures from the laboratory) should be provided with the laboratory data deliverables. Maintain both copies of the COC with the project files along with copies of associated shipping air bills (if used) and other sampling documentation.

Records should be managed in accordance with Ramboll Environ's Document Retention Policy, with copies of COCs, air bills, lab bottle order documentation, and sampling plans specific to a sampling event maintained together within the project files.

00WSITESOP\PRIN_WP\38000v2

ATTACHMENT A
SAMPLE COMPLETED COC FORM

RAMBOLL ENVIRON

CHAIN-of-CUSTODY

№ 09901

PAGE 1 of 1

☐ 18100 Von Karman Ave., Suite 600
Irvine, CA 92612
(949) 261-5151
(949) 261-6202 (fax)

☒ 707 Wilshire Blvd., Suite 4950
Los Angeles, Calif. 90017
(213) 943-6300
(213) 943-6301 (fax)

☐ 1702 E Highland Avenue, Suite 412
Phoenix, AZ 85016
(602) 734-7700
(602) 734-7701 (fax)

MSA#: SWBU-2015-123 WO#: SWBU-2014-122

PROJECT NAME / FACILITY ID: ABC INDUSTRIES

FIELD PERSON: JOHN DOE

PROJECT NUMBER: 05-12345A DATE: 03-24-14

PROJECT MANAGER: JANE SMITH

PROJECT LOCATION: 123 LOS. ALAMOS RD., LOS ANGELES, CA

LABORATORY: TESTAMERICA

IS THIS A UST PROJECT OR IS EDF REQUIRED? Y [✓ N] IF YES, GLOBAL ID #:

SAMPLER: JOHN DOE

SIGNATURE: John Doe

SAMPLE I.D. NUMBER	YEAR 2014 SAMPLE DATE	SAMPLE TIME	SAMPLE DEPTH (ft)	AIR SAMPLE VOLUME (L)	MATRIX (A) AIR (S) SOIL (G) GAS (W) WATER	NUMBER OF CONTAINERS	FILTERED/UNFILTERED (F/U)	PRESERVATION (SEE KEY)	ANALYSIS REQUIRED VOCS 8260B	TITLE 22 METALS 6010B/7471	PERCHLORATE 314								COMMENTS
ABC-TB-140324	3/24	0715	–	–	W	2	U	H	2										
ABC-MW011-140324	↓	1000	30	–	W	5	U	H	3	1	1								Filter metals
ABC-DS01-140324		–	–	–	W	5	U	H	3	1	1								in laboratory
ABC-SB002-5.0		1300	5.0-5.5	–	S	3	–	–	3										
ABC-RB-140324		1315	–	–	W	3	U	H	3										Send EDD to
ABC-SB002-10.0		1330	10.0-10.5	–	S	3	–	–	3										jsmith@environcorp.com
TOTAL	X	X	X			21													

John Doe 3/24/14

RELINQUISHED BY: John Doe	TIME/DATE: 3/24/14 1600	RECEIVED BY: Bob Bulder (COMPANY): TestAmerica	TIME/DATE: 3/24/14 1600	TURNAROUND TIME (CIRCLE ONE)	SAME DAY 24 HOURS 48 HOURS 72 HOURS 5 DAYS [✓ NORMAL]
RELINQUISHED BY: BoBulder TestAmerica	TIME/DATE: 3/24/14 1815	RECEIVED BY: SuzQue (COMPANY): TestAmerica	TIME/DATE: 3/24/14 1815	SAMPLE INTEGRITY INTACT: [✓ Y] N Temp 2.9°C	IF SEALED, SEAL INTEGRITY INTACT: [✓ Y] N
RELINQUISHED BY:	TIME/DATE:	RECEIVED BY: (COMPANY):	TIME/DATE:		

H = HCL; N = HNO3; S = H_2SO; U = UNKNOWN; NO = NONE; O = OTHER

FILE: LOG FORMS\Chain_of_Custody

FIELD GUIDANCE DOCUMENT NO. 1.07

PFAS SAMPLING

FIELD GUIDANCE DOCUMENT NO. 1.07

PFAS SAMPLING

Prepared By:	Jim Fenstermacher
Peer Reviewed By:	Jose Sananes Matthew Traister Jason Wilkinson Steve Luis Paul Hare Scott Hayter Clifford Yantz Carol Serlin
Approved By:	J. Mark Nielsen, PE
Applicable To:	North American offices
Effective Date:	October 6, 2020
Revision Date:	March 30, 2022
Revision Notes:	1. Clarification on Trizma use, updated Attachments A and B.
Documents Used as Reference During Preparation:	California State Water Quality Control Board Division of Water Quality, Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines, March 20, 2019. Department of Defense (DoD) Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Data Quality Workgroup, United States Department of Defense and Department of Energy Consolidated Quality Systems Manual (QSM) for Environmental Laboratories Version 5.3, May 2019. ITRC, Site Characterization Considerations, Sampling Precautions, and Laboratory Analytical Methods for Per- and Polyfluoroalkyl Substances (PFAS), March 2018. Michigan Department of Environmental Quality, General PFAS Sampling Guidance, October 16, 2018. U.S. Environmental Protection Agency, Validated Test Method 8327: Per-and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), June 2019. U.S. Environmental Protection Agency Office of Research and Development, EPA Method Development Update: Per- and Polyfluoroalkyl Substances (PFAS), April 16, 2019.

This document will be routinely evaluated and updated as new information becomes available. Updates to this FGD will be posted to the Site Solutions FGD SharePoint Site.

CONTENTS

ATTACHMENTS

1. INTRODUCTION

This Field Guidance Document (FGD) supplements and modifies the general guidelines provided in other FGDs developed by Ramboll US Consulting, Inc. (Ramboll) where environmental samples are to be collected for laboratory analysis of per- and polyfluoroalkyl substances (PFAS). These supplemental guidelines are based on evolving and ongoing recommendations being developed by various regulatory agencies (refer to **Attachment A**). While this document focuses primarily on groundwater sampling procedures, the guidelines presented in this FGD can be readily applied to sampling of other media (i.e., soil, surface water, sediment, storm and sanitary sewers). Consult with the PFAS Subject Matter Expert (SME) team (refer to **Attachment B**) to develop site-specific procedures for these media and other associated activities (e.g., drilling, well installation).

Due to the widespread use of PFAS (applications include food wrappers, water repellent outdoor gear, firefighting foams, mist suppressants, wire/cable coatings, specialty fabrics, and even car wash and ski wax materials) and the very low target detection limits (nanograms per liter, ng/L), specific measures should be implemented during sampling for PFAS to enhance sample integrity and generate representative data. Potential causes of non-representative PFAS results stem from (a) most commonly, the inadvertent introduction of PFAS into the sample through sampling equipment/supplies, personal care products (PCAs) and personnel protective equipment (PPE), or (b) the inadvertent loss of PFAS to the environment or equipment used in sample collection, which is less common but still requires diligence on the part of the sampling team. The procedures outlined in this FGD are to be used along with the latest versions of the PFAS Pre-Sampling Checklist in **Attachment C**.

Although this FGD supplements guidelines for collection of samples associated with typical field activities and projects, it should be understood that for certain projects, more specific sampling procedures, including site-specific or state-specific or regulatory program-specific guidelines, requirements, or procedures may be applicable. Specific requirements for each project will be reviewed by the Ramboll Principal-in-Charge/Project Director (PIC/PD) and Project Manager (PM) in consultation with the PFAS SME team (refer to **Attachment B**), and any additional requirements will be defined in a project-specific Work Plan, Field Sampling Plan, or Quality Assurance Project Plan (QAPP). It should be emphasized that this FGD is not meant to serve as a project-specific work plan, but as a reference for developing project-specific requirements.

This FGD does not supersede Ramboll health and safety procedures or site-specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. Ramboll employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP, followed by approved site-specific procedures, which may include those in this FGD. The Ramboll PIC/PD and/or PM shall verify that project field personnel review and sign the applicable HASP, and that the signed HASP and relevant project information are maintained in the project file for the duration of the project, or as established by Ramboll's applicable document handling and retention policies. The signatures of the PIC/PD and/or PM indicate approval of the methods and precautions outlined in the site-specific HASP.

For ease of reference, the procedures outlined in this FGD are color coded as follows:

- A red dot (●) identifies items or materials that are understood to contain PFAS or that PFAS are used in their manufacture and **should not be used** when sampling for PFAS.
- A yellow triangle (▲) identifies items or materials for which the potential for PFAS bias or cross-contamination is not fully understood and **may be allowable with special considerations** and/or adjustment to protocols after consultation with the PFAS SME team (refer to **Attachment B**).
- A green square (■) identifies items or materials that are understood to not be sources of PFAS bias or cross-contamination and are **allowed or preferred** when sampling.

2. EQUIPMENT/MATERIALS

Equipment and materials required for environmental sampling for PFAS analyses are generally the same as those typically required for collection of environmental samples for other analyses, except that PFAS sampling will impose certain restrictions to avoid use of PFAS containing items or material to avoid potential PFAS bias or cross-contamination. Refer to Equipment/Materials requirements detailed in the FGD for the specific sampling activity being performed, as modified in **Section 4.1** below.

Additional equipment may be specified in the site-specific HASP, Work Plan, Field Sampling Plan, or QAPP. More specialized sampling equipment may be required depending on the media being sampled, site conditions, and project-specific needs. Field personnel should understand and be familiar with the operation and safe handling of the equipment and materials that are required for PFAS sampling. A PFAS Pre-Sampling Checklist is provided in **Attachment C**. Refer to **Section 4.1** of this FGD regarding specific sampling equipment and material limitations.

3. REFERENCED GUIDANCE DOCUMENTS

The following FGDs may relate to this FGD and should be reviewed prior to mobilization, as needed, with the provision that content of this FGD supplements and modifies these FGDs due to the unique requirements related to PFAS sampling (e.g., restrictions on equipment and materials, the types and frequency of quality control [QC] samples):

- **SPI 27**, Subsurface Clearance.
- **FGD 1.01**, Field Notes and Records.
- **FGD 1.02**, Sample Handling, Shipping, and Chain of Custody.
- **FGD 1.03**, Data Management.
- **FGD 1.04**, Documenting Sampling Locations.
- **FGD 1.05**, Field Quality Control Samples.

- **FGD 4.04**, Field Screening – Water Quality.
- **FGD 4.06**, Equipment Calibration.
- **FGD 5.04**, Surface Soil Sampling.
- **FGD 5.05**, Soil Sampling for VOC Analysis.
- **FGD 5.07**, Subsurface Soil Sampling - Direct Push.
- **FGD 5.08**, Subsurface Soil Sampling - Split Spoon and Shelby Tube.
- **FGD 5.09**, Soil Boring Log Preparation.
- **FGD 5.15**, Stockpile Sampling.
- **FGD 5.16**, Soil Sampling for PCBs.
- **FGD 6.02**, Groundwater Sampling.
- **FGD 6.04**, Groundwater and Free Product Level Measurements.
- **FGD 6.06**, Temporary Overburden Well Installation and Sampling.
- **FGD 6.07**, Well Development.
- **FGD 6.09**, Groundwater Sampling - Private and Domestic Wells.
- **FGD 6.16**, Groundwater Sampling – Free Product/NAPL.
- **FGD 6.19**, Groundwater Sampling – Hydra Sleeves.
- **FGD 6.20**, Groundwater Sampling - Low Flow.
- **FGD 7.01**, Surface Water Sampling.
- **FGD 8.01**, Sediment Sampling.
- **FGD 8.05**, Sediment Pore Water Sampling.
- **FGD 14.01**, Sampling Equipment Decontamination.
- **FGD 15.01**, Waste Handling.
- **FGD 15.02**, Waste Sampling.
- **FGD 16.02**, Storm and Sanitary Sewer Grab Sampling.

The list above is not intended to be all-inclusive. Other FGDs and Standard Practice Instruction (SPI) may need to be referenced based on the specific requirements of a site-specific Work Plan, Field Sampling Plan, or QAPP (e.g., field screening FGDs, FGDs for sampling of other media, etc.).

4. PROCEDURES

4.1 Planning and Design Considerations

Strategic decisions will be approved by the PIC/PD and/or PM in consultation with the PFAS SME team before the initiation of associated field activities, and will be documented in the Work Plan, Field Sampling Plan, and/or QAPP. The Work Plan, Field Sampling Plan, and/or QAPP will be designed for the collection of quality data to meet the objectives of the site activities and will include information such as the location, depth, number of samples per location, and the laboratory analyses to be performed on each sample, as well as quality assurance/quality control (QA/QC) requirements. The Work Plan, Field Sampling Plan, and/or QAPP will generally provide some discretion in the field depending on the conditions encountered; however, significant departure from prescribed sampling activities should be discussed with and approved by the PIC/PD and/or PM.

When planning a PFAS sampling event, the following should be considered:

- *Laboratory Analysis*. The current state of practice for laboratory analysis for PFAS is continuing to evolve. The United States Environmental Protection Agency's (EPA's) third Unregulated Contaminant Monitoring Rule (UCMR3) required that Method 537 be used to analyze UCMR3 samples for perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), and four other PFAS in drinking water. Since then, Method 537.1 has been developed to quantify 18 PFAS in drinking water (including HFPO-DA or "GenX") using solid phase extraction (SPE) and liquid chromatography/tandem mass spectrometry (LC/MS/MS). EPA has also developed Method 533 to quantify 25 PFAS in drinking water by isotope dilution, anion exchange, SPE, and LC/MS/MS.

  The EPA is currently in the process of validating laboratory methodology for analysis of PFAS in non-drinking water matrices, including surface water, groundwater, wastewater, and solids. For non-drinking water samples, some U.S. laboratories have been commonly using "modified" methods based on Method 537.1. These modified methods often lack consistent sample collection or analytical guidelines and have not been validated or systematically assessed for data quality by a regulatory agency. However, most well-known laboratories can provide analysis of non-drinking water matrices using a modified Method 537.1 where the precision and accuracy are typically suitable to meet Ramboll's project objectives, with reporting limits typically in the ng/L or micrograms per kilogram (ug/kg) range for liquids and solids, respectively. For analyzing matrices other than drinking water, regulatory acceptance may be enhanced if the laboratory complies with quality control requirements provided in Table B-15 of the United States Department of Defense and Department of Energy Consolidated Quality Systems Manual (QSM) for Laboratories Version 5.3 dated 2019 (or later).

  As of the date of this document, EPA is currently developing several analytical methods for media other than drinking water, including:

  - **Method 8327**, which is designed to measure a group of 24 PFAS compounds in groundwater, surface water, and wastewater samples and is expected to:
    - Incorporate direct injection instead of SPE.
    - Retain LC/MS/MS for analyte resolution.
    - Not incorporate isotope dilution.
    - Be similar to American Society for Testing and Materials (ASTM) Method D7979 (a currently validated method for non-potable media).
    - Include a 24-analyte target compound list, including HFPO-DA ("Gen-X").
    - Allow sample holding times of 28 days.

        - Have target quantitation limits of 10 ng/L.
    - **Method 8328**, which is being developed to measure PFAS compounds in groundwater, surface water, wastewater and solid (soils, sediments, biosolids) samples expected to:
        - Retain SPE and therefore be a more complex method relative to direct injection.
        - Retain LC/MS/MS for analyte resolution.
        - Incorporate isotope dilution to account for matrix effects (e.g., sorption).
        - Intended to be more robust for complex matrices (e.g., wastewater influents, biosolids).
        - Include a 24-analyte target compound list, including HFPO-DA ("Gen-X").
        - Allow sample holding times of 28 days.
        - Have target quantitation limits of 10 ng/L.
    - **Method 3512**, which is a preparation procedure for diluting non-potable water samples with an organic solvent prior to analysis by the appropriate determinative method for PFAS in order to minimize sample size and solvent usage. The method is currently an appendix to Method 8327, but is expected to eventually become a standalone method.

  The laboratory methods to be used in support of a site-specific PFAS sampling program should be evaluated at the earliest stages of sampling program development, and should be discussed with the PFAS SME Team and/or the local regulatory agency(ies), as appropriate (refer to **Attachment B**).

  In addition, as outlined in **Section 4.8** below, consideration for QC sampling should be discussed with the laboratory at the early stages of planning or designing a PFAS sampling program.

- *Sample Preservation*. As detailed in **Section 4.6**, Method 537.1 is a drinking water method and specifies the use of Trizma as a preservative for PFAS samples to remove any residual free chlorine. However, Trizma does not have a functional purpose for environmental samples, and **should not** be used for preservation of non-drinking water or non-chlorinated water samples. Note, however, *that laboratories will typically supply Trizma pre-preserved bottleware unless otherwise directed*. Therefore, unless Trizma is specifically required for the project *communicate early and clearly* with the laboratory to ensure that pre-preserved bottleware ***will not*** *be provided*.
- *PFAS-Free Water*. Water used for equipment decontamination should be "PFAS-free." For the purpose of this FGD, PFAS-free water is defined as water that does not contain any site-specific target PFAS analytes above laboratory detection limits. Since site or public water supplies have been identified in many instances to contain detectable levels of PFAS, confirmation of PFAS-free public water, if public water will be used for equipment decontamination on the project, through laboratory analysis should be performed prior to the commencement of work. Alternatively, laboratory-supplied and verified PFAS-free water can be used for sampling equipment decontamination.

- *Sampling Equipment*. PFAS sampling equipment can be divided into three major groups:
    - Equipment and materials to be **avoided**, which includes:
        - ● Polytetrafluoroethylene (PTFE), including the trademarks Teflon® and Hostaflon®.
        - ● Fluorinated ethylene propylene (FEP), including the trademarks Teflon® FEP, Hostaflon® FEP, and Neoflon®.
        - ● Polyvinylidene fluoride (PVDF), including the trademark Kynar®.
        - ● Polychlorotrifluoroethylene (PCTFE), including the trademark Neoflon®.
        - ● Ethylene-tetrafluoroethylene (ETFE), including the trademark Tefzel®.
        - ● Trademarks Viton®, Gore-Tex® and Decon 90® products with the term "fluoro" in the product name.
        - ● Waterproof field notebooks.
        - ● New clothing, as it may have fabric treatment applied.
        - ● Post-It® notes or similar.
        - ● Decon 90®.
    - Equipment and materials that **may be permissible** pending discussion with a PFAS SME team member, which includes:
        - ▲ Chemical or blue ice is not known to be manufactured with PFAS-containing compounds; however, its use is to be avoided because blue ice packs are typically used across multiple sites and sampling events and may cross-contaminate samples from prior exposure to PFAS.
        - ▲ Aluminum foil.
        - ▲ Low-density polyethylene (LDPE) does not contain PFAS in the raw material but may contain PFAS contamination from the manufacturing process and should be avoided unless: (a) the manufacturer certifies the LDPE as PFAS-free; (b) it has been previously tested and demonstrated not to contain PFAS; and/or (c) an equipment blank of the product has been collected before initiation of field work to confirm the LDPE product does not impart measurable PFAS mass to the sample. For example, Ramboll has found equipment blanks performed on the LDPE double-bonded tubing from Leroy Plastics (Le Roy, NY) used for operating bladder pumps has consistently yielded non-detection results.
        - ▲ Glass can sorb PFAS mass (specifically PFOS and other higher molecular weight PFSAs), potentially suppressing the analytical results. Unless alternate materials are not available, sample contact with glass surfaces should be avoided.
        - ▲ Rental equipment, pumps, pressure washers, etc., where prior uses, care of maintenance, and an understanding or control of all relevant internal parts are not known.
        - ▲ Permanent markers (e.g., Sharpies®) may be used in the staging area, but not the sampling area.

  - Equipment and materials that are **preferred for use**, which include:
    - Loose-leaf paper, or notebooks that have not been coated with waterproofing materials may be used to record field notes.
    - LDPE storage bags (e.g., Ziploc®) that do not come into direct contact with the sample media may be used.
    - High-density polyethylene (HDPE), polypropylene, silicone, or acetate may be used.
    - HDPE, polypropylene, polyurethane, polyvinylchloride (PVC), silicone, stainless steel, neoprene, and nylon twine a permissible to come in contact with sampling media.
    - Alconox®, Liquinox® and Citranox® branded products may be used for equipment decontamination.
    - Waxed fabrics and well-washed cotton fabrics are preferred materials for clothing.
    - Double-bagged water ice.
    - Ball point pens or pencils are preferred for taking notes or writing in the sampling zone.
    - Hercules Megaloc® thread compound by Oatey.
    - Poly-Sal® brand drilling fluid additive/lubricant and PFAS-free pipe thread compounds that contain degradable guar gums are preferred materials to be used by drillers.

- *Field Clothing and Personal Protective Equipment*. Due to the extensive use of PFAS in many industries and products, and their unique properties in water and oil repellency, clothing (e.g., pants, jackets, boots, shoes, gloves, and jackets) and PPE may contain PFAS. During a PFAS investigation, clothing and PPE containing PFAS should be avoided to prevent cross-contamination. While preparing for sampling and to the extent reasonably possible, avoid clothing that has been advertised as having waterproof, water-repellant, or dirt and/or stain resistant characteristics as these types of clothing are more likely to have had PFAS used in their manufacturing. Consult with a PFAS SME as necessary, and allow common sense to prevail. For instance, a treated insulating undergarment used in the winter and covered by layers of well-washed over garments should be of little concern. Well-worn, treated work boots should likewise be of limited concern, provided typical care is taken to avoid excessive boot-to-equipment contact and boots are kept away from environmental samples or clean equipment when not being worn. Conversely, use of a brand-new treated rain jacket or newly treated boots should be avoided.

  Unless required by the site-specific HASP, field clothing and PPE to be **avoided** include:

  - Clothing that has recently been washed with fabric softener.
  - Coated (i.e., yellow) Tyvek®.
  - Clothing chemically treated for insect resistance and ultraviolet protection.

- Clothing that has been treated with water and/or stain resistant coatings such as:
    - Any Teflon® fabric protectors (e.g., Gore Tex)
    - Any Scotchgard™ fabric protectors
    - Bionic Finish®
    - GreenShield®
    - High-Performance Release Teflon®
    - Lurotex Protector RL ECO®
    - NK Guard S series
    - Oleophobol CP®
    - Repel Teflon® fabric protector
    - Repellan KFC®
    - Resists Spills™ and Releases Stains™
    - RUCO®
    - RUCO-COAT®
    - RUCO-GUARD®
    - RUCO-PROTECT®
    - RUCOSTAR®
    - Rucostar® EEE6
    - RUCOTEC®
    - Ultra Release Teflon®
    - Unidyne™

The types of field clothing and PPE that are **permissible** include:

- ▲ Latex gloves may be used if necessary to satisfy site-specific HASP requirements; however, large sampling programs should consider submitting a sample of the glove material for testing of PFAS content. Further, some regulatory agencies or states (e.g., California) prohibit the use of latex sampling gloves, and latex gloves should not be used by individuals who are sensitive or allergic to latex.
- ▲ Weather-proof boots may be used as they are not likely to be in significant contact or proximity to sampling equipment (assuming best practices are followed).
- ■ Powderless nitrile gloves.
- ■ PVC or wax-coated fabrics.
- ■ Clothing made from, containing, or treated with neoprene, polyurethane, or PVC.
- ■ Synthetic and natural fibers (preferably cotton) that are well-laundered (more than six times with no fabric softener) clothes and cotton overalls.
- ■ Non-coated (i.e., white) Tyvek.

- *Sun and Biological Protection*. Because sun and biological hazards (sunburn, mosquitos, ticks, etc.) may be encountered during sampling, the elimination of specific clothing materials or PPE (sunscreens and insect repellants) could pose a health and safety hazard to staff. The safety of field and contract staff must be the primary focus of decisions around site-specific field procedures and selection of sun and biological protection. With that in mind, however, any necessary deviations from this PFAS FGD must be made in consultation with a member of the Ramboll PFAS SME team.

  Ideally, rather than repellants and sunscreens, the preferences are (a) tucking pant legs into socks and/or boots to reduce exposed skin and reduce the risk of being bitten by ticks; (b) wearing well-washed, light-colored clothing to easily see ticks during field activities; and (c) wearing light-colored clothing, long sleeves, and large-brimmed hats to avoid sunburn. However, if it is necessary to use sunscreens and insect repellants, the following guidance is provided: (a) do not apply products near the sample collection area; (b) wash hands well following application or handling of sunscreen and/or repellents, and (c) subsequently don powderless nitrile gloves for the sampling activities.

Other entities (e.g., the states of California, Michigan and New Hampshire) are constantly testing and updating products, the most recent of which have been listed below, to evaluate PFAS content. If required, sun and biological protection products **preferred for use** (however, care should be taken to use these exact products because similar products from the same brand may contain PFAS) include:

- Alba Organics Natural Sunscreen
- Aubrey Organics
- Avon Skin So Soft Bug Guard-SPF 30
- Baby Ganics
- Banana Boat for Men Triple Defense Continuous Spray Sunscreen SPF 30
- Banana Boat Sport Performance Coolzone Broad Spectrum SPF 30
- Banana Boat Sport Performance Sunscreen Lotion Broad Spectrum SPF 30
- Banana Boat Sport Performance Sunscreen Stick SPF 50
- California Baby Natural Bug Spray
- Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30
- Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50
- Coppertone Sunscreen Stick Kids SPF 55
- Herbal Armor
- Jason Natural Quit Bugging Me
- Jason Natural Sun Block
- Kiss My Face
- L’Oréal Silky Sheer Face Lotion 50+
- Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50
- Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70
- Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70
- Neutrogena Beach Defense Water + Sun Barrier Spray Broad Spectrum SPF 30
- Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+
- Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30
- Repel Lemon Eucalyptus
- Sawyer Permethrin
- Yes To Cucumbers

▲ In addition, products listed as “baby-safe, “free,” or “natural” are typically PFAS-free, however any of the above products are preferred

Some sampling guidance documents recommend that personal hygiene and personal care products (PCPs; e.g., cosmetics, shampoo, sunscreens, dental floss, toothpaste, etc.) not be used prior to and on the day(s) of sampling over concerns regarding the potential presence of PFAS in these products. If sampling protocols are followed however, these items should not come into contact with sampling equipment or samples being collected, and employing best practices while sampling will minimize the potential that these products, PFAS-containing or not, bias the PFAS analytical results. The following precautions should be taken when dealing with personal hygiene or PCPs before sampling:

- ● Do not handle or apply PCPs in the sampling area.
- ● Do not handle or apply PCPs while wearing PPE that will also be worn during sampling.
- ▲ For best practices, shower at the end of the workday.
- ▲ Hair nets can be used if hair care products are a concern as a potential PFAS source.
- ■ Move to the staging area and remove PPE if applying PCPs becomes necessary.
- ■ Wash hands after the handling or application of PCPs and, when finished, put on a fresh pair of powderless nitrile gloves.

- *Food Packaging*. PFAS have been used by the paper industry as a special protective coating against grease, oil, and water for paper and paperboards, including food packaging, since the late 1950s. PFAS application for food packaging includes paper products that come into contact with food such as paper plates, food containers, bags, and wraps. In January 2016, the Food and Drug Administration banned the use of PFAS having eight or more carbon atoms (e.g., PFOA, PFOS and PFNA); however, short-chain PFAS have not been banned for use in the manufacturing of contact food materials in the U.S. and may still be present in the coating materials of some food wrappers.

  When staff require a break to eat or drink, they must remove their gloves, coveralls, and any other PPE in the staging area and move to the designated area for food and beverage consumption (e.g., the "clean zone"). When finished, staff must wash their hands, then don any coveralls or other PPE, and, lastly, put on a fresh pair of powderless nitrile gloves immediately before sampling.

  Other procedures to be followed include:

  - ● Avoid handling, consuming, or otherwise interacting with pre-wrapped food or snacks, carry-out food, fast food, or other food items while on-site during sampling events.
  - ■ Move to the staging area and remove PPE prior to leaving the sampling and staging areas if consuming food on site becomes necessary.

- *Filtration*. Field-filtration must be avoided as field filtering may result in potential cross contamination. Further, PFOS and higher molecular weight PFSAs may sorb onto glass filters in the field or in the lab. If field-filtered samples for PFAS or other analytes are to be collected because of a client or regulator request:

- Request clarification from the client or regulator regarding the intent of collecting filtered results (field or laboratory) and whether those results will be meaningful and/or necessary to meet the overall project goals for the PFAS sampling program.
- Use low-flow sampling to the extent practical to avoid field-filtration.
- Consider the use of centrifugation by the laboratory instead of filtration.
- If filtering cannot be avoided, do not use glass, and control for the use of field-filtration by collection of equipment blanks from the filters and filtering equipment in contact with the samples and, if possible, a spiked (positive) control provided by the laboratory.

4.2 Pre-Field Work Preparation Guidelines

Before initiating field activities, field staff should review and complete pertinent tasks identified in **FGD 2.02** (Site Preparation, Inspection and Housekeeping). Further, to the extent that non-dedicated, non-disposable equipment is to be used (e.g., water level indicator, trowel), to minimize potential cross-contamination between sampling locations (e.g., monitoring wells, soil borings), such equipment should be decontaminated before use as described in **Section 4.4** of this FGD. Used disposable equipment (e.g., tubing) that is considered investigation derived waste (IDW) should be managed in accordance with **FGD 15.01** (Waste Handling) following the sampling event.

At a minimum, the following tasks should be completed to prepare field staff for implementation of the work:

- Review and sign the site-specific HASP.
- Comply with **SPI 27**.
- Coordinate and obtain permission for site access (as necessary).
- Review the project-specific Work Plan, Field Sampling Plan, and/or QAPP, where applicable.
- Review and discuss with the PIC/PD and/or PM the proposed Work Plan, Field Sampling Plan, QAPP or other sampling and testing strategy documentation.
- Document that the equipment and materials required to complete the work have been secured and packed prior to travel.
- Confirm sampling locations.

When ordering equipment or sampling materials, be sure to specify with the rental company and laboratory representative that the equipment is to be used for a PFAS sampling program. Analytical laboratories will need to supply suitable containers without affecting the concentration of constituents in the sample. Reputable field equipment rental companies will have their own protocols for preparing and supplying equipment intended for use in PFAS sampling programs, including such things as supplying multiparameter probes and water level meters that have been modified or specially manufactured to be Teflon-free and PFAS-free. Similarly, confirm that drillers and other subcontractors are aware that the proposed field activities will include sampling for PFAS constituents, and that all materials brought on site are to be PFAS- and Teflon-free. For example, a potable or non-potable water source to be used for equipment decontamination on a drilling program may need to be pre-tested to demonstrate that it is PFAS-free.

Particularly for large sites where equipment is driven from sampling location to sampling location, consider using two dedicated vehicles – a "dirty" vehicle used for transport and handling of ancillary equipment, and a "clean" vehicle used for transport and handling lab water, fresh tubing, ice packs, bottleware, and coolers with samples.

Prior to initiating groundwater sampling activities, field personnel should field-verify the well identity and construction against available documentation (site plans, well construction logs, etc.). Typically, groundwater sampling or testing FGDs recommend "tagging" the bottom of the well as one means to verify the correct well is being sampled. In order to minimize introduction of materials and equipment into wells during PFAS sampling, it is recommended that for PFAS sampling depth-to-water readings necessary for low-flow sampling be collected first, followed by sampling for PFAS and any other required analytes, and last of all the well bottom be "tagged" for identification verification if necessary. If the well is found to have been incorrectly sampled, discard or relabel the samples, note in the field log, and notify the PM accordingly.

If dedicated equipment is encountered inside a monitoring well, obtain depth-to-water readings prior to disturbing the equipment, remove all equipment prior to sampling, and document (with photos, recommended) equipment encountered and measures taken prior to sampling. If the equipment or materials of construction are suspected of potentially compromising the PFAS sample integrity, contact the PM and PFAS SME team. Further, prior to the commencement of the field effort, field personnel should inspect, test, and/or calibrate equipment that may be used to take field measurements (refer to **FGD 4.06**, Equipment Calibration).

A preferred sampling sequence should be established in the Work Plan, Field Sampling Plan, and/or QAPP before the sampling event to reduce the risk of cross-contamination. In general, sampling should begin in areas where PFAS concentrations are known or expected to be lowest (i.e., upgradient or farthest downgradient), proceeding systematically to areas known or expected to have the highest PFAS concentrations (i.e., source areas). Samples known to be upgradient from all source areas should be sampled first, followed by those lateral to the suspected source areas, and then by those that are farthest downgradient from the suspected sources. Remaining locations should be progressively sampled from the most distant downgradient to those closer to the known PFAS source, moving upgradient. Bear in mind "upgradient" may mean relative to groundwater movement and/or dominant air depositional directions.

When evaluating multiple aqueous media, consider carefully the order of sample collection. Assuming "typical" levels of PFAS in the environment, a multi-media sample collection scheme could be in the following order:

- Drinking water (e.g., residential wells).
- Surface water.
- Groundwater.

- Wastewater and/or leachate waters.

If collecting surface water and sediment samples, the surface water sample at a given location should be collected before the sediment sample, and the sampling should proceed from downstream sampling locations to upstream sampling locations. Since the concentration of PFAS at the air-water interface may be higher than the concentration within the water column, surface water samples should generally be collected from below the air-water interface unless defined otherwise in the Work Plan, Field Sampling Plan, and/or QAPP.

4.3 General PFAS Sampling Guidelines

This FGD provides recommended practices for sampling of environmental media for PFAS analysis in addition to those related to the sampling activity itself.

- When sampling for PFAS, avoid placing samples in direct contact with cloth surfaces inside vehicles, especially newer vehicles.

- Subcontractors, as for Ramboll staff, are required to abide to the PFAS sampling requirements and restrictions outlined in the Work Plan, Field Sampling Plan, and/or QAPP. Once on site, inspect all lubricants, detergents, and any other equipment that will or could come in contact with environmental media to confirm that the subcontractor has understood and conforms to the requirements and restrictions outlined in the Work Plan, Field Sampling Plan and/or QAPP.

- Work areas may be covered areas with plastic (HDPE or LDPE) as long as no direct contact is made with the sampled media.
- If dedicated sampling equipment is found in a well, avoid using any in-well dedicated equipment for PFAS sampling until it is established to be PFAS-free. The equipment needs should be evaluated to see if it could be a source for PFAS as follows:
  - Retrieve the equipment from the well and collect an equipment blank from the equipment.
  - Sample the well using non-dedicated equipment brought to the site for the PFAS sampling program.
- At a minimum, change gloves between each sampling location, after collecting each QC sample, and after handling any non-sampling equipment (i.e., clipboards, coolers, sample labels, etc.).

4.4 Decontamination

All non-disposable equipment to be used in a PFAS sampling event should be decontaminated prior to first use, between sampling locations, and at end of each workday as described in **FGD 14.01** (Sampling Equipment Decontamination), the project-specific Work Plan, Field Sampling Plan, and/or QAPP. In addition:

- Laboratory-supplied, PFAS-free water should be used for decontamination; commercially available deionized water in an HDPE container, or municipal drinking water, may be used for decontamination if the water is verified to be PFAS-free ahead of the field sampling program.

- Alconox®, Liquinox®, and Citranox® should be used as surfactants for equipment decontamination.
- Decon 90® should **not** be used.
- If sampling equipment requires manual scrubbing, use a polyethylene or PVC brush.
- Decontamination procedures should include a final triple-rinse with PFAS-free water.

When sampling sources (e.g., soil and/or groundwater in source areas, tanks, etc.), a more thorough decontamination should be performed between samples. In addition, increasing the frequency of equipment blanks should also be considered.

4.5 Sample Containers

As outlined in **FGD 1.02** (Sample Handling, Shipping and Chain of Custody), equipment and sample containers that will come into contact with aqueous, solid or gas media should be constructed of materials that will not affect the concentration of constituents in the sample. The sample container requirements should be outlined in the project-specific Work Plan, Field Sampling Plan, and/or QAPP.

All bottles used for PFAS sampling should come from the laboratory that will also be performing the PFAS analysis. Each sample container must be kept sealed at all times and only opened during the sample collection. The sampling container cap or lid must never be placed directly on the ground or on a surface that is not known to be PFAS-free.

The current standard is for samples to be submitted in containers (including caps/lids) made of polypropylene or HDPE. Glass sample containers should not be used due to potential loss of analyte through adsorption to glass. Most laboratories require a minimum volume of 250 milliliters (mL) to perform an analysis, with a duplicate bottle held in reserve in the event of analytical loss of the first bottle. This may change however when other methods are adopted (e.g., 15 ml vials are proposed for Method 8327, and ASTM D7979 requires the use of three vials). Coordination with the laboratory is recommended if collecting samples in an area or from a location where elevated PFAS concentrations are known or expected to occur.

4.6 Sample Preservation

Method 537.1 is a drinking water method and specifies the use of Trizma as a preservative for PFAS samples to remove any residual free chlorine. Trizma does not have a functional purpose for environmental samples and the “modified” Method 537.1 protocols of most laboratories allow for collection of non-reagent preserved samples.

For non-drinking water/non-chlorinated samples (i.e., the vast majority of samples likely to be collected at client sites), **Trizma is not to be used**. Typically, laboratories will include Trizma pre-preserved bottleware unless otherwise directed; therefore, unless Trizma is specifically required for the project, communicate early and clearly with the laboratory to ensure that pre-preserved bottleware **will not** be provided.

Although private supply wells (residential, commercial or industrial) are used for drinking water, samples collected from private groundwater wells (in the well or at the tap) **should not** be preserved with Trizma because drinking water from the well is not likely disinfected with a chlorine-containing product on a regular basis. However, it is good practice to ask if the supply well has recently been disinfected before collecting a sample from the supply well, and if so, then Trizma should be considered for use as a preservative for that sample.

Upon receipt of sampling bottleware, field personnel should confirm receipt of the appropriate (i.e., preserved or non-preserved) bottleware. In addition, because the volume of Trizma preservative (when requested) needs to be accounted for by the laboratory when injecting internal calibration spikes into samples during sample preparation, field personnel should also confirm with the laboratory, or clearly indicate on the Chain-of-Custody record, the preservation status of the samples being shipped.

Samples should be chilled to 4°C to 6°C for preservation, using water ice that is double bagged in polyethylene plastic (i.e., Ziploc®). To avoid potential cross-contamination, reusable chemical or gel-based cooling products should not be used. Samples should be transported to the laboratory daily to maintain sample temperatures near target preservation temperatures with the limited longevity of water ice.

4.7 Sample Transport and Storage

Samples shall be handled, transported and stored in an attempt to maintain the structural integrity of the container and chemical qualities of the samples. Sample bottles should be handled as outlined in **FGD 1.02** (Sample Handling, Shipping and Chain of Custody). Samples should be kept in an ice-filled transport container during field work and covered to limit light penetration. As a typical procedure, laboratories will supply a thick plastic liner with each cooler to keep samples from contacting the inside of the cooler. Field samples and any ice are kept within the liner, which is then tucked and folded so that nothing else can contact the samples, and the Chain of Custody (COC) is placed in a polyethylene (i.e., Ziploc®) resealable storage bag that is placed on the bag and inside the cooler.

4.8 Quality Assurance/Quality Control

The QA/QC procedures should be outlined in the project-specific Work Plan, Field Sampling Plan, and/or QAPP and must be followed throughout the sample collection, processing, handling, and analysis process. In their absence, the QA/QC guidelines of **FGD 1.05** (Field Quality Control Samples) as modified below should be followed.

- *Trip Blanks*. The Trip Blank (TB) consists of a bottle of PFAS-free water that is prepared by the laboratory, shipped to the site (but not opened), and then returned to the laboratory for analysis. TBs are typically not required by regulatory agencies for PFAS analyses, and typically do not yield results meaningfully different from the field reagent blanks (below), but can be collected if requested or required by a specific agency or client.
- *Field Reagent Blanks*. Field Reagent Blanks (FRBs) should be collected during PFAS sampling events. An FRB is generated by manually pouring PFAS-free water in one sample container that is provided by the laboratory into an empty sample container that is also supplied by the laboratory in the field at the location of an environmental sample. An FRB differs from a TB in that the laboratory PFAS-free water is exposed to the sampling environment during the bottle-to-bottle transfer process. The purpose of an FRB is to quantify whether target analytes or other interferences are present in the field

environment, and can help provide insight if PFAS analytes are found in the associated Equipment Blank (EB) but not the TB.

FRBs are helpful in assessing whether the PFAS-free water supplied by the lab remains "PFAS-free" throughout the sampling event and confirming that the bottleware remains PFAS-free as well. One FRB should be collected for every 20 samples of a given medium, or once per event regardless of the number of media sampled if the sampling event is limited to one day. However, the frequency of collecting FRBs is a project-specific decision, and the location(s) of the FRB(s) should be considered in advance of the sampling event in consultation with a PFAS SME team member, with intentional bias towards location(s) where the possibility of introducing ambient PFAS is/are highest.

- *Equipment Blanks*. EBs are used to assess the potential contamination of samples by the equipment used at the site to collect those samples. To collect an EB, PFAS-free water provided by the laboratory is poured over, in, or through a particular piece of sampling equipment (for example, a new, disposable bailer, or a pump that has been decontaminated after its prior use) and collected in a sample container. Conceptually, field crews should attempt to transfer laboratory-supplied PFAS-free water to the EB sample container using the part of the equipment that comes in direct contact with the environmental samples.

  Like FRBs, one EB should be collected for every 20 samples of a given medium, or at least once per event regardless of the number of media sampled if the sampling event is limited to one day. However, the frequency of collecting EBs is a project-specific decision and when considering the number of EBs to collect, in consultation with a PFAS SME team member, thought should be given to the range of concentrations expected to be encountered (e.g., are there orders of magnitude between highest and lowest expected concentrations), the complexity of the field event (e.g., sampling of a limited number of wells, or sampling of multiple media types using multiple sampling devices and techniques), and whether EBs should be collected at the beginning, end, or randomly in the middle of the work day.

  EBs collected adequately through a sampling event can greatly increase data reliability by confirming the adequacy of decontamination methods when laboratory-reported results are consistently non-detect, and by providing insight to where, when and how any systematic issues with field procedures may have arisen if EB analytical results contain detections. For example, and as discussed in **Section 4.4**, it may be advisable to collect EBs at a higher frequency when sampling in a suspected or known source area to minimize the potential for having to qualify or discard an excessive amount of laboratory reported data.

- *Field Duplicates*. Field Duplicate (FD) samples should be collected in accordance with **FGD 1.05** (Field Quality Control Samples). In general, the frequency of FD collection for PFAS should be one per every 20 environmental samples of a given medium, or once per event regardless of the number of samples if the sampling event is limited to one day.

- *Matrix Spike and Matrix Spike Duplicates*. The Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples should be collected in accordance with **FGD 1.05** (Field Quality Control Samples), and are samples into which the laboratory adds a known mass of specific PFAS after receipt and log-in, but prior to analysis. Essentially, collecting an MS/MSD sample pair is the same as collecting two field duplicate samples at a sampling location except that these containers are identified with the sampling location as MS and MSD samples and are not "blind" to the laboratory. Laboratories add known amounts of analytes (typically concentrations at or near the middle of the calibration range) when they perform MS and MSD analyses, so it is often most useful to use locations that are known or believed to have relatively moderate analyte concentrations for collecting the MS/MSD samples such that the laboratory results remain within the instrument calibration limits. The necessity for and frequency of collecting MS/MSD sample pairs is a project-specific decision and depends on several factors (e.g., client, regulatory agency, or regulatory program directives). However, if required or if data validation is to be performed, then a frequency of one MS/MSD sample pair for every 20 environmental samples for each medium, or once per event per sampled media if the sampling event is limited to one day, is recommended.

- *Temperature Blanks*. When used on a project, temperature blanks must be provided by the lab in a new (not previously used) sample bottle of the same type and size of the other aqueous field samples collected during the sampling program. The bottle must be filled with PFAS-free water, must be labeled clearly as the temperature blank, and should remain in the cooler throughout the sampling event.

5. PRECAUTIONS AND OTHER CONSIDERATIONS

Precautions to be taken during environmental sampling for PFAS analyses are generally the same as those typically required for collection of environmental samples for other analyses. Refer to the Precautions and Other Considerations Section of relevant FGDs for the specific sampling activity being performed. For PFAS sampling, the following additional considerations are provided:

- There are far more individual PFAS than can be currently quantitated. Determining which PFAS to quantitate during the analysis is a project-specific determination based on several factors. One important factor to consider is guidance from the relevant regulatory agency. For example, some states have a standard PFAS list (e.g., New York is currently asking for 21 PFAS, and Michigan is currently asking for 28 PFAS). Another factor is the time period of the release and whether it was a legacy event, or possibly a more recent event where quantification of replacement chemicals (e.g., GenX instead of PFOA) could require the use of an expanded analyte list.
- Some states require that only personnel licensed or certified in the state where the work is being performed perform groundwater sampling. Therefore, state regulations and guidance governing groundwater should be consulted prior to conducting the work. In addition, local Ramboll staff should be contacted for any other regional or local requirements.

6. RECORDKEEPING

Document all sampling locations in accordance with **FGD 1.04** (Documenting Sampling Locations) and record all information in accordance with **FGD 1.01** (Field Notes and Records) and **FGD 1.03** (Data Management).

ATTACHMENT A
AVAILABLE PFAS SAMPLING REGULATORY GUIDANCE

Regulatory requirements and guidance related to the sampling and analysis of PFAS are continuously evolving. Thus, recent changes to sampling procedures, target analyte lists, or regulatory requirements in the state where sampling is to occur should be confirmed. Below are links to a representative sample of some of the more active regulatory programs and guidance information.

Consult with a PFAS SME during development of site-specific procedures for environmental sampling and/or other associated activities. In addition, consult the latest guidance or requirements from the regulatory agency of the state in which the work is to be completed, and the additional resources identified below..

US Environmental Protection Agency: https://www.epa.gov/water-research/pfas-methods-and-guidance-sampling-and-analyzing-water-and-other-environmental-media or https://www.epa.gov/pfas

CA: https://www.waterboards.ca.gov/pfas/

MA: https://www.mass.gov/info-details/per-and-polyfluoroalkyl-substances-pfas

MI: https://www.michigan.gov/documents/pfasresponse/General_PFAS_Sampling_Guidance_634597_7.pdf

NH: https://www4.des.state.nh.us/nh-pfas-investigation/

NJ: https://www.nj.gov/dep/srp/emerging-contaminants/

NY: https://www.dec.ny.gov/chemical/108831.html

PA: https://www.dep.pa.gov/Citizens/My-Water/drinking_water/PFAS/Pages/default.aspx

WI: https://dnr.wi.gov/topic/contaminants/PFAS.html

Additional Resources:

Interstate Technology & Regulatory Council: https://pfas-1.itrcweb.org/

US Department of Defense and Department of Energy:
https://denix.osd.mil/edqw/documents/manuals/qsm-version-5-3-final/

ATTACHMENT B
PFAS SME TEAM

PFAS Subject Matter Expert Team

Name	Location	Primary Expertise
Eric Wood*	Westford, MA	Litigation Support/Site Investigation
Jim Fenstermacher*	Blue Bell, PA	Site Investigation/Remediation
Linda Dell	Amherst, MA	Epidemiology
Janet Egli	Nashville, TN	Water, wastewater
Paul Hare	Albany, NY	Site Investigation/Remediation
Debra Kaden	Boston, MA	Toxicology
Matt Longnecker	Raleigh, NC	Epidemiology
Steve Luis	Irvine, CA	CST/Product Stewardship
John Newsted	Lansing, MI	Ecological Risk, Site Investigation, Transport
Mark Nielsen	Princeton, NJ	Site Investigation/Remediation
Jaana Pietari	Westford, MA	Forensics
Imants Reks	Syracuse, NY	Growth Team Lead
Sonja Sax	Amherst, MA	Epidemiology
Rebecca Siebenaler	Princeton, NJ	Human Health/Eco Risk and Due Diligence
Sarah Stoneking	Arlington, VA	CST/Site Investigation
Matthew Traister	Cincinnati, OH	Air Transport
Steve Washburn	Emeryville, CA	Litigation Support
Jason Wilkinson	Westford, MA	Site Investigation/Remediation
Annette Nolan	New South Wales, AUS	ANZ PFAS Lead
Raisa Gabriela Salvi	Sao Paulo, Brazil	South America PFAS Lead
Dorte Harrekilde	Odense, Denmark	Europe PFAS Lead
Aldo Trezzi	Milan, Italy	Europe PFAS Lead

Notes:

* PFAS SME team co-leaders.

ATTACHMENT C
PFAS PRE-SAMPLING CHECKLIST

PFAS Pre-Sampling Checklist

Site Name: ______________________ Task: ______________________

Weather (temp/precip): ______________________ Date: ______________________

Pre-Mobilization:

☐ The QAPP or other site-specific field guidance has been consulted for sample locations, QC sampling requirements, and sample nomenclature

Field Clothing and PPE:

☐ Using white Tyvek®; not using yellow Tyvek®

☐ Clothing has not been most recently washed with fabric softeners or other treatments

☐ Clothing has not been permanently chemically treated for insect resistance or UV protection

☐ Clothing has not been treated with materials or formulations potentially containing PTFE or other PFAS products listed in Section 4.1 of FGD 1.07

☐ Any personal care products, if used, have been applied outside sampling zone, hands have been washed, and new nitrile gloves are being used

☐ Any use of sunscreens or insect repellants is consistent with the commercial products named in Section 4.1 of FGD 1.07

Field Equipment:

☐ Subcontractor (e.g., driller) materials and equipment conform to the requirements of FGD 1.07

☐ Sampling equipment is free of PTFE and other potentially PFAS-containing components listed in Section 4.1 of FGD 1.07

☐ Sampling equipment is made from stainless steel, HDPE, acetate, silicon, high-density polypropylene, or nylon

☐ Waterproof field books, waterproof paper, and Post-It Notes® are not used

☐ Markers (e.g., Sharpies®) are used only in the staging area or are not used

Sample Containers:

☐ Water ice is in use only, not chemical (blue) ice packs

☐ Sample containers have been received and are made of HDPE or polypropylene

☐ Bottleware for non-drinking water samples do not contain preservative

☐ Caps are unlined and made of HDPE or polypropylene

Wet Weather (as applicable):

☐ Wet weather gear made of polyurethane and PVC only, or is being worn under white Tyvek® covering

Equipment Decontamination:

☐ On-site or off-site public or private water, if to be used for equipment decontamination, has been analyzed and is "PFAS-free," as defined in Section 4.1 of FGD 1.07

☐ Alconox®, Liquinox®, or Citranox® are being used as decontamination cleaning agents; Decon 90® is not being used

Food Considerations:

☐ Any pre-wrapped food or snacks, carry-out food, fast food, or other food items will remain in the staging area

☐ Any food items, will be consumed outside the sampling zone, hands will be washed, and new PPE and nitrile gloves will be used

Work Area and Vehicle Considerations:

☐ Work areas, including vehicle interiors if used for sample handling, are covered with HDPE or LDPE plastic to prevent contact with potentially PFAS-containing materials and surfaces

If any applicable boxes cannot be checked, describe deviations below and work with field personnel to address issues prior to commencement of that day's work. Materials present and identified as potentially containing PFAS through use of this checklist should be relocated to the support area or other area of the site away from the sampling locations and noted below.

______________________________ ______________

Field Team Leader Name and Signature Time

FIELD GUIDANCE DOCUMENT NO. 6.04

GROUNDWATER AND FREE PRODUCT LEVEL MEASUREMENTS

RAMBOLL ENVIRON

FIELD GUIDANCE DOCUMENT NO. 6.04

GROUNDWATER AND FREE PRODUCT LEVEL MEASUREMENTS

Prepared By:	Doug Burge Josh Myers
Peer Reviewed By:	Nick Zurweller Jason Schwankert Justine Petras Christopher Ritchie John Noble Luke Chmielecki Carol Serlin Jose Sananes Nestor Soler
Approved By:	J. Mark Nielsen
Applicable To:	All North American offices
Effective Date:	February 21, 2014
Revision Date:	July 12, 2016
Revision Notes:	1. Revised company name and format.
Documents Used as Reference During Preparation:	

CONTENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines established by Ramboll Environ for groundwater level measurements (depth to water) and free product level measurements (depth of free product) in groundwater monitoring wells or piezometers. These guidelines may also be applicable for measuring the depth to water or free product in other types of wells (potable and non-potable) or boreholes as applicable.

Groundwater level measurements are collected to determine the depth to groundwater within a well relative to ground surface, top of the well casing, and/or an established elevation datum. Similarly, free product measurements are collected to determine the depth to non-aqueous phase liquid (NAPL) accumulated within a well relative to an established elevation datum. The accumulated thickness of NAPL within a well can be determined if the bottom of the free product can be additionally measured. Properly collected and recorded measurements can be utilized for generation of potentiometric surface maps to establish groundwater flow direction, define horizontal and vertical hydraulic gradients, evaluate variations in groundwater elevations over time, evaluate NAPL mobility or recovery, and other project specific tasks.

Although this FGD provides guidelines for groundwater and free product level measurements, it should be understood that for certain projects more specific sampling procedures, including state-specific or regulatory program-specific guidelines, requirements or procedures, may be applicable. Specific requirements for these types of projects and activities will be reviewed by the Ramboll Environ Principal-in-Charge / Project Director (PIC) and Project Manager (PM) and any additional requirements will be defined in a project-specific Work Plan, sampling plan and/or FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans but rather a general reference for developing project specific requirements.

This FGD does not supersede Ramboll Environ Health and Safety procedures or Site-Specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. All Ramboll Environ employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP, followed by procedures recommended in this FGD. The Ramboll Environ PIC and PM shall ensure that all project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information are maintained in the project file for the duration of the project. The signatures of the PIC and PM indicate approval of the methods and precautions outlined in the HASP.

2. EQUIPMENT/MATERIALS

Below is a general checklist of equipment that may be required for typical groundwater level measurement efforts. This checklist only suggests general equipment that may be necessary for a project or task and should not be considered exhaustive.

2.1 General Water and Free Product Level Measurement Equipment Checklist

- Electronic water level indicator;
- Electronic oil/water interface probe for wells containing known or suspected NAPL;
- GPS or other locating device;
- Site map showing locations of wells; and
- Well construction records and previous water level measurements.

2.2 Project- or Task-Specific Water and Free Product Level Measurement Equipment Checklist

- Well lock keys;
- Steel tape measure or submersible water level meter for use in measuring total well depth;
- Decontamination supplies /equipment (non-ionic detergent, tub, brushes, etc.);
- Wash bottles/bucket;
- Trash Bags - used to dispose of gloves and any other non-hazardous waste generated during sampling;
- Appropriate waste container – used to dispose of any Investigation Derived Wastes (IDW) and/or decontamination wastes;
- Socket wrench (manhole bolt sizes vary; most commonly require a 9/16” socket);
- Water valve gate box key (for older style flush-mounted wells);
- Pry bar (or other equivalent tool to assist in the removal of the flush mounted well cover or handhole);
- Syringe (or other equivalent tool such as a turkey baster to assist in removing standing water in flush mounted wells); and
- Extra batteries for the water level meter (usually 9-volt).

2.3 Miscellaneous Additional Suggested Equipment

- Extra vehicle keys;
- Metal locator (to find buried/obstructed flush mounted wells);
- First aid kit;
- Mobile phone;
- Credit card for gas and emergencies;
- Road and site maps;
- Chemical protective gloves and other personal protective equipment (PPE) as required by the HASP;
- Field notebook and field data sheets;
- Waterproof pens;

- Bolt cutters (to remove rusted padlocks);
- Replacement padlocks; and
- Camera and extra batteries.

3. REFERENCED GUIDANCE DOCUMENTS

The following FGDs are related to this FGD and should be referenced, as needed:

- **FGD 1.01**, Field Notes and Records;
- **FGD 1.03**, Data Management;
- **FGD 1.06**, Field Surveying and Monitoring Well Elevation Surveying;
- **FGD 2.02**, Site Preparation, Inspection and Housekeeping;
- **FGD 4.06**, Equipment Calibration;
- **FGD 6.15**, Well Construction Record; and
- **FGD 14.01**, Sampling Equipment Decontamination.

The list above is not intended to be all inclusive. Other FGDs and Standard Practice Instruction (SPI) may need to be referenced based on the specific requirements of the site-specific Work Plans/sampling plan (e.g., field screening FGDs, FGDs for sampling of media, etc.).

4. PROCEDURES

4.1 Pre-Field Work Preparation Guidelines

Before initiating field activities, field staff should review and complete pertinent tasks identified in **FGD 2.02**, Site Preparation, Inspection and Housekeeping. At a minimum, the following tasks should be completed to prepare field staff for what may be expected during implementation of the work:

- Review and sign the site-specific HASP;
- Coordinate and obtain permission for site access;
- Review project-specific Work Plan/sampling plan;
- Review project-specific Quality Assurance Project Plan (QAPP), where applicable;
- Review and discuss with PIC and/or PM the proposed activities or Work Plan/sampling plan;
- Review the standard instruction manual provided by the manufacturer of the specific equipment being used for water level monitoring and field screening;
- Inspect the water level meter(s) for any signs of damage and test for proper operation;
- Identify well locations and any specific order in which they are to be collected (refer to Section 4.2 and Section 5.0), and confirm the measurement datum on each well casing;

- Obtain copies of recent or historic (i.e., same season) water or free product level data to be able to anticipate the approximate depth of water or free product minimizing unnecessary wetting of the tape and as a check of the measured levels;
- Obtain copies of well construction records (refer to **FGD 6.15**, Well Construction Record), as these can be used to confirm the well identification if not clearly identifiable; and
- Identify wells that are known or suspected to contain NAPL or other free product. An electronic oil/water interface meter must be used in these wells in lieu of an electronic water level indicator.

All significant field activity decisions will be approved by the PIC and/or PM before the initiation of field activities. The sampling plan should be designed for the collection of quality data that meet the goals of the study/monitoring program. The work plan/sampling plan should generally provide for some discretion in the field depending on encountered conditions; however, any significant departure from prescribed field activities shall be approved by the PIC and/or PM.

Prior to the commencement of the field effort, inspect, test, and/or calibrate equipment that will be used to take field measurements (refer to **FGD 4.06**, Equipment Calibration).

4.2 General Water Level Measurement Guidelines

Water level measurements are generally taken in monitoring wells, piezometers, or boreholes using electronic water level indicators. There are different manufacturers of electronic water level indicators including Solinst, Keck, and Heron. Electronic water level indicators consist of a reel of dual conductor wire embedded within a pre-marked tape, a probe with an insulating gap between the wire attached to the end of the tape, and an indicator on the reel. Generally, tapes are marked every 1/100th of a foot and/or millimeter. When the probe comes into contact with water, the circuit is closed and the indicator signals this contact with an audible buzzer and/or an optical light. The meters typically run on 9-volt batteries located within the reel as a power source. Many water level meters include a sensitivity adjustment on the indicator. The sensitivity adjustment diminishes potential short circuiting of the probe in moist environments such as those encountered in a well.

The following provides a recommended list of practices for water and/or free product level measurement activities:

- Where applicable, contact the identified key site personnel upon arrival to the Site and assess proposed work areas.
- All wells to be gauged should be inspected for damage, access constraints, and/or vehicle traffic proximate to the well location.
- Because groundwater or free product depth can vary due to natural fluctuations in ambient conditions (e.g., barometric pressure), all measurements for a specific sampling event should be collected within as short of a time frame as possible.

- Although equipment should be decontaminated between uses, to further limit potential cross-contamination between wells, perform measurements from least to most contaminated locations.
- All depth to water or free product measurements should be completed prior to any planned groundwater and/or product withdrawals, sampling or disturbance of groundwater unless otherwise specified in the work plan/sampling plan.
- All water or free product level measurements should be made relative to an established reference datum and should be recorded in the field notes. The reference datum is usually marked, notched or etched on the well or casing at the time of installation on the north side of the inner casing. In the absence of a marked, notched or etched reference datum take water level and depth measurements from the north side of the inner casing and mark or etch it for future reference. In the case of a casing notched or etched at a distinct angle, the measurements should be made from the highest point in the casing. Note this procedure in the field book.
- Record in the field book the model name, number, and serial number of the electronic water level meter or interface probe being used.
- Identify the well to be measured and confirm by checking for proper identification markings on the well, comparing to a site map, and if needed historical water and/or product level measurements and well construction records. If the well cannot be positively identified, contact the PIC or PM before proceeding. It may be possible to identify the well by comparison of the total well depth with the well construction records; however, such measurement should be discussed with the PIC or PM before proceeding in cases where the well is to be sampled after water level/free product measurements are collected.
- Decontaminate the water level meter probe, interface probe, and/or tape (if total well depth measurements are being conducted with a tape) prior to each use.
- Remove well cover or equivalent protective casing cover. Inspect the interior of the well box for insects, etc., that could present a biological hazard. If there is water in the well box, remove all water (at least to a level below the top of the inner well casing) prior to removing the well cap or plug. Indicate that water was removed from the well box and identify possible causes (e.g., missing bolts, damaged well cover, etc.).
- Remove the well cap or plug, noting well identification, time of day, and date in field book. Also note any abnormal conditions in the well (e.g., damaged inner casing, limited clearance between the bottom of the well box and the top of the inner well casing, absence of reference datum, etc.) If the top of the well casing has been damaged, the reference datum may no longer be accurate.
- If the wells are outfitted with expansion caps, these should be removed and the wells allowed to equilibrate for an appropriate period of time prior to the collection of water level measurements. This is especially critical for wells screened below the water table or in confined units. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.
- Record observance of positive or negative pressure in the well upon removal of the well cap. The presence of pressure/vacuum in the well could be qualitatively assessed during

loosening and removal of an expansion cap (resulting in air either being audibly pushed out or drawn in to the well casing) or using a piece of paper or other light object (i.e., easily moved or displaced by light air flow) placed immediately above the inner well casing and observing its movement (i.e., if it adheres to well casing, there is a negative pressure in the well; if it moves from the well casing, there is a positive pressure in the well). If pressure was observed, the water level should be measured multiple times over a 5 to 10 minute period to allow time for equilibration and confirm that the water level has reached static conditions.

- Monitor the headspace of well with a field screening device in accordance with the applicable manufacturer instructions and FGD. Record field screening readings in field book. The necessity and methodology to conduct field screening should be detailed in the site-specific HASP and sampling plan.
- Check that the indicator on the water level probe is working properly by pushing the test button on the reel. Replace batteries in the electronic water level meter or product interface probe if testing or operation of indicates the battery is not providing sufficient power. If the battery is replaced during a field measurement event this must be recorded in a field log book.
- Lower the probe slowly into the well taking care to minimize contact with the well casing. If significant kinks are observed in the tape, attempt to straighten manually and record observations in project field book or log.
- When a strong and steady signal from the indicator signals water or free product has been encountered slowly pull the tape up until the signal ceases.
- Manually lower and raise the probe to exactly locate the water or free product interface.
- At the point where the signal indicates free water surface or free product has been encountered, measure and record the depth of the probe using the marked tape.
- If free product is encountered, continue to manually lower the probe into the well until a strong and steady signal from the indicator signals that water has been encountered. Lower and raise the probe to exactly locate the water or free product interface. Measure and record the depth of the probe using the marked tape.
- Measurements should be referenced to the established reference datum.
- Repeat the measurement to verify accuracy. Measurement should be recorded to the nearest 1/100th of a foot or to the nearest millimeter.
- If total well depth measurements are required, these should be made in reference to the top of casing as well as the ground surface. These measurements should be performed after sampling.
- Withdraw the probe from the well, replace the well cap, and re-secure the well.
- Record in the field book any abnormal conditions within the well (e.g., evidence of blockage, root growth into the well casing, separated casing sections, etc.). Inform the PIC or PM so necessary maintenance, redevelopment or repairs are conducted before the next planned water level measurement event.

To minimize potential cross-contamination across wells, decontaminate the probe and portions of the tape that made contact with water and/or product as described in the

FGD 14.01 (Sampling Equipment Decontamination), project-specific sampling plan and/or QAPP.

4.3 QA/QC

Quality Assurance/Quality Control (QA/QC) procedures described in the project-specific Work Plan/sampling plan and/or QAPP must be followed throughout the water level measurement process.

5. PRECAUTIONS

All field activities require recording sufficiently detailed information throughout the implementation of field work. Additionally, implementation of the work may be faced some difficulties. However, certain precautions should be taken to ensure safety while conducting water level measurements.

- Operate electronic water level meters and product interface probes in accordance with the manufacturer's instructions and recommendations.
- The protective casing of flush-mount wells often fills with run-off surface water. If upon removing the well cover, the top of inner well casing is submerged, utilize a syringe, turkey baster, or equivalent tool to remove the excess water before removing the well cap in order to avoid surface water flow into the well.
- Well keys may not work with rusted/outdated well locks; bolt cutters may be used to remove the lock, which should be replaced upon completion of water level measurement. Do not use petroleum based solvent sprays to free seized locks as this may impact water quality in the well.
- Wells with a water-tight cap may experience a buildup of pressure, especially if they are screened below the static water level. Keep your face and body away from the top of the well when loosening or removing the cap.
- Ensure that the water level has reached the static level prior to recording the depth to water. Should the water level be in a state of flux due to pressure buildup, allow ample time for the water level to stabilize to static conditions before recording measurement (refer to Section 4.2).
- Water level probe indicator response may be indicative of potential faults that could be corrected in the field:
  - If the signal from the indicator is intermittent or weak it may be necessary to decrease the sensitivity since it may be short circuiting prior to encountering free water.
  - If there is no signal it may be necessary to increase the sensitivity since some groundwater is less conductive and may not complete the circuit.
  - If the signal is still intermittent, weak, or absent then replace the battery and reattempt the measurement.
- Cascading water may interfere with the measurement of free water; particularly in open boreholes or rock wells.

- Some well casings have sharp edges; care should be taken when lowering or withdrawing the tape to avoid damaging the tape and water level probe.
- Oil or other product floating on the water column may insulate the contacts of the probe resulting in a misleading indication of the depth to free water. A separate oil/water level indicator should be used if there is known or suspected product in a well (refer to Section 4.2).
- It should be noted that some water level indicators will have a 2 to 3 inch weight on the tip of the probe which can displace water in a well before the water indicator detects it. These models also make it difficult to detect small amounts of water in wells, i.e. less than 3 inches. If this is expected to be a potential issue, then request a model with the water indicator located on the tip of the probe.
- Meters should be inspected periodically to ensure accurate readings. Electronic water level meters and interface probes may not function properly if the electric wire is broken, cut, or if insulation is removed exposing the wire (resulting in short circuiting). Repaired meters may have had sections of the tape removed and/or spliced and may not meet data quality objectives. Damaged tapes or tapes suspected of being damaged should be repaired by the manufacturer or replaced.
- If using the water level meter for total depth measurements, confirm that the probe is designed for total immersion and the maximum acceptable depth of immersion.
- Tape lengths can be confirmed using a calibrated steel tape as necessary to adhere to data quality objectives. Discrepancies in tape length must be noted in the field log book and/or field sheet.
- For high conductivity groundwater (brine) decreasing the sensitivity control prevents bridging so a moist probe is not detected as being in water.

6. RECORDKEEPING

Document all water level measurement locations in accordance with **FGD 1.04** (Documenting Sampling Locations) and record all information in accordance with **FGD 1.01** (Field Notes and Records) and **FGD 1.03** (Data Management).

FIELD GUIDANCE DOCUMENT NO. 6.01

PERMANENT OVERBURDEN WELL INSTALLATION

RAMBOLL ENVIRON

FIELD GUIDANCE DOCUMENT NO. 6.01

PERMANENT OVERBURDEN WELL INSTALLATION

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CONTENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines established by Ramboll Environ for installation of permanent wells for environmental purposes in unconsolidated overburden materials using standard drilling techniques. Well installation using direct-push technologies (e.g., Geoprobe®) are discussed in **FGD 6.06** – Direct Push Overburden Well Installation and Sampling. Permanent overburden wells are a part of many environmental and hydrogeologic applications including groundwater wells, and wells for remedial purposes, including injections, soil vapor extraction, air sparging, and other applications.

Although this FGD provides guidelines for well installation in unconsolidated overburden materials, it should be understood that, for certain projects, more specific well design and installation procedures, including state-specific or regulatory program-specific guidelines, requirements or procedures, may be applicable. In addition, for wells to be installed in a multi-layered aquifer system, protective measures such as using double or telescopic casing (i.e., large diameter conductor casing) to seal off groundwater units above the target formation may be needed to prevent vertical cross contamination. Specific requirements for these types of projects and activities will be reviewed by the Ramboll Environ Principal-in-Charge / Project Director (PIC) and Project Manager (PM) and any additional requirements will be defined in a project-specific Work Plan, sampling plan, and/or FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans, but rather a general reference for developing project specific requirements.

It should be noted that this FGD does not supersede Ramboll Environ Health and Safety procedures or Site-Specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. All Ramboll Environ employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP, followed by procedures recommended in this FGD. The Ramboll Environ PIC and PM shall ensure that all project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information is maintained in the project file for the duration of the project. The signatures of the PIC and PM indicate approval of the methods and precautions outlined in the HASP.

2. EQUIPMENT/MATERIALS

Well construction materials shall consist of new, factory-sealed, commercially available well screen and casing. Where materials to be used in well construction are not factory-sealed, their use and cleaning requirements must be previously approved by the PIC and PM prior to installation. Well screens and casing will typically be constructed of polyvinyl chloride (PVC), but may also be constructed of stainless steel or polytetrafluoroethylene (PTFE or Teflon®), or other suitable materials, depending on subsurface conditions, expected contaminants and concentrations, or other site-specific factors. Regardless of material of construction, casing and screen should be generally consistent with applicable standards for use in groundwater monitoring wells (e.g., ASTM F480 *Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios [SDR], SCH 40 and SCH 80* and NSF International/ANSI Standard Number 14: *Plastics Piping System Components and Related*

Materials). Evidence of compliance shall be included in the current NSF listing and display of the NSF seal and markings in accordance with the requirements of ASTM Standard F480 on each section of casing. Plastic well casing must be rated by standard dimension ratio (SDR-rated) and conform to the minimum requirements of ASTM F480.

A general checklist of equipment that may be required for typical installation of groundwater wells is provided below. This checklist includes an overall summary of general equipment typically required for well installation efforts and should not be considered exhaustive. The drilling contractor will generally supply the equipment and materials necessary for drilling and installing the well, and field staff should confirm ahead of time that the driller will supply such materials. Additional equipment may be specified in the project-specific HASP. Ramboll Environ oversight personnel should understand the equipment and materials that are required for the driller to complete the scope of work.

1. General Well Installation Equipment Checklist:
   - Drilling rig and associated equipment (supplied by drilling contractor);
   - Well construction materials (supplied by drilling contractor);
   - Trash Bags - used to dispose of gloves and any other non-hazardous waste generated during well installation (refer to **FGD 15.01**, Waste Handling);
   - 55-gallon steel drums, Department of Transportation-rated (for legal waste hauling), or other appropriate waste containers (may be supplied by drilling contractor unless specialized containers are required) - for disposal of Investigation Derived Wastes (IDW) and/or decontamination wastes (refer to **FGD 15.01**, Waste Handling);
   - Personal Protective Equipment (PPE) and field screening equipment in accordance with the site-specific HASP;
   - Site information (e.g., maps, contact numbers, previous field logs);
   - Well construction specifications and diagrams;
   - Field notebook and test boring and well construction field log forms (if required) and all-weather or permanent pens as outlined in **FGD 1.01** (Field Notes and Records);
   - Weighted, calibrated measuring tape or line for depth measurements during well construction (typically provided by driller);
   - Tremie pipe (typically provided by driller);
   - Measuring tape;
   - Electronic water level indicator (refer to **FGD 6.04**, Groundwater and Free Product Level Measurements); and
   - Labeling materials for Investigation Derived Waste (IDW) containers as outlined in **FGD 15.01** (Waste Handling).
2. Additional Suggested Equipment:
   - Extra vehicle keys.
   - Credit card for gas and emergencies.

  - Road and site maps.
  - Camera and extra batteries.
  - If boreholes are to be logged, soils classification guidance chart as outlined on **FGD 5.01** (Soil and Rock Classification).
  - If boreholes are to be logged, color chart as outlined on **FGD 5.01** (Soil and Rock Classification).
  - If samples are to be collected, sample containers (appropriate for various analysis to be performed), cooler(s), labels, and COCs

3. PROCEDURES REFERENCED

The following Standard Practice Instruction (SPIs) and FGDs are related to this FGD and should be reviewed prior to mobilization, as needed:

- **SPI 27**, Subsurface Clearance.
- **FGD 1.01**, Field Notes and Records.
- **FGD 1.02**, Sampling Handling, Shipping and Chain of Custody**.**
- **FGD 1.04**, Documenting Sampling Locations.
- **FGD 1.05**, Field Surveying and Monitoring Well Elevation Surveying.
- **FGD 1.06**, Field Surveying and Monitoring Well Installation.
- **FGD 5.01**, Soil and Rock Classification.
- **FGD 5.09**, Soil Boring Logs.
- **FGD 6.04**, Groundwater and Free Product Level Measurements.
- **FGD 6.07**, Well Development.
- **FGD 6.15**, Well Construction Record.
- **FGD 15.01**, Waste Handling.

The list above is not intended to be all inclusive. Other FGDs and Standard Practice Instruction (SPI) may need to be referenced based on the specific requirements of the site-specific work plans/sampling plan (e.g., field screening FGDs, FGDs for sampling of media, etc.).

4. PROCEDURES

4.1 Planning and Design Considerations

Wells are designed to (a) enable measurement of the potentiometric surface; (b) allow sampling of a specific water-bearing zone; (c) measure or otherwise evaluate the hydraulic and/or physical properties of the water-bearing zone; and/or (d) assist with the remediation of subsurface media. Specific well design and installation procedures depend on state-specific or regulatory program-specific requirements or guidelines, project-specific objectives, site access constraints, and/or subsurface conditions. Field personnel should understand the reasoning behind the selected screen length, which will help to inform potential field modifications.

During the planning of a well installation, the following should be determined:

- *Anticipated Depth to Water and Subsurface Geology/Overburden Stratigraphy*.
- *Borehole Drilling Method*.
- *Borehole Diameter and Well Diameter.* In general, the borehole diameter is three (3) to five (5) inches greater than the outside diameter of the well screen or well riser pipe. This requirement ensures that sufficient annular space is available to install the filter pack and grout seal around the well screen and well riser, respectively. Other borehole requirements may apply depending on state-specific or regulatory program-specific guidelines or requirements, the type of drilling to be performed (e.g., direct-push Geoprobe®) and the subsurface conditions to be encountered.
- *Well Depth*.
- *Sampling and Logging of Boreholes Requirements.* Refer to soil sampling (**FGD 5.08**: Subsurface Soil Sampling – Split Spoon and Shelby Tube) and borehole logging FGDs (e.g., **FGD 5.01**: Soil and Rock Classification and **FGD 5.09**: Soil Boring Logs).
- *Well Construction Materials.* As described above, well casings and screens shall be constructed of non-corrosive and non-reactive material for the chemicals to be encountered.
- *Filter Pack Thickness, Gradation, and Composition.* Ideally, the well screen and filter pack should be designed based on the results of a sieve analysis conducted on samples collected from the aquifer or the formation that will be monitored. However, for formations consisting primarily of fine grained materials, commercial filter pack designed for a specific screen size could be used (refer to Table 1 below). If you do not have pre-existing knowledge of soil grain size at your site, consider conferring with a local driller to determine an appropriate filter pack size.

Table 1. Commercial Filter Pack

Screen Opening (in)	Typical U.S. Standard Sieve Size for Filter Pack	1% Passing Size (in)	10% Passing Size (in)	30% Passing Size (in)	60% Passing Size (in)	Uniformity Coefficient
0.005 to 0.006	No. 100	0.0035 to 0.0047	0.0055 to 0.0067	0.0067 to 0.0083	0.0085 to 0.0134	1.3 to 2.0
0.010	20 to 40	0.0098 to 0.0138	0.0157 to 0.0197	0.0197 to 0.0236	0.0200 to 0.0315	1.1 to 1.6

Notes:

Source: USEPA, 2013

The filter pack should be the only material in contact with the well screen as it limits subsurface materials from penetrating through the filter pack, and prevents the sand or filter pack from entering the well. It should consist of chemically inert, clean, well-sorted, well-rounded, and dimensionally stable, silica (quartz) sand of which the 80 to 90 percent retained size is greater than the screen aperture. The filter pack material should arrive bagged and labeled. The filter pack material shall be free of clay, dust, and organic material; and shall not consist of any other material that will adversely affect the performance of the well.

- *Transition Sand Layer and Thickness.* If necessary, the transition sand layer consists of a smaller grain size than the filter pack, and it is placed on top of the filter pack to protect against grout intrusion, particularly for deep well installations (greater than 200 feet deep). The thickness of the transition sand can vary from one or two feet to as thick as 10 to 20 feet and can increase the effective aquifer interval sampled by the well. An alternative to transition sands is to use a longer interval of annular seal material such as bentonite pellets.
- *Screen Length and Interval to be Screened*. The well assembly should be designed so that the well screen is placed within the formation target zone. The specific screen length and interval within the zone to be monitored will be selected based on project objectives and regulatory requirements or guidance, and may vary depending on project requirements. For water table wells, well screens should be placed such that a sufficient length of the screened interval is above the water table (typically 2 to 3 feet) throughout seasonal water table fluctuations, and the remainder of the screen is below the water table (typically 7 to 8 feet). Therefore, the total screen length will be dependent on the magnitude of the seasonal water table fluctuations.
- *Screen Slot Type and Size.* Screen slot type and size will be dependent on the gradation of the formation in which the screen will be constructed.
- *Location, Thickness, and Composition of Divider Seal to be Placed Directly Above the Filter Pack.* A divider seal will be placed immediately above the filter pack to separate the filter pack from the grout seal. Divider seal material shall be chemically compatible with anticipated contaminants. Chemically inert, hydrated bentonite chips or pellets are typically used as a divider seal.
- *Thickness and Composition of Annular Seal.* The typical cement-bentonite grout mixture consists of one sack (94 pounds) of Portland Type I/II cement, approximately 2 to 5 percent by weight powdered bentonite, and approximately 6 to 8.5 gallons of water. Additives to accelerate curing times are sometimes added (e.g., calcium chloride).
- *Well Completion and Protection Requirements.* Depending on the location, wells may be completed at the surface with a flush-mounted or stick-up (i.e., extend above the ground surface) protective cover. Local ordinances, well installation codes, and project requirements will often dictate the type of surface completion. Wells located in landscaped areas or asphalt or concrete covered surfaces, especially in areas of vehicular traffic, will typically be finished at the surface with a flush-mounted surface completion. Wells located in unpaved areas, especially in areas where there is little or no vehicular traffic, will typically be finished at the surface with a stick-up surface completion.

It should be noted that the specific well construction details, particularly the screen intervals and depth of each well, may need to be field-determined after consultation with the PIC and PM, and where applicable, a State-licensed Professional Geologist (PG) or Professional Engineer (PE). In addition, where applicable, ASTM D5092 *Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers* or other applicable regulations or guidance documents should be referenced. Factors that should be considered in finalizing the well screen interval include boring lithology, distribution of contaminants (if known), and/or subsurface conditions encountered during drilling. For wells to be completed in a contaminated aquifer above a confining layer, particular care must be taken to avoid penetrating the confining layer during drilling and creating a potential pathway for vertical cross-contamination. If this situation should occur due to unexpected field conditions or any other reason, contact the PIC or PM immediately to determine how best to seal the confining layer interval or entire borehole before proceeding with additional field activities.

4.2 Pre-Field Work Preparation Guidelines

Some states require that only drilling contractors licensed as a water or environmental well driller in the State where the work is being performed should perform well installations. Prior to mobilization, Ramboll Environ or the licensed driller shall procure the required groundwater well permits from the appropriate agency, as necessary. Copies of such permits shall be maintained in the project file for the duration of the project. In addition, depending on the proposed well location(s), other types of permits (encroachment, excavation, and wetlands), or property access agreements may be required.

Before initiating field activities, field staff should review and complete pertinent tasks identified in **FGD 2.02**, Site Preparation, Inspection and Housekeeping. At a minimum, the following tasks should be completed to prepare field staff for what may be expected during implementation of the work:

- Review and sign the site-specific HASP;
- Coordinate and obtain permission for site access and visit the site to identify any access constraints that could affect drilling;
- Complete subcontracts with drillers, utility locators, surveyors, etc.;
- Complete a subsurface clearance checklist (refer to **SPI-27**) - note, this typically requires 2 to 3 business days' notice for completion of public subsurface utility mark-outs;
- Review project-specific work plan/sampling plan, where applicable;
- Review project-specific Quality Assurance Project Plan (QAPP), where applicable; and
- Review and discuss with the PIC and/or PM the proposed work plan/sampling plan and sampling objectives.

4.3 General Description of Drilling Methods

Groundwater well installation requires the drilling of a borehole in which to set the well. Boreholes can be advanced using a variety of drilling techniques, but each has limitations and is generally best suited for specific applications. Selection of the drilling method employed for well installation will depend on the physical nature of the subsurface materials at the site (e.g., unconsolidated materials or consolidated materials, subsurface lithology), the depth to groundwater and depth of the well, as well as the nature of the drilling site in general (e.g., access constraints). The following is a general description of three common drilling methods for installation of wells in unconsolidated formations and a description of some limitations for each method[1].

- *Hollow Stem Augers*. Drilling using hollow-stem augers (HSA) relies on continuous auger flights with a cutting head at the lowermost end. The augers are rotated and advanced downward by the drill rig, which results in the soil cuttings being carried up to the surface by the auger flights. The augers act as a temporary casing for the borehole, preventing borehole wall material from collapsing into the open borehole. Small diameter drill rods with samplers (e.g., split spoons or Shelby tubes) can be used for sampling of soils below the continuous flight of augers (refer to **FGD 5.08**, Subsurface Soil Sampling - Split Spoon and Shelby Tube). HSA drilling is typically used in unconsolidated materials, but could be used to drill into the top of weathered bedrock. While HSA boreholes can be advanced to depths of 150 feet or greater in certain soils, the diameter of the borehole and hydrogeologic/geologic conditions will ultimately determine drilling depths.
- *Sonic Drilling.* Sonic drilling relies on a combination of rotation, vibration and pushing to advance concentric hollow drill stems by significantly reducing the friction between the sampling equipment and the surrounding soils. The drill head includes the mechanism necessary for rotary motion as well as a high frequency oscillator. Typically, an inner core barrel is initially advanced and a casing is then installed over the core barrel to protect the integrity of the borehole during sample retrieval. During drilling, the drill bit is vibrating up and down, as well being rotated and pushed. The vibration causes soil particles immediately around the drilling assembly to lose its structure, making soils in the unsaturated fluidize and soils in the saturated zone to behave like a slurry. In bedrock, the drill bit causes fractures at the rock face. Sonic drilling can be effectively used in unconsolidated soils, poorly consolidated materials (e.g., running sands, areas of coarse materials that may bind augers) and consolidated rock. Sonic drilling can typically be used to advance borehole diameters as large as 12 inches to depths of 250 feet. In comparison with other drilling methods, sonic drilling generates minimal soil cuttings and can reduce smearing of formation materials on the borehole walls. Since sonic drilling requires continuous recovery of cores, its main limitation is the lower production with increased sample depth, as each core must be retrieved before a subsequent interval is sampled.
- *Air Rotary Drilling*. Air rotary drilling relies on air pressure to remove soil cuttings. Drilling is accomplished by a roller-cone bit or down-hole percussion hammer, with pressurized air delivered to the roller-cone bit or down-hole percussion hammer through the drill pipe. Cuttings are mobilized by the air circulation and returned to the surface typically through dual-wall well casing. Cuttings are channeled at the surface through a diverter to a cyclone, where the cuttings are able to drop into drums or a roll-off type waste container. Pressurized air helps cool down the drill bit. Air rotary drilling is generally recommended for consolidated rock because of borehole wall stability issues or

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[1] Overburden wells can also be installed using direct-push technologies (e.g., Geoprobe®) – refer to **FGD 6.06** – Direct Push Overburden Well Installation and Sampling.

for strata where boulders or large obstructions are anticipated. Where unconsolidated materials overlie a consolidated formation, surface casings through the unconsolidated materials are typically employed to avoid short-circuiting of the air flow. When using air rotary drilling, precautions should be exercised to minimize and control the release of solid particles by the air drilling action and/or the air stream volatilizing or dispersing contaminants at the surface. To minimize dust generation, a fine water mist may be introduced at the cyclone. Alternately, a shroud is placed over the borehole and sometimes water is added when drilling above the water table to limit the generation of dust.

- *Mud Rotary Drilling*. Mud rotary drilling relies on a formulated mud slurry (e.g., bentonite) as a drilling fluid to lubricate the drill bit, stabilize the borehole wall, remove soil cuttings, and prevent or limit flow of groundwater or sand into the borehole. As the drill is rotated and advanced downward, drilling mud is pumped through the cutting head to the base of the borehole. As fresh mud is pumped, mud within the borehole circulates back to the surface through the annular space between the borehole and drilling rods, where it may move through some combination of a baffled tank, across a screened shaker table, or pit to allow cuttings to settle and cuttings-reduced mud to be re-circulated. The outflow of this pit feeds a suction pit, where the drilling fluid can be mixed with fresh mud, as necessary, and reintroduced to the borehole. Formation logging during mud rotary drilling is accomplished by monitoring rig chatter, observing sediment output at the shaker table, and/or by frequent sieving of the mud return. While a split spoon or Shelby tube could be used for sampling of soils using this method, the recirculation of mud must be halted and the drill string tripped out and retooled for the sampler to collect the samples (refer to **FGD 5.08**, Subsurface Soil Sampling - Split Spoon and Shelby Tube). Mud rotary drilling is suitable for poorly consolidated material where running sands or areas of coarse materials that may bind augers are encountered, or where very deep boreholes are required. It should be noted that the mud circulated during mud rotary drilling could adversely affect the hydraulic properties of the filter pack, the quality of water samples, and hydrogeologic properties of the formation in the vicinity of the well. To mitigate these potential adverse effects, a dispersing agent may be used and/or more intense well development efforts are typically required.

4.4 Well Installation Procedures

The following provides a recommended list of practices for well installation following completion of the borehole:

- Prior to initiating well construction, the driller and/or Ramboll Environ's oversight personnel should measure the depth to the bottom of the borehole to ensure the target depth has been met. The depth to water should be estimated from recovered soil samples, drilling conditions, and/or measured and recorded in accordance with the project-specific Work Plan and/or sampling plan, which may require waiting for water levels to equilibrate over time (refer to **FGD 6.04**, Groundwater and Free Product Level Measurements).
- If it is necessary to backfill the borehole to the appropriate well installation depth, or to repair a breached aquitard/confining layer, Ramboll Environ oversight personnel should consult with the PM or PIC to define procedures to be followed. Generally, the driller

may use bentonite pellets, or bentonite chips. Filter pack sand could be used if there is no concern for a breached aquitard/confining layer.

  - Selection of the backfill material will depend on site conditions, lithology, and project-specific requirements.
  - If the bottom of the borehole requires complete sealing of the underlying layers, bentonite chips, or bentonite pellets are typically used. Using neat cement or bentonite grout may impose difficulties in controlling the placement to discrete depths.
    - The vertical interval and volume of backfill should be calculated based on depth measurements and recorded.
    - When bentonite pellets or chips are used as backfill, the materials should be installed carefully and slowly into the borehole to minimize the risk of pellets/chips sticking to the side of the borehole and causing bridging when installed through the water column.
    - If backfilling the borehole is required, the total borehole depth should be measured frequently when adding backfill materials to the bottom of the borehole to minimize the potential for overfilling. Also, note that bentonite products can swell significantly during hydration potentially resulting in an over-fill condition.
    - If a borehole has been overfilled, it may require reaming of the base of the borehole to remove the overfilled material, or re-drilling of the borehole. Ramboll Environ oversight personnel should consult with the PM or PIC to define procedures to be followed.
  - The curing time may be defined by state-specific or regulatory program-specific guidelines or requirements. Typically, the curing time is approximately of 24 to 48 hours for neat cement, overnight for bentonite grout, and 1 hour for properly hydrated bentonite pellets, unless approved additives are mixed into the grout to accelerate the curing time. Well construction should not be initiated before the backfill has been allowed to cure.
  - The driller and/or Ramboll Environ's oversight personnel should re-measure and verify that the bottom of the borehole is at the target depth where the well should be set before proceeding with well construction. If it is not, the process described above should be repeated.

- To minimize errors and provide for clear communication of final well construction design based on site conditions encountered at the well site, Ramboll Environ recommends preparation of a one-page hand-drawn field diagram depicting final well construction design including target depths for well screen, centralizers, filter pack, seals, and grout; the diagram also can show important strata such as aquitards, water-bearing zones, or confining layers. A copy of the diagram can be provided to the driller, and a photograph of the diagram should be emailed to the PM or PIC for review and approval prior to well construction.
- Upon completion of the well borehole, the boring should be measured to verify the total depth, and the well casing assembled and lowered into the borehole. If using HSA

drilling for well installation, the well casing is lowered through the open center of the augers.

  - Prior to lowering into the borehole, the length of well casing materials, screen, and end cap should be measured to the nearest 0.1 foot.
  - Casing and screen materials must be clean, free of rust, grease, oil, or contaminants and be composed of materials that will not affect the quality of the water sample.
  - The well casing shall be watertight and well screens shall be permanently joined to the well casing.
    - Casing and screens shall be connected by flush-threaded or coupled joints and shall be completed with a bottom cap.
    - When using plastic casing and screen, the materials shall be constructed using flush threaded joints equipped with suitable O-rings.
    - Solvent, glue, or anti-seize compounds shall not be used to fasten the well casing joints, well screen joints, or end caps.
    - A collection sump may be installed below the screen. Its length will vary depending on lithology and project needs. The collection sump and bottom cap shall be connected to the well screen by flush threaded equipped with suitable O-rings.
  - The casing shall be centered in the borehole, be free of any obstructions, and allow sampling devices to be lowered into the well.
- Throughout the well installation process, the driller should make provisions to support the screen and riser pipe to prevent them from sinking into the backfill and/or ensuring that the well casing is installed plumb and straight. The well casing may be hung by a wireline in the borehole prior to filter pack placement so that the well can be situated at the desired depth interval and ensure that the well is sufficiently plumbed and straight after completion. For deep wells (greater than approximately 100 feet below grade), centralizers should be used to stabilize the casing and keep the well plumb and straight in the borehole. The number of centralizers should be minimized to facilitate measurement of the top of backfill layers. Extra care should be taken during installation of filter pack and divider seal materials to avoid bridging around wells equipped with centralizers.
- The screen should not be set immediately over the formation soils (i.e., borehole bottom) or top of backfill; rather, up to six (6) inches of fine sand shall be used as a buffer unless this distance would result in a breach of a confining layer, or the well screen requires setting directly on the impermeable zone due to site requirements.
- Once the well has been situated at the desired depth, filter pack sand should be emplaced in a calculated quantity sufficient to fill the annular space from the bottom of the boring to the design level, two to three feet above the top of the well screen. Prior to placing filter pack materials around the well, the top of the well casing should be covered using a well cap or other means to prevent material from entering the well.
  - The filter pack material may be placed in the well by pouring the sand into the open annulus, or placed as a slurry using a tremie pipe.

  - The filter pack material should be added carefully with continuous depth to filter pack measurements by the driller and/or Ramboll Environ oversight personnel to prevent bridging of the filter pack material.
  - If building the well inside a casing or HSA, as the filter pack material is added, the driller should gradually withdraw the HSA, allowing the sand to settle into the annular space of the borehole. As the augers are withdrawn, filter pack material should always be present within the lower portion of the bottom auger, such that the borehole annular space is filled concurrently with the withdrawal of the augers. This will prevent formation collapse into the annular space. Nonetheless, the driller should be careful not to allow the level of filter pack material to rise too high within the augers, as this may cause bridging or binding of the filter pack material and well casing within the augers. The well level should be carefully monitored with the removal of each length/section of HSA. If the well pulls up as augers are removed, contact the PM or PIC to determine whether the filter pack material should be removed and the well re-set.
  - After the filter pack has been added, and before the seal is placed in the annular space, the driller may gently surge the well with a surge block or submersible development pump to compact or help settle the filter pack. A surge block consists of a plunger made of PVC or rubber attached to a heavy rod or pipe and connected to a cable of sufficient length to reach the bottom of the screen. The top of the filter pack will need to be measured after surging and additional filter pack material may need to be added if settling has occurred. The amount of time spent surging the filter pack will be proportional to the length of saturated screen and continued at the discretion of field staff; however, surging should continue if the filter pack continues to drop. When required for a specific well installation (e.g., well depths greater than 200 feet), the driller may then place a layer of fine grained transition sand above the filter pack.

- Following installation of the filter pack, the annular space surrounding a well above the filter pack must be sealed a minimum of two feet above the filter pack to mitigate the migration of fluids into the well from the ground surface and from other water-bearing zones. This is most typically accomplished by adding bentonite; if chips or pellets are used, the material must be hydrated prior to grouting the remaining annular space. Only potable water should be used to hydrate the bentonite. Ideally, if the divider seal can be set adjacent to a low-permeability stratum (e.g. clay), this will minimize the likelihood that grout or water from higher groundwater zones, can impact the target screen interval. Divider seals emplaced entirely in coarse gravels are unlikely to prevent grout from flowing around the seal and compromising the well.
- After placement of the divider seal the remaining annular space must be filled (i.e., grouted) from the divider seal to within two feet of the ground surface to further mitigate the migration of fluids into the well from the surface and from other water-bearing zones. If pre-approved by the PM or PIC, it may be appropriate to use un-impacted native materials from the borehole as backfill above the divider seal in the unsaturated zone.
  - Only potable water shall be used to prepare the grout.

  - Cement or cement-bentonite grout is typically placed using a tremie pipe so that the grout fills the annular space from the bottom to the surface without allowing air- or water-filled pockets to form.
  - Extreme care should be exercised when using tremie pipe to pump in grout, especially in deeper wells, where hydraulic jetting can quickly penetrate the bentonite seal.
  - No work (e.g., development, water level measurement, sampling) shall be done on the well until after the grout has set overnight to 48 hours, unless otherwise required by state-specific or regulatory program-specific guidelines or requirements.
  - Alternatively, bentonite chips may be used to fill the annular space for shallow wells.
- During and after completion of the annular seal, a water-tight locking cap shall be placed at the open end of the well casing during installation of the well's protective casing.
- The well's protective casing shall then be installed by the driller.
  - For above-ground well completions (i.e., stick-ups), the well casing will typically extend two to three feet above the ground surface and a steel protective casing with a vented lockable cap will be installed. At some sites, the steel casing may be painted to conform to client or project well identification protocol. Any such painting should be done prior to installation and sufficient time should be allowed for paint to dry.
    - The driller will set the steel protective casing at least two feet below grade set in a typically four to six inch deep concrete pad (typically two foot square), poured over the cured annular fill. In geographic areas where heaving may occur due to freezing and thawing of the ground, the concrete pad should extend 18 inches below ground surface. In some instances, the protective casing can be set into the annular grout seal and capped with a concrete surface seal. The concrete pad constructed around the well casing and protective steel casing will serve as a surface seal; thus, it should be sloped slightly away from the well to prevent surface water from accumulating on the pad. The top of the concrete pad is typically constructed so it is approximately four inches off the ground.
    - After the protective steel casing and concrete pad are in place, the annular space between the well casing and the protective steel casing is typically filled with an inert material such as cement or grout up to the height of the pad; and filled to approximately 6 inches below the top of casing with pea gravel or coarse sand.
    - A "weep" hole may be drilled on the side of the protective steel pipe one to two inches above the cement pad, particularly in areas where freezing may occur, in order to prevent water from freezing within the protective pipe and potentially damaging the well casing. Often a small tube or pipe is inserted into the weep hole to direct water flow away from the concrete pad.
    - Bollards (i.e., protective posts) should be installed in areas where the well has the potential to be struck by vehicles or heavy equipment.
    - Upon installation of the protective casing, a "V" notch or other permanent physical mark should be made at the north edge of the top of the well casing. The permanent physical mark or notch should not interfere with the functionality

of the expanding cap. This permanent mark will be used as the reference point for well elevation surveying and water level monitoring.

    - The well name/identifier should be marked by scoring it into the concrete well pad (before the concrete sets), by using stencils and spray paint on the outside of the protective casing, by attaching an inscribed metal identification plate onto the protective casing, and/or imprinting onto the cap of the protective casing.

- For at-grade well completions (i.e., flush mounts), the well casing will terminate at or just below the ground surface and will be completed with a traffic-rated, gasketed (sealed), well box/vault or bolt-down manhole that is cemented into place around the well head.

    - The driller will set the well box/vault within a one- to two-foot deep concrete pad (typically one foot square), or manhole within a four- to six-inch deep concrete pad (typically two feet square) poured over the cured annular fill. In geographic areas where heaving may occur due to freezing and thawing of the ground, the concrete pad should extend 18 inches below ground surface. The concrete pad constructed around the well casing and well box/vault or manhole will serve as a surface seal; thus, it should be constructed just above the surrounding grade in order to provide positive drainage away from, and prevent ponding of water around the well. In traffic areas and sidewalks, extra care should be taken when setting the well box above the surrounding grade which should be minimized to prevent physical hazards (e.g., tripping) and to prevent snow plows from damaging the well.

    - After the well box/vault or manhole and concrete pad are in place, the annular space between the well casing and the well box should be filled with an inert sealing material such as cement. However, the well casing should extend approximately 3 inches above the sealant within the well box/vault or manhole while also leaving enough space for the locking well cap.

During the well installation process, all well construction details should be completely documented in the project field book or approved well installation field form in accordance with the procedures detailed in **FGD 6.15**, Well Construction Record.

4.5 Investigation-Derived Waste

Drill cuttings and decontamination fluids generated during well installation and subsequent decontamination activities shall be containerized pending analytical results and determination of disposal options as outlined in **FGD 15.01**, Waste Handling, unless project-specific requirements specify otherwise. Waste containment and disposal will occur in a manner that will not result in contamination of the site or other areas, or result in a hazard to individuals who may come in contact with containerized waste materials.

4.6 Well Development

For groundwater monitoring wells and remedial wells screened within the saturated zone, well development (refer to **FGD 6.07**, Well Development) should occur no sooner than 24 hours (48 hours preferred) following completion of the well (i.e., placement of the divider and annular seals), in order to allow the cement to set. If only bentonite chips are used in the divider/annular seal, well development may commence prior to 24-hours following well installation.

4.7 Well Location Surveying

Following well development, newly constructed monitoring wells shall be surveyed (refer to **FGD 1.06**, Field Surveying and Monitoring Well Elevation Surveying). Some states or regulatory programs may require that the survey be conducted by a surveyor licensed in the State where the well has been installed. The "V" notch cut on the top of each well casing shall be used as the surveyor's reference mark and as a reference for future water level measurements.

4.8 Well Construction Reporting

After well installation and surveying, well completion report(s) shall be completed and filed with the appropriate agency, as required by State and local law and/or the well construction permit. If this documentation is to be submitted by the driller, copies of such documentation shall be obtained for the project file. Reporting requirements for some States are provided in Attachment A of **FGD 6.15**, Well Construction Record. Project personnel should also consult with State and local laws or contact the local Ramboll Environ office to determine if specific reporting requirements apply.

5. PRECAUTIONS AND OTHER CONSIDERATIONS

All field activities require recording sufficiently detailed information throughout the implementation of field work. However, certain precautions should be taken to ensure safety while installing wells. Additionally, implementation of the work may face some difficulties and may require compliance with State-specific or regulatory program-specific requirements.

- It is important to always remain alert and aware of your surroundings. Well installation involves the use of drilling rigs and associated equipment, and is subject to hazards posed by heavy equipment, vehicle traffic, industrial machinery, hazardous chemicals and contaminants, and/or other physical, mechanical, and chemical hazards.
- A cable winch on the drilling rig is generally used during well installation, which subjects the cable to tension. Ramboll Environ field personnel should confirm that the driller has inspected the cables and winches on the drilling rig prior to the start of work. When cables are being used or when drilling is underway, it is recommended that personnel maintain a distance from the drilling rig of at least the height of the drilling rig mast or any tooling (e.g., drill string/rod) extending above the top of the mast. Prior to approaching the drill rig, be sure that the equipment is secure and that the driller is aware that you are approaching. Also, compressors and compressed air can be extremely dangerous when connectors and seals fail, so ample distance from such equipment, hoses and connectors is advised.
- At sites with certain contaminants and/or subsurface conditions, potentially toxic and/or explosive gases may accumulate at and around the well as it is being installed. Stay upwind of well installation activities and ensure that air monitoring is conducted and personal protective equipment is used in accordance in the site-specific HASP.

- Dust may be produced during the emplacement of sand filter pack material and mixing of cement and/or bentonite powder, and may be harmful if inhaled. Stay upwind of cement mixing activities and instruct drillers to pour powders gradually into water while mixing, in order to reduce dust.
- Only drillers licensed in the State where the work is being performed should be subcontracted to perform the work, if applicable. Most states have specific licensing requirements.
- In some States, drilling permits are to be procured by the driller prior to mobilization. In addition, well construction forms and documentation are to be submitted to the permitting entity by the driller (refer to Attachment A of **FGD 6.15**, Well Construction Record for requirements for some States). Local Ramboll Environ offices should also be consulted to determine if specific reporting requirements apply. Ramboll Environ should obtain from the driller copies of the required permits prior to mobilization and of the driller’s well construction records after well installation.
- The drilling contractor should be informed of the anticipated well construction design, and requirements as part of the contracting process so they can ensure that the appropriate and sufficient equipment, personnel, and materials are mobilized. The driller should define the specific equipment that will be used for well installation, so field personnel can prepare accordingly.
- When backfilling boreholes below the water table, bentonite pellets or coated bentonite chips are generally easier to place than standard bentonite chips because pellets do not hydrate as quickly, hence pellets or coated bentonite chips are the preferred method for small backfill jobs where significant confining zones have not been breached. Note, however, that some pellet coatings have been known to contain acetone, which may interfere with groundwater analysis. If used, samples of the coated bentonite pellets may be collected and held for future analysis if acetone is detected in the groundwater sample.
- At sites where the water table is very deep, the heat of neat cement annular seal curing could potentially warp the solid PVC well casing where it extends through the vadose zone. In these instances, the plumbness of the grouted well may be tested by lowering and raising a 10-foot length of pipe or a bailer along the entire depth of the well prior to acceptance of the completed well. Alternatively, the well could be constructed using a steel casing and stainless steel well screen. It may also be permissible to use bentonite chips/pellets to avoid the heat of curing problem.

6. RECORDKEEPING

Document all well construction details in accordance with **FGD 6.15** (Well Construction Record) and record all information in accordance with **FGD 1.01** (Field Notes and Records).

FIELD GUIDANCE DOCUMENT NO. 14.01

SAMPLING EQUIPMENT DECONTAMINATION

FIELD GUIDANCE DOCUMENT NO. 14.01

SAMPLING EQUIPMENT DECONTAMINATION

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Documents Used as Reference During Preparation:	ASTM D5088 – Standard Practice for Decontamination of Field Equipment Used at Waste Sites. 2015. NJDEP, August 2005. Field Sampling Procedures Manual. USEPA Region 9 Field Sampling Guidance Document #1230, Sampling Equipment Decontamination. 1999. USEPA Region 4 Science and Ecosystem Support Division Operating Procedure, Field Equipment Cleaning and Decontamination, #SESDPROC-205-R1. 2007. USGS, 2006. National Field Manual for the Collection of Water-Quality Data.

CONTENTS

1. INTRODUCTION

This Field Guidance Document (FGD) presents general guidelines established by Ramboll US Corporation (Ramboll) for the decontamination of non-dedicated sampling equipment used for environmental sampling. Decontamination procedures for heavy equipment (e.g., drill rigs, excavators, or other machinery that may be used as part of site investigations or remedial action implementation) are discussed in **FGD 14.02** (Heavy Equipment Decontamination) and decontamination procedures for biological sampling equipment are detailed in **FGD 14.03** (Biological Sampling Equipment Decontamination). The main purposes of non-dedicated sampling equipment decontamination are to (a) prevent cross-contamination of samples resulting from the reuse of the sampling equipment, thereby improving data quality and usability; (b) minimize the transfer of contaminants between sites where the sampling equipment are used; and (c) ensure that sampling equipment can be effectively reused multiple times. Thus, decontamination activities should be viewed as an integral component of the field program.

Sampling equipment decontamination generally is required prior to use, between successive uses, and upon completion of sampling activities (e.g., prior to storing owned equipment or returning rented equipment). Decontamination is performed to ensure that sampling equipment that contacts environmental media (e.g., soil, groundwater, sediment, and surface water) is free from chemical contaminants after each use; and is verified through collection and laboratory analysis of equipment blank samples.

Although this FGD provides guidelines for decontamination procedures associated with typical field activities and projects, it should be understood that for certain projects, more specific decontamination procedures or alternative methods, including state-specific or regulatory program-specific guidelines, requirements or procedures or compound-specific sampling techniques and/or protocols, may be applicable. In addition, compound-specific decontamination procedures may also be applicable. Specific requirements for these types of projects and activities will be reviewed by the Ramboll Principal-in-Charge (PIC) / Project Director and Project Manager (PM) and any additional requirements will be defined in a project-specific Work Plan, Sampling Plan and/or FGDs. It should be emphasized that these guidelines are not meant to be project-specific work plans, but rather a general reference for developing project specific requirements.

This FGD does not supersede Ramboll health and safety procedures or Site-Specific Health and Safety Plan (HASP) requirements; in the event of conflict between this FGD and the site-specific HASP, the procedures outlined in the HASP shall prevail. All Ramboll employees shall follow the guidelines, rules, and procedures contained in the site-specific HASP, followed by approved site-specific procedures, which may include those recommended in this FGD. The Ramboll PIC and/or PM shall ensure that all project personnel review and sign the applicable HASP, and that the signed HASP and relevant project information are maintained in the project file for the duration of the project or as established by applicable Ramboll's document handling and retention policies. The signatures of the PIC and/or PM indicate approval of the methods and precautions outlined in the HASP.

2. EQUIPMENT/MATERIALS

A general checklist of equipment that may be required for typical non-dedicated field equipment decontamination procedures is provided below. This checklist includes an overall summary of general equipment typically required for this equipment decontamination and should not be considered exhaustive. More specialized materials, rinses, or reagents may be required depending on the field sampling equipment and project specific needs.

2.1 General Equipment Checklist

- Site information (e.g., maps, contact numbers, keys or lock codes for gates or access points).
- Field notebook and all-weather or permanent pens as outlined in **FGD 1.01** (Field Notes and Records).
- Trash Bags - used to dispose of gloves and any other non-hazardous waste generated during sampling (refer to **FGD 15.01**, Waste Handling).
- Appropriate waste container – used to dispose of any Investigation Derived Wastes (IDW) and/or decontamination wastes (refer to **FGD 15.01**, Waste Handling).
- Labels for IDW containers as outlined in **FGD 15.01** (Waste Handling).

2.2 Equipment Decontamination Equipment Checklist

- ASTM Type II Distilled and distilled- deionized water (DI water).
- Low-sudsing, non-phosphate containing, laboratory grade detergent (e.g., Alconox or Liquinox, detergent 8).
- Potable water (e.g., tap water).
- Solvent rinse (i.e. high purity acetone or methanol).
- Brushes and other scrubbing devices with non-metallic bristles, such as polypropylene, polyethylene or other plastic.
- Brush with metal bristles or scraper for dry decontamination prior to wet decontamination.
- Spray bottles (at least one filled with potable or distilled water and one filled with DI water).
- 10% nitric acid solution if using carbon steel sampling equipment (e.g., split spoon samplers).
- Organic surfactants (e.g., Simple Green).
- Steam cleaner or pressure washer.
- Racks, stands, standpipes, or other equipment that may be needed for ultra-clean decontamination (e.g., submersible pumps).
- Aluminum foil, Parafilm, or other inert wrapping material.
- At least three 5-gallon buckets and/or larger tubs (for containing larger equipment or when using pressure washers).

- Plastic sheeting or other materials to protect the ground surface.

3. PROCEDURES REFERENCED

The following FGDs are related to this FGD and should be reviewed prior to mobilization, as needed:

- **FGD 1.01**, Field Notes and Records.
- **FGD 1.02**, Sample Handling, Shipping and Chain of Custody.
- **FGD 1.03**, Data Management.
- **FGD 1.05**, Field Quality Control Samples.
- **FGD 5.02**, Subsurface Soil Sampling - Test Pits and Excavations.
- **FGD 5.04**, Surface Soil Sampling.
- **FGD 5.05**, Soil Sampling for VOC Analysis.
- **FGD 5.07**, Subsurface Soil Sampling - Direct Push.
- **FGD 5.08**, Subsurface Soil Sampling - Split Spoon and Shelby Tube.
- **FGD 5.15**, Stockpile Sampling.
- **FGD 5.16**, Soil Sampling for PCB Analysis.
- **FGD 6.02**, Groundwater Sampling.
- **FGD 6.03**, Determination of Hydraulic Properties - Slug Test.
- **FGD 6.04**, Groundwater and Free Product Level Measurements.
- **FGD 6.07**, Well Development.
- **FGD 6.08**, Determination of Hydraulic Properties - Pump Test.
- **FGD 6.09**, Groundwater Sampling - Private and Domestic Wells.
- **FGD 6.10**, Groundwater Sampling for Low Level Mercury.
- **FGD 6.13**, Groundwater Sampling - Vertical Profiling.
- **FGD 6.14**, Determination of Hydraulic Properties - Packer Pressure Test.
- **FGD 6.16**, Groundwater Sampling - Free Product/NAPL.
- **FGD 6.20**, Groundwater Sampling - Low Flow.
- **FGD 7.01**, Surface Water Sampling.
- **FGD 8.01**, Sediment Sampling.
- **FGD 15.01**, Waste Handling.
- **FGD 15.02**, Waste Sampling.

The list above is not intended to be all inclusive. Other FGDs and Standard Practice Instruction (SPI) may need to be referenced based on the specific requirements of the site-specific Work Plan/Sampling Plan (e.g., field screening FGDs, and FGDs for sampling).

4. PROCEDURES

4.1 Planning and Design Considerations

All significant equipment decontamination decisions shall be approved by the PIC and/or PM before the initiation of field activities. The Work Plan/Sampling Plan should be designed to facilitate the collection of representative data that will meet the goals and data quality objectives of the study/monitoring program and should include specific requirements for non-dedicated field equipment decontamination. The Work Plan/Sampling Plan will generally provide some discretion for modifications in the field depending on encountered conditions; however, any significant departure from prescribed decontamination procedures should be discussed with and approved by the PIC and/or PM prior to implementation.

Prior to conducting the field investigation, consideration should be given to the equipment decontamination requirements, including:

- Contaminants of concern and type of sampling equipment, including material (e.g., stainless steel, HDPE, Teflon);
- Identification of where decontamination activities will take place, considering such factors as traffic patterns, the location of storm water inlets, surface water bodies, wetlands and other potentially sensitive areas;
- Design of the decontamination pad in consideration of the size of equipment being cleaned, measures to capture overspray or spills, the placement of liners, and other site-specific factors;
- Appropriate procedures and schedules for the collection and disposal of decontamination fluids;
- Appropriate procedures and schedules for the replacement of decontamination fluids; and
- Contingency measures and procedures in the event of a spill resulting from the decontamination activities.

For most decontamination activities, decontamination solutions should be prepared with concentrations of approximately 0.5% to 2% detergent by volume using distilled or potable water, depending on State-specific or regulatory program-specific requirements. In cases where detergent cleansing is not sufficient, cleaning solutions should be selected, or the decontamination train modified such that the cleaning agents are neither contaminants of concern at the site nor used in the specified analytical methods, as described below and in Table 1[1]:

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[1] ASTM-D5088: Standard Practice for Decontamination of Field Equipment Used at Waste Sites.

- Solvent rinses (e.g., acetone, methanol) or an organic surfactant solution (e.g., Simple Green) may need to be incorporated as the first step of the decontamination train to remove organic compounds with poor water solubility, such as oil, grease, or tar.
- To neutralize acidic or basic contaminants on equipment, a sodium bicarbonate solution (5% to 15% by volume) or sodium carbonate (10% to 20% aqueous solution).
- A rinsing solution consisting of trisodium phosphate (10% aqueous solution) to remove organic compounds (such as toluene, chloroform, trichloroethene, or polychlorinated biphenyls). Acid rinses (e.g., nitric, hydrochloric) may need to be incorporated into the decontamination train if metals analyses are to be performed. In such cases, additional health and safety as well as waste management measures will be required.

Table 1: Applications of Various Solutions for Decontamination of Field Equipment and Materials A B C

Solution	Concentrations	Remarks
Portable Water	Tap water	Used under high pressure or steam to remove heavy mud and dirt, or to rinse off other solutions.
Laboratory-grade water	Distilled Deionized Reagent grade distilled and deionized water	
Low sudsing non-phosphate detergents (Liquinox, Detergent 8)	Typical concentrations are 0.5 to 2% solution by volume	General all-purpose cleaner. Detergent 8 is recommended for spray cleaning.
Sodium bicarbonate (baking soda)	5 to 15% aqueous solution	Used to neutralize either acidic or strongly basic contaminants.
Sodium carbonate (washing soda)	10 to 20% aqueous solution	Effective for neutralizing inorganic acids, organic acids, heavy metals, metal processing wastes.
Trisodium phosphate (TSP Oakite)	10% aqueous solution	Similar to sodium carbonate. Good rinsing solution for organic compounds (such as toluene, chloroform, TCE, PBBs, and PCBs).
Calcium hypochlorite (HTH)	10% aqueous solution	Disinfectant, bleaching, and oxidizing agent for pesticides, fungicides, chlorinated phenols, dioxins, cyanides, ammonia and other non-acidic inorganic wastes.
Hydrochloric acid, nitric acid	10% nitric 10% to 20% hydrochloric	Used for inorganic bases, alkali and caustic wastes. This material is hazardous and its use should be limited. Care should be taken in both use and disposal of these materials.

Table 1: Applications of Various Solutions for Decontamination of Field Equipment and Materials [A B C]

Solution	Concentrations	Remarks
Citric, tartaric, oxalic acids or their respective salts	5% solution	Used to clean heavy-metal contaminants.
Organic solvents	Neat, undiluted	Used to remove organic compounds that have poor solubility in water, such as oil, grease, and tars. Do not use a solvent that is one of the analytes of interest or interferes with analyses. Porous materials such as polymers can absorb these solvents. These materials are hazardous and their use should be limited. Care should be taken in both use and disposal of these materials.

Notes:

[A] Examples of commonly recommended cleaning solvents include pesticide-grade" isopropanol, acetone, methanol, hexane, heptane, and ethanol. Note that these materials are hazardous themselves and their will generate hazardous wastes that must be properly contained, handled, shipped and disposed of.

[B] Adapted for Mickam et al. (1989), Moberly (1985), and Richter and Collentine (1983).

[C] Many of the solvents listed are themselves hazardous materials. Care should be taken in both use and disposal of these materials. The Safety Data Sheets should be consulted for the selection of the appropriate PPE, handling, and disposal.

4.2 Pre-Field Work Preparation Guidelines

Before initiating field activities, field staff should review and complete pertinent tasks identified in **FGD 2.02** (Site Preparation, Inspection and Housekeeping). In addition, since samples will be collected from various media, field staff should review and complete pertinent tasks identified in relevant FGDs (e.g., **FGD 6.02**, Groundwater Sampling; **FGD 5.04**, Surface Soil Sampling; **FGD 6.04**, Groundwater and Free Product Level Measurements, etc.).

In addition, at a minimum, the following tasks should be completed to prepare field staff for what may be expected during implementation of the work:

- Review and sign the site-specific HASP;
- Coordinate and obtain permission for site access;
- Review project-specific Work Plan/Sampling Plan, where applicable;
- Review project-specific Quality Assurance Project Plan (QAPP), where applicable;
- Review and discuss with the PIC and/or PM the proposed Work Plan/sampling plan outlining decontamination procedures;

- Review and complete pertinent tasks identified in the applicable sampling FGDs (e.g., **FGD 6.02**, Groundwater Sampling; **FGD 5.04**, Surface Soil Sampling; **FGD 6.04**, Groundwater and Free Product Level Measurements); and
- Review **FGD 15.01** (Waste Handling) for management of decontamination fluids and other IDW.

4.3 General Equipment Decontamination Procedures

Decontamination requirements and procedures for sampling/monitoring equipment will vary depending on (a) whether equipment is used for aqueous or non-aqueous media; (b) the analytical method detection levels; and (c) the contaminants of concern (COCs). Commonly used decontamination processes for various equipment and materials are summarized in Table 2 below.[2]

Table 2: Commonly Recommended Decontamination Procedures for Different Equipment and Different Materials of Construction [A] [B]

	Soapy Water Wash	Tap Water Rinse	10% Nitric Acid Rinse [C]	Organic-Free Water Rinse	Rinse with Solvent	Air Dry for 24h	Oven Dry	Store in Aluminum Foil or Polyethylene	Discard After Use
Glass	●	●	●	●	● [D]	●		●	
Teflon	●	●	●	●	● [E]	●		●	
Metals and Stainless Steel	●	●	Do not use	●	● [D]	●		●	
Teflon Tubing	●	●	●		● [E]		● [F]	●	
PVC Tubing				Use Only New PVC Tubing					●
Stainless Tubing	●	●	Do not use	●	● [D]	●		●	
Glass Tubing	●	●	●	●	● [D]	●		●	
Well Sounders	●	●		●					
Submersible Pumps	●	●		●					

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[2] ASTM-D5088: Standard Practice for Decontamination of Field Equipment Used at Waste Sites.

Table 2: Commonly Recommended Decontamination Procedures for Different Equipment and Different Materials of Construction [A] [B]

	Soapy Water Wash	Tap Water Rinse	10% Nitric Acid Rinse [C]	Organic-Free Water Rinse	Rinse with Solvent	Air Dry for 24h	Oven Dry	Store in Aluminum Foil or Polyethylene	Discard After Use

Notes:

[A] These procedures are based on commonly recommended practices. It should be noted that there is not a lot of experimental data to support some of these practices. Additional Information can be found in studies by Mickam et al., 1989, Parker 1995, Parker and Ranney 1997a, 1997b in press.

[B] Sampling equipment that employs a process whereby potentially contaminated material passes through internal mechanical workings (pump, housing, impellers, etc.) can be very difficult to decontaminate. This should be considered when identifying an appropriate decontamination process for equipment with internal sample contacting parts.

[C] This step is used in removing inorganic contaminants and can be eliminated if they are not of concern. It is typically not necessary for non-porous surfaces such as glass or stainless steel.

[D] Data by Parker and Ranney 1997a, 1997b should show that solvent rinsing may not be needed.

[E] Data by Parker and Ranney 1997a, 1997b, show that oven drying may be more effective than an organic solvent rinse for removing sorbed organic contaminants.

[F] Excessive heat that could damage the polymer should not be used. Check manufacturer's recommendations for heat tolerance.

The following provides a recommended list of practices for non-dedicated field sampling equipment decontamination:

- Construct the decontamination area in the predetermined location as follows:
  - Cover the surface of the decontamination area with plastic sheeting in a flat or lightly sloped or depressed area to ensure that the decontamination fluids and any spills from the decontamination activities are captured and can be easily removed. If needed, use 2" x 4" timber or hay bales to create a frame and overlay the plastic sheeting over it.
  - Place appropriate waste containers within the decontamination area to contain any investigation decontamination wastes and IDW and label the containers as outlined in **FGD 15.01** (Waste Handling) pending disposal.
- Don appropriate PPE prior to conducting decontamination (gloves, safety goggles, face shields, Tyvek suits, etc., as appropriate) and change PPE (particularly gloves) as needed during the process to avoid re-contaminating equipment.
- If sampling equipment is laden with soil or sediment or other residuals, dry decontaminate it by scrubbing with a brush or scraper over the appropriate IDW container before proceeding with the wet decontamination. In some cases, residuals will need to be removed using a steam cleaner or pressure washer. Special considerations/precautions should be employed to ensure decontamination fluids applied under high-pressure and the associated residuals are adequately contained.

- Information regarding the decontamination methodology, date, time and personnel should be recorded in the field note book (refer to Section 6).

4.3.1 Wet Decontamination, Non-Aqueous Sampling Equipment (Three-Step Decontamination)

Unless otherwise indicated in site-specific work plans or FGDs, at a minimum, non-aqueous sampling equipment should follow the following three step wet-decontamination process (see Section 4.3.2 for the Seven-Step Decontamination Process description):

- Set up three five-gallon buckets as follows:
  - Detergent wash bucket – fill two thirds of the bucket with a solution of detergent and potable or distilled water.
  - Potable water rinse bucket – fill one third of the bucket with potable water.
  - Distilled-deionized (DI) water rinse bucket – fill one third of the bucket with DI water. Fill a spray bottle with DI water.
- Place sampling equipment in the detergent wash bucket and remove all visible particulate matter and residual oil and grease using a brush with plastic bristles.
- Once all visible particulate matter has been removed, rinse the equipment in the potable water rinse bucket using copious amounts of potable water and the spray bottle filled with potable water.
- Once all detergent been removed from the sampling equipment, rinse the equipment in the DI water rinse bucket using the spray bottle filled with DI water.
- Inspect the decontaminated equipment before use. If contamination persists or is suspected, perform the decontamination procedures for aqueous sampling equipment described below. Otherwise, the sampling equipment is ready for use or storage after it has been allowed to air dry.

4.3.2 Wet Decontamination, Aqueous Sampling Equipment (Seven-Step Decontamination)

Unless otherwise indicated in site-specific work plans or FGDs, at a minimum, aqueous non-dedicated field sampling equipment (or non-aqueous non-dedicated field sampling equipment requiring additional decontamination) should follow the following seven step wet-decontamination process:

- Set up seven five-gallon buckets as follows (note that some may not be needed depending on the COCs and analyses to be performed):
  - Detergent wash bucket – fill two thirds of the bucket with a solution of detergent and potable or distilled water.
  - Potable water rinse bucket – fill one third of the bucket with potable water.
  - DI water rinse bucket – fill one third of the bucket DI water. Fill a spray bottle with DI water.

  - Nitric acid rinse (only if metals analysis is to be performed) – this bucket will initially be empty. Fill a spray bottle with a solution consisting of 10% nitric acid diluted with DI water.
  - DI water rinse bucket (only if metals analysis is to be performed) – fill one third of the bucket DI water. Fill a spray bottle with DI water.
  - Solvent rinse (only if organics analysis is to be performed) – this bucket will initially be empty. Fill a spray bottle with high purity acetone or methanol. Note that if acetone is known or suspected to be a COC or a Target Compound List analysis is to be performed, methanol should be used. However, methanol cannot be used when sampling media are impacted by gasoline or its by-products.
  - DI water rinse bucket (only if organics analyses is to be performed) – fill one third of the bucket DI water. Fill a spray bottle with DI water.
- Place sampling equipment in the detergent wash bucket and remove all visible particulate matter and residual oil and grease using a brush with plastic bristles. Sampling equipment may need to be opened or taken apart to ensure all components that contact samples are adequately decontaminated.
- Once all visible particulate matter has been removed, rinse the equipment in the potable water rinse bucket using copious amounts of potable water and the spray bottle filled with potable water.
- Once all detergent has been removed from the sampling equipment, rinse the equipment in the first DI water rinse bucket using the spray bottle filled with DI water.
- If metals analysis is to be performed, rinse the equipment in the nitric acid rinse bucket using the spray bottle filled with the nitric acid solution. Follow-up with a rinse in the second DI water rinse bucket using the spray bottle filled with DI water.
- If organics analysis is to be performed, rinse the equipment in the solvent rinse bucket using the spray bottle filled with solvent. After the solvent has been allowed to evaporate, follow-up with a rinse in the third DI water rinse bucket using the spray bottle filled with DI water.
- Inspect the decontaminated equipment before use. If contamination persists or is suspected, repeat the decontamination procedures.

4.3.3 Wet Decontamination, Aqueous Sampling Equipment (Field Ultra-Clean Decontamination)

In certain situations (e.g., contaminant or general chemistry parameters are being measured at very low detection limits), equipment such as sampling pumps, tubing, and/or stainless steel bailers that come into direct contact with groundwater (or surface water) may require additional cleaning to ensure removal of trace amounts of contaminants.[3] [4] These procedures should be detailed in the project-specific Work Plan.

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[3] New Jersey Department of Environmental Protection Field Sampling Procedures Manual, August 2005.

[4] U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, April 2004, accessed June 5, 2017, at http://pubs.water.usgs.gov/twri9A3/.

To effectively achieve decontamination of such equipment or where inorganic indicators or ambient sensitive constituents are being analyzed, the following ultra-clean decontamination procedures should be followed as specified in the project-specific Work Plan:

- Set up five sufficiently sized containers containing the following:
  - Detergent wash container – fill two thirds of the container with a solution of detergent and potable water.
  - Potable water rinse container – fill one third of the container with potable water.
  - DI water rinse container – fill one third of the container DI water. Fill a spray bottle with DI water.
  - Methanol rinse container – solvent-resistant container to be filled with approximately 2 liters of solvent (methanol), if organic constituents are being tested and project needs require additional decontamination. Fill a spray bottle with methanol.
  - Blank water – laboratory-provided DI water that is free of known constituents (target analytes). Fill a spray bottle with DI water.
  - Blank water rinse container - this bucket will initially be empty. Fill a spray bottle with organic-grade blank water (i.e., pesticide-grade or volatile-grade), prepared and/or quality assured by the analyzing laboratory.
- Place pump and other sampling equipment in the detergent wash bucket and remove all visible particulate matter and residual oil and grease using a brush with plastic bristles. State specific guidelines may require additional steps, such as soaking prior to removal of particulate matter.
- Once all visible particulate matter has been removed, rinse the equipment in the potable water rinse bucket using copious amounts of potable water and the spray bottle filled with potable water.
- Discard the initial detergent solution (containing particulate matter and residue from initial scrubbing) and replace with new detergent solution. Place the pump and other sampling equipment into the container such that the equipment is immersed.
  - Agitate equipment to effectively rinse.
  - For pumps, ensure that the intake is below the detergent solution level) and operate to achieve at least 3 recirculation cycles of the pump/tubing volume. If possible, adjust the flow rates (alternate high and low speeds) and/or introduce air periodically to increase cleaning efficiency.
  - When completed, pump approximately two pump/tubing volumes into a waste container (adding additional detergent solution to container, as needed for pump to operate).
- Remove equipment from container, and then rinse the inside of the container using potable water (until all sudsing stops).
- Rinse exterior of equipment/pump with potable water, and place into DI water rinse container (for pumps, water should be above the pump intake). Agitate equipment to rinse. For pumps, continue agitating within the DI water rinse container, and begin pumping but do not recirculate water – discharge to a waste container. Recirculate for

five or more equipment volumes (adding potable water/DI water as needed to maintain flow). To confirm adequate rinsing of pumps, capture a small aliquot of discharged water in a container, and shake to observe sudsing. Repeat until no suds appear.

- If the equipment is being used for inorganic constituent sampling only, change gloves, and rinse equipment in the DI water container. For pumps, use similar procedure as above (discharging water, not recirculating) and test for suds using a small bottle.
- If required, collect a field blank for Quality Assurance purposes in accordance with the project-specific Work Plan/Sampling Plan, or Quality Assurance Project Plan (QAPP) and **FGD 1.05** (Field Quality Control Samples).
- If the pump/equipment is being used for organic constituent sampling, place in the methanol rinse container. Make sure that the pump/equipment and nearby electrically powered equipment is grounded, and potential sources of sparks are eliminated before operating pumps. Don appropriate personal protective equipment (e.g., safety glasses, face shield, apron, nitrile/latex gloves, Tyvek suit, etc.) and work in a well-ventilated area downwind of the sampling locations, in accordance with the Site-Specific HASP.
- Immerse pump/equipment in the methanol rinse container (for pumps, to above the intake level). Agitate equipment, or for pumps, operate to discharge approximately 2 liters of solvent into a waste container (adding solvent to container as needed, to maintain flow). Stand back from pumps during operation as a safety precaution. Place any unused methanol into an appropriate waste container and let residual methanol in methanol rinse container evaporate to dryness.
- Change gloves, and then rinse pump/equipment exterior with organic-grade blank water and place into an air-dried container. Add organic-grade blank water to immerse equipment/pump to force residual methanol out of components, and capture in waste methanol container. If pump/equipment includes reusable tubing, rinse with an additional approximately 0.5 liter of organic-grade blank water per 10-feet of attached tubing.
- If equipment blanks are required, repeat this procedure using laboratory-provided blank water, and collect a field blank in accordance with the project-specific Work Plan/Sampling Plan, or Quality Assurance Project Plan (QAPP) and **FGD 1.05** (Field Quality Control Samples).

4.3.4 Storage of Decontaminated Sampling Equipment

To store the decontaminated sampling equipment, wrap the equipment in an inert wrapping material (e.g., aluminum foil, plastic wrap, Parafilm) and place in a sealed container that has been similarly decontaminated. Prior to storage equipment should be air dried to avoid bacterial growth. In some cases, inert gas or filtered air may need to be blown through equipment. Alternatively, the equipment can be chilled to avoid bacterial growth. If bacterial growth is observed, decontaminate again prior to use.

4.4 Quality Assurance/Quality Control

The effectiveness of the sampling equipment decontamination procedures is evaluated through collection of field blank samples. Guidance on the collection of field blanks is provided in **FGD 1.05** (Field Quality Control Samples). Details on the number of field blanks and the analyses to be performed on each sample, along with other Quality

Assurance/Quality Control (QA/QC) procedures should be outlined in the project-specific Work Plan/Sampling Plan, or Quality Assurance Project Plan (QAPP). In their absence, the QA/QC guidelines of **FGD 1.05** (Field Quality Control Samples) should be reviewed. However, it is generally recommended that field blanks be collected at a rate of 5% (1 per 20) of the total number of samples collected throughout the sampling event or one per sampling day if the total number of samples is less than 20. State-specific or regulatory program-specific guidelines may require that field blanks be collected more frequently.

5. PRECAUTIONS AND OTHER CONSIDERATIONS

All field activities require recording sufficiently detailed information throughout the implementation of field work. However, certain precautions should be taken to ensure safety while performing equipment decontamination activities.

- It is important to always remain alert and aware of your surroundings. Decontamination activities may be conducted in proximity to drill rigs or other heavy equipment and can be subject to hazards posed by nearby equipment, vehicle traffic, industrial machinery, hazardous chemicals and contaminants, and/or other physical, mechanical, and chemical hazards.
- Prior to mobilization, determine the proposed location of the decontamination areas and evaluate the need for security, barricading, and/or traffic control.
- When working out of sight of the general public or site employees are in potentially hazardous areas (e.g., wooded habitats), all field staff should utilize the "buddy system" and should ensure that the project-specific HASP includes safety measures and procedures
- Decontamination procedures may involve the use of hazardous materials including acids, and organic solvents, which can pose chemical hazards during transportation, storage, and handling. Prior to use of any such reagents, discuss the health and safety procedures with the PIC and/or PM, and consult the project-specific HASP, as appropriate.
- Decontamination procedures may involve the use of high-pressure applications such as pressure washers and special considerations should be given to containing those fluids and the associated residuals.
- Decontamination wastes are considered IDW and shall be containerized, labelled and managed as outlined in **FGD 15.01** (Waste Handling).
- A nitric acid rinse is generally only required if metals analyses is to be performed and/or if visual contamination persists or gross contamination is suspected following the three-step decontamination procedure. When an acid rinse is required additional health and safety as well as waste management measures will be required.
- A solvent rinse is generally only required if organics analyses is to be performed and/or if visual contamination persists or gross contamination is suspected following the three-step decontamination procedure. Note that if acetone is known or suspected to be a COC or a Target Compound List analysis is to be performed, methanol should be used.

However, methanol cannot be used when sampling media impacted by gasoline or its by-products.

6. RECORDKEEPING

Document all decontamination activities in accordance with **FGD 1.01** (Field Notes and Records). At a minimum, the following information should be recorded for each decontamination activity:

- Date and time.
- The decontamination methodology, including details on the source water and rinsates.
- Location (i.e., boring, well, sample number) where the equipment was used before and after decontamination.
- Location and description of the decontamination area.
- Details on the IDW generated and managed (i.e., stored, characterized, disposed).
- Identification of any field blank samples collected.

Appendix B
Quality Assurance Project Plan

Intended for

New York State Department of Environmental Conservation

Document type

Generic Quality Assurance Project Plan

Date

April 2024

GENERIC QUALITY ASSURANCE PROJECT PLAN

HUNTS POINT FORMER MGP

RAMBOLL Bright ideas. Sustainable change.

GENERIC QUALITY ASSURANCE PROJECT PLAN
HUNTS POINT FORMER MGP

Project Name	**Hunts Point Former MGP**
Recipient	**Con Edison of NY**
Document	**Generic Quality Assurance Project Plan**
Version	**1**
Date	**April 2024**
Description	**Procedures for sampling handling and analysis.**

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CONTENTS

Tables

Exhibits

List of Acronyms

ºC	Degrees Celsius
AI	Indoor air
APHA	American Public Health Association
AS	Sub-slab soil vapor
AO	Outdoor air
ASP	Analytical Services Protocol
AWWA	American Water Works Association
BOD	Biochemical Oxygen Demand
CFR	Code of Federal Regulations
COD	Chemical Oxygen Demand
%D	Percent difference
DBMS	data base management system
DQO	Data Quality Objective
DUSR	Data Usability Summary Report
EB	Equipment/field rinsate blank
EDD	Electronic Data Deliverable
ELAP	Environmental Laboratory Accreditation Program
FAP	Field Activities Plan
FD	Field duplicate
GS	Soil gas
HASP	Health and Safety Plan
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
MDL	Method detection limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ng	nanograms
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PAH	polynuclear aromatic hydrocarbons
PCB	Polychlorinated Biphenyl
PFAS	Per- and polyfluoroalkyl substances
PPE	personal protective equipment
QA	Quality Assurance
QAM	Quality Assurance Manual
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QL	Quantitation Limit
REG	regular environmental sample

%R	Percent recovery
%RPD	Relative Percent Difference
SDG	Sample Delivery Group
SE	Sediment
SI	Sample identification
SIM	selected ion monitoring
So	Soil
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitation Leaching Procedure
SS	Surface soil
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TB	Trip blank
TDS	Total dissolved solids
TKN	Total Kjeldahl Nitrogen
TOC	Total organic carbon
TSS	Total suspended solids
TVS	Total Volatile Solids
µg	Micrograms
USEPA	Unites States Environmental Protection Agency
VOC	Volatile Organic Compound
WASD	Work Assignment Scoping Document
WC	Waste characterization
WEF	Water Environment Federation
WG	groundwater
WP	Drinking water
WS	Surface water

1. INTRODUCTION

On behalf of Consolidated Edison Company of NY, Inc. (Con Edison), this generic Quality Assurance Project Plan (QAPP) has been prepared by Ramboll Americas Engineering Solutions, Inc. (Ramboll) to support activities at the Hunts Point former Manufactured Gas Plant (MGP; the "Site"). The Site is currently identified by the New York State Department of Environmental Conservation (NYSDEC) under a Voluntary Cleanup Agreement (VCA) index number of D2-0003-02-08. This QAPP specifies the quality assurance/quality control (QA/QC) procedures for field sampling, laboratory analysis and data generation for work assignments conducted at the Site.

The specific objective of the QAPP is to generate data that is scientifically sound, representative, comparable, defensible and of known quality that is sufficient to meet the investigation objectives and support the decision-making process for each work assignment. Project or site-specific work plans for the work assignment may contain additional scope and quality requirements that are not addressed in this QAPP and, if needed, addendums to this QAPP may be prepared. Project scope and descriptions for the work assignment will be provided in an associated work plan. The work plan may include sampling methods for the collection of groundwater, drinking water, surface water, soil, surface soil, sediment, ambient air, soil gas, sub-slab air and indoor air samples. A field sampling plan (FSP) will be provided alongside this QAPP which include field guidance documents (FGDs) for the field tasks and sampling methods.

Laboratory QA/QC is a comprehensive program used to define and document the quality of analytical data. QA involves planning, implementation, assessment, reporting and quality improvement to establish the reliability of laboratory data. QC procedures are the tools used to achieve this reliability. This QAPP defines how QA and QC are applied to the environmental activities at the project sites to assure that the type and quality of data generated meet project needs.

This QAPP has been prepared using the guidance provided in the following documents:

- United States Environmental Protection Agency (USEPA). Reissued 2006. *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations*, EPA QA/R-5. Washington, D.C.
- NYSDEC. 2010. DER-10 *Technical Guidance for Site Investigation and Remediation*. Albany, NY.

The following topics are generally addressed in this QAPP:

- Project background and description
- Data quality objectives
- Project organization and responsibilities
- Sampling design and method requirements
- Field instrumentation
- Sample handing and custody procedures
- Analytical methods requirements
- Data assessment procedures and quality control requirements
- Data acquisition requirements

- Data review and management
- Data validation and usability

2. GENERAL PROJECT, LABORATORY AND DATA VALIDATION INFORMATION

2.1 Project Background, Description and Scope

The work plan completed for each work assignment will present the project background, project description, scope and schedule for each of the work assignments addressed by this contract.

Additional information or an addendum to this QAPP may be prepared for each work assignment including laboratory detection limits and related QA/QC information for analytical methods and laboratory assigned to the task. Project scope and descriptions of the work assignment will be provided in the work plan.

2.2 Laboratory Analysis

Samples collected for each work assignment will be submitted to a New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP) certified laboratory. The ELAP lab certification for below referenced lab is provided in **Exhibit E-1**.

Samples may be submitted to the following laboratory for the analyses**:**

- SGS North America, Inc. of Dayton, New Jersey (SGS Dayton; New York Certification Number 10983) for the following analyses:
  - Volatile organic compounds (VOCs) by USEPA Method 8260D for aqueous and solid samples
  - Semi-VOCs (SVOCs) by USEPA Method 8270E for aqueous and solid samples
  - Metals by USEPA Methods 6010D for aqueous and solid samples
  - Total petroleum hydrocarbons (TPH) via USEPA method 8015B for solid samples
  - Per-and Polyfluorinated Alkyl Substances (PFAS) by USEPA method 1633 for aqueous (non-potable) and solid samples

Samples collected will be shipped from the field location to the laboratory performing the analyses. **Table 1** presents the analytical methods, sample collection containers and volumes, preservation, holding times and associated quality control sample frequency.

The QC requirements provided in the laboratory standard operation procedures (SOPs) are to be followed by the laboratory and utilized during data review. The laboratories performing the analyses be responsible for the quality control of the data reported. The laboratory SOPs are provided in **Exhibit E-2**.

The laboratory will evaluate non-detected results to the method detection limits (MDLs) and report the non-detected results referencing the quantitation limit (QL). The QL concentration is established by the lowest standard in the instrument calibration. For the remaining data, results that are less than the QLs but greater than or equal to the MDLs will be reported using the “J” flag. For example, for a target analyte with a QL of 10 µg/L and an MDL of 2 µg/L, a non-detected result is reported as 10 µg/L "U", indicating that a concentration greater than or equal to the MDL was not detected by the laboratory. A detected concentration of 6 µg/L is reported as 6 "J" and a detected concentration of 23 µg/L is reported without a laboratory flag. The laboratory must include both QLs and MDLs on the sample result sheet that is reported to the data user. The most current QLs and MDLs will be reported by the laboratory. Prior to sample analysis, the laboratory QLs and MDLs will be compared to the regulatory limits provided in **Table 2-1A, Table 2-1B, Table 2-2, Table 2-3, Table 2-4, Table 2-5,** and **Table 2-6** to identify QL and or/MDLs of target analytes that exceed the regulatory limits.

Communications with the project organizations (external to the lab) associated with each work assignment will be documented by the laboratory in the data packages.

The analytical data will be reported in USEPA Contract Laboratory Program (CLP)-like full deliverable format in both hardcopy and electronic data format. The data packages will provide documentation consistent with NYSDEC ASP-defined full data package deliverables (Category B). Laboratory SOPs and Quality Assurance Manual (QAM) applicable to the work assignment will be provided to the Ramboll PM prior to completing the analyses. These laboratory SOPs will be utilized during data review.

Analytical data will be reported as an Electronic Data Deliverable (EDD) formatted in accordance with NYSDEC’s requirements populated with NYSDEC valid values.

Laboratory data reports will be provided by the laboratory within 30 calendar days following receipt of a complete Sample Delivery Group (SDG). A CLP-like full-deliverable laboratory data package will be provided. Each data package will contain information to support data validation by USEPA Region II SOPs. The completed copies of the chain-of-custody records, accompanying each sample from the time of initial bottle preparation to completion of analysis, must be included in the analytical reports.

2.3 Data Validation

Following receipt of final laboratory data packages, data validation will be performed for samples collected for the work assignments in accordance with this QAPP. Data will be evaluated using the QA/QC criteria established in the analytical methods utilized by the laboratory and the laboratory SOPs, where applicable.

Samples analyzed for PFAS, if needed, will be evaluated in compliance with Appendix H of the NYSDEC document Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) under NYSDEC's Part 375 Remedial Programs dated April 2023 (**Exhibit E-3**).

Data affected by excursions will be qualified using the current USEPA Region II data validation guidelines and NYSDEC Data Usability Summary Report (DUSR) guidance (NYSDEC, 2010). Upon request of the data validator, the laboratory will provide additional or supplemental information within three working days of the request during the validation process.

The specific data quality requirements including precision, accuracy, representativeness, completeness, comparability, and sensitivity will be assessed during data validation. Data usability with respect to the data quality objectives (DQOs) and data uses will be compared to the project requirements. In the event that the completeness objective of 95 percent is not achieved, samples will be recollected at the discretion of the Project Manager.

2.4 Documentation

Data generated for each work assignment will be submitted to the NYSDEC in an EDD format that complies with the NYSDEC's Environmental Data Submission EDD format. Data will be managed in a relational data base management system (DBMS). Laboratory analytical data will be provided in EDD format for direct upload into the DBMS. Data validation qualifiers will be entered into the DBMS and checked independently.

Records will be incorporated into the final project files for the samples. The field logs, data packages, and records will be included in the project files, which will be archived by the project organizations associated with each work assignment for a period of ten years.

3. DATA QUALITY OBJECTIVES AND CRITERIA

The DQO process comprises the following steps, applying general guidance presented in the USEPA Guidance for the Data Quality Objectives Process (USEPA QA/G-4), February 2006. The DQO process establishes the acceptance criteria, which serve as the basis for collecting data of sufficient quality and quantity to support the goals of the project activities. DQOs will be established for each work assignment and presented in the associated work plan.

3.1 DQO Process

The process consists of the following seven iterative steps for the DQO process:

1. **Step 1** - State the Problem – Define the problem that has initiated the work assignment. As environmental problems are often complex combinations of technical, economic, social, and political issues, it is critical to the success of the process to separate each problem, define it completely, and express it in an uncomplicated format.
2. **Step 2** - Identify the Goal of the Study – Identify the key questions that the study attempts to address, along with alternative actions or outcomes that may result based on the answers to these key questions.
3. **Step 3** - Identify information inputs (the data types that will be required before project decisions can be made) – Determine the types of information needed to address the problem.
4. **Step 4** -Define the Boundaries of the Study (the spatial and temporal features pertinent for decision making) – Identify the area from which samples will be drawn and specify the spatial and temporal features.
5. **Step 5** - Develop the analytic approach (how will the study results be analyzed and conclusions made from the data) – Develop an analytic approach that will provide guidance for how to analyze the study results and draw conclusions from the data.
6. **Step 6** - Specify performance or acceptance criteria (performance or acceptance criteria that the collected data will need to achieve) – Define the acceptance criteria that the collected data will need to achieve in order to keep uncertainty to within acceptable levels. Performance criteria, together with the appropriate level of QA practices, will guide the design of new data collection efforts, while acceptance criteria will guide the design of procedures to acquire and evaluate existing data relative to the intended use.
7. **Step 7** - Develop the plan for obtaining data- Develop a design for collecting and measuring environmental samples to address the problem.

To meet DQOs established for each work assignment, results will be compared to the following regulatory criteria, where applicable:

For groundwater and surface water:
- 6 CRR-NY Part 703 *Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations*.

For drinking water:
- 10 CRR-NY Part 5-1.51 *Public Water Systems; Maximum Contaminant Levels; Monitoring Requirements; Notifications Required*.

For sediment:

- *Screening and Assessment of Contaminated Sediment*, NYSDEC Division of Fish and Wildlife and Marine Resources; June 24, 2014.

For soil samples:

- 6 CRR-NY Part 375-6 *Remedial Program Soil Clean Up Objectives*.

For air samples:

- *Guidance for Evaluation of Soil Vapor Intrusion in the State of New York*; New York State Department of Health (NYSDOH); October 2006 (as updated) and updated matrices dated May 2017.

For Per- and polyfluoroalkyl substances (PFAS) samples:

- Screening levels per NYSDEC document *Sampling, Analysis, And Assessment of Per- and Polyfluoroalkyl Substances (PFAS) under NYSDEC's Part 375 Remedial Programs* dated April 2023.

3.2 Analytical Levels

Analytical levels as defined by USEPA as follows:

- **Screening Data** – Screening data are generated by rapid, less precise methods of analysis with less rigorous sample preparation. Sample preparation steps may be restricted to simple procedures such as dilution with a solvent, instead of elaborate extraction/digestion and cleanup. Screening data provide analyte identification and quantitation, although the quantitation may be relatively imprecise. At least 10% of the screening data should be confirmed using analytical methods and QA/QC procedures and criteria associated with definitive data. Screening data without associated confirmation data are not considered to be data of known quality. During sampling activities, the following data may be measured in the field: dissolved oxygen, temperature, oxidation-reduction potential, pH, turbidity, and specific conductance.

- **Definitive Data** – Definitive data are generated using rigorous analytical methods, such as USEPA and Standard Method reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data in the form of paper printouts or computer-generated electronic files. Data may be generated at the Site or at an off-site location, as long as the QA/QC requirements are satisfied. For the data to be definitive, either analytical or total measurement error must be identified. The level of QC that is performed for definitive data involves the QC efforts and calibration procedures described in this QAPP, analytical methods listed in **Table 1**, and QC requirements listed in the laboratory SOPs. Laboratory control limits for accuracy and precision will be used to evaluate sample data.

The QA/QC program described in this QAPP was developed in order to assess adherence to DQOs. The remainder of this QAPP describes the specific approaches that will be taken to achieve the required DQOs.

Precision describes the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements that have been made in an identical manner, compared to their average value. Precision can be expressed in a variety of manners that include absolute methods such as deviation from the mean or median values, standard deviation and variance, or relative methods (*e.g.*, relative deviation from the mean or median). The overall precision will be determined through the analysis of field duplicates, laboratory duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples.

Accuracy is defined as the degree of difference between measured or calculated values and the true value. The closer the numerical value of the measurement comes to the true value, or actual concentration, the more accurate the measurement is. Accuracy is expressed in terms of absolute or relative error. Accuracy will be determined through analysis of spiked samples and the analysis of standards with known concentrations.

Representativeness refers to the degree to which a sample taken from a Site accurately reflects the matrix at the Site. It is a qualitative parameter that is most concerned with the design of the sampling program. Factors that should be considered in the determination of representativeness include appropriateness of sampling and analytical methodologies, representativeness of the selected media, and representativeness of the selected analytical procedures. Representativeness will be achieved using procedures for the collection and preservation of samples as described in the work plan.

Comparability refers to the use of consistent procedures, second source reference standards, reporting units, and standardized data format with document control. Adherence to standard procedures and the analysis of external source standard materials maximizes the probability that data generated from a particular method at a given laboratory can be validly compared to the data of another. This QAPP has been written to provide data that will be comparable to other data collected, as standard methods will be utilized for these sampling and analysis activities.

Completeness refers to the process of obtaining the required data. Completeness is also defined as the percentage of measurements judged to be useable. Samples for which the critical data points fail completeness objectives will require reanalysis of samples (within the specified holding times) until the DQOs are met. The completeness goal has been specified at 95% for the work assignment activities.

Sensitivity refers to a measurable concentration of an analyte that has an acceptable level of confidence. MDLs are the lowest concentration of an analyte that can be measured with 99% confidence that the analyte concentration is greater than zero. QLs are levels above the MDLs at which the laboratory has demonstrated the quantitation of analytes.

3.3 Field Sampling Objectives

The objective of the field sampling program is to obtain samples that represent the environmental matrix being investigated. This will be accomplished through the use of proper sampling techniques and equipment as presented in the FSP. Field screening activities may not require sample collection but, nonetheless, involve measurements for which QA concerns are appropriate. The primary QA objective of field screening is to obtain reproducible measurements to a degree of accuracy consistent with the intended use of the measurements and to document measurement procedures.

3.4 Laboratory Objectives

To obtain data of a quality sufficient to meet the work assignment DQOs, the laboratory will adhere to the specific analyses and QA/QC requirements in the analytical methods listed in **Table 1**. The methods cited in this QAPP provide data of sufficient quality for comparisons to the regulatory criteria. The laboratory SOPs and QAM applicable to the work assignment will be available to the data validators.

4. PROJECT ORGANIZATION

4.1 Project Organization and Qualifications

Ramboll personnel will perform the oversight for the field activities. Project direction will be provided by Con Edison, with oversight from NYSDEC. A list of key project personnel is listed below. Ramboll project team resumes are included as **Exhibit E-4**.

Company/ Organization	Title	Name	Phone Number	Email
NYSDEC	Case Manager	Ronnie E. Lee	518-402-9615	Ronnie.lee@dec.ny.gov
Con Edison	Project Manager	Melissa Abt	718-201-4331	AbtM@coned.com
Ramboll	Project Officer	Timothy Olean	508-395-6960	tim.olean@ramboll.com
	Project Manager	William Moore	973-820-1044	william.moore@ramboll.com
	Field Manager	Matt Miller	609-951-9003	mmmiller@ramboll.com
	Ramboll QA Officer	Kristin Drucquer	405-905-4772	kdrucquer@ramboll.com
	Field Personnel	TBD	TBD	TBD

4.1.1 Ramboll Project Officer

The Ramboll Project Officer has overall responsibility for meeting the stated project objectives. In addition, they are responsible for providing the Ramboll Project Manager with access to Ramboll corporate resources.

4.1.2 Ramboll Project Manager

The Ramboll Project Manager is responsible for implementing the project and has the authority to commit the resources necessary to meet project objectives and requirements. Their primary function is to meet the technical, financial, and scheduling objectives and will provide direction to the Ramboll Project Team.

4.1.3 Ramboll QA Officer

The Ramboll QA Officer (QAO) will manage and be responsible for QA/QC review of data generated from the sampling activities. Data processing and validation will be overseen and reviewed by the Ramboll QAO. If QA problems or deficiencies requiring special action are identified, the Ramboll QAO, Project Manager, and Project Officer will determine the appropriate corrective action. The QAO will then be responsible for follow-up and oversight of corrective action implementation, to the satisfaction of QCI.

The QAO may perform data validation activities or designate additional data validators to work under her direction. Data validators will be responsible for review of laboratory data for compliance with the project-specific DQOs and for such parameters as precision, accuracy, representativeness, comparability, sensitivity and completeness. Data validators will notify the QAO of any major QA deficiencies.

4.1.4 Ramboll Field Investigation Manager

The Ramboll Field Investigation Manager will be responsible for directing and coordinating the day-to-day activities while field activities are underway.

4.1.5 Field Sampling Personnel

Ramboll field sampling personnel will be responsible for collection, packaging, preservation, and shipping of environmental samples in accordance with the QAPP and applicable NJDEP regulations and guidance. Field sampling personnel will also collect field data and monitor Site health and safety.

4.1.6 Health and Safety Coordinator

The Ramboll Health & Safety Coordinator and will be responsible for monitoring Site health and safety during the sampling events.

4.2 Laboratory Organization

SGS Dayton will analyze the samples collected during sampling activities. The laboratory shipping addresses, and National Environmental Laboratory Accreditation Conference (NELAC) Certification number is as follows:

SGS Dayton
2235 Route 130
Dayton, New Jersey 08810
732-355-4562
NY Certification Number: 10983

Tammy Esposito-McCloskey is the Laboratory Project Manager for SGS Dayton. The Laboratory Project Manager will be responsible for:

- Coordinating laboratory analysis
- Supervising in-house chain-of-custody
- Scheduling sample analysis
- Overseeing data review
- Overseeing preparation of analytical reports

It will be the responsibility of the Laboratory Project Manager to approve final analytical reports prior to submission to Ramboll.

4.3 Data Validation

Data generated for each work assignment will be submitted for data validation as described in this QAPP.

- Personnel performing data validation must be:
- Independent of the laboratory generating the data
- Experience in data validation
- Aa Bachelor’s degree in chemistry or natural sciences
- One year experience in the implementation and application of analytical laboratory methodologies; and
- A minimum of one year experience evaluating data packages for regulatory compliance.

4.4 Special Training Requirements

Field investigation personnel must comply with the training requirements for hazardous waste operations, codified in 29 CFR 1910.120(e). Each individual must have successfully completed a

40-hour course appropriate to the level of work that is performed. In addition, each individual must have completed an 8-hour refresher course within the last 12 months if the initial training was more than 12 months ago. Personnel acting in the capacity of an on-site supervisor, directly responsible for supervising employees engaged in hazardous waste operations, shall also have successfully completed an 8-hour Supervisor training course. Field personnel must have documentation (copies of certificates, or I.D. cards) available on site as proof of compliance with the training requirements.

5. SAMPLING DESIGN

5.1 Sampling Network

The specific analytical methods, sample matrices, and numbers of samples to be collected will be presented in the work plan.

The specific target analyte lists associate with analytical methods to be performed by the laboratory are presented in **Table 2-1A, Table 2-1B, Table 2-2, Table 2-3, Table 2-4, Table 2-5** and **Table 2-6**.

5.2 Sample Location and Designations

A sample designation system will be used to identify samples for laboratory analysis. A list of identifiers used for each sample will be maintained in the project logbook or sampling logs by the field personnel. Sample locations will be identified on a site map that will be included in the work plan.

Each sample that is collected will be designated by a unique sample identification number. Designations shall use current valid values for environmental data submission to NYSDEC as listed on the NYSDEC website (https://www.dec.ny.gov/chemical/62440.html) The following information will be utilized to identify samples for the work assignments. This may be modified if needed for specific samples.

1. Sample identification (ID) with the following standard format:

Sample Matrix-Location ID-Sample Depth Interval (if applicable) – Date
Example 1: WG-MW-6S-101620
Example 2: SO-SB-102-9-10-101620

  - Example sample types - SO (soil), SS (surface soil), WS (surface water), WG (groundwater), WP (drinking water), GS (soil gas), SE (sediment), AS (sub-slab soil vapor), AO (outdoor air) and AI (indoor air).
  - Date - Date sample collected (listed on the chain-of-custody record). Sample times are not recorded for field duplicates and trip blanks.

2. QC Sample Types–Field duplicate (FD), Matrix spike (MS), Matrix spike duplicate (MSD), trip blank (TB), equipment blank (EB).

  - Field duplicate example: WG-FD-1-101616
  - Matrix spike / matrix spike duplicate example: WG-OBG-6S-MS/MSD-101616
  - Trip blank example: TB-1-101616
  - Field blank example: EB-1-101616

3. Waste characterization samples (WC)
  - Example: WC-sample matrix-sample location-date

4. Sample Purpose:

   - REG = regular environmental sample
   - FD = field duplicate
   - MS = matrix spike
   - MSD = matrix spike duplicate
   - TB = trip blank
   - EB = equipment blank

5. Grab/Composite – Identifies samples collected as a grab sample or a composite sample.

6. Field duplicates will be identified with a unique sample identification number, such that the laboratory will not be aware of the sample location utilized as the blind duplicate. The field sampling personnel will note the duplicate sample in the logbook so that this information will be available when the laboratory data is reviewed.

5.3 Field Guidance Documents

The following Ramboll field guidance documents (FGDs) will be utilized during the sampling event**:**

- FGD: Field Records and Notes
- FGD: Soil Classification
- FGD: Subsurface Soil Sampling – Direct Push Technology
- FGD: Sample Naming, Labeling, Handling, Shipping, and Chain of Custody
- FGD: PFAS Sampling
- FGD: Groundwater and Free Product Level Measurements
- FGD: Permanent Well Overburden Well Installation
- FGD: Sample Equipment Decontamination

These FGDs outlining are included as attachments in the FSP.

5.4 Sampling Precautionary Measures for PFAS

If samples are required to be collected and analyzed for PFAS, they will be collected in accordance with Appendix B and Appendix C of the NYDEC Sampling, Analysis, And Assessment of Per- And Polyfluoroalkyl Substances (PFAS) guidance document, dated April 2023. Field staff will review and comply with Ramboll's PFAS Sampling Field Guidance procedures (included in the FSP) to ensure field clothing, PPE, sun/biological protection, and personnel hygiene prior to and during sampling is PFAS free.

If conditions are identified where soil sampling for PFAS is required, a precleaned stainless steel sampling spoon will be used to obtain the sample. Once the soil sample is obtained, it will be deposited into a stainless-steel bowl for mixing prior to filling the laboratory provided PFAS-free sample containers. The soil sample will be placed directly into the bowl and mixed thoroughly by rolling the material into the middle until the material is homogenized. Once the mixing of the material is complete, the soil sample will be placed in the applicable container.

Additionally, if conditions are identified where groundwater sampling for PFAS is required, no sampling equipment components or sample containers will come in contact with aluminum foil, LDPE, glass, or polytetrafluoroethylene (PTFE; Teflon™) materials including plumbers tape and sample bottle cap liners with a PTFE layer. Temporary and/or monitoring wells will be sampled in accordance with the sampling procedure (grab. volume purge, and/or low flow purge) identified in the work plan.

Sampling equipment will be pre-cleaned using a twostep decontamination process starting with Alconox, and then followed with a rinse using laboratory provided PFAS-free water. The laboratory will provide documentation that sources of water and containers used for decontamination are PFAS free. Sampling personnel will 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.

Ramboll’s Decontamination FGD is included in the FSP. Details regarding the type of PFAS-free sampling containers and laboratory sampling handling requirements for PFAS are provided in **Table 1**.

6. FIELD INSTRUMENTATION AND INSPECTION OF SUPPLIES

The following field equipment is expected to be used:

- Photo-ionization detector (PID) used for screening soils/wells and head space
- TSI DUSTTRAK DRX Dust/Aerosol Monitor (or similar device) for CAMP monitoring
- Electronic Water Level Indicator
- Electronic Oil/Water Interface Probe (in the event that non-aqueous phase liquids [NAPL] are encountered)
- Horiba U-10 Water Quality Analyzer or equivalent (for measurement of field indicator parameters including pH, temperature, specific conductivity, dissolved oxygen, oxidation-reduction potential, turbidity, etc.).

6.1 Field Equipment Calibration

Field instruments will be calibrated in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Equipment to be used for the field sampling will be examined to confirm that it is in good operating condition. This includes checking the manufacturer's operating manual and the instructions for each instrument to confirm that the maintenance requirements are being observed.

In general, instruments will be calibrated daily prior to use and will be recalibrated as required. All calibration procedures performed will be documented in the field logbook. Calibration checks will be performed at the intervals specified by the manufacturer. In the event that an internally calibrated field instrument fails to meet calibration procedures, it will be returned to the manufacturer for service.

6.2 Field Equipment, Preventative Maintenance, and Documentation

Preventative maintenance procedures will be carried out on field equipment by Ramboll personnel in accordance with the procedures outlined in the manufacturers' specifications and/or equipment manuals.

Maintenance activities involving field equipment will be recorded in the field logbook. Field equipment will be check by qualified field representatives prior to being used in the field. Problems encountered while operating the instrument will be documented in the field logbook. If problem equipment is detected or should require service, the equipment will be returned and a qualified technician will perform the maintenance required. Use of the instrument will not be resumed until the problem is resolved.

6.3 Inspection Requirements for Supplies

The use of standard materials of a known purity and quality is necessary for the generation of reproducible data. The laboratory will monitor the use of laboratory consumable materials including solutions, standards, and reagents as described in this QAPP.

Solvent materials are also verified prior to use. Each new lot of solvent is analyzed to verify the absence of interfering constituents. Reagent and method blanks are routinely analyzed to evaluate possible laboratory-based contamination of samples.

The sample containers used for this project will be supplied by the laboratory. The containers will be pre-cleaned sample containers that will be purchased from a USEPA-certified manufacturer (I-Chem 200 or equivalent container) or are cleaned using USEPA protocols.

The Laboratory Project Manager and the field representatives will be ultimately responsible for checking supplies for contamination.

Chemical reagents and solvents used by the field personnel will be provided by the laboratory.

7. SAMPLING HANDLING AND CUSTODY

7.1 Field and Laboratory Custody Procedures

Chain-of-custody procedures as described in this QAPP will be instituted and followed throughout the work assignment field activities. These procedures include field custody, laboratory custody and evidence files. Samples are physical evidence and will be handled according to strict chain-of-custody protocols. The project organization must be prepared to produce documentation that traces the samples from the field to the laboratory and through analysis.

USEPA has defined custody of evidence as follows:

- In actual possession
- In view after being in physical possession
- In a locked laboratory
- In a secure, restricted area.

7.2 Sample Containers and Field Storage

Table 1 lists the proper sample collection information. If field storage is required, the samples will be stored in a secured storage facility.

The laboratory will supply appropriate sample containers for solid and aqueous samples in coolers as well as preservatives (as presented in **Table 1**). QA measures for these samples will begin with the sample containers; pre-cleaned containers will be purchased from a USEPA-certified manufacturer (I-Chem 200 or equivalent).

Immediately after collection, samples will be transferred to properly labeled sample containers, and properly preserved. **Table 1** lists the proper sample container, sample volumes, preservation, and holding times.

Samples requiring refrigeration for preservation will be promptly transferred to coolers packed with wet ice and/or ice packs. If field storage is required, the samples will be stored in a secured storage facility and a cooler temperature of less than or equal to 6 °C will be maintained.

7.3 Field Documentation

The field sampler is personally responsible for the care and custody of the sample until transferred.

The field logbook, forms or electronic media will be used to note information regarding collection of samples, activities completed, and observations. All entries will be signed and dated. When used, field logbooks will be waterproof and bound. Waterproof paper will not be used for sites where samples will be analyzed for PFAS. The logbook will be dedicated to the work assignment and pages will not be removed. Corrections will be made by drawing a single line through the incorrect data and initialing and dating the correction that was made to the side of the error. An initialed diagonal line will be used to indicate the end of an entry or the end of the day's activities.

The following presents information that may be recorded by the field sampling team:

- Name and title of author, date, and time of site entry, and physical/environmental conditions during the field activity;
- Meteorological data;
- Work assignment number, client name, and Site name;
- Name and title of field crew members;
- Sample media;
- Sample collection method, including equipment utilized;
- Number and volume of samples collected;
- Description of sample locations;
- Date and start and end time of sample collection;
- Sample and QA/QC identification numbers;
- Sample distribution;
- Field observations;
- Field measurements made and equipment used;
- Calculations, results, and calibration data for field sampling and measurements;
- References for maps and photographs of the sample location; and
- Dates and method of sample shipments.

A completed sample identification label or tag that will be sequentially numbered will be attached to each investigative sample and the sample placed in a shipping container. The identification on the label/tag must be sufficient to enable cross-reference with the logbook. The sample label/tag will be recorded using waterproof, non-erasable ink and will be attached to the sample container using adhesive. Permanent marker will not be used on sample labels/tags.

The sample labels/tags will contain the following information:

- Sample location/number identification;
- Site/Work assignment name;
- Date and time of sample collection;
- Designation of the sample as a grab or composite;
- Type of sample matrix;
- Name/initials of the sampler;
- Whether the sample is preserved or unpreserved;
- Space for laboratory sample number (only on the sample label/tag); and
- General types of analysis to be performed.

7.4 Field Custody Procedures and Documentation

For the environmental samples, chain-of-custody records will be kept starting at the time that sample containers are placed in the coolers for transportation to the laboratory. One completed chain-of-custody record must be kept with each sample cooler at all times.

Example chain-of-custody forms are provided in the laboratory's QAM.

The following measures will be taken when completing a chain-of-custody record:

- The chain-of-custody forms will be completed in waterproof, non-erasable ink.
- The chain-of-custody forms will be completed neatly using printed text. If a simple mistake is made, the error will be lined out with a single line and initialed and dated.
- Each separate sample entry will be sequentially numbered.
- The use of "ditto" or quotation marks to indicate repetitive information in columnar entries should be avoided. If numerous repetitive entries must be made in the same column, a continuous vertical arrow will be used between the first entry and the next different entry.
- When more than one chain-of-custody form is used for a single shipment, each form will be consecutively numbered using the "page ___ of ___" format.
- If necessary, additional instructions will be placed directly onto the chain-of-custody form.
- Acronyms used on a chain-of-custody form will be defined.

For environmental samples, the chain-of-custody form will contain the following information:

- Laboratory name and address;
- Work assignment name and number;
- Sample description/location;
- Date and time of sample collection;
- Type and matrix of sample;
- Number of sample containers;
- Analysis requested/comments;
- Sampler signature/date/time;
- Date and signature of the field representative;
- Date and signature of the laboratory representative;
- Carrier used to ship coolers; and
- Air bill number (if shipped by a commercial carrier).

In the case that high concentrations are suspected to be present in the samples, a note to that effect will be included on the chain-of-custody form.

In the field logbook, field samplers will note the information previously presented.

Samples will be packed prior to shipment using the following procedures (where applicable):

- Select a sturdy cooler in good repair and clean. Secure and tape the drain plug with fiber or duct tape.
- Be sure the lids on all bottles are tight (will not leak) and baggies are sealed.
- Where applicable, add ice that has been placed in heavy-duty polyethylene bags and properly sealed on top of or between the samples. Pack samples securely to eliminate breakage during shipment with ice packs to maintain the inside temperature of less than or equal to 6°C.
- Sampling containers will be packed with packing materials. When possible, sample container preparation and packing for shipment will be completed in a well-organized and clean area. Sample containers will be prepared for shipment by wiping containers clean of debris/water

using paper towels. Paper towels will be disposed with the personal protective equipment (PPE).

- Place chain-of-custody record into a Ziploc plastic bag, tape the bag to the inner side of the cooler lid, and close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Two custody seals will be affixed to the latch and lid of the cooler. The number of the security seal, if applicable, will be recorded on the chain-of-custody form. The custody seals will consist of adhesive-backed tape that easily rips if it is disturbed. The field sampler will initial and date the seal. The seals must be broken to open the cooler and will indicate tampering if the seal is broken before receipt at the laboratory.
- A label containing the name and address of the shipper will be placed on the outside of the container.

7.5 Sample Transportation

The field sampling team will either hand deliver or ship the cooler via an overnight delivery service or contact the laboratory to send a courier for pick up. Prior to shipment of sample coolers, the field sampling team will contact the laboratory to notify the laboratory of the shipment.

Samples will remain in the custody of the sampler until transfer of custody is completed. Transfer consists of:

- Delivery of samples to the Laboratory Sample Custodian; and/or
- Signature of the Laboratory Sample Custodian on the chain-of-custody form as receiving the samples and signature of sampler as relinquishing the samples.

The chain-of-custody document will be completed by the field sampler and provided for each sample cooler. When transferring the possession of samples, individuals relinquishing and receiving will sign, date, and note the time on the chain-of-custody. Custody of samples must be continuous between parties and time gaps must not be present. Each shipment of samples to the laboratory must have its own chain-of-custody record with the contents of the shipment, method of shipment, name of courier, and other pertinent information written on the record. The original record accompanies the shipment and the copies are kept with the field forms and distributed to the Project Manager. Freight bills, postal service receipts, and bills of lading will be retained as permanent documentation.

If a carrier is used to take samples between the sampler and the laboratory, the air bill number must be written on the chain-of-custody.

Samples will be shipped or transported within 24 to 48 hours of being collected and will arrive at the laboratory no later than 72 hours after sample collection, unless specific alternatives are arranged with the laboratory as part of the project.

7.6 Laboratory Custody Procedures

Laboratory custody procedures continue when the samples are received by the laboratory. When the samples arrive at the laboratory, the Laboratory Sample Custodian will sign the courier’s air bill or bill of lading (unless hand-delivered) and will note the cooler temperature on the chain-of-custody form, where applicable. If the cooler temperature is greater than 6 °C, the Project Manager will be notified. If the samples were shipped, the courier's air bill number will be attached to the chain-of-custody and the air bill number will be written on the chain-of-custody form. If the cooler or container/box arrives at the laboratory after hours, an external chain-of-custody will be properly filled out and will accompany the cooler until the laboratory receives the cooler.

The Laboratory Sample Custodian's duties and responsibilities upon sample receipt will be to:

- Document receipt of samples by signing the record with the date and time of sample receipt.
- Note the cooler temperature on the chain-of-custody form where applicable.
- Inspect sample shipping cooler for the presence or absence of custody seals (only if shipped via overnight courier) and for container integrity.
- Sign the appropriate forms or documents, verify, and record the agreement or disagreement of information on sample documents and, if there are discrepancies, record the problem and notify the Project Manager.
- Assign a number for each sample upon receipt. That sample number will be placed on the sample label which will remain attached to the sample container.
- Log sample information into the laboratory sample tracking system.
- Label sample with a unique, sequential laboratory sample number.
- Place samples in the walk-in cooler or sample storage area that is a secure, limited-access storage.

If QC samples have not been properly identified during sample collection, the Laboratory Project Manager will contact the Project Manager to assign QC samples prior to the start of sample analysis.

The laboratory will immediately contact the Project Manager if issues pertaining to sample condition or documentation are detected (*e.g.*, broken security seal; compromised sample containers; chain-of-custody information in disagreement with sample labels).

7.7 Final Evidence Files

The final evidence file will be the central repository for documents that constitute evidence relevant to sampling and analysis activities as described in this QAPP. The project organization is the custodian of the evidence file and maintains the contents of evidence files for the Site, including relevant records, reported, logs, field notebooks, pictures, subcontractor reports, and data reviews.

Copies of the laboratory data packages will be stored by the laboratory for incorporation into the sample file. The Laboratory Project Manager will be responsible for laboratory data packages. Upon completion of the analyses, the Project Manager will assimilate the field and laboratory data. In this way, the file for the samples will be generated. The final file for the sample will be stored at the project organization and will consist of the following:

- Laboratory data packages, including the following:
  - summary and supportive raw data from the analysis of environmental and QC samples

  - case narrative
  - chain-of-custody records and associated laboratory check-in records
  - chromatograms
  - mass spectra
  - Continuing, verification calibrations calibration summary and supportive raw data
  - bench and work sheets
  - standard preparation logs (provided upon request)
  - analytical run logs and analytical sequence reports
  - sample preparation log
  - corrective action forms
- Chain-of-custody records
- Data validation DUSR reports
- Field notebooks/logbooks and data
- Field collection report
- Non-conformance forms
- Corrective action forms
- Pictures and drawings, if applicable
- Progress and QA reports
- Contractor and subcontractor reports
- Correspondence

The evidence file must be maintained in a secured, limited access area until submittals for the project have been reviewed and approved, and for a minimum of 10 years past the submittal date of the final report.

8. LABORATORY SAMPLE STORAGE AND HANDLING

At the laboratory, the laboratory personnel will be required to log samples and sample extracts in and out of storage as the analysis proceeds.

There must not be a lapse in the custody for the sample containers and exchanges of custody must be documented on the form. Samples will be returned to secure storage at the close of business. Care must be exercised to properly complete, date, and sign records needed to generate the data package.

Procedures to be followed by the laboratory include:

- Samples will be handled by the minimum number of people possible.
- The laboratory will set aside a secured sample storage area consisting of a clean, dry, refrigerated, isolated room.
- A specific person will be designated sample custodian. Incoming samples will be received by the custodian who will indicate receipt by signing the chain-of-custody form.
- The custodian will ensure that samples which are heat-sensitive, light-sensitive, radioactive, or which require special handling in other ways, are properly stored and maintained prior to analysis.
- The analytical area will be restricted to authorized personnel only.
- After sample analyses are complete, the analytical data will be kept secured and released to authorized personnel only.

9. ANALYTICAL METHOD REQUIREMENTS

The generic list of analytical methods, associated target analytes and regulatory limits that may be utilized for work assignment activities are presented in provided in **Table 2-1A, Table 2-1B, Table 2-2, Table 2-3, Table 2-4, Table 2-5,** and **Table 2-6**. The FSP include the specific analytical method and target analyte list (if different than those provided in the tables list above) applicable to each work assignment. Prior to sample analysis, the most current laboratory QLs and MDLs will be provided by the laboratory conducting the analyses. The laboratory limits will be compared to the regulatory limits provided in **Table 2-1A, Table 2-1B, Table 2-2, Table 2-3, Table 2-4, Table 2-5,** and **Table 2-6** to identify laboratory limits for target analytes that exceed the regulatory limits. Target analytes with QLs or MDLs that exceed regulatory limits will be discussed with NYSDEC prior to sample analysis.

9.1 Analytical Methods and Laboratory Analysis

To obtain data of a quality sufficient to meet the work assignment DQOs, the methods from **Table 1** will be used for analysis of environmental samples.

The laboratory will adhere to the specific analyses and QA/QC requirements in the analytical methods and additional requirements listed the laboratory’s SOP and in this QAPP or the referenced regulatory documents. The most recent laboratory control limits for accuracy and precision will be used to evaluate the sample data.

In the event of an analytical system failure, the Laboratory Project Manager will identify the situation and provide corrective action guidance. The QAO will be notified and the situation will be documented in the data package case narrative.

Matrix interferences will be identified and documented during the analytical process. Samples may be diluted only if analytes of concern generate responses in excess of the linear range of the instrument. MDLs and QLs may only be achieved in an undiluted sample free of matrix interferences or of high concentrations of target analytes. If matrix interferences are encountered or if high concentrations of target compounds are present, established MDLs and QLs may not be achievable without impacting the instrument quality. If the laboratory has taken appropriate actions and matrix interferences prevent the laboratory from achieving the specified detection limits, the project organization’s QAO will be contacted as soon as the situation is identified. The Laboratory Project Manager will document, in the data package case narrative, how the laboratory demonstrated good analytical practices in order to attempt to achieve the specified reporting detection limits.

Blanks will not be subtracted from target analyte results.

The generated data will be input into the laboratory DBMS.

Laboratories analyzing samples for submittal to the NYSDEC must meet the required Environmental Laboratory Accreditation Program (ELAP) Certification for the associated methods. Prior to sample collection, the project organization will confirm the laboratory’s conformance with ELAP certification, where applicable.

Data generated will be submitted to the NYSDEC in an EDD format that complies with the NYSDEC's Environmental Data Submission EDD format. Data will be managed in a relational DBMS. Laboratory analytical data will be provided in EDD format for direct upload into the DBMS. Data validation qualifiers will be entered into the DBMS and checked independently.

Complete descriptions of analytical procedures to be used in the laboratory are described in the methods and the laboratory SOPs. Applicable laboratory SOPs, Quality Assurance Manual (QAM) and Proficiency Testing for the work assignment will be provided as attachments to the FSP.

9.2 Target Analytes and Detection Limits

The MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. The QL is the lowest concentration that can be reliably quantified within specified limits of precision and accuracy during routine laboratory operations.

The laboratory will evaluate non-detected results for aqueous and solid environmental samples to the MDLs and report the non-detected results referencing the QL. The laboratory will report non-detected results for air samples to the QL.

The QL concentration is established by the lowest standard in the instrument calibration. Results that are less than the QLs but greater than or equal to the MDLs will be reported using the “J” flag. For example, for a target analyte with a QL of 10 µg/L and an MDL of 2 µg/L, a non-detected result is reported as 10 µg/L "U", indicating that a concentration greater than or equal to the MDL was not detected by the laboratory. A detected concentration of 6 µg/L is reported as 6 "J" and a detected concentration of 23 µg/L is reported without a laboratory flag. The laboratory must include both QLs and MDLs on the sample result sheet that is reported to the data user and the most recent MDLs and QLs will be reported.

Laboratories periodically update the MDL and QL values as part of internal laboratory policy. When updated, they should be provided to the Program Manager.

9.3 Regulatory Criteria

The NYSDEC regulatory limits for methods listed in **Table 1** are provided in **Table 2-1A, Table 2-1B, Table 2-2, Table 2-3, Table 2-4, Table 2-5** and **Table 2-6**. These regulatory limits will be used to evaluate analytical data for the work assignment sampling activities.

To meet the DQOs for the work assignment, the sample results will be compared to the following regulatory criteria:

For groundwater and surface water:
- 6 CRR-NY Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations.

For drinking water:

- 10 CRR-NY Part 5-1.51 *Public Water Systems; Maximum Contaminant Levels; Monitoring Requirements; Notifications Required.*

For sediment:

- *Screening and Assessment of Contaminated Sediment*, NYSDEC Division of Fish and Wildlife and Marine Resources; June 24, 2014

For soil samples:

- 6 CRR-NY Part 375-6 *Remedial Program Soil Clean Up Objectives*.

For air samples:

- *Guidance for Evaluation of Soil Vapor Intrusion in the State of New York*; New York State Department of Health (NYSDOH); October 2006 (as updated) and updated matrices dated May 2017.

For Per- and polyfluoroalkyl substances (PFAS) samples:

- Screening levels per NYSDEC document *Sampling, Analysis, And Assessment of Per- and Polyfluoroalkyl Substances (PFAS) under NYSDEC's Part 375 Remedial Programs* dated April 2023.

10. LABORATORY AND FIELD QA/EC PROCEDURES

The overall effectiveness of a QA/QC program depends on operating in the field and laboratory according to a program that systematically ensures the precision and accuracy of analyses by detecting errors and preventing their recurrence or measuring the degree of error inherent in the methods applied.

Quality Assurance is an integrated system of activities involving planning, quality assessment, reporting and quality improvement to ensure that a program meets defined standards of quality with a stated level of confidence. Quality Control involves the technical activities that measure the quality of a program so that it meets the needs of users.

A brief description of laboratory QC analyses is presented in the following sections.

10.1 Laboratory QA/QC Checks

A brief description of laboratory QA/QC analyses is presented in the following subsections.

10.1.1 GC/MS Tuning

Tuning and performance criteria are established to verify mass resolution, identification, and to some degree, instrument sensitivity. These criteria are not sample specific; conformance is determined using standard materials. Therefore, these criteria should be met in all circumstances.

10.1.2 Calibration

Compliance requirements for satisfactory instrument calibration are established to verify that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of analysis, and continuing calibration and performance checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

10.1.3 Blanks

Several types of blanks will be analyzed by the laboratory. Corrective action procedures will be implemented for blank analyses if target compounds are detected at concentrations greater than the applicable criteria. The criteria for evaluation of blanks apply to any blank associated with a group of samples collected, prepared and/or analyzed at the same time, where applicable. If problems with a blank exist, data associated with the project must be carefully evaluated to determine whether or not there is an inherent variability in the data for the project, or if the problem is an isolated occurrence not affecting other data.

A method blank is an analyte-free blank that undergoes the preparation procedures applied to a sample. These samples are analyzed to examine whether sample preparation and analysis techniques result in sample contamination. The laboratory will prepare and analyze a method blank with each group of samples that are extracted, digested, or analyzed at the same time.

Field rinsate blanks are analyzed to assess contamination introduced during field sampling procedures and sample shipment, respectively. A field blank will be prepared for sampling when a particular piece of sampling equipment is employed for sample collection and subsequently decontaminated in the field for use in additional sampling. Field rinsate blank collection begins with two sets of identical bottles; one set filled with target analyte-free water provided by the laboratory, and one empty set of bottles identical to those provided for aqueous sample collection. The blank water used to generate the field blank will be provided by the laboratory using the same source of water as that used to prepare method blanks. For sampling that includes analysis for PFAS, the water should be documented as PFAS-free. At the field location, in an area suspected to be contaminated, the water is passed from the full set of bottles through the dedicated or field decontaminated sampling device(s) and into the empty set of bottles. This will constitute identical bottle to bottle transfer. The field rinsate blank samples will be subject to the same analyses as the environmental samples. The field blank will be composed in the field by collecting a blank water rinse from the equipment after execution of the last step of the proper field decontamination protocol. The identical bottle to bottle transfer technique will be used to generate the field blank. Preservatives or additives will be added to the field blank, where appropriate, for the sampling parameters. One field rinsate blank will be collected for every 20 samples or one per matrix for less than 20 samples for each analysis type, unless otherwise specified in the FSP. The field rinsate blank will be analyzed for the same parameters as the samples collected the same day that the field blank was generated.

For analysis of PFAS by Method 1633, empty sample bottles without preservation and the prepared Field Blank are both shipped to the sampling site. The sampler must pour the preserved reagent water from the laboratory prepared Field Blank into the empty sample bottles and label these bottles as the Field Blank.

For analysis of PFAS by Method 1633, one equipment blank every day that sampling is conducted will be collected and a minimum of one equipment blank for every 20 samples. The equipment 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.

Trip blanks will be prepared as other samples submitted for VOC analysis and will contain analyte-free water or preservative, as appropriate. A trip blank will be prepared by the laboratory, using the same preservation technique as that used to prepare the sample containers, from the same source as the method blank water, and sent to the sampling site in the cooler with the other sample containers. The trip blank will undergo shipment from the sampling site to the laboratory in coolers with the environmental samples to be analyzed for VOCs. Trip blanks will be analyzed for VOCs to determine if contamination has taken place during sample handling and/or shipment. Trip blanks will be included in sample coolers at a frequency of one trip blank per cooler containing samples to be submitted for VOC analysis.

10.1.4 Internal Standards Performance

Internal standards, which are compounds not found in environmental samples utilized for target analyte quantitation, will be spiked into samples, blanks, and laboratory control samples at the time of sample preparation for applicable methods. Internal standards should meet the criteria specified in the laboratory SOPs.

10.1.5 Surrogate Recovery

Accuracy and matrix biases for individual samples are monitored for organic analyses using surrogate additions. Surrogates are compounds similar in nature to the target analytes; the surrogates are spiked into aqueous and solid samples, blanks, and QC samples prior to sample preparation for organic analyses. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects due to such factors as interferences and high concentrations of analytes. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective.

10.1.6 Laboratory Control/Laboratory Control Duplicate Samples

Laboratory control samples (LCSs) and laboratory control duplicate samples (LCSDs) are standard solutions that consist of known concentrations of the complete list of target analytes spiked into laboratory analyte-free matrix. They are prepared or purchased from a certified manufacturer from a source independent from the calibration standards to provide an independent verification of the calibration procedure. These QC samples are then prepared and analyzed following the same procedures employed for environmental sample analysis to assess method accuracy independently of sample matrix effects. Percentage recoveries are evaluated to assess the efficiency of the preparation and analysis method independent of environmental sample matrix effects. If performed by the laboratory, the LCSD is evaluated for laboratory precision.

10.1.7 MS/MSD Samples

MS/MSD data are generated to determine long-term precision and accuracy of the analytical method with respect to sample matrices. Generally, the MS/MSD data alone are not used to evaluate the precision and accuracy for associated organic samples since data may reflect specific matrix effects only present within one sample.

One set of MS/MSD samples will be collected for every 20 samples (minimum frequency of 5%) or one per matrix for less than 20 samples. If less than 20 samples are collected, one MS/MSD set will be collected. Whenever possible, MS/MSD samples will be prepared and analyzed within the same batch as the environmental samples. MS/MSD samples will be spiked at the laboratory with the complete list of target analytes.

10.1.8 Analyte Identification and Quantitation

The objective of the qualitative criteria is to minimize the number of erroneous identifications of compounds. An erroneous identification can either be a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present). The identification criteria can be applied much more easily in detecting false positives than false negatives. Negatives, or non-detect compounds on the other hand, represent an absence of data and are therefore much more difficult to assess. The objective for quantitative requirements is to maximize the accuracy of data and sensitivity of the instrument. Unless sample screening indicates the presence of high concentration target analytes, samples will be analyzed undiluted to maximize sensitivity. Samples must be reanalyzed at the appropriate dilution when concentrations exceed the linear calibration range to maximize accuracy. Matrix interferences will be identified and documented. Samples may be diluted only if analytes of concern generate responses in excess of the linear range of the instrument.

10.2 Field QA/QC Checks

In order to evaluate data quality, QA/QC samples will be collected during the sampling activities. **Table 1** lists the sample matrices and corresponding QC samples to be collected by analysis.

10.2.1 Field Duplicate Samples

Field duplicate samples will be collected from the same location as the parent sample and will be analyzed for the same parameters as the parent sample. The actual identification of the duplicate QC samples will be recorded in the field logbook. Collection of field duplicate samples provides for the evaluation of the laboratory's precision performance by comparing analytical results of two samples from the same location. They are also collected to evaluate field sample collection precision procedures. Samples are collected from one location and sent to the laboratory blind (with two different sample identifications).

Duplicates of solid samples submitted for VOC analysis are obtained from the same discrete location without mixing. Duplicates for the remaining analyses require homogenization by filling a decontaminated stainless-steel tray or bowl with the sample and mixing it with a decontaminated stainless-steel instrument. The mixed sample is divided in half and scooped alternatively from each half to fill the sample container.

One field duplicate sample will be collected for every 20 samples (minimum frequency of 5%) or one per matrix for less than 20 samples. If less than 20 samples are collected, one field duplicate sample will be collected.

10.2.2 MS/MSDs

The MS/MSD samples will be collected from the same location as the parent sample and will be analyzed for the same parameters as the parent sample. Each sample will be labeled with the same number as the original sample, designated as MS or MSD, and submitted to the laboratory for the appropriate analyses. MS/MSD samples are duplicate samples that are collected in the field and have spiking solutions added at the laboratory during sample preparation. MS/MSD samples are considered identical to the original sample. The percent recovery of the spiked amount indicates the accuracy of the extraction as well as interferences caused by the matrix. Relative percent differences (%RPD) between spike sample recoveries or between duplicate samples will indicate the precision of the data.

One MS/MSD sample set will be collected for every 20 samples submitted to the laboratory (minimum frequency of 5%) or one MS/MSD for less than 20 samples.

10.2.3 Field Blanks

One field rinsate blank, presented in Section 10.1.3, will be collected per 20 samples or once per day as specified in the FSP.

10.2.4 Trip Blanks

Trip blanks, presented in Section 10.1.3, will be included in sample coolers at a frequency of either one trip blank per cooler, or one trip blank per shipment of samples sent to the laboratory for VOCs.

10.2.5 Temperature Blanks

Temperature blanks will consist of vials of water that have undergone shipment from the sampling site to the laboratory in coolers with the environmental samples to be analyzed for the sampling program. The temperature of these blanks will be measured at the laboratory upon receipt of the sample cooler to verify compliance with the cooler temperature requirement.

10.3 Corrective Action

Generally, the following corrective actions may be taken by the laboratory. When analytical parameters that are within the control of the laboratory, including calibration, instrument performance, and blank criteria, are not met, the cause of the problem will be located and corrected. The analytical system will then be recalibrated. Sample analysis will not begin until calibration, instrument performance, and blank criteria are met. When matrix spike, standard, or duplicate analyses are out of control, samples analysis will cease. The problem will be investigated. Depending on the results of the overall QC program for the sample set, the data may be accepted, accepted with qualification, or determined to be unusable.

If, through the application of the corrective actions listed in the method or laboratory SOP, the data is determined to be unusable, the QC analysis will be re-prepared and reanalyzed. If QC criteria are met upon reanalysis, only the new results are reported. If QC criteria are still not met upon reanalysis, both sets of sample results will be reported and the QAO will be notified of the situation at the time of sample analysis.

If matrix interferences are suspected, the QAO will be contacted. Unless sample screening indicates the presence of high concentration target analytes, samples may be diluted in the analysis only if analytes of concern generate responses in excess of the linear range of the instrument.

If the laboratory has taken appropriate actions and matrix interferences prevent the laboratory from achieving the specified detection limits, the QAO will be contacted as soon as the situation is identified. The Laboratory Project Manager will document, in the data package case narrative, how the laboratory demonstrated good analytical practices in order to attempt to achieve the specified reporting detection limits.

10.4 Data Assessment Procedures

As presented in Section 3.2, data for accuracy/bias, precision, representativeness, sensitivity, comparability and completeness will be evaluated.

The definitions and equations used for the assessment of data quality are discussed below.

<u>Accuracy/Bias</u> - Is a measure of the nearness of an analytical result, or a set of results, to the true value. It is usually expressed in terms of error, bias, or percent recovery (%R).

Normally, the term accuracy is used synonymously with percent recovery. It describes either the recovery of a synthetic standard of known value, or the recovery of known amount of analyte (spike) added to a sample of known value. The %R or accuracy can be calculated by using:

Standards: %R = (observed value/true value) x 100

Spikes: %R = [((conc. spike + sample conc.) - sample conc.)x100)]/conc. spike

Precision - Refers to the agreement or reproducibility of a set of replicate results among themselves without assumption of any prior information as to the true result. It is usually expressed in terms of the percent difference (%D) or RPD.

The %D is calculated by using:

%D = (larger SR - smaller SR x 100)/smaller SR

Where: SR is the sample result.

The RPD is calculated by using:

RPD = (OSR - DSRx 100)/((OSR + DSR)/2)

Where: OSR is the original sample result and DSR is the duplicate sample result.

Average - The average or arithmetic mean (X) of a set of n values (Xi) is calculated by summing the individual values and dividing by n:

$$X = (\sum Xi_{I=1\, to\, n}) \div n$$

Range - The range (Ri) is the difference between the highest and lowest value in a group. For n sets of duplicate values (X2, X1), the range (Ri) of the duplicates and the average range (R) of the n sets are calculated by the following:

Ri = X2 - X1

$$R = \sum Ri_{i=1\, to\, n} \div n$$

Standard deviation and variation - The standard deviation (S) of a sample of n results is the most widely used measure to describe the variability of a data set. It is calculated by using the following equation:

$$S = \sqrt{\frac{\Sigma (Xi - \overline{X})^2}{n-1}}\ n_{\text{to}\, i-1}$$

Where: X is the average of the n results and Xi is the value of result. Normally, X ± S will include 68% and X ± 2S includes about 95% of normally distributed data.

The variance is equal to S2. The percent relative standard deviation (%RSD), or coefficient of variation (CV), is the standard deviation divided by the mean and multiplied by 100 as follows:

$$CV = 100S/X$$

The Laboratory Project Manager, with individual laboratory group leaders, will identify any data that should be rated as "unacceptable" based on the assessment of the QA/QC criteria.

Bias - Results of sample spiking are used to calculate the quality control parameter for accuracy evaluation, the percent recovery (%R).

$$\%R = 100(S1\ S2)/T1$$

where: T1 = True concentration of the spike
S1 = Observed spiked sample concentration
S2 = Sample concentration without spike addition

Sensitivity - The measure of sensitivity is made by a comparison of laboratory QLs to the requirements for the DQOs. This comparison will be performed prior to sample analysis, with expected laboratory RLs, and following sample analysis, with actual QLs.

Completeness -Completeness is the fraction of usable data obtained from a measurement system (*e.g.*, sampling and analysis) compared to that which was planned and is calculated as follows:
Completeness = (Usable Laboratory Measurements Made/ Laboratory Measurements Planned) / x 100%

11. DATA REVIEW

For data to be scientifically valid, legally defensible, and comparable, valid procedures must be used to prepare and manage the data.

11.1 Data Reporting Procedures

Specific laboratory procedures and instrumentation can be found in the laboratory QAM and SOPs. The general data production and reporting procedures described below will be employed at the laboratory.

11.1.1 Data Reduction

Data reduction consists of manual and computer data reduction procedures and calculations. Computer data reduction procedures and calculations will be checked manually by the laboratory to verify that compound identification and quantitation adhere to method requirements. The laboratory will be responsible for maintaining a listing of computer-based data reduction programs and SOPs for data reduction. Sample preparation or extraction logs will be used to document sample preparation information (for example, preparation weights, volumes, reagents). Instrument injection logs or bench sheets will also be maintained for each instrument.

11.1.2 Laboratory Data Review

Analytical results are generally entered into the laboratory computer system by the analyst, independently reviewed by another analyst or supervisor experienced in the method, and approved by the Laboratory Manager. The following are requirements that are generally examined as part of this review:

- Initial calibration criteria were met. Standards in the calibration curve covered the expected concentration ranges of the samples including the QL.
- Initial and continuing calibrations met the acceptance criteria defined in the method standard procedure.
- Sample results fell within the range of the standard curve.
- Method blanks were processed with each analytical batch and no detectable levels of contamination were identified.
- MS/MSD and duplicate analyses were performed at the required frequency and results were within the control limits.
- LCS analyses were performed with each analytical batch and the results obtained were within control limits.
- Calculations have been accurately performed.
- Reporting units are correct.
- Data for the analysis provide a complete audit trail.
- Reported QLs comply with data quality requirements.

The analyst's supervisor will check a minimum of 10% of the data back to raw data in the secondary review. When required analyses on the samples in a project are complete, entered, and reviewed, a report will be generated. The report will be forwarded to the assigned Laboratory Project Manager or designee for review. The report will then be reviewed for the following items (at a minimum):

- QC data will be reviewed to identify whether or not internal specification and contract requirements have been me.
- Non-conformance reports, if any, will be reviewed for completion of corrective actions and their impact of results. Non-compliance and corrective action procedures will be documented in the case narrative in the final report.

The report requires the signature of the Laboratory Project Manager or designee. Electronic data are copied onto computer tape, inventoried, and stored off-site in a secure facility, or within locked cabinets on-site. This data archive system is maintained for a minimum of ten years.

Following final review, one hardcopy of the laboratory data package and a portable document format (PDF) copy will be transmitted to the Project Manager.

12. DATA DELIVERABLES AND DATA MANAGEMENT

Definitive data will be generated in the laboratory. The laboratory-generated data will be entered into the laboratory DBMS and presented in data packages. The laboratory will perform the data review process, including a minimum of 10 percent check of the data back to raw data in the secondary review by a laboratory supervisor.

The analytical data will be reported in USEPA CLP-like full deliverable format in both hardcopy and electronic data format. The data packages will provide documentation consistent with NYSDEC ASP-defined deliverables (Category B).

Data validation of the sample data will be performed as described in this QAPP.

All data generated will be submitted to the NYSDEC in an EDD format that complies with the NYSDEC's Environmental Data Submission EDD format and specified valid values. Data will be managed in a relational DBMS by Ramboll and NYSDEC. Laboratory analytical data will be provided in EDD format without errors for direct upload into the Ramboll DBMS.

The laboratory is responsible for providing an EDD that matches the hardcopy and electronic data package for sample and analysis information. The EDD records must be the same format (*i.e.*, flat file format). Field samples that are not collected from the work assignment site must not be included in the laboratory report or EDD.

The DBMS will be used to provide custom queries and reports to support data validation, data analysis, and report preparation. Data validation qualifiers will be entered into the Ramboll DBMS. The Ramboll DBMS will be checked independently to minimize data transmittal error and loss.

Generally, the information flow will include the following steps:

- Samples will be collected in the field and transported to the laboratory.
- Samples will be analyzed at the laboratory and data generated.
- The laboratory data will be sent to the data validator for evaluation and to the Project Manager for preliminary evaluation.
- An EDD will be provided by the laboratory and provided to the data validator for addition of data qualifiers.
- Qualified data will be sent to data management personnel and entered into the Ramboll DBMS.
- The final data set from the Ramboll DBMS will be provided to the Project Manager for data evaluation in terms of project goals.
- The EDD will be uploaded to the NYSDEC database (NYENVDATA@dec.ny.gov).
- Project decisions based on results of the data analysis will be reported to NYSDEC.

Records will be incorporated into the final project files for the samples. The field logs, data packages, and records will be included in the project files. The project files will be archived by the project organization for a period of ten years.

13. DATA VALIDATION AND USABILITY

13.1 Scope of Validation

Data validation will be performed on the data collected during the work assignment activities utilizing the current USEPA Region II validation guidance and NYSDEC DUSR guidance (NYSDEC, 2010) as described in the following section.

Samples analyzed for poly- and perfluoroalkyl substances (PFAS) will also be evaluated using Appendix I of the NYSDEC document Sampling, Analysis, And Assessment of Per- and Polyfluoroalkyl Substances (PFAS) under NYSDEC's Part 375 Remedial Programs dated April 2023 (**Exhibit E-3)**

Full data validation, which includes review of raw data to satisfy the DUSR requirements, will be performed on the data from the samples collected during the sampling activities.

Experienced data validators, meeting the requirements in this QAPP including being independent of the laboratory generating the data, will provide data validation services.

Upon request by the data validator, the laboratory will provide additional or supplemental information within three working days of the request.

13.2 Validation Procedures

Data Validation is a process of determining the suitability of a measurement system for providing useful analytical data. Data validation is essentially a three-step process in which the analytical data’s QA/QC information is first compared to a series of QA/QC criteria. Based on the results of this comparison, the analytical data are then assigned qualifiers, which provide an indication of the data’s usability. Finally, an overall evaluation of the data’s usability is performed.

Utilizing the DUSR process as guidance, the following questions will be considered during the validation:

1. Is the data package complete as defined under the requirements for the most current USEPA Contract Laboratory Program (CLP) deliverables?
2. Have the holding times been met?
3. Do all the QC data: blanks, instrument tunings, calibration standards, calibration verifications, surrogate recoveries, spike recoveries, duplicate analyses, laboratory controls and sample data fall within the protocol required limits and specifications?
4. Have the data been generated using established and agreed upon analytical protocols?
5. Does an evaluation of the raw data confirm the results provided in the data summary sheets and quality control verification forms?
6. Have the correct data qualifiers been used?
7. Have any exceedances been specifically noted in the report?

The analytical data generated for the work assignment will be evaluated by the data validator using the analytical methods utilized by the laboratories (as presented in the FSP), the QA/QC requirements listed in the methods, the laboratory SOPs and professional judgment.
Data affected by excursions from the QA/QC criteria will be qualified using the current USEPA Region II data validation guidance documents the NYSDEC DUSR guidance (NYSDEC, 2010) and professional judgment.

Full data validation consists of a review of data summary forms and raw analytical data that are provided in the data packages. During the full validation, data validators will recalculate selected laboratory sample calculations using raw data when verifying sample results. In addition, data validators will review raw data to verify that compound identification was performed correctly and transcription errors are not present.

The following QA/QC information will be included in the full validation, where applicable:

- QAPP compliance
- Chain-of-custody record
- Sample collection
- Sample preservation
- Percent solids
- Holding times
- Initial, Continuing, Verification Calibrations
- Blank analysis
- MS/MSD analysis
- LCS analysis
- Field duplicate analysis
- Surrogate recovery
- Internal standards performance
- GC/MS instrument performance check/ tune reports
- Analytical sequence
- Isotopic Standard (Extraction and Injection) performance
- ICP interference check analysis
- ICP serial dilution analysis
- Laboratory duplicate analysis
- Sample dilutions
- Target analyte quantitation, identification, and quantitation limits (RLs)
- Documentation completeness

13.3 Assignment of Qualifiers

Data affected by excursions from the previously described QA/QC criteria will be qualified using the current USEPA Region II validation guidance documents, the NYSDEC DUSR guidance (NYSDEC, 2010) and professional judgment. The application of the validation guidelines will be modified to reflect method and QAPP requirements.

For the data associated with the work assignments, if the LCS or LCSD recovery is less than the laboratory control limit but greater than 10%, the non-detected results are qualified as J, biased low. If the LCS or LCSD recovery is less than 10%, the non-detected results must be rejected. In accordance with the USEPA guidance, and utilizing professional judgment, the following qualifiers will be applied in the data validation:

“R”	Indicates that the QL or sample result is determined to be unusable due to a major deficiency in the data generation process. The data should not be used for any qualitative or quantitative purposes.
“U”	Indicates that the analyte was analyzed for, but a concentration was not detected. The sample QL is reported. This qualifier is also used in the validation process to signify that the detection limit of an analyte was revised due to blank contamination.
“J”	Indicates that the concentration should be considered approximate. This qualifier is used when the data validation process identifies a deficiency in the data generation process. This qualifier is also applied by the laboratory when the analyte concentration is greater than the MDL but less than the QL. In the latter case, the identification of the analyte is not in question but the quantitation of the analyte concentration may be uncertain.
“J+”	The result is an approximate quantity, but the result may be biased high.
“J-“	The result is an approximate quantity, but the result may be biased low.
“UJ”	Indicates that the analyte was analyzed for, but a concentration was not detected. The sample RL is reported and should be considered approximate. This qualifier is used when the data validation process identifies a deficiency in the data generation process.
“JN “	Indicates that there is presumptive evidence that the analyte is present, but it has not been confirmed due to confirmation excursions.

The following guidelines will be used regarding the assignment of qualifiers and the evaluation of data:

- The data quality evaluation results in only one type of qualifier (“U”, “J”, “UJ,” or “R”) for each analyte; in a case when several qualifiers are applicable to the same analyte, the cumulative effect of the various QA/QC excursions is employed in assigning the final data qualifiers. For example, if a sample result is affected by low surrogate recoveries, for which the “UJ” qualifier is applied, but low MS/MSD recoveries result in the rejection of the sample result (application of the “R” qualifier), the final data qualifier is the “R” qualifier.

13.4 Data Usability Evaluation

The specific data quality requirements including precision, accuracy, representativeness, comparability, sensitivity, and completeness will be assessed during data validation. Data usability with respect to the DQOs and data uses will be compared to the project requirements. In the event that the completeness objective of 95 percent is not achieved, samples may be recollected at the discretion of the Project Manager.

Based on the QA/QC information review and the qualifiers assigned to the analytical data, an overall evaluation of the data’s usability will be performed. Data usability is defined as the percentage of data that remains unqualified or is qualified as approximate or non-detected due to blank contamination, divided by the data reported by the laboratory times 100. The percent usability excludes the data qualified as rejected due to major QA/QC excursions. The non-usable data is defined as the percentage of the data qualified as rejected divided by the data reported by the laboratory times 100. The data usability will be provided for each type of analysis performed.

The data usability evaluation considers the data parameters of precision, sensitivity, accuracy, representativeness, comparability, and completeness which are described as follows:

- Precision is evaluated through the review of field duplicate samples, laboratory duplicates, and MS/MSD samples.
- Sensitivity is evaluated through the review of QLs, blank analyses and holding time results.
- Accuracy is evaluated through the review of MS recoveries, LCS recoveries, internal standard recoveries, calibration, instrument performance checks, target analyte identification and quantitation and sample preservation.
- Representativeness is evaluated through the review of sample preservation and sampling containers.
- Comparability is evaluated through the review of the analytical methods and reporting procedures for consistency.
- Completeness is defined as the overall percentage of sample results that are determined to be usable.

13.5 Data Validation DUSR

The data validation DUSR will contain separate QA sections in which data quality information collected during the investigation is summarized. The validation report will include the following:

- Data validation guidelines used to evaluate the data;
- Data qualifiers applied to sample results;
- Summary of samples collected and analyses performed;
- Narrative that identifies major and minor analysis excursions detected for each parameter evaluated for each analysis;
- Additional issues and information that may be beneficial to the data user;
- Data summary forms.

The data validation DUSR will be prepared under the direction of the QAO and will include the report on the usability of the data.

14. DATA ASSESSMENT PROCEDURES

14.1 Data QC Review

Data assessment is a systematic process of reviewing data against a set of criteria to identify outliers or errors and to delete suspect values or to flag them for the user. Laboratory data review starts with the laboratory quality control procedures discussed in Section 10 of this QAPP.

Sample results obtained from the laboratory will be qualitatively and quantitatively assessed by the Project Manager or designee. Factors to be considered in the data assessment will include, but are not necessarily limited to, the following:

- Were all samples collected and handled using the custody procedures, methodologies and SOPs proposed in the QAPP and FSP?
- Were samples obtained from all proposed sampling locations?
- Do any analytical results exhibit elevated laboratory QLs?
- Were any reported analytes not expected to be present?
- Which data points were found to be unusable based on the data validation results?
- Have sufficient data of appropriate quality been generated to meet the key objectives of the work assignment as identified in the FSP?

14.2 Data Review

The internal laboratory data review process will be used to evaluate data prior to submission to the Project Manager. Data validation will be used to determine the quality and quantity of usable analytical data generated based upon the FSP requirements.

14.3 Reconciliation with DQOS

The work assignment report will include an evaluation of how representative the analytical results are of the medium being evaluated based on measures such as sampling design and quality control results. It will also include a discussion on the sufficiency of the data set for meeting project DQOs. The work assignment report will also contain a discussion of any unusable data and follow up actions for subsequent data collection to meet the project DQOs.

14.4 Project Completeness Assessment

The Project Manager will examine the project data for consistency with historical data, data quality, and usability.

15. PROJECT REPORTING

15.1 Data Validation Report

The data validation report will contain separate QA sections in which data quality information collected during the work assignment is summarized.

The data validation DUSR will be prepared under the direction of the QAO or the designated data validator and will include the report on the usability of the data.

15.2 Work Assignment Report

A work assignment report will be prepared at the conclusion of the site activities and will include sample data results and the findings of the work assignment.

16. REFERENCES

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TABLES

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
VOCs (USEPA Methods 5030C/5035A/8000C/ 8260C/8260D)[1]	Aqueous	3 - 40-milliliter glass vials with Teflon® lined septum caps	≤6°C HCL to pH≤2 FC Sealed and Headspace Free	Analysis within 14 days from collection for preserved samples. Analysis within 7 days from collection for samples not acid preserved.	TBD	One for every 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 20 samples or one per sampling event
VOCs Low Level (USEPA Methods 5035A/8000C/8260C/ 8260D)[1]	Solid	Encore™, Terra Core™ (or similar) sampler used to collect and transport sample in accordance with USEPA Method 5035A OR 125 milliliter wide mouth glass container filled head-space free sealed with Teflon® lined lid	≤6°C Sealed	At the laboratory within 48 hours from collection: For Encore sampler: extrude sample to a sealed vial and freeze to -7°C Analysis must be performed within 14 days from collection. Otherwise, 48 hours from collection to analysis.	TBD	One for every 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 20 samples or one per sampling event
VOCs Medium Level (USEPA Methods 5035A/8000C/8260C/ 8260D)[1]	Solid	Encore™, Terra Core™ (or similar) sampler in accordance with USEPA Method 5035A. 5 grams sample volume required OR 125 milliliter wide mouth glass container filled head-space free sealed with Teflon® lined lid	<6°C Sealed	For Encore: At the laboratory within 48 hours of collection: Add methanol solution to 5 grams of sample in accordance with USEPA Method 5035A. If methanol added. 14 days from collection to analysis Otherwise, 48 hours from collection to analysis.	TBD	One per 20 samples collected	One ea. per cooler with VOC samples. Methanol trip blank.	One for every 20 samples collected	One per 20 samples or one per sampling event
VOCs Low Level-SPLP/TCLP (USEPA Methods 5035A/8000C/1311/ 1312/8260C)[1]	Solid	Encore™, Terra Core™ (or similar) sampler used to collect and transport sample in accordance with USEPA Method 5035A. 25 Grams of sample required OR 40-milliliter glass vials with Teflon® lined septum caps OR 125 milliliter wide mouth glass container filled head-space free sealed with Teflon® lined lid	≤6°C Sealed	At the laboratory: Extrude Encore sample to a sealed vial and freeze to -7°C within 48 hours from collection. For TCLP/SPLP -VOCs, 14 days from collection to extract generation. 14 days from extract generation to analysis.	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 20 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	Matrix	Sample Containers and Volumes	Preservation	Holding Times	Number of Samples*	Field Duplicate	Trip Blank	MS/MSD or Spike Duplicate	Field Rinsate Blank
VOCs (Method TO-15)[2]	Air	6.0 Liter SUMMA® vacuum canisters- Individual Cannister or Batch Certified	None	Analysis within 30 days from collection to analysis. Used and un-used canisters must be returned to the laboratory within 30 days of shipment of the canisters to the sampling location	TBD	One per 20 samples collected	NA	NA	NA
Dissolved Gas (RSK 175)[3]	Aqueous	3- 40-milliliter glass vials with Teflon® lined septum caps	≤6°C HCL to pH≤2	Analysis within 14 days from collection for preserved samples	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 20 samples or one per sampling event
VOCs (USEPA Method 524.2, Rev 4.1)[4]	Aqueous	4-40 milliliter glass vials with Teflon® lined septum caps Samples collected in duplicate	4°C, RC After dechlorination, add 2 drops of 1:1 HCL for each 40 ml of sample to pH≤2. Seal sample bottle, Teflon® face down, mix for one minute. For foaming sample, collect unpreserved samples and analyze within 24 hours of collection.	14 days from collection for preserved samples For un-preserved sample, collect unpreserved samples and analyze within 24 hours of collection.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Halogenated Volatiles (USEPA Methods 8000C/8021B)[7]	Aqueous	3- 40-milliliter glass vials with Teflon® lined septum caps	≤6°CHCL to pH≤2 FC Sealed and Headspace Free	Analysis within 14 days from collection for preserved samples. Analysis within 7 days from collection for samples not acid preserved.	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 10 samples or one per sampling event
Volatiles (USEPA Method 624)[17]	Aqueous	4- 40-milliliter glass vials with Teflon® lined septum caps	≤6°CHCL to pH≤2 RC	Analysis within 14 days from collection for preserved samples. Analysis within 7 days from collection for samples not acid preserved.	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 10 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
Volatiles (USEPA Method 502.2)[4]	Aqueous	4- 40-milliliter glass vials with Teflon® lined septum caps Samples collected in duplicate	≤6°CHCL to pH≤2 RC	Analysis within 14 days from collection.	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 10 samples or one per sampling event
Volatiles (USEPA Method 601)[17]	Aqueous	4- 40-milliliter glass vials with Teflon® lined septum caps	≤6°C RC	Analysis within 14 days from collection.	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 10 samples or one per sampling event
Volatiles (USEPA Method 602)[17]	Aqueous	4- 40-milliliter glass vials with Teflon® lined septum caps	≤6°C HCL to pH≤2 RC	Analysis within 14 days from collection.	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Organic Halides (USEPA Method 9020B)[10]	Aqueous	1-250 milliliter plastic bottle with Teflon septa and protected from light. 125 milliliters sample volume required.	4°C H_2SO_4 to pH<2	28 days from collection for analysis	TBD	One per 20 samples collected	1 each in cooler with VOC samples	One for every 20 samples collected	One per 10 samples or one per sampling event
SVOCs/1,4-Dioxane/SIM (USEPA Methods 3510C/8000C/ 8270D/8270E/SIM)[5]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
SVOCs/1,4-Dioxane/SIM (USEPA Methods 3541/3550B/ 8000C/8270D/8270E)[5]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
SVOCs/SPLP/TCLP Preparation (USEPA Methods 3541/ 3550B/8000C/1311/ 1312/ 8270D)[5]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	For SPLP - 14 days from collection to extract generation. 7 days from extract generation to extraction. 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
SVOCs (USEPA Method 625)[17]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C RC	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Phenols (USEPA Method 604)[17]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C RC	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20	NA	One for every 20	One per 20 samples or one per

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
						samples collected		samples collected	sampling event
Phenols (USEPA Method 8041)[6]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
PAHs (USEPA Method 610)[17]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C RC	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
PCBs (USEPA Methods 3510C/8000C/8082A)[6]	Aqueous	2-one liter 250 ml amber glass container with Teflon® lined screw caps	≤6°C	Project Holding Time: 7 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
PCBs (USEPA Methods 3545A/8000C/8082A)[6]	Solid	4 oz. wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	Project Holding Time: 14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Organochlorine Pesticides (USEPA Methods 3510C/8000C/8081B)[6]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Organochlorine Pesticides/PCBs (USEPA Method 608)[17]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C	Project Holding Time: 7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Organochlorine Pesticides (USEPA Methods 3545A/8000C/8081B)[6]	Solid	4 oz. wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Organochlorine Pesticides/TCLP/SPLP Preparation (USEPA Methods 3545A/8000C/1311/ 1312/8081B)[6]	Solid	4 oz. wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
Organophosphorus Pesticides (USEPA Methods 3510C/8000C/8141B)[6]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Organophosphorus Pesticides (USEPA Methods 3545A/8000C/8141B)[6]	Solid	4 oz. wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Chlorinated Herbicides (USEPA Methods 3510C/8000C/8151A)[7]	Aqueous	2-one liter amber glass container with Teflon® lined screw caps	≤6°C	7 days from collection to extraction; 40 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Chlorinated Herbicides (USEPA Methods 3510C/8000C/8151A)[7]	Soil	4 oz. wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Nonhalogenated Organics (USEPA Method 8015B/8015C)[6]	Aqueous	3- 40-milliliter glass vials with Teflon® lined septum caps	≤6°C HCL to pH≤2 FC Sealed and Headspace Free	Analysis within 14 days from collection for preserved samples.Analysis within 7 days from collection for samples not acid preserved.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Nonhalogenated Organics (USEPA Method 8015B/8015C)[6]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required.	≤6°C	14 days from collection to extraction; 40 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
PFAS (USEPA Method 537.1)[8]	Aqueous	Pre-cleaned 250 ml. HDPE container. 250 ml. sample volume required	≤6°C Hands must be washed and nitrile gloves are used. Samples do not need to be headspace-free.	14 days from collection to extraction; 28 days from extraction to analysis.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
PFAS (USEPA Method 537.1)[8]	Solids	Pre-cleaned 2-4.5 ounce plastic cup. 10 gram sample volume required	≤6°C	28 days from collection to extraction; 28 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
									sampling event
PFAS (USEPA Method 1633)[8b]	Aqueous	2 x Pre-cleaned 500 ml. HDPE container and 1 x 125 ml HDPE container (for TSS). Must be QEC brand bottles. 500 ml. sample volume required	≤6°C Hands must be washed and nitrile gloves are used. Samples do not need to be headspace-free.	28 days from collection to extraction; 28 days from extraction to analysis. Sample can be frozen for 90 day holding time.	TBD	One for every 20 samples collected	1 x 500 ml plastic w/ DI water	One for every 20 samples collected 6 x 500 ml plastic (QEC) unpreserved + 500 ml plastic (QEC) with DI water	One per 20 samples or one per sampling event. 2x 500 ml plastic (QEC) unpreserved + 2x 500 ml plastic (QEC) with DI water
PFAS (USEPA Method 1633)[8b]	Solids	Pre-cleaned 80 ml plastic (QEC brand) cup. 10 gram sample volume required	≤6°C	90 days from collection to extraction; 28 days from extraction to analysis	TBD	One for every 20 samples collected	1 x 500 ml plastic w/ DI water	One for every 20 samples collected. 1x 250 ml plastic (QEC)	One per 20 samples or one per sampling event. 1x 250 ml plastic (QEC) unpreserved + 1x 250 ml plastic (QEC) with DI water
Metals (USEPA Methods 3005A/6010C/6010D/ 6020A/6020B)[9]	Aqueous	1-1000 milliliter polyethylene or fluorocarbon (TFE or PFA) container. 500 milliliters sample volume required.	HNO3 to pH<2 ≤6°C	180 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Metals (USEPA Methods 3050B/6010C/6010D/ 6020A/6020B)[9]	Solid	2 ounce wide mouth polyethylene or fluorocarbon (TFE or PFA) container. 50 grams sample volume required.	≤6°C	180 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Metals – TCLP/SPLP (USEPA Methods 3005A/6010C/1311/ 1312/6020A/6020B)[9]	Solid	200 grams sample volume required	≤6°C	SPLP - 180 days from collection to extract generation, 180 days from extraction to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
Mercury (USEPA Method 7470A)[10]	Aqueous	1-1000 milliliter polyethylene or fluorocarbon (TFE or PFA) container. 500 milliliters sample volume required.	≤6°C HNO3 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Mercury (USEPA Method 7471B)[6]	Solid	2 ounce wide mouth polyethylene or fluorocarbon (TFE or PFA) container. 50 grams sample volume required.	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Hardness (SM20 2340C)[11]	Aqueous	1-250 milliliter polyethylene or fluorocarbon (TFE or PFA) container. 100 milliliters sample volume required.	<6°C HNO3 to pH<2	180 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Cyanide (USEPA Method 9012B)[7]	Aqueous	1-500 milliliter polyethylene or fluorocarbon (TFE or PFA) container. 250 milliliters sample volume required.	≤6°C NaOH to pH≥12 OA	14 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Cyanide (USEPA Method 9012B)[7]	Solid	2 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	≤6°C	14 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Hexavalent Chromium (USEPA Method 7196A/7199)[12, 7]	Aqueous	1-1000 milliliter plastic bottle. 500 milliliters sample volume required.	≤6°C Adjust pH to 9-9.5 using buffer solution	Analyze within 24 hours from collection.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Hexavalent chromium (USEPA Method 3060A/7196A)[12]	Solid	2 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	≤6°C	30 days from collection to analysis Analysis performed within 24 hours of extraction.	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Nitrate (USEPA Method 353.2)[13] By calculation/subtraction:	Aqueous	NA	NA	NA	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
Total Nitrate/Nitrite by 353.2/ (NO2 by SM20 4500NO2B)									
Nitrate (USEPA Method 353.2)[13] By calculation/subtraction: Total Nitrate/Nitrite by 353.2/ (NO2 by SM20 4500NO2B)	Solid	NA	NA	NA	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Nitrate/Nitrite (USEPA Method 353.2)[13]	Aqueous	2 -50 milliliter polyethylene or fluorocarbon (TFE or PFA) container. 50 milliliters sample volume required.	≤6°C H_2SO4 to pH<2	28 days from collection to analysis if preserved	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Nitrate/Nitrite (USEPA Method 353.2)[13]	Solid	4 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Nitrite (SM20 4500 NO2B)[11]	Aqueous	2- 125 milliliter plastic/glass container. 5 milliliters sample volume required.	≤6°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Nitrite (SM20 4500 NO2B)[11]	Solid	4 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	≤6°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Chloride, Sulfate, Bromide, Fluoride (USEPA Method 300.0)[14]	Aqueous	1-500 milliliter plastic bottle. 100 milliliters sample volume required.	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Chloride, Sulfate, Bromide, Fluoride (USEPA Method 300.0)[14]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	<6°C	28 days from collection for analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
Sulfide (SM20 4500 S2)[11]	Aqueous	1-1000 milliliter plastic bottle. 500 milliliters sample volume required.	<6°C 4 drops 2N zinc acetate/100 mL, NaOH to pH >9	7 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Sulfide (SM20 4500 S2)[11]	Solid	4 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	<6°C	7 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Phosphorus (USEPA Method 365.3)[14]	Aqueous	One-250 milliliter polyethylene bottle 100 milliliters sample volume required	≤6°CH$_2$SO4 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Phosphorus (USEPA Method 365.3)[14]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required.	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total and Ortho Phosphate (SM20 4500-PE)[11]	Aqueous	1-500 milliliter plastic bottle. 100 milliliters sample volume required.	≤6°CH$_2$SO4 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total and Ortho Phosphate (SM20 4500-PE)[11]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required.	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Dissolved Solids (TDS) (SM 2540-C)[11]	Aqueous	1-1000 milliliter plastic bottle. 500 milliliters sample volume required.	≤6°C	7 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Suspended Solids (TSS) (SM20 2540D)[11]	Aqueous	1-1000 milliliter plastic bottle. 500 milliliters sample volume required.	≤6°C	7 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Ammonia (SM20 4500 NH3-B/C)[11]	Aqueous	1-1000 milliliter plastic bottle. 500 milliliters sample volume required.	≤6°C H2SO4 to pH<2	28 days from collection for analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
									sampling event
Ammonia (SM20 4500 NH3-B/C)[11]	Solid	4-ounce wide mouth glass container with Teflon® lined lid. 100 grams sample volume required.	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Alkalinity (Total, Bicarbonate, Carbonate) (SM20 2320B)[11]	Aqueous	1-1000 milliliter polyethylene or fluorocarbon (TFE or PFA) container. 200 milliliters sample volume required.	≤6°C	14 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Organic Carbon (TOC) (SM20 5310C/USEPA Method 9060A)8[11, 15]	Aqueous	1-1000 milliliter glass amber bottle. 500 milliliters sample volume required.	≤6°C H2SO4 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Organic Carbon (TOC)(Lloyd Kahn)[16]	Solid	4 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	≤6°C	14 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Inorganic Carbon (SM20 5310B)[11]	Aqueous	1-250-milliliter amber container. 100 milliliters sample volume required	≤6°CH 2SO4 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Inorganic Carbon (SM20 5310B)[11]	Solid	1-250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required.	≤6°C	28 days from collection for analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Biochemical Oxygen Demand (BOD) (SM20 5210B)[11]	Aqueous	1-1000 milliliter plastic bottle. 1000 milliliters sample volume required.	≤6°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Chemical Oxygen Demand (COD) (USEPA Method SM 5220 C)[11]	Aqueous	1-250-milliliter plastic container. 100 milliliters sample volume required	≤6°C H_2SO4 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
Total Kjeldahl Nitrogen (TKN) (USEPA Method 351.2)[14]	Aqueous	1-500 milliliter plastic bottle. 100 milliliters sample volume required.	≤6°C H_2SO4 to pH<2	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Total Kjeldahl Nitrogen (TKN) (USEPA Method 351.2)[14]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 10 samples or one per sampling event
Corrosivity (USEPA Method 9045D)[15]	Solid	8-ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Ignitability (USEPA 40 CFR Part 261.21)[17]	Solid	8-ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Flashpoint (USEPA Method 1010A)[15]	Solid	8-ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Reactive Cyanide (USEPA Chapter 7-9012B)[7]	Solid	300 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	14 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Reactive Sulfide (USEPA Chapter 7-9034)[7]	Solid	300 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	28 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Oil & Grease (USEPA Method 1664A)[18]	Solid	60 milliliter pre-cleaned wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C Preserve to pH < 2 with HCL. Alert laboratory to	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
			acidify prior to analysis.						
Acidity (SM20 2310B) [11]	Aqueous	One 500-milliliter polyethylene bottle. 200 milliliters sample volume required.	4°C	14 days from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Surfactants (Methylene Blue Active Substances (MBAS) (SM20 5540C) [11]	Aqueous	One 500-milliliter polyethylene bottle. 250 milliliters sample volume required.	4°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Color (SM20 2120B) [11]	Aqueous	One 250-milliliter polyethylene bottle. 100 milliliters sample volume required.	4°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Volatile Solids (TVS) (USEPA Method 160.4) [14]	Aqueous	One 1000-milliliter polyethylene bottle. 500 milliliters sample volume required.	4°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Phenols (USEPA Method 9056) [19]	Aqueous	1-1000 milliliter amber glass container with Teflon® lined screw caps. 500 milliliters sample volume required.	≤6°C H_2SO_4 to pH<2	28 days from collection for analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
Total Residual Chlorine (SM20 4500-CL) [11]	Aqueous	1-1000 milliliter amber glass container with Teflon® lined screw caps. 500 milliliters sample volume required.	≤6°C H_2SO_4 to pH<2	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
pH (USEPA Method SM4500 H+ B)[11]	Aqueous	1-100 milliliter plastic bottle. 50 milliliters sample volume required.	≤6°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
pH (USEPA Method 9045D)[15]	Solid	4 ounce wide mouth glass container with Teflon® lined lid. 50 grams sample volume required.	≤6°C	48 hours from collection to analysis	TBD	One for every 20 samples collected	NA	One for every 20 samples collected	One per 20 samples or one per sampling event
SPLP Preparation (USEPA Method 1312)[10]	Solid	250 milliliter wide mouth glass container with Teflon® lined lid.	NA	NA	NA	NA	NA	NA	NA

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	**Matrix**	**Sample Containers and Volumes**	**Preservation**	**Holding Times**	**Number of Samples***	**Field Duplicate**	**Trip Blank**	**MS/MSD or Spike Duplicate**	**Field Rinsate Blank**
		100 grams sample volume required							
TCLP Preparation (USEPA Method 1311)[12]	Solid	300 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	NA	NA	NA	NA	NA	NA	NA
Percent Solids (SM20 2540G)[11]	Solid	100 milliliter wide mouth glass container with Teflon® lined lid. 100 grams sample volume required	≤6°C	NA	NA	NA	NA	NA	NA
Temperature, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), turbidity, pH	Aqueous	Field collection and analysis	NA	NA	NA	NA	NA	NA	NA

NOTES:
MS/MSD indicates matrix spike/matrix spike duplicate sample.
VOC indicates volatile organic compound.
SVOC indicates semivolatile organic compound.
SIM indicates selected ion monitoring.
PCBs indicates polychlorinated biphenyls.
PAHs indicates polynuclear aromatic hydrocarbons.
PFAS indicates Per- and polyfluoroalkyl substances.
TCLP indicates Toxicity Characteristic Leaching Procedure.
SPLP indicates Synthetic Precipitation Leaching Procedure.
RC indicates that if residual chlorine is present in samples, add sodium thiosulfate (VOCs) or sodium sulfite (SVOCs) to the sample container before filling.
* Indicates sample numbers will be determined during project implementation.
Method references:

1. USEPA. 2006. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition. Washington D.C.
2. USEPA. 1999. Compendium Method TO-15: Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). EPA/625/R-96/010b. Cincinnati, Ohio.
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8b. USEPA. 2021. Draft Method 1633. Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS, USEPA, Office of Science and Technology Engineering and Analysis Division, Washington, DC.

9. USEPA. 2014. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update V. Washington D.C.
10. USEPA. 1994. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update II. Washington D.C.
11. AWWA, APHA and WEF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. Washington, D.C.
12. USEPA. 1992. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update I. Washington D.C.

Table 1. Field Sampling Summary

						QC Sampling Frequency			
Parameter and Method	Matrix	Sample Containers and Volumes	Preservation	Holding Times	Number of Samples*	Field Duplicate	Trip Blank	MS/MSD or Spike Duplicate	Field Rinsate Blank
13. USEPA. 1993. Method 353.2. Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry. Revision 2.0. Washington, D.C. 14. USEPA. 1993. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA-600/R-93/100. Washington, D.C. 15. USEPA. 2004. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update IIIB. Washington D.C. 16. USEPA. 1988. Determination of Total Organic Carbon in Sediment, Region II, Environmental Services Division, Monitoring Management Branch, Edison, New Jersey. 17. USEPA. 2001. 40 CFR Part 136, Appendix A. Washington, D.C. 18. USEPA. 2009. Method 1664, Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) By Extraction and Gravimetry. Washington, D.C. 19. USEPA. 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition. Washington D.C.									

Table 2-1A. Laboratory limits and regulatory limits for VOCs in aqueous and solid samples

Target Analytes	CAS Number	USEPA Method* (8260, 624, 524.2, 8021, 502.2, 601, 602, 9020B)	Laboratory QL Aqueous (µg/L)	Laboratory MDL Aqueous (µg/L)	Laboratory QL Low Level Solid (µg/Kg)	Laboratory MDL - Low Level Solid (µg/Kg)	Laboratory QL Medium Level Solid (µg/Kg)	Laboratory MDL Medium Level Solid (µg/Kg)	Class GA Groundwater (µg/L)	Part 375 Unrestricted SCOs (µg/Kg)	Part 375 Protection Of Groundwater (µg/Kg)
VOCs - TCL											
1,1,1-Trichloroethane	71-55-6	TBD							5	680	680
1,1,2,2-Tetrachloroethane	79-34-5	TBD							5	NC	600
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	TBD							5	NC	6,000
1,1,2-Trichloroethane	79-00-5	TBD							1	NC	NC
1,1-Dichloroethane	75-34-3	TBD							5	270	270
1,1-Dichloroethene	75-35-4	TBD							5	330	330
1,2,3-Trichlorobenzene	87-61-6	TBD							5	NC	NC
1,2,4-Trichlorobenzene	120-82-1	TBD							5	NC	3,400
1,2,4-Trimethylbenzene	95-63-6	TBD							5	3600	3,600
1,2-Dibromo-3-chloropropane	96-12-8	TBD							0.04	NC	NC
1,2-Dibromoethane	106-93-4	TBD							0.0006	NC	NC
1,2-Dichlorobenzene	95-50-1	TBD							3	1100	1,100
1,2-Dichloroethane	107-06-2	TBD							0.6	20	20
1,2-Dichloropropane	78-87-5	TBD							1	NC	NC
1,3-Dichlorobenzene	541-73-1	TBD							3	2400	2,400
1,3-Dichloropropane	142-28-9	TBD							5	NC	300
1,3,5-Trimethylbenzene	108-67-8	TBD							5	8400	8,400
1,4-Dichlorobenzene	106-46-7	TBD							3	1800	1,800
2-Butanone (Methylethyl ketone)	78-93-3	TBD							50**	120	120
2-Hexanone	591-78-6	TBD							50**	NC	NC
4-Methyl-2-pentanone (methyl isobutyl ketone MIBK)	108-10-1	TBD							NC	NC	1,000
Acetone	67-64-1	TBD							50**	50	50
Benzene	71-43-2	TBD							1	60	60
Bromochloromethane	74-97-5	TBD							5	NC	NC
Bromodichloromethane	75-27-4	TBD							50**	NC	NC
Bromoform	75-25-2	TBD							50**	NC	NC
Bromomethane	74-83-9	TBD							5	NC	NC
n-butyl acetate	123-86-4	TBD							NC	NC	NC
Carbon disulfide	75-15-0	TBD							60**	NC	2,700
Carbon tetrachloride	56-23-5	TBD							5	760	760
Chlorobenzene	108-90-7	TBD							5	1100	1,100
Chloroethane	75-00-3	TBD							5	NC	1,900
Chloroform	67-66-3	TBD							7	370	370
Chloromethane	74873	TBD							5	NC	NC
cis-1,2-Dichloroethene	156-59-2	TBD							5	250	250
cis-1,3-Dichloropropene	10061-01-5	TBD							0.4	NC	NC
Cyclohexane	110-82-7	TBD							NC	NC	NC
Dibromochloromethane	124-48-1	TBD							50**	NC	NC
Dichlorodifluoromethane	75-71-8	TBD							5	NC	NC
Ethylbenzene	100-41-4	TBD							5	1000	1,000
Hexachlorobenzene	118-74-1	TBD							0.04	330	NC
Isopropyl Alcohol	67-63-0	TBD							NC	NC	NC
Isopropylbenzene	98-82-8	TBD							5	NC	2,300
Methyl acetate	79-20-9	TBD							NC	NC	NC
Methyl tert-butyl ether	1634-04-4	TBD							10**	930	930
Methylcyclohexane	108-87-2	TBD							NC	NC	NC
Methylene chloride	75-09-2	TBD							5	50	50
n-Butyl benzene	104-51-8	TBD							5	12000	12,000
n-Propylbenzene	103-65-1	TBD							5	3900	NC
p-Isopropyl toluene	99-87-6	TBD							5	NC	10,000
Pyridine	110-86-1	TBD							NC	NC	NC
sec-Butylbenzene	135-98-8	TBD							5	11000	11,000
Styrene	100-42-5	TBD							5	NC	NC
tert-Butylbenzene	98-06-6	TBD							5	5900	5,900
Tetrachloroethene	127-18-4	TBD							5	1300	1,300
Toluene	108-88-3	TBD							5	700	700
trans-1,2-Dichloroethene	156-60-5	TBD							5	190	190
trans-1,3-Dichloropropene	10061-02-6	TBD							0.4	NC	NC
Trichloroethene	79-01-6	TBD							5	470	470
Trichlorofluoromethane	75-69-4	TBD							5	NC	NC
Vinyl chloride	75-01-4	TBD							2	20	20
m,p-Xylene	17601-23-1	TBD							5***	NC	NC
o-Xylene	95-47-6	TBD							5***	NC	NC
Xylenes (total)	1330-20-7	TBD							5	260	1,600
VOCs- Other Target Analytes											
2-Chloroethyl vinyl ether	110-75-8	TBD							NC	NC	NC
Acrolein	107-02-8	TBD							5	NC	NC
Acrylonitrile	107-13-1	TBD							0.07	NC	NC
Benzyl Chloride	100-44-7	TBD							NC	NC	NC
1,1-Dichloropropene	563-58-6	TBD							5	NC	NC
1,2,3-Trichloropropane	96-18-4	TBD							0.04	NC	NC

Table 2-1A. Laboratory limits and regulatory limits for VOCs in aqueous and solid samples

Target Analytes	CAS Number	USEPA Method* (8260, 624, 524.2, 8021, 502.2, 601, 602, 9020B)	Laboratory QL Aqueous (µg/L)	Laboratory MDL Aqueous (µg/L)	Laboratory QL Low Level Solid (µg/Kg)	Laboratory MDL - Low Level Solid (µg/Kg)	Laboratory QL Medium Level Solid (µg/Kg)	Laboratory MDL Medium Level Solid (µg/Kg)	Class GA Groundwater (µg/L)	Part 375 Unrestricted SCOs (µg/Kg)	Part 375 Protection Of Groundwater (µg/Kg)
1,2,4-Trimethylbenzene	95-63-6	TBD							5	NC	NC
1,2,4-Trichlorobenzene	120-82-1	TBD							5	NC	NC
1,3,5-Trimethylbenzene	108-67-8	TBD							5	NC	NC
1,3,5-Trichlorobenzene	108-70-3	TBD							5	NC	NC
1,1,1,2-Tetrachloroethane	79-34-5	TBD							5	NC	NC
1,3-Dichloropropane	142-28-9	TBD							5	NC	NC
2,2-Dichloropropane	590-20-7	TBD							NC	NC	NC
2-Chlorotoluene	95-49-8	TBD							5	NC	NC
4-Chlorotoluene	106-43-4	TBD							5	NC	NC
4-Isopropyl benzene	99-87-6	TBD							5	NC	NC
Bromobenzene	108-86-1	TBD							5	NC	NC
Dibromomethane	74-95-3	TBD							5	NC	NC
Ethyl Ether	60-29-7	TBD							NC	NC	NC
Ethyl Methacrylate	97-63-2	TBD							NC	NC	NC
Hexachloroethane	67-72-1	TBD							5	NC	NC
Hexachlorobutadiene	87-68-3	TBD							0.5	NC	NC
Hexachlorocyclopentadiene	77-47-4	TBD							5	NC	NC
Methacrylonitrile	126-98-7	TBD							5	NC	NC
Methyl Acrylate	96-33-3	TBD							3	NC	NC
Methyl Iodide	74-88-4	TBD							5	NC	NC
Methyl Metacrylate	80-62-6	TBD							50	NC	NC
Naphthalene	91-20-3	TBD							10	NC	NC
Pentachloroethane	76-01-7	TBD							5	NC	NC
Pentachlorobenzene	608-93-5	TBD							5	NC	NC
Propionitrile	107-12-0	TBD							NC	NC	NC
Tetrahydrofuran	109-99-9	TBD							50	NC	NC
trans-1,4-Dichloro-2-butene	110-57-6	TBD							5	NC	NC

Notes:

TBD - To Be Determined based on Work Assignment

QL indicates quantitation limit.

MDL indicate method detection limit.

QLs and MDLs will be provided by the laboratory selected.

ug/L indicates micrograms per Liter.

ug/Kg indicates micrograms per kilogram.

* Indicates the method will be determined based on the specific task requirement.

** Indicates guidance value not standard.

*** 5 ug/L is the criteria for total Xylenes

Target compound list (TCL) reference:

USEPA. 2016. SOM02.4- Statement of Work For Organic Superfurd Methods, Multi-Media, Multi-Concentration. Washington D.C.

Regulatory criteria and notes:

For groundwater and surface water -6 CRR-NY Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations

For drinking water - 10 CRR-NY Part 5-1.51 Public Water Systems; Maximum Contaminant Levels; Monitoring Requirements; Notifications Required.

For sediment- Screening and Assessment of Contaminated Sediment, NYSDEC Division of Fish and Wildlife and Marine Resources; June 24, 2014

For soil - 6 CRR-NY Part 375-6 Remedial Program Soil Clean Up Objectives.

NC- No Criteria provided for these constituents in the specified regulation or guidance document.

Table 2-1B. Laboratory limits and regulatory limits for dissolved gases in aqueous samples				
Target Analytes	**CAS Number**	**USEPA Method**	**Laboratory QL Aqueous (µg/L)**	**Laboratory MDL Aqueous (µg/L)**
Dissolved Hydrocarbon Gas				
Methane	74-82-8	RSK-175		
Ethane	74-84-0	RSK-175		
Ethene	74-85-1	RSK-175		
Propane	74-98-6	RSK-175		

Notes:

QL indicates quantitation limit.

MDL indicates method detection limit.

QLs and MDLs will be provided by the laboratory selected.

ug/L indicates micrograms per Liter.

Method Reference:

Kampbell, D.H., Vandegrift, S.A., 1998. Analysis of Dissolved Methane, Ethane, and Ethylene in Ground Water by a Standard Gas Chromatographic Technique, Journal of Chromatographic Science, Volume 36.

Regulatory criteria and notes:

No regulatory action limits are available.

Table 2-2. Laboratory limits and regulatory limits for SVOCs in aqueous and solid samples

Target Analytes	CAS Number	USEPA Method* (8270, 625, 604, 8041, 610)	Laboratory QL Aqueous (µg/L)	Laboratory MDL Aqueous (µg/L)	Laboratory QL Solid (µg/Kg)	Laboratory MDL - Solid (µg/Kg)	Regulatory Criteria (ug/L)	Class GA Groundwater (µg/L)	Part 375 Unrestricted SCOs (µg/Kg)	Part 375 Commercial SCOs (µg/Kg)	Part 375 Industrial SCOs (µg/Kg)	Groundwater Protection SCOs (µg/Kg)
SVOC's- TCL												
1,4-Dioxane	123-91-1	8270**SIM**						0.35[1]	100	130,000	250,000	100
1,1´-Biphenyl	92-52-4	TBD						5	NC	NC	NC	NC
1,1-Biphenyl	95-52-4	TBD						NC	NC	NC	NC	NC
2,4,5-Trichlorophenol	95-95-4	TBD						1**	NC	NC	NC	NC
2,4,6-Trichlorophenol	88-06-2	TBD						1**	NC	NC	NC	NC
2,3,4,6-Tetrachlorophenol	58-90-2	TBD						NC	NC	NC	NC	NC
2,4-Dichlorophenol	120-83-2	TBD						1**	NC	NC	NC	NC
2,4-Dimethylphenol	105-67-9	TBD						1**	NC	NC	NC	NC
2,4-Dinitrophenol	51-28-5	TBD						1**	NC	NC	NC	NC
2,4-Dinitrotoluene	121-14-2	TBD						5	NC	NC	NC	NC
2,6-Dinitrotoluene	606-20-2	TBD						5	NC	NC	NC	NC
2-Chloronaphthalene	91-58-7	TBD						10***	NC	NC	NC	NC
2-Chlorophenol	95-57-8	TBD						1**	NC	NC	NC	NC
2-Methylnaphthalene	91-57-6	TBD						NC	NC	NC	NC	NC
2-Methylphenol	95-48-7	TBD						1**	330	500,000	1,000,000	330
2-Nitroaniline	88-74-4	TBD						5	NC	NC	NC	NC
2-Nitrophenol	88-75-5	TBD						1**	NC	NC	NC	NC
3,3´-Dichlorobenzidine	91-94-1	TBD						5	NC	NC	NC	NC
3 -Methylphenol	108-39-4	TBD						1**	330	500,000	1,000,000	330
3-Nitroaniline	99-09-2	TBD						5	NC	NC	NC	NC
4,6-Dinitro-2-methylphenol	534-52-1	TBD						1**	NC	NC	NC	NC
4-Bromophenyl phenyl ether	101-55-3	TBD						NC	NC	NC	NC	NC
4-Chloro-3-methylphenol	59-50-7	TBD						1**	NC	NC	NC	NC
4-Chloroaniline	106-47-8	TBD						5	NC	NC	NC	NC
4-Chlorophenyl phenyl ether	7005-72-3	TBD						NC	NC	NC	NC	NC
4-Methyl phenol	106-44-5	TBD						NC	330	500,000	1,000,000	330
4-Nitroaniline	100-01-6	TBD						5	NC	NC	NC	NC
4-Nitrophenol	100-02-7	TBD						1**	NC	NC	NC	100
4-Nitrophenol	100-02-7	TBD						NC	NC	NC	NC	NC
Acetophenone	98-86-2	TBD						NC	NC	NC	NC	NC
Acenaphthene	83-32-9	TBD						20***	20,000	500,000	1,000,000	98,000
Acenaphthylene	208-96-8	TBD						NC	100,000	500,000	1,000,000	107,000
Aniline	62-53-3	TBD						5	NC	NC	NC	NC
Anthracene	120-12-7	TBD						50***	100,000	500,000	1,000,000	1,000,000
Atrazine	1912-24-9	TBD						7.5	NC	NC	NC	NC
Benzo[a]anthracene	56-55-3	TBD						0.002***	1,000	5,600	11,000	1,000
Benzo[a]pyrene	50-32-8	TBD						ND	1,000	1,000	1,100	22,000
Benzo[b]fluoranthene	205-99-2	TBD						0.002*	1,000	5,600	11,000	1,700
Benzo[g,h,i]perylene	191-24-2	TBD						NC	100,000	500,000	1,000,000	1,000,000
Benzo[k]fluoranthene	207-08-9	TBD						0.002***	800	56,000	110,000	17,000
bis(2-Chloroethoxy)methane	111-91-1	TBD						5	NC	NC	NC	NC
bis(2-chloroethyl)ether	111-44-4	TBD						1	NC	NC	NC	NC
bis(2-chloroisopropyl)ether	108-60-1	TBD						5	NC	NC	NC	NC
bis(2-Ethylhexyl)phthalate	117-81-7	TBD						5	NC	NC	NC	NC
Butyl benzyl phthalate	85-86-7	TBD						50***	NC	NC	NC	NC
Carbazole	86-74-8	TBD						NC	NC	NC	NC	NC
Caprolactam	105-60-2	TBD						NC	NC	NC	NC	NC
Chrysene	218-01-9	TBD						0.002***	1,000	56,000	110,000	1,000
Dibenz[a,h]anthracene	53-70-3	TBD						NC	330	560	1,100	1,000,000
Dibenzofuran	132-64-9	TBD						NC	7,000	350,000	1,000,000	6,200
Diethyl phthalate	84-66-2	TBD						50***	NC	NC	NC	NC

Table 2-2. Laboratory limits and regulatory limits for SVOCs in aqueous and solid samples

Target Analytes	CAS Number	USEPA Method* (8270, 625, 604, 8041, 610)	Laboratory QL Aqueous (µg/L)	Laboratory MDL Aqueous (µg/L)	Laboratory QL Solid (µg/Kg)	Laboratory MDL - Solid (µg/Kg)	Regulatory Criteria (ug/L)	Class GA Groundwater (µg/L)	Part 375 Unrestricted SCOs (µg/Kg)	Part 375 Commercial SCOs (µg/Kg)	Part 375 Industrial SCOs (µg/Kg)	Groundwater Protection SCOs (µg/Kg)
SVOC's- TCL												
Dimethyl phthalate	131-11-3	TBD						50***	NC	NC	NC	NC
Di-n-butyl phthalate	84-74-2	TBD						50	NC	NC	NC	NC
Di-n-octyl phthalate	117-84-0	TBD						50***	NC	NC	NC	NC
Fluoranthene	206-44-0	TBD						50***	100,000	500,000	1,000,000	1,000,000
Fluorene	86-73-7	TBD						50***	30,000	500,000	1,000,000	386,000
Hexachlorobenzene	118-74-1	TBD						0.04	330	6,000	12,000	1,400
Hexachlorobutadiene	87-68-3	TBD						0.5	NC	NC	NC	NC
Hexachlorocyclopentadiene	77-47-4	TBD						5	NC	NC	NC	NC
Hexachloroethane	67-72-1	TBD						5	NC	NC	NC	NC
Indeno[1,2,3-cd]pyrene	193-39-5	TBD						0.002***	500	5,600	11,000	8,200
Isophorone	78-59-1	TBD						50***	NC	NC	NC	NC
Naphthalene	91-20-3	TBD						10***	12,000	500,000	1,000,000	12,000
Nitrobenzene	98-95-3	TBD						0.4	NC	NC	NC	NC
N-Nitroso-di-n-propylamine	621-64-7	TBD						NC	NC	NC	NC	NC
N-Nitrosodiphenylamine	86-30-6	TBD						50***	NC	NC	NC	NC
Pentachlorophenol	87-86-5	TBD						1**	800	6,700	55,000	800
Phenanthrene	85-01-8	TBD						50	100,000	500,000	1,000,000	1,000,000
Phenol	108-95-2	TBD						1**	330	500,000	1,000,000	330
Pyrene	129-00-0	TBD						50***	100,000	500,000	1,000,000	1,000,000
SVOCs, Phenols- Other Target Analytes												
1,2,4-Trichlorobenzene	120-82-1	TBD						5	NC	NC	NC	NC
1,2-Diphenylhydrazine	122-66-7	TBD						0.05	NC	NC	NC	NC
Benzidine	92-87-5	TBD						5	NC	NC	NC	NC
bis (2-Chloroisopropyl) ether	108-60-1	TBD						5	NC	NC	NC	NC
n-Nitrosodimethylamine	62-75-9	TBD						NC	NC	NC	NC	NC
2,6-Dichlorophenol	87-65-0	TBD						NC	NC	NC	NC	NC
Dinoseb	88-85-7	TBD						1**	NC	NC	NC	NC

Notes:

TBD - To be Determined based on Work Assignment tasks

QL indicates quantitation limit.

MDL indicate method detection limit.

QLs and MDLs will be provided by the laboratory selected.

ug/L indicates micrograms per Liter.

ug/Kg indicates micrograms per kilogram.

* Indicates the method will be determined based on the specific task requirement.

** Included in Phenolic Compounds which is sum of substances.

*** Indicates Guidance Criteria not standard.

Target compound list (TCL) Reference:

United States Environmental Protection Agency (USEPA). 2016. SOMo2.4- Statement of Work For Organic Superfurd Methods, Multi-Media, Multi-Concentration. Washington D.C.

Regulatory criteria and notes:

1 - New York State Department of Environmental Conservation (NYSDEC), 2023 Addendeum to Technical Operational Guidance Series (TOGS) 1.1.1 for 1,4-dioxane.

For groundwater and surface water -6 CRR-NY Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations

For soil samples - 6 CRR-NY Part 375-6 Remedial Program Soil Clean Up Objectives.

NC- No criteria provided for these constituents in the specified regulation or guidance document.

Table 2-3. *Laboratory limits and regulatory limits for PFAS in aqueous and solid samples* (USEPA Method 1633)

Target Analytes	CAS Number	USEPA Method	Laboratory Limits				Interim SCOs[1]						TOGs Groundwater[2]
			Laboratory Solids QL ug/kg	Laboratory Solids MDL ug/kg	Laboratory Aqueous QL ng/L	Laboratory Aqueous MDL ng/L	Unrestricted ug/kg	Residential ug/kg	Restricted Residential ug/kg	Commercial ug/kg	Industrial ug/kg	Protection of Groundwater ug/kg	Groundwater Screening Levels ng/L
Perfluoroalkyl sulfonic acids													
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1633	0.2	0.07	2	0.66							
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	1633	0.2	0.1	2	1							
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	1633	0.2	0.11	2	1.1							
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	1633	0.2	0.1	2	0.98							
Perfluorooctanessulfonic acid (PFOS)	1763-23-1	1633	0.2	0.05	2	0.43	0.88	8.8	44	440	440	1	2.7
Perfluorononanesulfonic acid (PFNS)	68259-12-1	1633	0.2	0.14	2	1.4							
Perfluorodecanesulfonic acid (PFDS)	335-77-3	1633	0.2	0.11	2	1.1							
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	1633	0.2	0.05	2	0.4							
Perfluoroalkyl carboxylic acids													
Perfluorobutanoic acid (PFBA)	375-22-4	1633	0.8	0.11	8	0.93							
Perfluoropentanoic acid (PFPeA)	2706-90-3	1633	0.4	0.07	4	0.73							
Perfluorohexanoic acid (PFHxA)	307-24-4	1633	0.2	0.03	2	0.29							
Perfluoroheptanoic acid (PFHpA)	375-85-9	1633	0.2	0.05	2	0.5							
Perfluorooctanoic acid (PFOA)	335-67-1	1633	0.2	0.08	2	0.75	0.66	6.6	33	500	600	0.8	6.7
Perfluorononanoic acid (PFNA)	375-95-1	1633	0.2	0.05	2	0.4							
Perfluorodecanoic acid (PFDA)	335-76-2	1633	0.2	0.07	2	0.62							
Perfluoroundecanoic acid (PFUnA)	2058-94-8	1633	0.2	0.06	2	0.55							
Perfluorododecanoic acid (PFDoA)	307-55-1	1633	0.2	0.08	2	0.77							
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	1633	0.2	0.09	2	0.79							
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	1633	0.2	0.1	2	0.76							
Per- and Polyfluoroether carboxylic acids													
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1633	0.8	0.18	8	1.8							
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	1633	0.8	0.12	8	1.2							
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	1633	0.4	0.03	4	0.3							
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	1633	0.4	0.06	4	0.56							
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	1633	0.4	0.13	4	1.3							
Fluorotelomer sulfonic acids													
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	1633	0.8	0.28	8	2.3							
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	1633	0.8	0.1	8	0.91							
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	1633	0.8	0.19	8	1.5							
Fluorotelomer carboxylic acids													
3:3 Fluorotelomer carboxylic acid (3:3 FTCA)	356-02-05	1633	1	0.24	10	2.4							
5:3 Fluorotelomer carboxylic acid (5:3 FTCA)	914637-49-3	1633	5	0.62	5	7.1							
7:3 Fluorotelomer carboxylic acid (7:3 FTCA)	812-70-4	1633	5	0.63	5	6.2							
Perfluorooctane- sulfonamides													
Perfluroroctane sulfonamide (PFOSA)	754-91-6	1633	0.2	0.07	0.002	0.69							
N-methylperfluorooctane sulfonamide (NMeFOSA)	31506-32-8	1633	0.2	0.06	0.002	0.64							
N-ethylperfluorooctane sulfonamide (NEtFOSA)	4151-50-2	1633	0.2	0.05	0.002	0.53							
Perfluorooctane- sulfonamidoacetic acids													
N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	2355-31-9	1633	0.2	0.08	0.002	0.51							
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	2991-50-6	1633	0.2	0.13	0.002	0.91							
Perfluorooctane- sulfonamide ethanols						0							
N-methylperfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	1633	2	0.28	0.02	2.8							
N-ethylperfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	1633	2	0.73	0.02	3.8							
Perfluorooctane- sulfonamide ethanols													
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic (F-53B Major) (9Cl-PF3ONS)	756426-58-1	1633	0.8	0.26	0.008	2.4							
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (F-53B Minor)	763051-92-9	1633	0.8	0.18	0.008	1.8							
Perfluoro(2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	1633	0.4	0.03	0.004	0.27							

Notes:

QLs indicates quantitation limits.
MDLs indicate method detection limits.
ug/kg indicates migrogram per kilogram
ng/L indicates nanogram per liter.
MDLs, RLs and control limits provided by SGS Dayton current as of April 2024.

Method reference

USEPA. 2024. Method 1633. Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS, USEPA, Office of Science and Technology Engineering and Analysis Division, Washington, DC.

Regulatory Criteria:

1 - NYSDEC, Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) under NYSDEC's Part 375 Remedial Programs dated April 2023.
2 - New York State Department of Environmental Conservation (NYSDEC), 2023 Addendeum to Technical Operational Guidance Series (TOGS) 1.1.1 for PFOA and PFOS

Table 2-4. Laboratory limits and regulatory limits for metals in aqueous and solid samples

Target Analytes	CAS Number	Method* (Reference)	Laboratory QL Aqueous µg/L	Laboratory MDL - Aqueous µg/L	Laboratory QL Solid mg/Kg	Laboratory MDL - Solid mg/Kg	Class GA Groundwater µg/L	Part 375 Unrestricted Use SCOs mg/Kg	Part 375 Protection of Groundwater SCOs mg/Kg
Metals- TAL									
Aluminum	7429-90-5	6010C/6010D/6020A/6020B (1)					NC	NC	NC
Antimony	7440-36-0	6010C/6010D/6020A/6020B (1)					3	NC	NC
Arsenic	7440-38-2	6010C/6010D/6020A/6020B (1)					25	13	16
Barium	7440-39-3	6010C/6010D/6020A/6020B (1)					1,000	350	820
Beryllium	7440-41-7	6010C/6010D/6020A/6020B (1)					3**	7.2	47
Cadmium	7440-43-9	6010C/6010D/6020A/6020B (1)					5	2.5	7.5
Calcium	7440-70-2	6010C/6010D/6020A/6020B (1)					NA	NA	NA
Total Chromium	7440-47-3	6010C/6010D/6020A/6020B (1)					50	1/30[h]	19/NC[h]
Cobalt	7440-48-4	6010C/6010D/6020A/6020B (1)					NA	NA	NA
Copper	7440-50-8	6010C/6010D/6020A/6020B (1)					200	50	1,720
Iron	7439-89-6	6010C/6010D/6020A/6020B (1)					300	NA	NA
Lead	7439-92-1	6010C/6010D/6020A/6020B (1)					25	63	450
Magnesium	7439-95-4	6010C/6010D/6020A/6020B (1)					35,000**	NA	NA
Manganese	7439-96-5	6010C/6010D/6020A/6020B (1)					300	1,600	2,000
Mercury	7439-97-6	7470A/7471B (2, 3)					0.7	0.18	0.73
Nickel	7440-02-0	6010C/6010D/6020A/6020B (1)					100	30	130
Potassium	7440-09-7	6010C/6010D/6020A/6020B (1)					NA	NA	NA
Selenium	7782-49-2	6010C/6010D/6020A/6020B (1)					10	3.9	4.0
Silver	7440-22-4	6010C/6010D/6020A/6020B (1)					50	2	8.3
Sodium	7440-23-5	6010C/6010D/6020A/6020B (1)					20,000	NA	NA
Thallium	7440-28-0	6010C/6010D/6020A/6020B (1)					0.5**	NA	NA
Vanadium	7440-62-2	6010C/6010D/6020A/6020B (1)					NA	NA	NA
Zinc	7440-66-6	6010C/6010D/6020A/6020B (1)					2,000**	109	2,480
Total Cyanide	57-12-5	9012 (5)					200	27	40

Notes:

MDLs indicate method detection limits.

QLs indicates quantitation limits.

mg/kg indicates milligrams per kilogram.

ug/L indicates micrograms per Liter.

QLs and MDLs will be provided by laboratory selected.

* Indicates the method will be determined based on the specific task requirement.

** Indicates guidance value not standard.

[h] - No Total Chromium Criterion available. Values are hexavlent/trivalent.

Target analyte list (TAL) reference:

USEPA. 2016. ISM02.4- Statement of Work For Inorganic Superfurd Methods, Multi-Media, Multi-Concentration. Washington D.C.

Method references:

1- USEPA. 2014. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update V. Washington D.C.
2- USEPA. 1994. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update II. Washington D.C.
3- USEPA. 2007. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update IV. Washington D.C.
4- AWWA, APHA and WEF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. Washington, D.C.
5- USEPA. 1996. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update III. Washington D.C.

Regulatory criteria and notes:

For groundwater and surface water -6 CRR-NY Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations

For soil samples - 6 CRR-NY Part 375-6 Remedial Program Soil Clean Up Objectives.

NC- No Criterion provided for constituent in the specified regulation or guidance document.

Table 2-5 Laboratory limits and regulatory limits for inorganics and other analyses in aqueous and solid samples

Target Analytes	CAS Number	Method (Reference)	Laboratory QL Aqueous µg/L	Laboratory MDL - Aqueous µg/L	Laboratory QL Solid mg/Kg	Laboratory MDL - Solid mg/Kg	Class GA Standards or Giidance Value (µg/L)	Part 375 Unrestricted SCOs (µg/Kg)	Part 375 Protection Of Groundwater (µg/Kg)
Inorganics and Other analyses									
Hexavalent Chromium	---	7196A/7199 (1, 2)					50	1	19
Nitrate	---	353.2/ (NO2 by SM20 4500NO2B) (3)					10,000*	NC	NC
Nitrate/Nitrite	---	USEPA Method 353.2 (3)					10,000*	NC	NC
Nitrite	---	SM20 4500 NO2B (4)					10,000*	NC	NC
Chloride	---	USEPA Method 300.0 (5)					250,000	NC	NC
Sulfate	---	USEPA Method 300.0 (5)					250,000	NC	NC
Bromide	---	USEPA Method 300.0 (5)					NC	NC	NC
Fluoride	---	USEPA Method 300.0 (5)					1,500	NC	NC
Sulfide	---	SM20 4500 S2 (4)					NC	NC	NC
Total Phosphorus	---	USEPA Method 365.3 (5)					NC	NC	NC
Total and Ortho Phosphate	---	SM20 4500-PE (4)					NC	NC	NC
TDS	---	SM20 2540-C (4)					NC	NC	NC
TSS	---	SM20 2540-D (4)					NC	NC	NC
Ammonia	---	SM20 4500 NH3-B/C (4)					2,000	NC	NC
Alkalinity	---	SM20 2320B (4)					NC	NC	NC
Total Hardness	---	SM20 2340C (4)					NC	NC	NC
Total Organic Carbon (TOC)	---	SM20 5310C/USEPA Method 9060A/Lloyd Kahn (4,6, 7)					NC	NC	NC
Total Inorganic Carbon	---	SM20 5310B (4)					NC	NC	NC
Biochemical Oxygen Demand (BOD)	---	SM20 5210B (4)					NC	NC	NC
Chemical Oxygen Demand (COD)	---	SM20 5220C (4)					NC	NC	NC
Total Kjeldahl Nitrogen (TKN)	---	USEPA Method 351.2 (5)					NC	NC	NC
Corrosivity	---	USEPA Method 9045D (6)					NC	NC	NC
Ignitability	---	USEPA 40 CFR Part 261.2 (8)					NC	NC	NC
Flashpoint	---	USEPA Method 1010A (6)					NC	NC	NC
Reactive Cyanide	---	USEPA Chapter 7- Method 9012B (2)					NC	NC	NC
Reactive Sulfide	---	USEPA Chapter 7- Method 9034 (2)					NC	NC	NC
Oil & Grease	---	USEPA Method 1664A (9)					NC	NC	NC
Acidity	---	SM20 2310B (4)					NC	NC	NC
Surfactants (Metylene Blue Active Substances (MBAS)	---	SM20 5540C (4)					NC	NC	NC
Color	---	SM20 2120B (4)					NC	NC	NC
Total Volatile Solids (TVS)	---	USEPA Method 160.4 (5)					NC	NC	NC
Total Phenols	---	USEPA Method 9065 (10)					1	NC	NC
Total Residual Chlorine	---	SM20 4500-CL (4)					NC	NC	NC
pH	---	SM20 4500 H+B/USEPA Method 9045D (4, 6)					6.5 to 8.5	NC	NC

Notes:

MDLs indicate method detection limits.

QLs indicates quantitation limits.

mg/kg indicates milligrams per kilogram.

ug/L indicates micrograms per Liter.

QLs and MDLs will be provided by laboratory selected.

Method references:

1- USEPA. 1992. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update I. Washington D.C.

2 - USEPA. 1996. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update III. Washington D.C.

3- USEPA. 1993. Method 353.2. Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry. Revision 2.0. Washington, D.C.

4- AWWA, APHA and WEF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition. Washington, D.C.

5- USEPA. 1993. Methods for the Determination of Inorganic Substances in Environmental Samples, EPA-600/R-93/100. Washington, D.C.

6- USEPA. 2004. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition, Update IIIB. Washington D.C.

7- USEPA. 1988. Determination of Total Organic Carbon in Sediment, Region II, Environmental Services Division, Monitoring Management Branch, Edison, New Jersey.

8- USEPA. 2001. 40 CFR Part 136, Appendix A. Washington, D.C.

9- USEPA. 2009. Method 1664, Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) By Extraction and Gravimetry. Washington, D.C.

10- USEPA. 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, 3rd Edition. Washington D.C.

* - applies to the sum of nitrate and nitrite.

Regulatory criteria and notes:

For groundwater and surface water -6 CRR-NY Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations

For soil samples - 6 CRR-NY Part 375-6 Remedial Program Soil Clean Up Objectives.

NC- No Criterion provided for these constituents in the specified regulation or guidance document.

EXHIBIT E-1 – SGS LAB CERTIFICATION

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2025
Issued April 01, 2024

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. HEMEX PATEL
SGS NORTH AMERICA INC. - DAYTON
2235 ROUTE 130
DAYTON, NJ 08810

NY Lab Id No: 10983

is hereby APPROVED as an Environmental Laboratory for the category
ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved subcategories and/or analytes are listed below:

Perfluorinated Alkyl Acids

11CL-PF3OUDS	EPA 1633 (Draft)
4:2FTS	EPA 1633 (Draft)
6:2FTS	EPA 1633 (Draft)
8:2FTS	EPA 1633 (Draft)
9CL-PF3ONS	EPA 1633 (Draft)
ADONA	EPA 1633 (Draft)
Hexafluoropropylene Oxide Dimer Acid	EPA 1633 (Draft)
NETFOSAA	EPA 1633 (Draft)
NMEFOSAA	EPA 1633 (Draft)
Nonafluoro-3,6-Dioxaheptanoic Acid	EPA 1633 (Draft)
Perflourotridecanoic Acid (PFTRDA)	EPA 1633 (Draft)
Perfluordecanoic Acid (PFDA)	EPA 1633 (Draft)
Perfluoro-3-Methoxypropanoic Acid	EPA 1633 (Draft)
Perfluoro-4-Methoxybutanoic Acid	EPA 1633 (Draft)
Perfluorobutanesulfonic Acid (PFBS)	EPA 1633 (Draft)
Perfluorobutanoic Acid (PFBA)	EPA 1633 (Draft)
Perfluorododecanoic Acid (PFDOA)	EPA 1633 (Draft)
Perfluoroheptanesulfonic Acid (PFHPS	EPA 1633 (Draft)
Perfluoroheptanoic Acid (PFHPA)	EPA 1633 (Draft)
Perfluorohexanesulfonic Acid (PFHXS	EPA 1633 (Draft)
Perfluorohexanoic Acid (PFHXA)	EPA 1633 (Draft)
Perfluorononanoic Acid (PFNA)	EPA 1633 (Draft)
Perfluorooctanesulfonic Acid (PFOS)	EPA 1633 (Draft)
Perfluorooctanoic Acid (PFOA)	EPA 1633 (Draft)
Perfluoropentanesulfonic Acid (PFPES	EPA 1633 (Draft)
Perfluoropentanoic Acid (PFPEA)	EPA 1633 (Draft)
Perfluorotetradecanoic Acid (PFTA)	EPA 1633 (Draft)

Serial No.: 68660

Property of the New York State Department of Health. Certificates are valid only at the address shown and must be conspicuously posted by the laboratory. Continued accreditation depends on the laboratory's successful ongoing participation in the Program. Consumers may verify a laboratory's accreditation status online at https://apps.health.ny.gov/pubdoh/applinks/wc/elappublicweb/, by phone (518) 485-5570 or by email to elap@health.ny.gov.

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ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved subcategories and/or analytes are listed below:

Perfluorinated Alkyl Acids

Perfluoroundecanoic Acid (PFUNA)	EPA 1633 (Draft)
PFEESA	EPA 1633 (Draft)

Serial No.: 68660

Property of the New York State Department of Health. Certificates are valid only at the address shown and must be conspicuously posted by the laboratory. Continued accreditation depends on the laboratory's successful ongoing participation in the Program. Consumers may verify a laboratory's accreditation status online at https://apps.health.ny.gov/pubdoh/applinks/wc/elappublicweb/, by phone (518) 485-5570 or by email to elap@health.ny.gov.

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2025
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CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. HEMEX PATEL
SGS NORTH AMERICA INC. - DAYTON
2235 ROUTE 130
DAYTON, NJ 08810

NY Lab Id No: 10983

is hereby APPROVED as an Environmental Laboratory for the category
ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE
All approved subcategories and/or analytes are listed below:

Perfluorinated Alkyl Acids

8:2FTS	EPA 1633 (Draft)
NETFOSAA	EPA 1633 (Draft)
NMEFOSAA	EPA 1633 (Draft)
Perflourotridecanoic Acid (PFTRDA)	EPA 1633 (Draft)
Perfluordecanoic Acid (PFDA)	EPA 1633 (Draft)
Perfluorobutanoic Acid (PFBA)	EPA 1633 (Draft)
Perfluorododecanoic Acid (PFDOA)	EPA 1633 (Draft)
Perfluoroheptanoic Acid (PFHPA)	EPA 1633 (Draft)
Perfluorohexanoic Acid (PFHXA)	EPA 1633 (Draft)
Perfluorononanoic Acid (PFNA)	EPA 1633 (Draft)
Perfluorooctanesulfonic Acid (PFOS)	EPA 1633 (Draft)
Perfluorooctanoic Acid (PFOA)	EPA 1633 (Draft)
Perfluoropentanoic Acid (PFPEA)	EPA 1633 (Draft)
Perfluorotetradecanoic Acid (PFTA)	EPA 1633 (Draft)
Perfluoroundecanoic Acid (PFUNA)	EPA 1633 (Draft)

Serial No.: 68662

Property of the New York State Department of Health. Certificates are valid only at the address shown and must be conspicuously posted by the laboratory. Continued accreditation depends on the laboratory's successful ongoing participation in the Program. Consumers may verify a laboratory's accreditation status online at https://apps.health.ny.gov/pubdoh/applinks/wc/elappublicweb/, by phone (518) 485-5570 or by email to elap@health.ny.gov.

EXHIBIT E-2 – SGS-DAYTON STANDARD OPERATING PROCEDURES

LAB SUPERVISOR: Bridget Kelley

QA OFFICER: Olga V. Azarian

EFFECTIVE DATE: 4-25-23

TITLE: METHOD 8260D, VOLATILE ORGANIC COMPOUNDS BY GAS CHROMATOGRAPHY/ MASS SPECTROMETRY (GC/MS)
REFERENCES: SW846 8260D (Revision 4, June 2018), SW846 8000D (Revision 5, March 2018)
REVISED SECTIONS: 10.4.1, 11.3.2, 12.1
DELETED SECTIONS: 11.3.3, 11.3.4

1.0 SCOPE AND APPLICATION

1.1 This SOP describes the analytical procedures, which are utilized by SGS to acquire samples for analysis of volatile organic compounds by gas chromatographic/mass spectrometric (GC/MS) following purge and trap utilizing the internal standard technique. The compounds in Table 1 may be determined by this method. An option has been included for the analysis of 1,4-Dioxane by selected ion monitoring GC/MS (GC/MS-SIM).

1.2 This analytical method is designed for nearly all types of samples, regardless of water content, including ground water, aqueous sludges, liquors, waste solvents, oily wastes, tars, filter cakes, sediments and soils.

1.3 The applicable concentration range of this method is compound, matrix, and instrument dependent. Volatile water-soluble compounds can be included in this analytical technique. However, for some low-molecular weight halogenated hydrocarbons, aromatics, ketones, nitriles, acetates, acrylates, ethers, and sulfides, quantitation limits are approximately ten times higher because of poor purging efficiency. Determination of some structural isomers (i.e. xylenes) may also be hampered by coelution.

2.0 SUMMARY OF METHOD

2.1 Volatile compounds are introduced into the gas chromatograph by purge-and-trap (Method 5030/5035). Method 5030 may be used directly on ground water samples. Method 5035 is used for low-concentration and medium-concentration soils, sediments, and wastes. Medium concentration samples are preserved and stored in methanol prior to purge-and-trap analysis.

2.2 An inert gas is bubbled through a 5 ml sample contained in a specifically designed purging chamber at ambient temperature. The purgeables are efficiently transferred from the aqueous phase to the vapor phase. The vapor is swept through a sorbent column where the purgeables are trapped. After purging is completed, the sorbent column is heated and backflushed with the inert gas to desorb the purgeables onto a gas chromatographic (GC) column.

2.3 The volatile compounds are separated by the temperature programmed GC column and detected using a mass spectrometer, which is used to provide both qualitative and quantitative information.

2.4 The peaks detected are qualitated by comparison to characteristic ions and retention times specific to the known target list of compounds.

2.5 Once identified the compound is quantitated by comparing the response of major (quantitation) ion relative to an internal standard technique with an average response factor generated from a calibration curve.

2.6 Additional unknown peaks with a response > 10 % of the closest internal standard may be processed through a library search with comparison to a database of approximately 75,000 spectra. An estimated concentration is quantitated by assuming a response factor of 1.

2.7 Water soluble volatile organic and other poor purging compounds maybe analyzed using this methodology, however this method is not the method of choice for these compounds and the laboratory's ability to achieve all calibration and quality control criteria for this method cannot be guaranteed. These compounds are noted as (pp) in Table 7.

2.8 The method includes an analytical option for the analysis of 1,4-Dioxane by GC/MS-SIM. The selected ions that are characteristic of the analytes of interest are analyzed using lower concentrations of calibration standards under the same MS conditions. SIM analysis is performed upon client request and is documented in the report.

3.0 REPORTING LIMIT AND METHOD DETECTION LIMIT

3.1 Reporting Limit. The reporting limit for this method is established at the lowest concentration standard in the calibration curve and may vary depending on matrix interferences, sample volume or weight and percent moisture. Detected concentrations below this concentration cannot be reported without qualification. See Table 10.

3.1.1 Compounds detected at concentrations between the reporting limit and MDL are quantitated and qualified as “J”, estimated value. Program or project specifications may dictate that “J” qualified compounds are not to be reported.

3.2 Method Detection Limit. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B, revision 2. This value represents the lowest reportable concentration of an individual compound that meets the method qualitative identification criteria.

3.2.1 Experimental MDLs must be determined annually for this method.

3.2.2 Process all raw data for the replicate analysis in each MDL study. Forward the processed data to the QA group for archiving.

3.2.3 Calculated MDLs may not be feasible in the analysis of samples, particularly in regard to compounds in table 11 and common laboratory solvents (methylene chloride and acetone). In these cases, the MDLs may be raised from the calculated value to a maximum of half the LOQ to avoid false positives being reported.

4.0 DEFINITIONS

BLANK - an analytical sample designed to assess specific sources of laboratory contamination. See individual types of Blanks: Method Blank, Instrument Blank, Storage Blank, Cleanup Blank and Sulfur Blank.

4-BROMOFLUOROBENZENE (BFB) - the compound chosen to establish mass spectral instrument performance for volatile (VOA) analyses.

CALIBRATION FACTOR (CF) - a measure of the gas chromatographic response of a target analyte to the mass injected. The calibration factor is analogous to the Relative Response Factor (RRF) used in the Volatile and Semivolatile fractions.

CONTINUING CALIBRATION - analytical standard run every 12 hours to verify the initial calibration of the system.

CONTINUOUS LIQUID-LIQUID EXTRACTION - used herein synonymously with the terms continuous extraction, continuous liquid extraction, and liquid extraction. This extraction technique involves boiling the extraction solvent in a flask and condensing the solvent above the aqueous sample. The condensed solvent drips through the sample, extracting the compounds of interest from the aqueous phase.

EXTRACTED ION CURRENT PROFILE (EICP) - a plot of ion abundance versus time (or scan number) for ion(s) of specified mass (Es).

INITIAL CALIBRATION - analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the mass spectrometer to the target compounds.

INTERNAL STANDARDS - compounds added to every standard, blank, matrix spike, matrix spike duplicate, sample (for volatiles), and sample extract (for semivolatiles) at a known concentration, prior to analysis. Internal standards are used as the basis for quantitation of the target compounds.

MATRIX - the predominant material of which the sample to be analyzed is composed. For the purpose of this SOP, a sample matrix is either water or soil/sediment. Matrix is not synonymous with phase (liquid or solid).

MATRIX SPIKE - aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

MATRIX SPIKE DUPLICATE - a second aliquot of the same matrix as the matrix spike (above) that is spiked in order to determine the precision of the method.

METHOD BLANK - an analytical control consisting of all reagents, internal standards and surrogate standards that is carried throughout the entire analytical procedure. The method blank is used to define the level of laboratory, background and reagent contamination.

METHOD DETECTION LIMITS (MDLs) - The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is distinguishable from method blank results.

PERCENT DIFFERENCE (%D) - As used in this SOP and elsewhere to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference.)

PERCENT MOISTURE - an approximation of the amount of water in a soil/sediment sample made by drying an aliquot of the sample at 105°C. The percent moisture determined in this manner also includes contributions from all compounds that may volatilize at or below 105 °C, including water. Percent moisture may be determined from decanted samples and from samples that are not decanted.

PRIMARY QUANTITATION ION - a contract specified ion used to quantitate a target analyte.

REAGENT WATER - water in which an interferant is not observed at or above the minimum detection limit of the parameters of interest.

RECONSTRUCTED ION CHROMATOGRAM (RIC) - a mass spectral graphical representation of the separation achieved by a gas chromatograph: a plot of total ion current versus retention time.

RELATIVE PERCENT DIFFERENCE (RPD) - As used in this SOP and elsewhere to compare two values, the relative percent difference is based on the mean of the two values, and is reported as an absolute value, i.e., always expressed as a positive number or zero. (In contrast, see percent difference.)

RELATIVE RESPONSE FACTOR (RRF) - a measure of the relative mass spectral response of an analyte compared to its internal standard. Relative Response Factors are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples.

RELATIVE RETENTION TIME (RRT) - the ratio of the retention time of a compound to that of a standard (such as an internal standard).

INSTRUMENT BLANK – a system evaluation sample containing lab reagent grade water with internal standards and surrogate standards added. An instrument blank is used to remove and/or evaluate residual carryover from high level standards, spike samples and field samples.

5.0 HEALTH & SAFETY

5.1 The analyst must follow normal safety procedures as outlined in the SGS Health and Safety Plan and Personal Protection Policy, which include the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents must be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets must be made available to all personnel involved in these analyses.

5.3 The following analytes covered by this method have been tentatively classified as known or suspected, human or mammalian carcinogens: benzene, carbon tetrachloride, 1,4-dichlorobenzene, 1,2-dichlorethane, hexachlorobutadiene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, chloroform, 1,2-dibromoethane, tetrachloroethene, trichloroethene, and vinyl chloride. Primary standards of these toxic compounds must be prepared in a hood. A NIOSH/Mass approved toxic gas respirator must be worn when the analyst handles high concentrations of these toxic compounds.

6.0 INTERFERENCES

6.1 The data from all blanks, samples, and spikes must be evaluated for interferences.

6.2 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 demonstrated to be free from contamination under the conditions of the analysis by running laboratory reagent blanks. The use of non-TFE tubing, non-TFE thread sealants, or flow controllers with rubber components in the purging device must be avoided.

6.3 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal into the sample during shipment and storage. A trip blank prepared from reagent water and carried through the sampling and handling protocol can serve as a check on such contamination.

6.4 Contamination by carry-over can occur whenever high level and low-level samples are sequentially analyzed.

6.4.1 Whenever an unusually concentrated sample is encountered, it must be followed by an analysis of an instrument blank to check for cross contamination. Refer to Table 11 for compounds that may cause carryover for this method.

6.4.2 It may be necessary to wash the purging device with methanol, rinse it with organic-free water, and then dry the purging device in an oven at 105^0 C. Follow the instrument manual for instructions on cleaning. Document the occurrence in the maintenance log and notify the manager/supervisor.

6.4.2.1 Clean and bake purging tube.

6.4.2.2 Clean or replace purge needle.

6.4.2.3 Clean and bake sample filter or sparge filter.

6.4.2.4 Clean and bake sample loop.

6.4.2.5 Replace trap if necessary.

6.4.2.6 Replace water management module if necessary.

6.4.2.7 Rinse transfer line with methanol. Caution: disconnect the trap before rinsing.

6.4.3 In extreme situations, the entire purge-and trap device may require dismantling and cleaning. Follow the instrument's manual for instructions on disassembly. Document the occurrence in the maintenance log and notify the manager/supervisor. Screening of the samples prior to purge-and-trap GC/MS analysis is highly recommended to prevent contamination of the system. This is especially true for soil and waste samples.

6.4.4 If the contamination has been transferred to gas chromatograph, any of the following approaches may be used to cleanup the instrument.

6.4.4.1 Baking out the column between analyses.

6.4.4.2 Change the injector liner to reduce the potential for cross-contamination.

6.4.4.3 Remove a portion of the analytical column in the case of extreme contamination.

6.4.5 The oven temperature program must include a post-analysis bake out period to ensure that semivolatile hydrocarbons are stripped from the chromatographic column.

6.5 Special precautions must be taken during the analysis to avoid contamination from methylene chloride and other common laboratory solvents.

6.5.1 The sample storage and analytical area must be isolated from all atmospheric sources of methylene chloride or other common solvents.

6.5.2 Laboratory clothing worn by the analyst must be clean and used in designated areas only. Clothing previously exposed to solvent vapors in the organics sample preparation laboratory can contribute to sample contamination.

6.6 Samples with suspected or known permanganate levels must be preserved with ascorbic acid at collection. The purpose of the ascorbic acid is to remove the permanganate which is an oxidizer. There is potential that the analytes of concern will undergo an oxidative transformation which would no longer be representative of the concentrations as the site.

7.0 SAMPLE HANDLING AND PRESERVATION AND HOLDING TIME

7.1 HANDLING and PRESERVATION

7.1.1 Water samples

7.1.1.1 Container - 40 ml glass screw-cap VOA vial with Teflon-faced silicone septum. The 40-ml glass VOA vials are pre-cleaned and certified.

7.1.1.2 Acrolein & Acrylonitrile

7.1.1.2.1 If acrolein and acrylonitrile are to be analyzed, collect 3, 40 mL VO vials of sample unpreserved. Samples for acrolein and acrylonitrile analysis receiving no pH adjustment must be analyzed within 7 days of sampling. All samples must be footnoted stating samples were unpreserved and analyzed within 7 days.

7.1.1.3 Collect all samples in triplicate. Test all samples for residual chlorine using test paper for free and total chlorine. If samples contain residual chlorine, three milligrams of sodium thiosulfate must be added for each 40 ml of water sample.

7.1.1.4 Fill sample bottles to overflowing, but do not flush out the dechlorinating agent. Sample must be taken with care so as to prevent any air or bubbles entering vials creating headspace.

7.1.1.5 Adjust the pH of all samples to ≤ 2 at the time of collection, but after dechlorination, by carefully adding two drops of 1:1 HCl for each 40 ml of sample. Seal the sample bottles, Teflon face down, and mix for one minute. Or VOA vials containing the preservative (HCL) may be used.

Note: Do not mix the sodium thiosulfate with the HCl in the sample bottle prior to sampling.

7.1.1.6 The samples must be protected from light and refrigerated at 0 - ≤ 6 °C from the time of receipt until analysis.

7.1.1.7 An alternate preservative that may be used when suspected or known levels of permanganate exist in a sample is 25 mg of ascorbic acid per 40 ml vial.

7.1.1.7.1 Ascorbic acid is added to remove the permanganate which is an oxidizer.

7.1.1.7.2 Fill the sample bottles to overflowing, but do not flush out the ascorbic acid.

7.1.1.7.3 The samples must be protected from light and refrigerated at 0 - ≤ 6 °C from the time of receipt until analysis.

7.1.2 Soil Samples

7.1.2.1 Refer to the SOP for SW846 Method 5035 for preservation requirement of non-aqueous solids.

7.2 HOLDING TIME

7.2.1 Water Samples.

7.2.1.1 All samples are to be analyzed within 14 days of sampling (HCl preserved for aqueous sample) unless otherwise specified by the contract. The sample preservation deficiency is noted in the analytical run logbook when the analyst checks the pH at the bench. If the pH is not <2, the analyst notifies the supervisor, who then notifies Client Service Dept. A comment is added to the result page and Non-Conformance Summary.

7.2.1.2 Acrolein & Acrylonitrile

7.2.1.2.1 Samples for acrolein and acrylonitrile analysis receiving no pH adjustment must be analyzed within 7 days of sampling.

7.2.2 Soil Samples

7.2.2.1 Refer to the SOP for SW846 Method 5035 for holding time requirement of non-aqueous solids.

7.2.2.2 All samples are analyzed within 14 days of sampling unless otherwise specified.

8.0 APPARATUS AND MATERIALS

8.1 SYRINGE

8.1.1 10, 25, 50, 100, 250, 500, 1000 and 5000 µl graduated syringes, held manually (Hamilton/equiv.).

8.1.2 5 ml and 50 ml glass gas tight syringes with Luerlok end, if appropriate for the purging device.

8.2 BALANCE

8.2.1 Analytical balance capable of weighing 0.0001 gram.

8.2.2 Top loading balance capable of weighing 0.1 gram.

8.3 PURGE AND TRAP DEVICES

8.3.1 The autosampler models are used for purging, trapping and desorbing the sample into GC column.

- O.I. Model 4560 sample concentrator with 4551 vial multi-sampler
- O.I. Model 4560 sample concentrator with 4552 Water/Soil multi-sampler
- EST Analytical Encon Evolution concentrator with EST Centurion multi-sampler

8.3.2 The sample purge vial must be designed to accept 5 ml of sample with a water column at least 3 cm deep.

8.3.3 The auto-sampler is equipped with a heater capable of maintaining the purge chamber at 40 °C to improve purging efficiency. The heater is to be used for low level soil/sediment analysis, but not for water or medium level soil/sediment analysis.

8.3.4 The OI #10 trap is 42 cm with an inside diameter of 0.105 inches. The trap must be packed to contain the following absorbents (3-ring) and must be conditioned at 210 °C for 30 minutes by backflushing with a Helium or Nitrogen gas flow at least 20 ml/min before initial use.

- Tenax (2,6-Diphenylene oxide polymer).

- Silica gel.
- Carbon Molecule Sieve (CMS).

8.3.5 The EST K trap for EST instruments: Carboack B/Carboxen 1000 &1001 with recommended conditions as follows:

Temperature (°C)/Time (minutes)

Desorb	Bake	Precondition
250/0.5-6	260/4	270/60

8.3.6 The desorber must be capable of rapidly heating the trap to 190^0 C for desorption. Do not exceed 210 ^{0}C during bake-out mode. Alternatively, follow manufacturer's instructions.

8.4 GAS CHROMATOGRAPH/MASS SPECTROMETER SYSTEM

8.4.1 Gas Chromatograph.

8.4.1.1 An analytical system complete with a temperature programmable gas chromatograph and all required accessories including syringes, analytical columns, and gases.

8.4.1.2 The injection port must be suitable for split or splitless with appropriate interface.

8.4.1.3 The narrow bore capillary column is directly coupled to the source for HP-6890/7890 or Agilent 6890/7890 model.

8.4.1.4 The wide bore capillary column is interfaced through a jet separator to the source for HP-5890 model.

8.4.2 Column.

- 75 m x 0.53mm ID x 3 μm film thickness capillary column coated with DB-624 (J&W Scientific), or equivalent. Condition as per manufactures directions.

- 105 m x 0.53mm ID x 3 μm film thickness capillary column coated with HP-VOA, or equivalent. Condition as per manufactures directions.

- 60 m x 0.25mm ID x 1.4 μm film thickness capillary column coated with DB-624 (J&W Scientific), or equivalent. Condition as per manufactures directions.

- 60 m x 0.45mm ID x 1.7 μm film thickness capillary column coated with DB-VRX (J&W Scientific), or equivalent. Condition as per manufactures directions.

- 30 m x 0.25mm ID x 1.4 μm film thickness capillary column coated with RTX-624, or equivalent. Condition as per manufactures directions.

- 20 m x 0.25mm ID x 1.4 μm film thickness capillary column coated with RTX-624, or equivalent. Condition as per manufactures directions.

8.4.3 Mass Spectrometer.

8.4.3.1 HP5973, HP5970 Agilent 5973, or Agilent 5975 is capable of scanning from 35 to 270 amu every 2 seconds or less, utilizing 70-volt (nominal) electron energy in the electron impact ionization mode.

8.4.3.2 The mass spectrometer must be capable of producing a mass spectrum which meets all the criteria in Table 3 when injecting or purging 50 ng of the GC/MS tuning standard - Bromofluorobenzene (BFB).

8.4.3.3 SIM Mode **–** Capable of selective ion grouping at specified retention times for applications requiring quantitation limits below the normal range of electron impact mass spectrometry or for increased compound sensitivity (Table 2a).

8.5 DATA SYSTEM

8.5.1 Data Acquisition and Instrument Control (HP Chemstation) **-** A computer system is interfaced to the mass spectrometer, which allows the continuous acquisition and storage on a machine-readable media (disc) of all mass spectra obtained throughout the duration of the chromatographic program.

8.5.2 Data Processing (HP Enviroquant) - The software accommodates searching of GC/MS data file for target analytes which display specific fragmentation patterns. The software also allows integrating the abundance of an EICP between specified time or scan number limits. The data system includes the recent version of the EPA/NBS or NIST98 mass spectral library for qualitative searches of non-target compounds present in the chromatogram. The data system flags all data files that have been edited manually by laboratory personnel.

8.5.3 Off-line Magnetic Tape Storage Device (Lagato Networker) - The magnetic tape storage device copies data for long-term, off-line storage.

9.0 REAGENTS AND STANDARDS

9.1 Solvent

9.1.1 Methanol: purge-and-trap grade quality or equivalent. Store separately, away from the other solvents.

9.2 Reagent Water

9.2.1 Reagent water is defined as water in which an interferant is not observed at the method detection limit of the parameters of interest.

9.2.2 Reagent water is generated by either passing tap water through a bed of approximately one pound of activated carbon or by using the water purification system at SGS that is a series of deionizers and carbon cartridges.

9.3 Stock Standard Solutions

9.3.1 Commercially prepared standards used.

9.3.1.1 EPA Method 524.2 Volatiles (78 components): Absolute (or equivalent) at 200 μg/ml or 2,000 μg/ml concentration.

9.3.1.2 Custom Volatiles Mix A: Restek (or equivalent) at 2,000 μg/ml concentration.

9.3.1.3 Custom Volatiles Mix B: Restek (or equivalent) at 2,000 - 100,000 μg/ml concentration.

9.3.1.4 VOC Gas Mixture: Restek (or equivalent) contains 200 μg/ml or 2,000 μg/ml of the following compound**s** in methanol.

- Bromomethane
- Chloroethane
- Chloromethane
- Dichlorodifluoromethane
- Trichlorofluoromethane
- Vinyl Chloride

9.3.1.5 Multiple neat compounds and individual compounds at varying concentrations in methanol.

9.3.1.6 Surrogate standard mixture: Absolute (or equivalent) at a concentration of 10,000 μg/ml each surrogate compound.

- 1,2-Dichloroethane-d_4
- Dibromofluoromethane
- Toluene-d_8
- 4-Bromofluorobenzene

9.3.1.7 Internal standard mixture: Sigma-Aldrich (or equivalent) neat compounds diluted to 20,000 μg/ml except Tert Butyl Alcohol-d_9, which is diluted to a concentration of 50,000 μg/ml. The following five internal standards are used that exhibit similar analytical behavior to the compounds of interest.

- 1,4-Dichlorobenzene-d_4
- 1,4-Difluorobenzene
- Chlorobenzene-d_5
- Pentafluorobenzene
- Tert Butyl Alcohol-d_9

9.3.1.8 1,4-Dioxane Solution for SIM: Absolute (or equivalent) at 100 μg/ml in methanol.

9.3.1.9 Ketones mixture: Absolute (or equivalent) at 20,000 μg/ml for Acetone, 2-Butanone, 4-methyl-2-pentanone (MIBK), and 2-hexanone prepared at concentrations 300 ug/ml for soil matrix and 300 ug/ml for aqueous matrix.

9.3.2 Unopened stock standard (ampoules) must be stored according to manufacturer's documented holding time and storage temperature recommendations (usually placed on the ampoule).

9.3.3 After opened, stock standards, internal standards, and surrogate solutions must be replaced after 6 months (one month for purgeable gases standard) or sooner if manufacture expiration date come first or comparison with quality control check samples indicates degradation.

9.3.4 Store all stock standards in vials with minimal headspace and Teflon lid liners after open, protect from light, and refrigerate to –10ºC or colder or as recommended by the standard manufacturer.

9.3.5 Return the standards to the freezer as soon as the analyst has completed mixing or diluting the standards to prevent the evaporation of volatile target compounds.

9.4 Internal Standard and Surrogate Solution

9.4.1 Five internal standard and surrogate spiking solutions are prepared in methanol per Table 8.A.

9.4.1.1 25 µg /ml internal standard and surrogate mixture.

9.4.1.2 250 µg /ml internal standard and surrogate mixture.

9.4.1.3 100 µg/ml surrogate mixture.

9.4.1.4 25 µg /ml internal standard mixture.

9.4.1.5 250 µg /ml internal standard mixture.

9.4.2 A calibration range must be constructed for the surrogate compounds. Accordingly, appropriate amounts of surrogates are mixed with each calibration solution to define a range similar to the target compounds.

9.4.3 Each 5 ml sample, QC sample, and blank undergoing analysis must be spiked with any one of the above spiking solutions (depending upon the type of standards addition modules used), resulting in a concentration of 50 µg/l of each compound.

9.4.4 Prepare fresh internal standard and surrogate spiking solutions every six months, or sooner, if manufacturer’s expiration dates come first or if the solution has degraded or evaporated.

9.5 Secondary Dilution Standards

9.5.1 Using stock standard solutions prepare secondary dilution standards in methanol containing the compounds of interest, either singly or mixed together.

9.5.1.1 100 µg/ml V8260 (ABK) mixture: prepared from 2,000 µg/ml stock solution and mixtures from neat compounds prepared in-house. (see Table 8-C)

9.5.1.2 100 µg/ml V8260 Acrolein: prepared from 90-95% neat compound. (see Table 8-C)

9.5.1.3 100 μg/ml Gas mixture: prepared from 2,000 μg/ml stock solution. (see Table 8-C)

9.5.2 Replace after one month for non-gas mixtures (one week for gas mixtures) or sooner if manufacture expiration date come first or comparison with quality control check samples indicates degradation.

9.5.3 Store all secondary dilution standards in vials with no headspace and Teflon lid liners, protect from light, and refrigerate to – 10°C or colder or according to manufacturer's storage temperature recommendations.

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9.5.4 Return the standards to the freezer as soon as preparation is finished to prevent the evaporation of volatile compounds.

9.6 Aqueous Calibration Standard Solutions

9.6.1 Initial Calibration Standards

9.6.1.1 Prepare a minimum of five aqueous calibration standard solutions containing the surrogate compounds as Table 8-D.1 or 8-D.2.

9.6.1.2 To prepare a calibration standard, add a measured volume of secondary dilution standard solutions and the surrogate spiking solution to an aliquot of reagent water in the flask. Use a micro-syringe and rapidly inject the methanol standard into the expanded area of the filled volumetric flask. Remove the needle as quickly as possible after injection. Bring to volume. Mix by inverting the flask three times only. Discard the contents contained in the neck of the flask.

9.6.1.2.1 1,4-Dioxane for SIM analysis is prepared from primary stock standard (100ppm).

9.6.2 Continuing Calibration Standard

9.6.2.1 A continuing calibration standard at a concentration of 50 μg/l is prepared as the scheme outlined in Table 8-E.

9.6.3 Aqueous standards are not stable and may be stored up to 24 hours if held in Teflon sealed screw-cap vials with zero headspace at 4^0C (± 2^0C). Protect the standards from light. If not so stored, they must be discarded after use, unless they are set up to be purged by an autosampler.

9.6.4 When using an autosampler, standards may be retained up to 12 hours if they are in purge tubes connected via the autosampler to the purge and trap device.

9.7 Second Source Calibration Check Standard (ICV)

9.7.1 Prepare the second source calibration check standards from separate manufacturer source or from a manufacturer's batch prepared independently from the batch used for calibration curve following the procedures in Section 9.6. At a minimum, an ICV must be analyzed with every initial calibration.

9.7.2 For 1,4-Dioxane via SIM: Prepare the second source calibration check standard using 20 µl of a 100ppm (Absolute or equivalent) to 100 mL of reagent water which yields a 20 ppb standard.

9.8 4-Bromofluorobenzene (BFB) Standard

9.8.1 Two BFB solutions are prepared in methanol per Table 8-B.

9.8.1.1 25 µg /ml solution for direct injection.

9.8.1.2 250 µg /ml solution for purging.

9.8.2 The solution must be replaced after 6 months or sooner if mass spectrum indicates degradation or if manufacture expiration date comes first.

9.9 Ascorbic Acid

10.0 CALIBRATION

10.1 Daily Maintenance. Routine Daily maintenance must be performed before any tuning, calibration or sample analysis activities are initiated. These include checks of the following items:

<u>Purge and Trap Device:</u>

Clean & bake purge tube
Bake trap and transfer lines
Check or refill internal/surrogate spike solution on SIM/SAM vials
Clean/replace syringe (if necessary)
Change and refill rinse bottle
Empty and rinse waste bottle

<u>GC Oven:</u> (if necessary)

Change septum
Change liner
Clip column, indicated by carbon build-up

10.2 Initial Calibration

10.2.1 The calibration range covered for routine analysis under RCRA, and SIM, employs standards of 0.2, 0.5, 1(specified compounds only), (2)*, 5, 10, 20, 50, 100, 200,(300 or 400)* µg/l. (*instrument dependent). Optionally 4 and 8 ug/l standards may replace the 5 and 10 ug/l standards. A minimum of five standards must be run sequentially. The low calibration standard defines the reporting limit. Lower concentration standards (0.2, 0.5, 1.0 or 2.0 µg/l) may be needed to meet the reporting limit requirements of state specific regulatory programs. Refer to Table 8-D-1 and 8-D-2 for calibration standard preparation.

10.2.2 The surrogates are introduced to the calibration standards automatically by the autosampler. For this calibration option the surrogate linear response is less important, since multiple concentrations of surrogates are not being measured. Instead, the surrogate concentration remains constant throughout and the recovery of this known concentration can easily be attained without demonstrating if the response is linear.

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10.2.2.1 Optional: The surrogates can be added manually. In order to compensate for the difference between the automatic and manual surrogate additions a correction factor must be applied to the amount of surrogate added in Table 8-D. To determine the correction factor divide the surrogate concentration from an automatic injection by the surrogate concentration from a manual injection for each of the surrogates. Average the result for each of the surrogates to determine the correction factor. Finally multiply the correction factor by the appropriate amount of surrogate from Table 8-D and add this amount to the standard.

10.2.3 For water and medium-level soil calibration: Transfer and fill up (no air space) each standard to labeled 40 ml vial and cap with Teflon septum, then place the vial into O.I. sample tray.

10.2.4 For low-level soil calibration: Transfer 5 ml of each standard to labeled 40 ml vial and cap with Teflon septum, then place the vial into O.I. sample tray.

10.2.4.1 When calibrating for Method 5035 low-level samples, if the sodium bisulfate option was used, add 1g of sodium bisulfate to the 40-ml vial before aliquot 5 ml of each standard into vial otherwise do not add sodium bisulfate. This is equivalent to the amount of sodium bisulfate added to the samples and will maintain a consistent purging efficiency of the compounds. Cap the vial with Teflon septum and place it into O.I sample tray.

10.2.5 The linear range covered by this calibration is the highest concentration standard.

10.2.6 Program the autosampler to add internal standard mixture (and optionally surrogate) to each standard. This results in a concentration of 50 μg/l for each internal standard (and surrogate).

10.2.6.1 For O.I. SIM spiker: Automatically adds 5 μl of 50 μg/ml internal standard solution **(**Section 9.4.1.4) or Internal Standard/Surrogate solution (Section 9.4.1.1) to each standard.

10.2.6.2 For O.I. SAM spiker: Automatically adds 1 μl of 250 μg/ml internal standard solution (Section 9.4.1.5) or Internal Standard/Surrogate solution Section 9.4.1.2) to each standard.

10.2.7 Analyze the standard solutions using the conditions established in Section 11.0. Whenever the highest concentration standard is analyzed, it is usually followed by the analyses of two reagent water blanks. Further analysis may not proceed until the blank analysis is demonstrated to be free of interferences.

10.2.8 Each analyte is quantitatively determined by internal standard technique using the closest eluting internal standard and the corresponding area of the major ion. See Table 7.

10.2.9 The Response Factor (RF) is defined in Section 13.1. Calculate the mean RF for each target analyte using minimum of five RF values calculated from the initial calibration curve.

10.2.10 For the initial calibration to be valid, the following criteria must be met.

10.2.10.1 The percent relative standard deviation (% RSD) (see Section 13.2) of all target analytes must be less than or equal to 20%.

10.2.10.2 If the average response factor criteria cannot be achieved, and if the problem is associated with one or more of the standards, reanalyze the standards and recalculate the RSD. The instrument logbook must have clear documentation as to what the suspected problem was.

10.2.10.3 Alternately, if the average response factor criteria cannot be achieved, the calibration range can be narrowed by dropping the low or high point of the curve. Multiple levels may be removed, but removal of interior levels is not permitted

10.2.10.3.1 The changes to the upper end of the calibration range will affect the need to dilute samples above the range, while changes to the lower end will affect the overall sensitivity of the method. Consider the regulatory limits or action levels associated with the target analytes when adjusting the lower end.

10.2.10.3.2 The laboratory may remove an entire single standard calibration level from the interior of the calibration curve when the instrument response demonstrates that the standard was not properly introduced to the instrument, or an incorrect standard was analyzed. If a calibration standard was removed from the interior of the calibration, this particular standard calibration level must be removed for all analytes. Removal of calibration points from the interior of the curve is not to be used to compensate for lack of maintenance or repair to the instrument.

10.2.10.3.2.1 The laboratory must adjust the LOQ/reporting limit and quantitation range of the calibration based on the concentration of the remaining high and low calibration standards.

10.2.10.3.2.2 The laboratory must ensure that the remaining initial calibration standards are sufficient to meet the minimum requirements for number of initial calibration points as mandated by the method, or regulatory requirements.

10.2.10.3.2.3 The laboratory may replace a calibration standard provided that:

a) the laboratory analyzes the replacement standard within twenty-four (24) hours of the original calibration standard analysis for that particular calibration level;

b) the laboratory replaces all analytes of the replacement calibration standard if a standard within the interior of the calibration is replaced;
c) the laboratory limits the replacement of calibration standards to one calibration standard concentration.

10.2.10.3.2.4 The laboratory must document a technically valid reason for either removal or replacement of any interior calibration point.

10.2.10.4 If the average response factor criteria still cannot be achieved, employ an alternative calibration linearity model. Specifically, linear regression using a least squares approach may be employed.

10.2.10.4.1 If linear regression is employed select the linear regression calibration option of the mass spectrometer data system. Forcing the calibration model through the origin (for analytes that are consistently detected in the blanks) allows for a better estimate of the background level of blank contaminants. An accurate estimate of background contamination is necessary to set method reporting limits for analytes when blank levels are problematic.

10.2.10.4.2 The correlation coefficient (r value) must be ≥0.99 for each compound to be acceptable. The calculation of relative error (%RE) must be performed for two calibration levels (near the mid-point of the initial calibration and the standard at the lowest level):

$$\%\,Relative\ Error = \frac{x'_i - x_i}{x_i} \times 100$$

x_i = True value for the calibration standard
x'_i = Measured concentration of the calibration standard

10.2.10.4.2.1 When calculating the calibration curves using the linear regression model, two quantitation checks must be performed by re-fitting the response from the standard at or near the mid-point of the initial calibration and the standard at the lowest level back into the curve.

10.2.10.4.2.2 The recalculated concentration of these two quantitation checks must be within ± 30% of the standard's true concentration for mid-point and ±50% for lowest level.

10.2.10.5 The initial calibration criteria for this method apply to all additional compounds of concern specified by the client.

10.2.10.6 If more than 10% of the compounds included with the initial calibration exceed the 20% RSD limit and do not meet the minimum correlation coefficient for the linear calibration option, then the chromatographic system is considered too reactive for the analysis to begin. Perform corrective action and recalibrate if the calibration criteria cannot be achieved.

10.2.10.7 A quadratic calibration model is allowed if the linear regression fails.

10.2.10.7.1 This may only be used for historically poor performing compounds (e.g. ketones).

10.2.10.7.2 A minimum of six calibration points is required. Do not employ 0,0 as a calibration point.

10.2.10.7.3 Quadratic calibration models cannot be used to extend the calibration range.

10.2.10.7.4 The calculation of relative error (%RE) must be performed for two calibration levels- the standard at or near the mid-point of the initial calibration and the standard at the lowest level. The relative error at the lowest level must be within ± 50% of the standard's true concentration, and at the mid-point it must be ±30% of the true concentration.

10.2.10.8 It is recommended that the minimum response factor for the most common target analytes in table 12 must 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. Poor purging compounds such as ketones may not meet the recommendations.

10.3 Initial Calibration Verification (ICV) - Second Source Calibration Check Standard

10.3.1 The calibration is verified with a calibration check standard at 50 μg/l from an external source (Section 9.7). It must be analyzed immediately following the initial calibration.

10.3.2 The percent difference (% D) (Section 13.3) for this standard must meet the criteria of 30% for all the target compounds.

10.3.2.1 If % D is greater than 30%, reanalyze the second source check. If the criteria cannot be met upon re-injection, re-prepare the second source solution using a fresh ampoule and repeat the process.

10.3.2.2 If the %D criteria cannot be achieved after re-preparation of the second source, prepare a third source and repeat the process. Make fresh calibration standards using one of the two standard sources that match each other and repeat the initial calibration.

10.4 Continuing Calibration Verification Standard (CCV)

10.4.1 A continuing calibration verification standard at a concentration near mid-level of the initial calibration range (50 μg/l) must be acquired every 12 hrs or at the beginning of each analytical batch. If samples are analyzed within twelve hours of initial calibration, the CCV may be omitted, and injection of the last ICal standard may be used as the starting time reference for evaluation.

NOTE: The 12-hour clock starts at the time of injection of daily CCV.

10.4.1.1 For water and medium level soil analysis: Transfer and fill up (no air space) the calibration verification standard to labeled 40 ml vial and cap with Teflon septum, then place the vial into O.I. sample tray. Analyze as per Section 11.7.

10.4.1.1.1 Vary the concentration of the continuing calibration verification standard on alternate verifications (i.e. every other calibration verification) using an alternative concentration standard. The standard selected must be lower than the midpoint calibration standard.

10.4.1.2 For low-level soil analysis: Transfer 5 ml of the calibration verification standard to labeled 40 ml vial and cap with Teflon septum, then place the vial into O.I. sample tray. Analyze as per Section 11.7.

10.4.1.2.1 When calibrating for Method 5035 low-level samples, if the sodium bisulfate option was used add 1g of sodium bisulfate to the 40-ml vial before aliquot 5 ml of the calibration verification standard into vial, otherwise do not use sodium bisulfate. This is equivalent to the amount of sodium bisulfate added to the samples and will maintain a consistent purging efficiency of the compounds. Analyze as per Section 11.7.

10.4.1.3 A continuing calibration standard is analyzed whenever the analyst suspects that the analytical system is out of calibration. If the calibration cannot be verified, corrective action is performed to bring the system into control. Analysis may not continue until the system is under control.

10.4.2 For the continuing calibration to be valid, all of the following specified criteria must be met.

10.4.2.1 Each of the most common target analytes in the calibration verification standard must meet the minimum response factors as noted in Table 12.
This criterion is particularly important when the common target analytes are also critical project-required compounds. This is the same check that is applied during the initial calibration.

10.4.2.2 All target compounds of interest must be evaluated using a 20%variability criterion. Use percent difference when performing the average response factor model calibration. Use percent drift when calibrating using a regression fit model. If the percent difference or percent drift for a compound is less than or equal to 20%, then the initial calibration for that compound is assumed to be valid.

10.4.2.3 Due to the large numbers of compounds that may be analyzed by this method, some compounds will fail to meet the criteria. If the criterion is not met (i.e., greater than 20% difference or drift) for more than 20% of the compounds included in the initial calibration, then corrective action must be taken prior to the analysis of samples.

10.4.2.4 In cases where compounds fail, they may still be reported as non-detects if it can be demonstrated that there was adequate sensitivity to detect the compound at the applicable quantitation limit. For situations when the failed compound is present, the concentrations must be reported as estimated values.

10.4.2.4.1 Compounds with response factors that exceed the 20% D in the CCV compared to the initial calibration with high bias may only be reported as an estimated value.

10.4.2.4.2 Compounds that do not meet the 20% D in the CCV compared to the initial calibration due to low response factors can only be reported if the low sensitivity of the instrument is still achieved. This sensitivity must be verified by running a low-level standard check at the RL. If a positive result for the compound is found, then adequate sensitivity has been demonstrated and the run can proceed. Non-detect results for samples may be reported, positive results, if reported, must be done as an estimated value.

10.4.3 If the first continuing calibration verification (CCV) does not meet criteria, a second standard can be analyzed immediately or after the corrective action was performed. If the second CCV fails to meet criteria, then corrective actions must be performed. Such as: auto-tuning, routine system cleaning and routine system maintenance. Notify the team leader/manager.

10.4.3.1 If the second CCV trial fails, the lab must demonstrate acceptable performance <u>after</u> corrective action with two consecutive passing calibration verifications (CCVs) OR a new initial calibration. The Instrument Logbook and Maintenance Logbook must have clearly documented notations as to what the problem was and what corrective action was implemented.

10.4.3.1.1 If the lab has not verified calibration, samples cannot be analyzed.

10.4.3.1.2 However, in the case where samples are analyzed on the system where the CCV does not meet the criteria the data must be flagged.

10.4.3.1.2.1 The data may be usable if the response for the verification exceed high (high bias) and the associated samples are non-detects.

10.4.3.1.2.2 If the criteria for the CCV is low (low bias), those sample results may be reported only if they exceed a maximum regulatory limit/decision level.

10.4.3.2 If the calibration verification is being performed using an auto sampler for night batch, two (2) vials of standard solution are placed in the device for analysis. The second standard must meet continuing calibration criteria and is used for calibration verification. The second check may be discarded only if there is a purge failure or incorrect spike concentration provided the first calibration standard meets the requirement. In this case, the first calibration standard is used as calibration verification following team leader/manager approval. Document this occurrence on instrument log.

10.4.3.2.1 Both CCVs must be evaluated. If vial 1 fails and vial 2 passes this meets the criteria of 10.4.3 of consecutive and immediate passing CCV.

10.4.3.2.2 If CCV number 2 fails, the analysis cannot continue unless it was determined that there was an isolated mechanical failure.

10.4.4 If any of the internal standard areas change by a factor of two (- 50% to + 100%) or the retention time changes by more than 30 seconds from the midpoint standard of the last initial calibration, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate.

10.4.4.1 Reanalyze the continuing calibration standard. New initial calibration is required if reanalyzed standard continues to fail the internal standard requirements.

10.4.4.2 All samples analyzed while the system was out of control must be reanalyzed following corrective action.

10.5 Corrective Action Maintenance for Failed Tuning and Calibration Procedures

10.5.1 Inability to achieve criteria for instrument tuning or calibration may indicate the need for instrument maintenance. Maintenance may include routine system cleaning and replacement of worn expendables or the need for outside service if the scope of the repair exceeds the capability of the staff.

10.5.2 If maintenance is performed on an instrument, return to control must be demonstrated before analysis can continue. Return to control is demonstrated as follows:

10.5.2.1 Successful instrument tune using PFTBA.

10.5.2.2 Successful tune verification by the analysis of 4-bromofluorobenzene.

10.5.2.3 Successful initial calibration or continuing calibration.

11.0 PROCEDURE

11.1 Instrument conditions.

11.1.1 Recommended instrument conditions are listed in Table 2 and 2a (SIM only). Modifications of parameters specified with an asterisk are allowed as long as criteria of calibration are met. Any modification must be approved by team leader/manger.

11.1.2 Optimize GC conditions for analyte separation and sensitivity. Once optimized, use the same GC conditions for the analysis of all standards, blanks, samples, and QC samples.

11.2 Purge and Trap Device conditions.

11.2.1 See Table 2.

11.2.2 Daily Maintenance. Routine Daily maintenance must be performed before any tuning, calibration or sample analysis activities are initiated. These include checks of the following items:

<u>Purge and Trap Device:</u>

- Clean & bake purge tube.
- Bake trap and transfer lines.
- Check or refill internal/surrogate spike solution on SIM/SAM vials.
- Clean/replace syringe (if necessary).
- Change and refill rinse bottle.
- Empty and rinse waste bottle.

11.3 Step 1: GC/MS performance check.

- Inject 50ng of BFB solution directly on column or
- Purge 50ng/mL of BFB solution onto the GC column.

11.3.1 The GC/MS system must be checked to verify acceptable performance criteria are achieved (see Table 3).

11.3.2 **This performance test must be passed before each initial calibration.** Evaluate the tune spectrum by selecting the mass spectrum at the peak apex or by using an average spectrum (e.g., three highest abundance spectra, or across entire BFB peak).

11.3.2.1 Select the scans at the peak apex and one to each side of the apex.

11.3.2.2 Calculate an average of the mass abundances from the three scans.

11.3.2.3 Background subtraction is allowed. Select a single mass spectrum or an average mass spectrum across a short time range acquired within 20 seconds of the elution of BFB. The background subtraction must be used only to eliminate column bleed or instrument background ions. Do not subtract part of the tuning compound peak.

11.3.3 If all the criteria are not achieved, the analyst must retune the mass spectrometer with team leader/manager and repeat the test until all criteria are met.

11.3.3.1 Alternatively, an additional scan on each side of the peak apex may be selected and included in the averaging of the mass. This will provide a spectrum of five averaged scans centered on the peak apex. NOTE: The selection of additional mass scans for tuning may only be performed with supervisory approval on a case-by-case basis.

11.3.3.2 Note: All subsequent standards, samples, MS/MSDs, BS, and blanks associated with a BFB analysis must use identical mass spectrometer conditions.

11.4 Step 2: Daily calibration check

11.4.1 Initial calibration

11.4.1.1 Refer to Section 10.2.

11.4.1.2 An initial calibration must be established (or reestablished) on each instrument:

- Prior to any sample analyses.

- Whenever a new column is installed;
- Whenever instrument adjustments that affect sensitivity are made; and
- Whenever a continuing calibration standard fails to meet the specified acceptance criteria, on the second trial.

11.4.2 Initial Calibration Verification - Second Source Calibration Check Standard

11.4.2.1 This standard is only analyzed when initial calibration provided. Refer to Section 10.3.

11.4.3 Continuing Calibration verification standard

11.4.3.1 Refer to Section 10.4.

11.4.4 The method blank (step 3) cannot be analyzed until the continuing calibration verification meets the criteria.

11.5 Step 3: Method blank

11.5.1 The acceptable method blank must be analyzed for every 12-hour time period or sooner.

11.5.1.1 Water and medium-level soil samples - Place a 40 ml vial, filled with DI water onto the autosampler.

11.5.1.2 Low-level soil samples without sodium bisulfate - Transfer 5 ml of DI water to a 40 ml vial and cap with Teflon septum, then place the vial into O.I. sample tray.

11.5.1.2.1 Low-level soil samples with sodium bisulfate (Method 5035) - Add 1g of sodium bisulfate into a 40 ml vial before adding 5 ml of DI water. Cap the vial with a Teflon septum, then place the vial onto the autosampler.

11.5.2 Program the autosampler to add internal standard and surrogate solution to the method blank for a concentration of 50 µg/l for each internal standard and surrogate.

11.5.2.1 For O.I. SIM spiker: Automatically adds 10 µl of 25 µg/ml internal standard and surrogate solution (Section 9.4.1.1) to the method blank.

11.5.2.2 For O.I. SAM spiker: Automatically adds 1 µl of 250 µg/ml internal standard and surrogate solution (Section 9.4.1.2) to the method blank.

11.5.3 No compound can be present above the laboratory's MDL. Common laboratory solvents (i.e. methylene chloride, acetone, hexane) may be present up until the RL. Blanks may contain analyte concentrations greater than acceptance limits if the associated samples in the batch are unaffected (i.e., targets are not present in samples or sample concentrations are $\geq$10x the blank).

11.5.4 Surrogates must meet recovery criteria specified in house limits.

11.5.5 If the method blank does not meet surrogate criteria or contains target analytes above the MDL, then

11.5.5.1 All samples analyzed following an out of control method blank must be reanalyzed if conditions in 11.5.3 are not met.

11.5.5.2 Check for the potential of contamination interference from the following areas. Make sure all items are free contamination.

- the analytical system,
- dust and vapor in the air,
- glassware and
- Reagents.

11.5.5.3 Re-analyze the method blank following the system evaluation. In this situation, the instrument logbook must have clearly documented notations as to what the problem was and what corrective action was implemented to enable the second blank to pass.

11.5.5.4 If re-analyzed method blank remains out of control, notify team leader or manager.

11.5.6 If two consecutive method blanks are analyzed during unattended operations, the second analysis must meet criteria for the subsequent sample analysis to be valid. Always report the second method blank. The second analysis can only be discarded because of a purge failure provided that the first blank meets the requirement. In this case, the first blank is reported following team leader/manager approval. Document this occurrence on the instrument log.

11.5.7 Re-analysis 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.

11.6 Step 4: Blank spike (BS)

11.6.1 An acceptable blank spike must be analyzed with every analytical batch. The maximum number of samples per analytical batch is twenty.

11.6.2 Spike 50 ml of reagent water with appropriate amount of the standards to prepare a blank spike containing 50 μg/L of each analyte. In situations where lower detection limits are required, a blank spike at 20 μg/L may be prepared. The stock solution for the BS must be from the same source as the initial calibration solution. Refer to Table 8-F for the preparations of the blank spikes.

11.6.2.1 Water and medium-level soil samples - Place a 40 ml vial, filled with DI water onto the autosampler.

11.6.2.2 Low-level soil samples without sodium bisulfate - Aliquot 5 ml of the blank spike into vial and cap with Teflon septum, then place the vial into O.I. sample tray.

11.6.2.2.1 Low-level soil samples with sodium bisulfate for Method 5035 - Add 1g of sodium bisulfate to labeled 40 ml vial before aliquot 5 ml of the blank spike into vial and cap with Teflon septum, then place the vial into O.I. sample tray.

11.6.3 Initiate auto addition of internal standard and surrogate into the syringe per 11.5.2.

11.6.4 Compare the percent recoveries (% R) (see Section 13.5) to the in-house limits acceptance criteria. If a blank spike is out of control, all the associated samples must be reanalyzed. The exception is if the blank spike recovery is high and no hits reported in associated samples and QC batch. In that case, the sample results can be reported with footnote (remark) and no further action is required. Or if the blank spike recovery is low and the hits in the samples are above regulatory levels.

11.6.5 Do not analyze samples and MS/MSD (step 5) unless the BS meets acceptance criteria.

11.6.6 The blank spike and matrix spike must be the same source and concentration.

11.7 Step 5: Samples /MS/MSD analysis

11.7.1 All samples and standard solutions must be allowed to warm to ambient temperature before analysis.

11.7.2 Select the sample dilution factor to assure the highest concentration analyte is above the calibration range midpoint, but below the upper limit of the range depend on project requirements. See Table 9 for dilution guideline.

- Utilize FID screen data.
- Utilize acquired sample data.
- Utilize the history program.
- Sample characteristics (appearance, odor).

11.7.3 Water samples.

11.7.3.1 Using <u>O.I. Model 4560 sample concentrator with 4551 or 4552 vial multisampler,</u>

- Place the 40 ml vial in the tray, or
- Load 5ml sample into purge tube if sample volume limited.

11.7.3.2 A matrix spike and matrix spike duplicate are performed independently by spiking 20ul of the appropriate standards into the 40ml sample vial. If there are not enough vials for this procedure, a matrix spike and a sample duplicate are performed in place of an MS/MSD.

11.7.4 Sediment/ soil sample

11.7.4.1 <u>Low-level soil method</u>

11.7.4.1.1 Collect the sample using the procedures detailed in the SOP for SW846 Method 5035 low - level soil samples.

11.7.4.1.2 Weigh out 5 g of each sample into a labeled, tared vial filled with 5 ml DI water. Add the matrix spike by manually puncturing the septum with a small-gauge needle. Transfer the 40ml vial to the autosampler tray. Stir and heat the sample at the time of analysis.

11.7.4.2 Medium-level soil method

11.7.4.2.1 Collect the sample using the procedures detailed in the SOP for SW846 Method 5035 medium - level soil samples.

11.7.4.2.2 Select a methanol aliquot of appropriate volume (see Table 9) determined via screening and transfer to 40 ml of reagent water.

11.7.5 Program the autosampler to inject the internal standard and surrogate solution into the robotic syringe used to withdraw sample from the 40 ml vial. This addition to 5 ml of sample is equivalent to a concentration of 50 μg/L of each internal standard and surrogate.

11.7.5.1 For O.I. SIM spiker: Automatically adds 5 μl of 50 μg/ml internal standard and surrogate solution (Section 9.4.1.1) to each sample.

11.7.5.2 For O.I. SAM spiker: Automatically adds 1 μl of 250 μg/ml internal standard and surrogate solution (Section 9.4.1.2) to each sample.

11.7.6 Purge the sample for 9 minutes with Helium or Nitrogen.

11.7.6.1 Low-level soil sample must be performed at 40 °C while the sample is being agitated with the magnetic stirring bar or other mechanical means.

11.7.6.2 To improve the purging efficiency of water-soluble compounds, aqueous samples may also be purged at 40 °C as long as all calibration standards (for 1,4-Dioxane SIM option, purge temperature is 80°C), samples and QC samples are purged at the same temperature and acceptable method performance is demonstrated.

11.7.7 One sample is randomly selected from each analytical batch of similar matrix types and spiked in duplicate to determine whether the sample matrix contributes bias to the analytical results. A matrix spike and matrix spike duplicate are performed by spiking the sample for a concentration of 50 μg/l or 50 μg/kg based on 5 g dry weight. In situations where lower detection limits are required, a blank spike at lower concentration may be prepared.

11.7.8 Desorb the sample for a maximum of 4 minutes by rapidly heating the trap to 190 °C while backflushing with Helium. Desorb time may require performance optimization between 0.5 and 4.0 minutes as dictated by trap manufacturers specifications or instrument characteristics.

11.7.9 Program the purge and trap system to automatically rinse purge tube at least twice with heated organic-free water (reagent water) between analyses to avoid carryover of target compounds. For samples containing large amounts of water-soluble materials, suspended solids, high-boiling compounds, or high purgeable levels, it may be necessary to wash out the purging device with methanol solution between analyses, rinse it with distilled water.

11.7.10 Bake the trap at least 10 minutes at 210 °C to remove any residual purgeable compounds.

11.7.11 If the initial analysis of the sample or a dilution of the sample has a response for any ion of interest that exceeds the working range of the GC/MS system, the sample must be reanalyzed at a higher dilution.

11.7.11.1 When ions from a compound in the sample saturate the detector, this analysis must be followed by the analysis of reagent water blank. If the blank analysis is not free of interferences, then the system must be decontaminated. Sample analysis may not resume until the blank analysis is demonstrated to be free of interferences.

11.8 Sample dilutions

11.8.1 Using Screening Data to Determine Dilution Factors

11.8.1.1 Dilution for High Concentration Analytes Exceeding the Calibration Range

11.8.1.1.1 The highest concentration target compound detected in the screen data is compared to the highest concentration calibration standard used for determinative volatile organics analysis.

11.8.1.1.1.1 Divide the calibration concentration of the screen concentration by the highest concentration calibration standard.

11.8.1.1.1.2 If the result is >1, sample dilution is considered.

11.8.1.1.2 The result from step 11.8.1.1.1 determines the dilution factor. The dilution factor is targeted to assure that the highest concentration diluted analyte is at the mid-range concentration of the calibration curve for the determinative analysis.

11.8.1.1.3 In all cases a conservative approach to dilution is applied to minimize the increase of detection and reporting limits

11.8.1.2 Dilution for High Concentration Matrix Interferences

11.8.1.2.1 The peak height of the background is compared to the peak height of the later eluting calibration standards from the screening analysis.

11.8.1.2.1.1 A rough estimate of background concentration is calculated by dividing the background peak height by the peak height of the selected screening standard and multiplying by its concentration.

11.8.1.2.2 If the result is >1, sample dilution is considered.

11.8.1.2.3 The result from step 11.8.1.2.1 determines the dilution factor. The dilution factor is targeted to avoid Carry-over contamination between samples and facilitate qualitative and quantitative analysis of target compounds present in the sample.

11.8.1.2.4 In all cases a conservative approach to dilution is applied to minimize the increase of detection and reporting limits

11.8.2 If the concentration of any target compound in any sample exceeds the initial calibration range, a new aliquot of that sample must be diluted and re-analyzed. Until the diluted sample is in a sealed sample vial, all steps in the dilution procedure must be performed without delay.

11.8.3 Water Samples.

11.8.3.1 Prepare all dilutions of water samples in volumetric flasks or Class A graduated cylinder. Intermediate dilutions may be necessary for extremely large dilutions.

11.8.3.2 Calculate the approximate volume of reagent water, which will be added to the volumetric flask or graduated cylinder and add slightly less than this quantity to the flask. Refer to Table 9 for dilution guideline.

11.8.3.3 Inject the proper sample aliquot from a syringe into the volumetric flask or graduated cylinder. It is also permissible to pour the sample directly into a graduated cylinder for some dilutions. Dilute the flask to the volume mark with reagent water. Cap the flask and invert the flask three times.

11.8.3.4 Fill a 40 ml sample vial and seal with a Teflon baked silicon septum, load the diluted sample into the autosampler and analyze according to Section 11.7.

11.8.4 Low-level Soil Samples.

11.8.4.1 Screen data is used to determine the appropriate sample preparation procedure for a sample, the low-level soil method or the medium-level soil method.

11.8.4.2 If any target compound exceeds the initial calibration range from the analysis of 5 g sample, a smaller sample size must be analyzed. However, the smallest sample size permitted is 0.5 g. If smaller than 0.5 g sample size is needed to prevent any target compounds from exceeding the initial calibration range, the medium level method must be used.

11.8.4.2.1 Samples that must use medium level method will be analyzed under separate calibration curve.

11.9 Data interpretation

11.9.1 Qualitative identification.

11.9.1.1 The targeted compounds shall be identified by analyst with competent knowledge in the interpretation of mass spectra by comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound.

11.9.1.2 The characteristic ions for target compounds that can be determined are listed in Table 7. Table 4 and Table 5 list the characteristic ions for internal standards and surrogate compounds respectively.

11.9.1.3 The criteria required for a positive identification are listed below.

11.9.1.3.1 The sample component must elute at the same retention time (RT) as the daily standard. Criteria are the RT of sample component must be within ± 10 seconds of the standard component (delta RT 0.17 minute) or within ±10 seconds relative to the shift of the associated Internal standard (delta RT of the IS ± 0 seconds).

11.9.1.3.2 The relative intensities of these ions must agree within ± 30 % between the daily standard and sample spectra. (Example: For an ion with an abundance of 50 % in the standard spectra, the corresponding sample abundance must be between 20 and 80 %.)

11.9.1.3.2.1 Compounds can have secondary ions outside criteria from co-eluting compounds and/or matrix effect that can contribute to ion abundances. The interference on ion ratios can’t always be subtracted out by software programs resulting in qualified compound identification.

11.9.1.3.2.2 Quantitation reports display compounds that have secondary ions outside the ratio criteria with a “#” flag.

11.9.1.3.3 Structural isomers that produce very similar mass spectra must be identified as individual isomers if they have sufficiently different GC retention times. Isomers are considered resolved if the height of the valley between two isomer peaks is less than 50 % of the average of the two peak heights or 1- [valley height]/ [average peak height] is ≥50%. Otherwise, structural isomers are identified as isomeric pairs. The resolution of structural isomers must be verified in the ICV and daily CCV standards to verify if the instrument performance is adequate regarding separation of compound of interest which are structural isomers.

11.9.2 Quantitative analysis

11.9.2.1 Once a target compound has been identified, its concentration (Section 13.4) will be based on the integrated area of the quantitation ion, normally the base peak (Table 7). The compound is quantitated by internal standard technique with an average response factor generated from the initial calibration curve.

11.9.2.2 If the sample produces interference for the primary ion, use a secondary ion to quantitate (see Table 7). This is characterized by an excessive background signal of the same ion, which distorts the peak shape beyond a definitive integration. Also, interference could severely inhibit the response of the internal standard ion. This secondary ion must also be used to generate new calibration response factors.

11.10 Library search for tentatively identified compounds.

11.10.1 If a library search is requested, the analyst must perform a forward library search of NBS or NIST08 mass spectral library to tentatively identify 15 non-reported compounds.

11.10.2 Guidelines for making tentative identification are listed below.

11.10.2.1 These compounds must have a response greater than 10 % of the nearest internal standard. The response is obtained from the integration for peak area of the Total Ion Chromatogram (TIC).

11.10.2.2 The search is to include a spectral printout of the 3 best library matches for a particular substance. The results are to be interpreted by analyst.

11.10.2.3 Molecular ions present in the reference spectrum must be present in the sample spectrum.

11.10.2.4 Relative intensities of major ions in the reference spectrum (ions > 10 % of the most abundant ion) must be present in the sample spectrum.

11.10.2.5 The relative intensities of the major ions must agree within ± 20 %. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must between 30 and 70%).

11.10.2.6 Ions present in the sample spectrum but not in the reference spectrum must be reviewed for possible background contamination or presence of coeluting compounds.

11.10.2.7 Ions present in the reference spectrum but not in the sample spectrum must be verified by performing further manual background subtraction to eliminate the interference created by coeluting peaks and/or matrix interference.

11.10.2.8 Quantitation of the tentatively identified compounds is obtained from the total ion chromatogram based on a response factor of 1 and is to be tabulated on the library search summary data sheet.

11.10.2.9 The resulting concentration must be reported indicating: (1) that the value is estimate, and (2) which internal standard was used to determine concentration. Quantitation is performed on the nearest internal standard.

11.10.2.10 Mass spectral library search algorithm 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 80% may be considered confirming evidence.

11.11 An instrument blank is a system evaluation sample containing lab reagent grade water with internal standards and surrogates. An instrument blank is used to remove and or evaluate residual carryover from high level standards, spike samples and field samples. Since target compound lists have expanded to overlap some volatile and semi-volatile compounds, instrument blanks are necessary to remove carryover contamination.

11.11.1 The compounds that may exhibit carryover for this method are listed in Table 11.

11.11.2 If instrument blanks following a standard or spike sample exhibits carry-over effect, then any samples that show the same carryover profile, after a comparable concentration must be considered suspect and rerun for confirmation. For example, if an instrument blank has 1ppb detected after a 200ppb standard, then any sample following a sample containing 200ppb or above of the same compound must be confirmed for possible carryover.

11.11.3 If an Instrument Blank(s) was run following suspect high concentration samples and it exhibits the same carryover profile after a comparable concentration must be considered suspect and rerun for confirmation.

11.11.4 In some cases, several instrument blanks may have to be run to eliminate contamination from over loaded samples.

11.11.5 The analytical system is considered free of carryover, when no target analytes can be detected above the MDL.

11.12 Selected Ion Monitoring (SIM) Option

11.12.1 Instrument Set-Up: Modify the method for SIM analysis and define ion groups with retention times, ions and dwell times to include base peak ion for the target compounds of interest, surrogates, and internal standards (Table 2a.) Select a mass dwell time of 50 milliseconds for all compounds.

11.12.2 Calibration: Calibrate the mass spectrometer in the selected ion monitoring mode using 9 calibration standards of 0.25, 0.4, 1, 2, 5, 20, 50, 100 and 200 ug/l. Spike each standard with the SIM specific internal standard solution at 5 ug/ml. Calculate individual response factors and response factor RSDs. The initial calibration must meet the criteria in section 10.2.10.

11.12.3 Initial Calibration Verification. Verify the initial calibration after its completion using a 20 ug/l calibration standard purchased or prepared from a second standards reference materials source. The initial calibration verification must meet the criteria from Section 10.3.

11.12.4 Continuing Calibration Verification. Verify the initial calibration every 12 hours using a 5 or 20 ug/l calibration. The continuing calibration verification must meet the criteria from Section 10.4.

11.12.5 Surrogate Standard Calculation. Report surrogate spike accuracy for the surrogates spiked for the full scan GC/MS analysis.

12.0 QUALITY CONTROL

12.1 QC Requirements Summary

BFB	Before every initial calibration
Initial Calibration	Whenever needed
ICV - Second Source Calibration Check Standard	Following initial calibration
Calibration Verification Standard	Every 12 hours
Method Blank	Every 12 hours
Blank Spike	One per analytical batch*
Matrix Spike	One per analytical batch*
Matrix Spike Duplicate or Sample DUP (depends on sample volume)	One per analytical batch*
Surrogate	Every sample and standard
Internal Standard	Every sample and standard

*The maximum number of samples per analytical batch is twenty.

12.2 GC/MS Performance Check - BFB

12.2.1 Refer to Section 11.3.

12.3 Initial calibration
12.3.1 Refer to Section 10.2

12.4 Second Source Calibration Check Standard

12.4.1 Refer to Section 10.3.

12.4.2 Calibration Verification Standard

12.4.3 Refer to Section 10.4.

12.4 Method Blank

12.4.1 Refer to Section 11.5

12.5 Blank Spike

12.5.1 Refer to Section 11.6

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

12.6.1 One sample is selected at random from each analytical batch of similar matrix types and spiked in duplicate to check precision and accuracy.

12.6.2 Assess the matrix spike recoveries (Section 13.5) and relative percent difference (RPD) (Section 13.6) against the control limits.

12.6.3 If the matrix spike recoveries do not meet the criteria, check the blank spike recovery to verify that the method is in control. If the blank spike did not meet criteria, the method is out of control for the parameter in question and must be reanalyzed or qualified with an estimate of potential bias. Otherwise, matrix interference is assumed and the data is reportable. No further corrective action is required.

12.7 Surrogates

12.7.1 All standards, blanks, samples, and matrix spikes contain surrogate compounds, which are used to monitor method performance. If the recovery of any surrogate compound does not meet the control limits, the result must be flagged and:

12.7.1.1 The calculation must be checked.

12.7.1.2 The sample must be reanalyzed if the recovery of any one surrogate is out of control limit.

12.7.2 If the sample exhibits matrix interference, defined as excessive signal levels from target or non-target interfering peaks. In this case, reanalysis may not be required following team leader/manager approval.

12.7.3 If surrogate recoveries are acceptable upon reanalysis, the data from the reanalysis is reported. If the reanalysis date did not meet the hold time, then both sets of data must be submitted with the reanalysis reported.

12.7.4 If surrogates are still outside control limits upon reanalysis, then both sets of data must be submitted with the first analysis reported.

12.8 Internal Standard

12.8.1 Retention time for all internal standards must be within ± 30 seconds of the corresponding internal standard in the latest continuing calibration or 50 μg/l standard of initial calibration

12.8.2 The area (Extracted Ion Current Profile) of the internal standard in all analyses must be within 50 to 200 % of the corresponding area in the latest calibration standard (12 hr. time period).

12.8.3 If area of internal standard does not meet control limits, the calculations must be checked. If a problem is not discovered, the sample must be reanalyzed.

12.8.4 If areas are acceptable upon reanalysis, the reanalysis data is reported.

12.8.5 If areas are unacceptable upon reanalysis, then both sets of data are submitted with the original analysis reported.

13.0 CALCULATION

13.1 Response Factor (RF)

$$RF = \frac{As \times Cis}{Ais \times Cs}$$

where:

As = Area of the characteristic ion for the compound being measured.
Ais = Area of the characteristic ion for the specific internal standard.
Cs = Concentration of the compound being measured (ug/l).
Cis = Concentration of the specific internal standard (ug/l).

13.2 Percent Relative Standard Deviation (% RSD)

$$\%RSD = \frac{SD}{RFav} \times 100$$

where:
SD = Standard Deviation
RFav = Average response factor from initial calibration.

13.3 Percent Difference (%D)

$$\%D = \frac{(RFav - RFcv)}{RFav} \times 100$$

where:
RFcv = Response factor from Calibration Verification standard.
RFav = Average response factor from initial calibration.

13.4 Concentration (Conc.)

<u>For water:</u>

$$\text{Conc. } (\mu g/l) = \frac{Ac \times Cis \times Vp}{Ais \times RF \times Vi}$$

<u>For soil/sediment low level</u> (on a dry weight basis):

$$\text{Conc. } (\mu g/kg) = \frac{Ac \times Cis \times Vp}{Ais \times RF \times Ws \times M}$$

<u>For soil/ sediment medium level (on a dry weight basis)</u>

$$\text{Conc. } (\mu g/kg) = \frac{Ac \times Cis \times Vp \times Vt}{Ais \times RF \times Vme \times Ws \times M}$$

Where:
Ac = Area of characteristic ion for compound being measured.
Ais = Area of characteristic ion for internal standard.
Cis = Concentration of internal standard
RF = Response factor of compound being measured(from initial calibration)
Vi = Initial volume of water purged (ml)
Vp = 5 ml (Total Purge Volume)
Vme = Volume of Methanol aliquot
Vt = Ml Solvent + ((100-% solid)/100 x Ws)

Ws = Weight of sample extracted (g).
M = (100 - % moisture in sample) / 100 or % solids / 100

13.5 Percent Recovery (% R)

$$\% R = \frac{\text{Concentration found}}{\text{Concentration spiked}} \times 100$$

13.6 Relative Percent Difference (RPD)

$$RPD = \frac{|\,MSC - MSDC\,|}{(1/2)\,(MSC+MSDC)} \times 100$$

Where:
MSC = Matrix Spike Concentration
MSDC = Matrix Spike Duplicate Concentration

13.7 Linear regression by the internal standard technique.

$$C_s = \left(\frac{\frac{A_s}{A_{is}} - b}{a} \right) \times C_{is}$$

Where:
Cs = concentration of target analyte
As = Area of target analyte
Cis = concentration of the internal standard
b = Intercept
a = slope of the line

$$a = \frac{N\,\Sigma xy - \Sigma x\,\Sigma y}{N\,\Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{\Sigma y - a\,\Sigma x}{N}$$

N = number of points
x = amount of analyte
y = response of instrument

13.8 Correlation Coefficient

$$r = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma(x - \bar{x})^2\,\Sigma(y - \bar{y})^2}}$$

Where r = correlation coefficient
x = amount of analyte

y = response of instrument

$\bar{x}$ = average of x values

$\bar{y}$ = average of y values

13.9 Quadratic curve with internal standard technique

$$C_s = \frac{-b \pm \sqrt{b^2 - 4a\left(c - \frac{A_s \times C_{is}}{A_{is}}\right)}}{2a}$$

Where:
Cs = concentration of target analyte
As = Area of target analyte
Cis = concentration of the internal standard
b = Intercept
a = slope of the line

14.0 DOCUMENTATION

14.1 The Analytical Logbook. The logbook must be completed by the analyst daily. Each instrument will have a separate logbook. The daily sequence must be recorded in the logbook by giving a file number to every instrument standard, QC, and samples in appropriate spaces. The files must be never overwritten or skipped intentionally. In case where the file is skipped or overwritten, a thorough explanation must be documented in the notes section. Upon completion, every analytical batch must be reviewed and signed by a supervisor/team lead. Supervisor signature indicates all documentation was performed correctly.

14.1.1 If samples or blank spike require reanalysis, a brief explanation of the reason and corrective action must be documented in the Comments section.
14.1.2 If maintenance was done on the instrument in order to pass the CCV or any other reason, the analyst must document it in the logbook.

14.2 Standards Preparation Logbook must be completed for all standard preparations. All information must be completed; the page must be signed and dated by the appropriate person.

14.2.1 The SGS lot number must be cross-referenced on the standard vial.

14.3 Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. Each instrument has a separate log.

14.4 Any corrections to laboratory data must be done using a single line through the error. The initials of the person and date of correction must appear next to the correction.

14.5 Supervisory personnel must review and sign all laboratory logbooks monthly to ensure that information was recorded properly. Additionally, the instrument maintenance logbooks and the accuracy of the recorded information must also be verified and signed off on the first page of the logbook quarterly by a supervisor/team lead.

14.6 Acrolein and Acrylonitrile data reported from a preserved sample must be footnoted: “Results reported from the HCl preserved sample. This reported result can only be used for screening purposes for Acrolein and Acrylonitrile.” Any samples analyzed form an unpreserved vial must be footnoted stating samples were unpreserved and analyzed within 7 days.

15.0 POLLUTION PREVENTION & WASTE MANAGEMENT

15.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 15.2.

15.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

15.2.1 Non-hazardous aqueous wastes

15.2.2 Hazardous aqueous wastes

15.2.3 Chlorinated organic solvents

15.2.4 Non-chlorinated organic solvents

15.2.5 Hazardous solid wastes

15.2.6 Non-hazardous solid wastes

Table 1 TARGET COMPOUNDS		
Acetone	1,4-Dichlorobenzene	Methylene Bromide
Acetonitrile	Dichlorodifluoromethane	Methylene Chloride
Acrolein	1,1-Dichloroethane	1-Methylnaphthalene
Acrylonitrile	1,2-Dichloroethane	2-Methylnaphthalene
Allyl Chloride	1,1-Dichloroethene	Naphthalene
Benzene	cis-1,2-Dichloroethene	2-Nitropropane
Benzyl chloride	trans-1,2-Dichloroethene	Pentachloroethane
Bromobenzene	1,2-Dichloropropane	Propionitrile
Bromochloromethane	1,3-Dichloropropane	Propyl Acetate
Bromodichloromethane	2,2-Dichloropropane	n-Propylbenzene
Bromoform	1,1-Dichloropropene	Styrene
Bromomethane	cis-1,3-Dichloropropene	Tert Butyl Alcohol
2-Butanone (MEK)	trans-1,3-Dichloropropene	tert-Amyl Methyl Ether
Butyl Acetate	1,4-Dioxane	tert-Butyl Ethyl Ether
n-Butyl Alcohol	Epichlorohydrin	1,1,1,2-Tetrachloroethane
n-Butylbenzene	Ethyl Acetate	1,1,2,2-Tetrachloroethane
sec-Butylbenzene	Ethyl Ether	Tetrachloroethene
tert-Butylbenzene	Ethyl Methacrylate	Tetrahydrofuran
Carbon Disulfide	Ethylbenzene	Toluene
Carbon Tetrachloride	p-Ethyltoluene	trans-1,4-Dichloro-2-Butene
Chlorobenzene	Freon 113	1,2,3-Trichlorobenzene
Chlorodifluoromethane	Heptane	1,2,4-Trichlorobenzene
Chloroethane	Hexachlorobutadine	1,1,1-Trichloroethane
2-Chloroethyl Vinyl Ether	Hexachloroethane	1,1,2-Trichloroethane
Chloroform	Hexane	Trichloroethene
Chloromethane	2-Hexanone	Trichlorofluoromethane
Chloroprene (2-chloro-1,3-butadiene)	Iodomethane (Methy iodide)	1,2,3-Trichloropropane
o-Chlorotoluene	IsoAmyl Alcohol	1,2,4-Trimethlylbenzene
p-Chlorotoluene	Isobutyl Alcohol	1,3,5-Trimethylbenzene
Cyclohexane	Isopropyl Acetate	2,2,4 Trimethylpentane
Cyclohexanone	Isopropylbenzene	Vinyl Acetate
di-Isobutylene	p-Isopropyltoluene	Vinyl Chloride
di-Isopropyl Ether	Methacrylonitrile	Vinyltoluene
1,2-Dibromo-3-Chloropropane	Methyl Acetate	m,p-Xylene
Dibromochloromethane	3 Methyl-1-Butanol	o-Xylene
1,2-Dibromoethane	Methyl Tert Butyl Ether	Ethanol
Dibromomethane	Methylcyclohexane	Methyl Acrylate
1,2-Dichlorobenzene	Methyl Methacrylate	1-chloro-1,1-difluoroethane
1,3-Dichlorobenzene	4-Methyl-2-pentanone (MIBK)	1,1,1-trifluoroethane
1,1-dichloro-1-fluroethane	2,2-Dichloropropane	1,3-Butadiene
3,3-Dimethyl-1-Butanol	Tert-Butyl Formate	Tert-amyl alcohol
2-methylnaphthalene	1,2,3-Trimethylbenzene	

Table 2 RECOMMENDED OPERATING CONDITION	
Gas Chromatograph/ Mass Spectrometer	
Carrier Gas (linear velocity)	Helium at *30 cm/sec (or hydrogen)
Mass range	35 – 270 amu *
Electron Energy	70 volts (nominal)
Scan time	not to exceed 2 sec. per scan
Injection port temperature	200 - 225 °C
Source temperature	200 - 250 °C
Transfer line temperature	220 - 280 °C
Analyzer temperature	220 - 250 °C
Gas Chromatograph temperature program*	
Initial temperature	*40 °C
Time 1	*3 minutes
Column temperature rate	*8 degrees/min.
Final temperature	*220 °C.- 240 °C
Total run time	*25 – 50 mins
Split ratio	*20:1
Purge and Trap Device	
Purge time	9 min. (at 40 °C for low-level soil) SIM – 6 min @ 80 °C
Purge gas	Helium or Nitrogen
Desorb**	1 min. at 190 °C
Bake	>10 min. at 210 °C
Transfer line	100 - 130 °C
Valve temperature	approx. transfer line temperature

(*) Parameter modification allowed for performance optimization provided operational and QC criteria is achieved. (must be approved by team leader/manager)

(**) Desorb time may require performance optimum between 0.5 and 4.0 minutes as dictated by trap manufacturers specifications or instrument characteristics

Table 2a SIM Group Parameters		
Group No.	**Retention Time (minutes)**	**Ions**
1	0 – 10.8	58, 65, 66, 88
2	10.8 – 16.0	95, 174, 176, 96,64

Table 3 BFB KEY IONS AND ION ABUNDANCE CRITERIA	
Mass	**Ion Abundance Criteria**
50	15-40% of mass 95
75	30-60% of mass 95
95	Base peak, 100% relative abundance
96	5-9% of mass 95
173	< 2% of mass 174
174	> 50% of mass 95
175	5-9% of mass 174
176	>95% and <101% of mass 174
177	5-9% of mass 176

Table 4 INTERNAL STANDARD QUANTITION IONS	
Internal Standard	**Primary/Secondary Ions**
1,4-Difluorobenzene	114 / 63,88
Chlorobenzene-d5	117 / 82, 119
Pentafluorobenzene	168
1,4-Dichlorobenzene-d4	152 / 115, 150
Tert Butyl Alcohol-d9	65/66
Internal Standard (SIM)	
4-BFB	95/174,176

Table 5 SURROGATE QUANTITION IONS	
Surrogate Compound	**Primary/Secondary Ions**
1,2 Dichloroethane – d_4	102
Dibromofluoromethane	113
Toluene-d8	98
4-Bromofluorobenzene	95 / 174, 176
1,4-dioxane-d8	96, 64

Table 7 Volatile Internal Standards with Corresponding Analytes Assigned for Quantitation					
Analyte	**Primary Characteristic Ion**	**Secondary Characteristic Ion (s)**	**Analyte**	**Primary Characteristic Ion**	**Secondary Characteristic Ion (s)**
Tert Butyl Alcohol-d9	65		Dibromomethane	93	95, 174
Tert Butyl alcohol	59	57	Di-isobutylene	57	
Ethanol	45	46	Epichlorohydrin (pp)	57	57, 49, 62, 51
1,4-Dioxane (pp)	88	58,43,57	Heptane	57	
Pentafluorobenzene	168		Methyl cyclohexane	83	
1,1,1-Trichloroethane	97	99, 61	Methyl methacrylate	100	69, 41, 39
1,1-Dichlorethane	63	65, 83	n-Butanol (pp)	56	41
1,1-Dichloroethene	96	61, 63	Propyl Acetate	43	
2,2-Dichloropropane	77	97	tert Amyl Methyl Ether	73	
2-Butanone (pp)	72	43, 72	Trichloroethene	95	97, 130, 132
Acetone (pp)	58	43	**Chlorobenzene-d5**	117	82,119
Acetonitrile (pp)	41	41, 40, 39	1,1,1,2-Tetrachloroethane	131	133, 119
Acrolein (pp)	56	55,58	1,3-Dichloropropane	76	78
Acrylonitrile (pp)	53	52, 51	Bromoform	173	175, 254
Allyl Chloride	76	41	Butyl Acetate	56	
Bromochloromethane	128	49, 130	Chlorobenzene	112	77, 114
Bromomethane	94	96	Dibromochloromethane	129	127
Carbon disulfide	76	78	Ethylbenzene	91	106
Carbon tetrachloride	117	119	m-Xylene	106	91
Chlorodifluouromethane	51	86	o-Xylene	91	106
Chloroethane	64	66	3,3-Dimethyl-1-Butanol	57	69
Chloroform	83	85	p-Xylene	106	91
Chloromethane	50	52	Styrene	104	78
Chloroprene	53	53, 88, 90, 51	Ethyl methacrylate	69	69, 41, 99, 86, 114
cis-1,2-Dichloroethene	96	61, 98	Toluene	92	91
Cyclohexane	84		**Toluene-d_8 (S)**	98	
Dibromofluoromethane (S)	113		Tetrachloroethene	164	129,131,166
Dichlorodifluoromethane	85	87	Cyclohexanone	55	
1,1-Dichloropropene	75	110, 77	2-Hexanone (pp)	58	43, 57, 100
Diethyl ether	74	45, 59	trans-1,3-Dichloropropene	75	77, 39
1,3-Butadiene	54		**1,4 Dichlorobenzene-d4**	152	115,150
Diisopropyl ether	45	102	1,1,2,2-Tetrachloroethane	83	131, 85
Ethyl acetate (pp)	45	43, 88, 61	1,2,3-Trichlorobenzene	180	182, 145
Ethyl tert Butyl Ether	59		1,2,3-Trichloropropane	110	77,75
Hexane	56		1,2,4-Trichlorobenzene	180	182, 145
Isopropyl acetate	87	43	1,2,4-Trimethylbenzene	105	120

Table 7 Volatile Internal Standards with Corresponding Analytes Assigned for Quantitation

Analyte	Primary Characteristic Ion	Secondary Characteristic Ion (s)	Analyte	Primary Characteristic Ion	Secondary Characteristic Ion (s)
Tert-Amyl alcohol	59	73,55	1,2-Dibromo-3-chloropropane(pp)	157	155, 75
Freon 113	151		1,2-Dichlorobenzene	146	111,148
Iodomethane	142	127, 141	1,3,5-Trimethylbenzene	105	120
Isobutyl alcohol (pp)	43	43, 41, 42, 74	1,3-Dichlorobenzene	146	111, 148
Methacrylonitrile (pp)	67	41, 39, 52, 66	1,4-Dichlorobenzene	146	111, 148
Methyl Acetate	43	74	2-Chlorotoluene	126	91
Methylene chloride	84	86, 49	**4-Bromofluorobenzene (S)**	95	174, 176
Methyl-t-butyl ether	73	57	2-methylnaphthalene	142	141,115,143
Propionitrile (ethyl cyanide)(pp)	54	54, 52, 55, 40	Dibromofluoromethane		
Tetrahydrofuran	71	42	4-Chlorotoluene	91	126
trans-1,2-Dichloroethene	96	61, 98	Benzyl chloride	91	91, 126, 65, 128
Trichlorofluoromethane	101	151, 153	Bromobenzene	156	77, 158
Vinyl acetate	86	43	Hexachlorobutadiene	225	223, 227
Vinyl chloride	62	64	Hexachloroethane (pp)	201	166, 199, 203
Methyl Acrylate	85	55	Isopropylbenzene	105	120
Tert-Butyl Formate	59	57, 41	Naphthalene	128	-
1-chloro-1, 1-difluoroethane	65	45,85	n-Butylbenzene	92	91, 134
1,1,1-trifluoroethane	69	69,45	n-Propylbenzene	91	120
1,1-dichloro-1-fluroethane	81	45,61	Pentachloroethane (pp)	167	167,130,132,165,169
2,2-Dichloropropane	77	97,79	p-isopropyltoluene	119	134,91
1,2,3-Trimethyl benzene	105	120,119			
1,4 Difluorobenzene	114	63, 88	sec-Butylbenzene	105	134
1,1,2-Trichloroethane	83	97, 85	tert-Buytlbenzene	119	91, 134
1,2-Dibromoethane	107	109, 188	trans-1,4-Dichloro-2-butene (pp)	53	88, 75
1,2 Dichloroethane	62	98			
1,2 Dichloropropane	63	112	**(pp) = Poor Purging Efficiency**		
2,2,4 Trimethylpentane	57		(S)=Surrogate		
2-Chloroethyl-vinylether (pp)	63	65, 106			
Dichloroethane-d_4 (S)	65	102			
2-Nitropropane	46	-			
3 Methyl –1 butanol	70	55			
4-Methyl-2-pentanone (pp)	58	43, 85, 100			
Benzene	78	-			
Bromodichloromethane	83	85, 127			
cis-1,3-Dichloropropene	75	77, 39			
Methylcyclohexane	83				

Table 7-1 SIM - Volatile Internal Standards with Corresponding Analytes Assigned for Quantitation

Analyte	Primary Characteristic Ion	Secondary Characteristic Ion (s)
4-BFB	95	174, 176
1,4-Dioxane	88	58
1,4-dioxane-d8	96	64

Table 8 STANDARDS PREPARATION

A) Internal standard and Surrogate mixtures:

	a) 50/500 µg/ml	b) 250/2,500 µg/ml
Internal Standard Mixture (20,000 µg/ml)	0.25 ml	3.125 ml
Tert Butyl Alcohol-d$_9$ (50,000 µg/ml)	1.0 ml	12.5 ml
Surrogate Mixture (10,000 µg/ml)	0.5 ml	6.25 ml
Methanol	98.25 ml	228.125 ml
Total	100 ml	250 ml

- 50/500 µg/ml internal standard and surrogate mixture: The mixture is prepared by measuring 0.25 ml of 20,000 µg/ml Internal Standard Mixture (Ultra or equivalent), 1.0 ml of 50,000 µg/ml TBA-d$_9$ (Absolute or equivalent), 0.5 ml of 10,000 µg /ml Method 8260A Surrogate Standard Mixture (Absolute or equivalent) and bringing to 100 ml with methanol.

- 250/2,500 µg/ml internal standard and surrogate mixture: The mixture is prepared by measuring 3.125 ml of 20,000 µg/ml Internal Standard Mixture (Ultra or equivalent), 12.5 ml of 50,000 µg/ml TBA-d$_9$ (Absolute or equivalent), 6.25 ml of 10,000 µg /ml Method 8260A Surrogate Standard Mixture (Ultra or equivalent) and bringing to 250 ml with methanol.

B) Bromofluorobenzene (BFB):

	a) 25 µg/ml	b)) 250 µg/ml
BFB (25,000 µg/ml)	0.1 ml	0.1 ml
Methanol	99.9 ml	9.9 ml
Total	100 ml	10 ml

- 25 µg/ml solution for direct injection: The BFB is prepared at 25 µg /ml by measuring 0.1 ml of 25,000 µg /ml (Absolute Stock or equivalent) and diluting to 100 ml with methanol.

- 250 µg /ml solution for purging: The BFB is prepared at 250 µg /ml by measuring 0.1 ml of 25,000 µg /ml (Absolute Stock or equivalent) and diluting to 10 ml with methanol.

C) Secondary dilution standards:

2nd Dilution Standards	Stock Solution	Concentration (µg/ml)	Volume Added (µl)	Final Volume in Methanol (ml)	Final Concentration (µg/ml)
V8260 Mixture	502.2 CAL2000 Mega Mix	2,000	5,000	100	100
	524 Cal Mix 7A	2,000	5,000		100
	524 Cal Mix 8	2,000	5,000		100
	Ketone mix	20,000	1,500		300
	Multiple neat compounds	Neat			100
	Multiple single component standards	5000-20,000	500-2000		100
Acrolein	Acrolein	Neat (95%)	12.5	100 (4:1 ratio of DI water : methanol)	100

Gas Mixture	VOC Gas Mixture	2,000	1,250	25	100
	Cyclohexane	neat	3.2		100

- 100 µg /ml V8260 mixture: The mixture is prepared at 100 µg /ml by measuring 5 ml of 2,000 µg/ml 502.2 Mega Mix stock standard, 5 mL of 2,000 µg/ml 524 Cal Mix 7A, 5 mL of 2,000 µg/ml 524 Cal Mix 8, appropriate amount of some neat compounds and single component standards, and bringing to 100 ml with methanol.

- 100 µg/ml V8260 Acrolein: The mixture is prepared at 100 µg/ml by measuring 12.5 µl of 95% acrolein to 100 ml of a 4:1 ratio of DI water:methanol to reduce the amount of methanol injected into the system per run.

- 100 µg /ml gas mixture ***: The mixture is prepared at 100 µg /ml by measuring 1.25 ml of 2,000 µg/ml stock standard, 3.2 µl of neat cyclohexane and bring to 25 ml with methanol.
  ******* Gas mixture must be prepared weekly.

D).1 Initial Calibration Standards: using DI water bring to 50 ml final volume for the 1 -400 ppb standards and 500 ml for the 0.2 and 0.5 ppb standards: All mixtures used must be **secondary dilution** standards at **100 ppm**. Note: Larger volumes may be prepared if needed i.e. if 100 ml final volume is used the volume of the standard added would be doubled.

Standard and Surrogate Concentration	V8260 Mix (100 ppm)	V8260 Acrolein (100 ppm)	Gas compound Mix (100 ppm)	Surrogate Mix when added manually (100ppm)
0.2 ppb	1.0 µl	1.0 µl	1.0 µl	1.0 µl#
0. 5 ppb	2.5 µl	2.5 µl	2.5 µl	2.5 µl#
1 ppb	0.5 µl	0.5 µl	0.5 µl	0.5 µl#
2 ppb *	1.0 µl	1.0 µl	1.0 µl	1.0 µl#
4 ppb *	2.0 µl	2.0 µl	2.0 µl	2.0 µl#
5 ppb	2.5 µl	2.5 µl	2.5 µl	2.5 µl#
8 ppb *	4.0 µl	4.0 µl	4.0 µl	4.0 µl#
10 ppb *	5 µl	5 µl	5 µl	5 µl#
20 ppb	10 µl	10 µl	10 µl	10 µl#
50 ppb	25 µl	25 µl	25 µl	25 µl#
100 ppb	50 µl	50 µl	50 µl	50 µl#
200 ppb	100 µl	100 µl	100 µl	100 µl#
300 ppb *	150 µl	150 µl	150 µl	150 µl#
400 ppb *	200 µl	200 µl	200 µl	200 µl#

* depending upon the instrument.
\# See Section 10.2.2.1 for correction factor.

- When calibrating for Method 5035 low-level soil samples, add 1g of sodium bisulfate to the 40-ml vial before aliquot 5 ml of each standard into vial if applicable. This is equivalent to the amount of sodium bisulfate added to the samples and will maintain a consistent purging efficiency of the compounds.

Table 8 STANDARD PREPARATION (Continued)

D).2 Initial Calibration Standards for 1,4-Dioxane using SIM

Standard Concentration (ppb)	1,4-Dioxane Solution (100ppm)	DI Water – Final Volume (ml)
0.25	1.25 µl	500
0.4	2 µl	500
1	1 µl	100
2	2 µl	100
5	2.5 µl	50
20	10 µl	50
50	25 µl	50
100	50 µl	50

E) **Continuing Calibration Standard: using DI water bring to 50 ml final volume:** All mixtures used are secondary dilution standards at 100 ppm.

Concentration	V8260 Mix (100 ppm)	V8260 Acrolein (100 ppm)	Gas compound Mix (100 ppm)
50 ppb	25 µl	25 µl	25 µl

- When calibrating for Method 5035 low-level soil samples, add 1g of sodium bisulfate to the 40-ml vial before aliquot 5 ml of the continuing calibration standard into vial if applicable. This is equivalent to the amount of sodium bisulfate added to the samples and will maintain a consistent purging efficiency of the compounds.

F) **Blank Spike (BS): using DI water bring to 50 ml final volume:** All mixtures used are 100 ppm secondary dilution standards.

Concentration	V8260 Mix (100 ppm)	V8260 Acrolein (100 ppm)	Gas compound Mix (100 ppm)
50 ppb	25 ul	25 ul	25 ul

For lower detection level required (test code: V8260LL)

Concentration	V8260 Mix (100 ppm)	V8260 Acrolein (100 ppm)	Gas compound Mix (100 ppm)
20 ppb	10 ul	10 ul	10 ul

- When calibrating for Method 5035 low-level soil samples, add 1g of sodium bisulfate to the 40-ml vial before aliquot 5 ml of the blank spike into vial if applicable. This is equivalent to the amount of sodium bisulfate added to the samples and will maintain a consistent purging efficiency of the compounds.

Table 9 GUIDELINE FOR DILUTION PREPARATION
Water Sample

Dilution	Sample amount taken	Final volume A (volumetric)	Take from final volume A	Final volume B (volumetric)
1:2	25 ml	50 ml		
1:5	10 ml	50 ml		
1:10	5 ml	50 ml		
1:20	2.5 ml	50 ml		
1: 25	2 ml	50 ml		
1:50	1 ml	50 ml		
1:100	0.5 ml	50 ml		
1:200	250 µl	50 ml		
1:250	200 µl	50 ml		
1:500	100 µl	50 ml		
1:1000	50 µl	50 ml		
1:2000	25 µl	50 ml		
1:2500	20 µl	50 ml		
1:5000	10 µl	50 ml		
1:10000	0.5 ml	50 ml	0.5 ml	50 ml
1:20000	0.5 ml	50 ml	250 µl	50 ml
1:25000	0.5 ml	50 ml	200 µl	50 ml
1:50000	0.5 ml	50 ml	100 µl	50 ml
1:100000	0.5 ml	50 ml	50 µl	50 ml

Soil-Low level (Non-Encore sample)

Dilution	Sample amount taken	Final volume
1:2	2.5 gram	5 ml
1:5	1 gram	5 ml
1:10	0.5 gram	5 ml

Soil-medium level

Additional Dilution	Sample in Methanol amount taken	Final volume (volumetric)
1:1	1 ml	50 ml
1:2	0.5 ml	50 ml
1:5	200 µl	50 ml
1:10	100 µl	50 ml
1:20	50 µl	50 ml
1: 25	40 µl	50 ml
1:50	20 µl	50 ml
1:100	10 µl	50 ml
1:200	5 µl	50 ml
1:250	4 µl	50 ml
1:500	2 µl	50 ml

Table 10 REPORTING LIMITS

Compound	Water	Soil	Compound	Water	Soil
	µg/l	µg/kg		µg/l	µg/kg
Chlorodifluoromethane	5	5	Chloroform	1	2
Dichlorodifluoromethane	2	5	Freon 113	5	5
Chloromethane	1	5	Methacrylonitrile	10	10
Vinyl chloride	1	2	Butyl Acetate	5	5
Bromomethane	2	5	1,1,1-Trichloroethane	1	2
Chloroethane	1	5	Heptane	5	5
Trichlorofluoromethane	2	5	n-Propyl acetate	5	5
Ethyl ether	2	2	2-Nitropropane	10	10
Acrolein	10	10	Tetrahydrofuran	10	10
1,1-Dichloroethene	1	1	2-Chloroethyl Vinyl Ether	10	25
Tertiary butyl alcohol	10	25	n-Butyl alcohol	250	250
Acetone	10	10	Cyclohexane	5	2
Methyl acetate	5	5	Carbon Tetrachloride	1	2
Allyl chloride	5	5	1,1-Dichloropropene	1	2
Acetonitrile	100	100	Isopropyl Acetate	5	5
Iodomethane	2	5	Benzene	0.5	0.5
Isobutyl alcohol	50	50	1,2-Dichloroethane	1	1
Carbon disulfide	2	2	Trichloroethene	1	1
Methylene chloride	2	5	Methyl methacrylate	10	10
Methyl tert butyl ether	1	1	1,2-Dichloropropane	1	1
Trans-1,2-Dichloroethene	1	1	2-ethylhexyl acrylate	2	2
Di-isopropyl ether	2	2	Dibromomethane	1	5
2-Butanone	10	10	1,4-Dioxane	130	130
1,1-Dichloroethane	1	1	Bromodichloromethane	1	2
Hexane	5	5	cis-1,3-Dichloropropene	1	2
Chloroprene	5	5	4-Methyl-2-pentanone	5	5
Acrylonitrile	10	10	Toluene	1	1
Vinyl acetate	10	10	trans-1,3-Dichloropropene	1	2
Ethyl acetate	5	5	Ethyl methacrylate	10	10
2,2-Dichloropropane	1	2	1,1,2-Trichloroethane	1	2
Cis-1,2-Dichloroethene	1	1	2-Hexanone	5	5
Bromochloromethane	1	5	Cyclohexanone	50	200

Table 10 REPORTING LIMITS (Continued)

Compound	Water	Soil	Compound	Water	Soil
	µg/l	µg/kg		µg/l	µg/kg
Tetrachloroethene	1	2	4-Chlorotoluene	2	2
1,3-Dichloropropane	1	2	1,3,5-Trimethylbenzene	2	2
Dibromochloromethane	1	2	tert-Butylbenzene	2	2
1,2-Dibromoethane	1	1	1,2,4-Trimethylbenzene	2	2
Chlorobenzene	1	2	sec-Butylbenzene	2	2
1,1,1,2-Tetrachloroethane	1	2	1,3-Dichlorobenzene	1	1
Ethylbenzene	1	1	p-Isopropyltoluene	2	2
m,p-Xylene	1	1	1,4-Dichlorobenzene	1	1
o-Xylene	1	1	1,2-Dichlorobenzene	1	1
Styrene	1	2	n-Butylbenzene	2	2
Bromoform	1	5	1,2-Dibromo-3-choropropane	2	2
Isopropylbenzene	1	2	1,2,4-Trichlorobenzene	1	5
Bromobenzene	1	5	Hexachlorobutadiene	2	5
1,1,2,2-Tetrachloroethane	1	2	Naphthalene	5	5
Trans-1,4-Dichloro-2-butene	5	5	1,2,3-Trichlorobenzene	1	5
1,2,3-Trichloropropane	2	5	Epichlorohydrin	100	100
n-Propylbenzene	2	2	3-Methyl-1-butanol	50	100
2-Chlorotoluene	2	2	Hexachloroethane	2	5
Ethanol	100	200	Methyl Acrylate	5	5
Benzyl Chloride	5	5	Methylcyclohexane	5	2
2,2,4-Trimethylpentane	5	5	1,1,1-trifluoroethane (Freon 143a)	5	5
1-chloro-1,1-difluoroethane (Freon 142b)	5	5	1,1-dichloro-1-fluoroethane (Freon 141b)	5	5
1,3-Butadiene	5	5	Pentachloroethane	5	5
1.4-Dioxane (SIM)	0.4	5	2-methylnaphthalene	5	5
Tert-Butyl Formate	5	5	Tert-amyl alcohol	25	25
1,2,3-Trimethylbenzene	2	2			

Table 11 COMPOUNDS THAT MAY EXHIBIT CARRYOVER

Compound
1,2,4-Trichlorobenzene
Hexachlorobutadiene
Naphthalene
1,2,3-Trichlorobenzene

Table 12 GUIDANCE MINIMUM RELATIVE RESPONSE FACTOR CRITERIA

Compound	Minimum Response Factor
Dichlorofluoromethane	0.01
Chloromethane	0.01
Vinyl chloride	0.01
Bromomethane	0.01
Chloroethane	0.01
Trichlorofuoromethane	0.01
1,1-Dichloroethene	0.06
Freon 113	0.05
Acetone	0.01
Carbon Disulfide	0.100
Methyl Acetate	0.01
Methylene chloride	0.01
trans-1,2 Dichloroethene	0.100
cis-1,2 Dichloroethene	0.2
Methyl tert-butyl Ether	0.100
1,1 Dichloroethane	0.3
2-Butanone	0.01
Chloroform	0.3
1,1,1 Trichloroethane	0.05
Cyclohexane	0.01
Carbon Tetrachloride	0.100
Benzene	0.2
1,2 Dichloroethane	0.07
Trichloroethene	0.200
Methylcyclohexane	0.05
1,2-Dichloropropane	0.2
Bromodichloromethane	0.3
cis-1,3-Dichloropropene	0.3
trans-1,3-dichloropropene	0.3

Table 12 cont'd Compound	Minimum Response Factor
Tetrachloroethene	0.1
2-Hexanone	0.01
Dibromochloromethane	0.2
1,2-Dibromoethane	0.2
Chlorobenzene	0.4
Ethyl benzene	0.4
m,p-Xylene	0.2
o-Xylene	0.2
Styrene	0.2
Bromoform	0.100
Isopropylbenzene	0.4
1,1,2,2-Tetrachloroethane	0.2
1,3-Dichlorobenzene	0.5
1,4-Dichlorobenzene	0.6
1,2-Dichlorobenzene	0.6
1,2-Dibromo-3-chloropropane	0.01
1,2,4-Trichlorobenzene	0.4
1,3-Butadiene	0.100
3,3-Dimethyl-1-butanol	0.010
1,4-Dioxane (SIM)	0.010
4-Methyl-2-Pentanone	0.03
Toluene	0.3
1,1,2-Trichloroethane	0.2
Bromochloromethane	0.1
1,2,3-Trichlorbenzene	0.4

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
10.4.1	Revised frequency of BFB
11.3.2	Revised frequency of BFB
12.1	Revised frequency of BFB

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added

History of Revisions

Version #	Date of Revision	Revised By
01	01/20/2021	Maria Ruschke
02	03/05/2021	Olga Azarian
03	07/22/2021	Olga Azarian
04	04/12/2022	Olga Azarian
05	04/25/2023	Olga Azarian

END OF DOCUMENT

LAB SUPERVISOR: ______________________

QA OFFICER: ______________________

EFFECTIVE DATE: 9-21-2023

TITLE: METHOD 8270E, SEMIVOLATILE ORGANIC COMPOUNDS BY GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS)

REFERENCES: SW846 8270E, revision 6, June 2018
REVISED SECTIONS: 9.5.1.1, 10.1.1

1.0 SCOPE AND APPLICATION

1.1 The following method describes the analytical procedure that is utilized by SGS to analyze semi volatile organic compounds in extracts prepared from all types of solid waste matrices, soils, and water samples. Options are incorporated for the analysis of sixteen (16) polyaromatic hydrocarbons (PAH) and other compounds listed in table 8A by selected ion monitoring GC/MS (GC/MS-SIM).

1.2 Table 1 lists the neutral, acidic, and basic organic compounds that can be determined by this method. The applicable concentration range of this method is compound and instrument dependent. Some compounds may require special treatment due to the limitations caused by sample preparation and/or chromatographic problems.

2.0 SUMMARY OF METHOD

2.1 This method is performed in accordance with the following extraction methodologies in SW846: 3510, 3520, 3546, 3550 and 3580.

2.2 The resultant methylene chloride extract is injected into a tuned and calibrated GC/MS system equipped with a 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.

2.3 The peaks detected are identified qualitatively by comparison to characteristic ions and retention times specific to the known target list of compounds.

2.4 Once identified, the compound is quantitated by internal standard techniques with an average response factor generated from the calibration curve.

2.5 Additional unknown peaks with a response greater than 10 % of the closest internal standard may be processed through a library search with comparison to a NIST08 database. An estimated concentration is quantitated by assuming a response factor of 1.

2.6 This method includes analytical options for PAHs and other selected compounds by GC/MS-SIM. The extract is fortified with an additional SIM specific internal standard mix and analyzed using selected ions that are characteristic of the compounds of interest following the analysis of lower concentration calibration standards analyzed under the same MS scan conditions. Qualitative and quantitative identification is conducted using the procedures employed for full scan analysis.

2.7 An option for preparing aqueous samples using a reduced initial volume (~250 ml) for analysis by a large volume injection (LVI) technique is also described.

3.0 REPORTING LIMIT & METHOD DETECTION LIMIT

3.1 Reporting Limit. The reporting limit for this method is established at or above the lowest concentration standard in the calibration curve, depending on the requirements of different regulatory programs. The RL must be above the established MDL. Detected concentrations below this concentration cannot be reported without qualification. See table 9 and 10. The RL concentrations are calculated for water matrix in ug/L using formula in sec. 13.4.1 and for soil matrix in ug/kg using formula in sec.13.4.2.

3.1.1 Compounds detected at concentrations between the reporting limit and MDL are quantitated and qualified as “J”, estimated value. Program or project specifications may dictate that “J” qualified compounds are not to be reported.

3.2 Method Detection Limit. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B, Revision 2.

3.2.1 Experimental MDLs must be determined in accordance with SGS SOP EQA075.

3.2.2 Process all raw data for the replicate analysis in each MDL study. Forward the processed data to the QA group for archiving.

4.0 DEFINITIONS

BATCH - a group of samples which behave similarly with respect to the sampling or the testing procedures being employed, and which are processed as a unit. For QC purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or less will all be handled as a separate batch.

BLANK - an analytical sample designed to assess specific sources of laboratory contamination.

CONTINUING CALIBRATION - a mid-range calibration check standard run every 12 hours to verify the initial calibration of the system.

EXTRACTED ION CURRENT PROFILE (EICP) - a plot of ion abundance versus time (or scan number) for ion(s) of specified mass (Es).

INITIAL CALIBRATION - analysis of analytical standards for a series of different specified concentrations which cover the working range of the instrument; used to define the linearity and dynamic range of the response of the mass spectrometer to the target compounds.

INTERNAL STANDARDS - compounds added to every standard, blank, matrix spike, matrix spike duplicate, and sample extract at a known concentration, prior to analysis. Internal standards are used as the basis for quantitation of the target compounds and must be analytes that are not sample components.

MATRIX - the predominant material of which the sample to be analyzed is composed.

MATRIX SPIKE - aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

MATRIX SPIKE DUPLICATE - a second aliquot of the same matrix as the matrix spike (above) that is spiked in order to determine the precision of the method.

METHOD BLANK - an analytical control consisting of all reagents, internal standards and surrogate standards, is carried throughout the entire preparatory and analytical procedure. The method blank is used to define the level of laboratory, background and reagent contamination.

METHOD DETECTION LIMITS (MDLs) - The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is distinguishable from method blank results.

PERCENT DIFFERENCE (%D) - As used to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference.)

PRIMARY QUANTITATION ION - a contract specified ion used to quantitate a target analyte.

REAGENT WATER - water in which no interferant is observed at or above the minimum detection limit of the parameters of interest.

RECONSTRUCTED ION CHROMATOGRAM (RIC) - a mass spectral graphical representation of the separation achieved by a gas chromatograph; a plot of total ion current versus retention time.

RELATIVE PERCENT DIFFERENCE (RPD) - As used to compare two values, the relative percent difference is based on the mean of the two values, and is reported as an absolute value, i.e., always expressed as a positive number or zero. (In contrast, see percent difference.)

RELATIVE RESPONSE FACTOR (RRF) - a measure of the relative mass spectral response of an analyte compared to its internal standard. Relative Response Factors are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples.

RELATIVE RETENTION TIME (RRT) - the ratio of the retention time of a compound to that of a standard (such as an internal standard).

RESOLUTION - also termed separation or percent resolution, the separation between peaks on a chromatogram, calculated by dividing the depth of the valley between the peaks by the peak height of the smaller peak being resolved, multiplied by 100.

INITIAL CALIBRATUION VERIFICATION (SECOND SOURCE CALIBRATION STANDARD) - a standard from a separate source than the calibration curve that is used to verify the accuracy of the calibration standards. An external check must be run whenever an initial calibration is performed.

SURROGATES - pure analytes added to every blank, sample, matrix spike, matrix spike duplicate, and standard in known amounts before extraction or other processing; used to evaluate analytical efficiency by measuring recovery. Surrogates are brominated, fluorinated, or isotopically labeled compounds not expected to be detected in environmental media.

5.0 HEALTH & SAFETY

5.1 The analyst must follow normal safety procedures as outlined in the SGS Health and Safety Plan and Personal Protection Policy, which include the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents must be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets is made available to all personnel involved in these analyses.

5.3 The following analytes covered by this method have been tentatively classified as known or suspected human or mammalian carcinogens: benzo(a)anthracene, benzidine, 3,3’-dichlorobenzidine, benzo(a)pyrene, dibenzo(a,h)anthracene, N-nitrosodimethylamine, and 4,4’-DDT. Prepare primary standards of these toxic compounds in a hood. A NIOSH/Mass approved toxic gas respirator must be worn when the analyst handles high concentrations of these toxic compounds.

6.0 INTERFERENCES

6.1 The data from all blanks, samples, and spikes must be evaluated for interferences.

6.2 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other stages of sample processing. Refer to "The Preparation of Glassware for Extraction of organic contaminants" SOP for practices utilized in the extraction department.

6.3 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 and diversity of the industrial complex or municipality being sampled.

6.4 To reduce carryover when high-concentration samples are sequentially analyzed, the syringe must be rinsed out between samples with solvent. Whenever an unusually concentrated sample is encountered, it must be followed by the analysis of solvent to check for cross contamination.

7.0 SAMPLE COLLECTION, PRESERVATION, & HOLDING TIMES

7.1 Water samples may be collected in 1-liter or 250 ml-LVI glass bottles with Teflon insert in caps. Soil samples may be collected in 250-mL wide-mouth amber glass bottles.

7.1.1 Samples must be taken with care to prevent any portion of the collected sample coming in contact with the sampler's gloves, thus avoiding possible phthalate contamination.

7.2 The samples must be protected from light and refrigerated at ≤6° C from the time of receipt until extraction and analysis.

7.3 Store the sample extracts at -10 °C in amber vials (protected from light), in sealed vials equipped with unpierced PTFE-lined septa.

7.5 HOLDING TIME

7.5.1 Aqueous samples must be extracted within 7 days of sampling.

7.5.2 Soil, sediments and concentrated waste samples must be extracted within 14 days of sampling.

7.5.3 Extracts must be analyzed within 40 days following extraction.

8.0 APPARATUS & MATERIALS

8.1 GAS CHROMATOGRAPH/MASS SPECTROMETER SYSTEM

8.1.1 Gas Chromatograph. HP-5890, HP-6890, Agilent 6890-N, or Agilent 7890 which includes an analytical system that is complete with a temperature programmable gas chromatograph and all required accessories including syringes, capillary chromatographic columns, and gases.

8.1.1.1 The injection port is designed for split or splitless injection with capillary columns.

8.1.1.2 The capillary column is directly coupled to the source.

8.1.2 Column.

8.1.2.1 30 m x 0.25 mm fused silica (0.25 μm film thickness) DB-5MS or equivalent capillary column. Condition the column as per manufacture's directions.

8.1.3 Mass Spectrometer (HP-5972, HP-5973 or Agilent 5975).

8.1.3.1 Full Scan Mode -Capable of acquiring mass spectra from mass/charge (m/z) 35-500 amu at a rate fast enough to acquire at least 5 (preferably 10 or more) mass spectra across each chromatographic peak of interest, using 70-volt (nominal) electron energy in the electron impact ionization mode.

8.1.3.2 SIM Mode- Capable of selective ion grouping at specified retention times for increased compound sensitivity (table 2a) or for applications requiring quantitation limits below the normal range.

8.1.3.3 Capable of producing a mass spectrum which meets all the EPA performance criteria in Table 3 when injecting 50 ng of Decafluorotriphenyl phosphine (DFTPP).

8.2 DATA SYSTEM

8.2.1 Acquisition and Instrument Control: HP Chemstation. A computer system is interfaced to the mass spectrometer that allows the continuous acquisition and storage on machine readable media (disc) of all mass spectra obtained throughout the duration of the chromatographic program.

8.2.2 Data Processing: HP Enviroquant. The software accommodates searching of GC/MS data files for analytes which display specific fragmentation patterns. The software also allows integrating the abundance of an EICP between specified time or scan number limits. The data system includes the NIST08 spectra library for qualitative searches of non-target compounds present in the chromatogram. It flags all data files that have been edited manually by laboratory personnel.

8.2.3 Offline Magnetic Media Storage Device - the magnetic media storage device copies data for long term, offline storage.

8.3 SYRINGE

8.3.1 10 μL graduated, auto sampler (Hamilton or equiv.).

8.3.2 Micro liter syringes, various sizes

9.0 REAGENTS AND STANDARDS

9.1 Solvents - Ultra pure, chromatography grade methylene chloride and acetone.

9.2 Stock Standard Solutions.

9.2.1 Certified, commercially prepared standards, from two separate sources are used.

9.2.1.1 Base Neutrals.

- Base/Neutrals Mix #1 (Absolute: Semivolatile Organics Standard Mix # 1).
- Base/Neutrals Mix #2 (Absolute: Semivolatile Organics Standard Mix # 2).
- PAH Mix (Absolute: Semivolatile Organics Standard Mix # 7).
- PAH Mixture #2 (Ultra).
- PAH Selected Ion Monitoring Mixture
- Benzidines Mix (Absolute: Semivolatile Organics Standard Mix # 6).
- Toxic Substances #2 (Absolute: Semi volatile Organics Standard Mix # 5).
- Pyridines Mixture (Ultra).
- Additional requested compound(s) mix (Absolute).
- Base Neutral Mixture (2^{nd} Source).

Acids

- Phenols Mix (Absolute: Semivolatile Organics Standard Mix # 8).
- Toxic Substances #1(Absolute: Semivolatile Organics Standard Mix # 4).
- Acid Mixture (2^{nd} Source). Internal Standard Mixtures.

9.2.2 Internal Standard Mixtures

9.2.2.1 Ultra (or equivalent) at a concentration of 4,000 μg/mL for each of the following compounds:

Full Scan

- 1,4-Dichlorobenzene-d4
- Naphthalene-d8
- Acenaphthene-d10
- Phenanthrene-d10
- Chrysene-d12
- Perylene-d12

SIM

- 1,2-Dichlorobenzene-d4
- 1-Methylnaphthalene-d10
- Fluorene-d10
- Fluoranthene-d10
- Benzo(a)pyrene-d12
- 1,4-Dioxane-d8 (for Isotopic Dilution analysis of 1,4 Dioxane)

9.2.2.2 The internal standards must permit most of the components of interest in a chromatogram to have retention times of 0.8 - 1.20 relative to one of the internal standards.

9.2.2.3 Each 1 mL sample extract, and standard undergoing analysis must be spiked with 10 µl of the internal standard mixtures, resulting in a concentration of 40 µg/mL of each internal standard for full scan analysis and 4µg/mL for SIM analysis. 20 ug/mL of 1,4-Dioxane-d8 is added during extraction for Isotopic Dilution analysis of 1,4-Dioxane via SIM. For LVI, each sample extract will be spiked with 2 µl of the internal standard mixtures.

9.2.3 Surrogate Standard Mixture.

9.2.3.1 B/N Surrogate Standard Mix: RESTEK (or equivalent) at a concentration of 5,000 µg/mL each surrogate compound.

- Nitrobenzene-d5.
- 2-Fluorobiphenyl.
- p-Terphenyl-d14.

9.2.3.1.1 For DOD PAH target analytes by SIM; additional surrogates are required.

- Fluoranthene-d_{10}
- 2-methylnaphthalene-d_{10}

9.2.3.2 Acid Surrogate Standard Mix: RESTEK (or equivalent) at a concentration of 7,500 µg/mL each surrogate compound.

- Phenol-d5.
- 2-Fluorophenol.
- 2,4,6-Tribromophenol.

9.2.4 DFTPP Tune Stock.

9.2.4.1 Protocol (or equivalent) at a concentration of 2,500 µg/mL for the following compounds.

- Decafluorotriphenylphosphine.
- 4,4'-DDT.
- Benzidine.
- Pentachlorophenol.

9.2.5 Store standards at -10°C or less when not in use or according to the manufacturer's documented holding time and storage temperature recommendations. Stock standard solutions must be replaced after 1 year or sooner if manufacture's expiration date comes first or comparison with quality control check samples indicates degradation.

9.3 Surrogate Spiking Solutions.

9.3.1 One surrogate spiking solution, containing both base/neutral and acid surrogates at a concentration of 50µg/mL is prepared in extractions. Spike each sample, and blank with 1 mL of solution prior to extraction, for a final concentration of 50 µg/l of each surrogate compound in the extract. For LVI spike, each sample with 200 µl of surrogate solution.

9.3.2 A calibration range must be constructed for the surrogate compounds. Accordingly, appropriate amounts of surrogates are mixed with each calibration solution to define a range similar to the target compounds.

9.3.3 Store at -10 °C or less or according to the manufacturer's documented storage temperature recommendations. Prepare fresh surrogate spiking solutions every six months, or sooner, if the manufacturer's expiration dates come first or if the solution has degraded or evaporated.

9.4 Intermediate Calibration Standard Solution.

9.4.1 The calibration stock solution is prepared by adding an appropriate amount of each stock and surrogate compounds into a 10 mL volumetric flask. Dilute the solution to the volume with methylene chloride and mix thoroughly. Refer to Table 7A for details.

9.5 Calibration Standards.

9.5.1 Initial Calibration Standards.

9.5.1.1 Calibration standards containing the surrogate compounds must be made by quantitative dilutions of the above intermediate solution. The calibration standards are prepared at a minimum of five concentrations to cover the range of 1 - 100 µg/mL for full scan, 0.2 – 20 µg/mL for LVI, and 0.02 – 5ug/mL for SIM, 0.002 – 2 ug/mL for SIM LVI,0.02—20 ug/ml for 1,4-Dioxane by SIM isotopic dilution, depending upon project specific requirements. Suggested levels and preparations are shown in Table 7A and 7B.

9.5.2 Continuing Calibration Verification.

9.5.2.1 The concentration of the mid range standard used for continuing calibration verification is 50 µg/mL for full scan, 10 µg/mL for LVI, 1.0 µg/mL for SIM, and 0.2 µg/mL for SIM LVI.

9.5.3 Store the calibration standards in a refrigerator at ≤ 6 °C and prepare every 6 months or before the manufacturer’s expiration date, whichever is sooner. Standards must be replaced immediately if the analysis of check standards indicates degradation.

9.6 Initial Calibration verification (ICV) -Second source calibration check standard.

9.6.1 The ICV standard is prepared per Table 7E, using the intermediate solutions prepared in Extraction. The ICV must be prepared from a second manufacturer or from a manufacturer’s lot prepared independently from the lot used for calibration.

9.6.2 The ICV is analyzed after each initial calibration.

9.7 GC/MS Performance Checks.

9.7.1 The solution is prepared at 50 µg/mL by making a 1:50 dilution of DFTPP stock solution (Section 9.2.4) in methylene chloride.

9.8 Matrix Spike Solutions.

9.8.1 The matrix spike solutions for both Base/Neutral and Acid are prepared in Acetone at a concentration of 100 µg/mL for each compound. Prepare the matrix spike, matrix spike duplicate and blank spike by spiking the selected sample and the blank with 1 mL of these solutions for a final concentration of 50 µg/l of each compound. MS/MSD and BS must be prepared with target analytes from the same source as used for the initial calibration. For LVI, spike with 200 µl of the spiking solution

9.9 All organic new standard solutions are analyzed prior to use to verify the accuracy of the prepared concentration.

9.9.1 The prepared standard solution is analyzed using the determinative (instrumental) technique for the method.

9.9.2 The solution is analyzed following the completion of instrument calibration or a calibration check.

9.9.3 The concentration of the standard solution is determined using the software routines used in determining the acceptability of calibration verification.

9.9.4 The data is evaluated, and the percent difference determined. The standard solution is approved for use if all designated compounds are present in the solution and the percent difference is less than the established criteria (±20%).

10.0 CALIBRATION

10.1 Initial Calibration.

10.1.1 The calibration range covered for routine analysis under RCRA employs standards of 1, 2, 5, 10, 25, 50, 80, 100 µg/mL for full scan, 0.2, 0.4, 1, 2, 5, 10, 16, 20 µg/mL for LVI, and 0.01 (bis(2-chloroethyl) ether (BCEE) only) 0.02, 0.05, 0.10, 0.20, 0.5, 1.0, 2.5, 5.0 µg/mL for SIM, and 0.002, 0.004, 0.01, 0.02, 0.04, 0.1, 0.2, 0.5, 1.0, 2.0 µg/mL for SIM LVI; 0.02, 0.01, 0.05, 0.1, 0.2, 0.5, 1.0, 5.0, 10.0, 20.0 ug/ml for 1,4-dioxane by SIM isotopic dilution. A minimum of five standards must be run sequentially. The reporting limit is established by the concentration of the lowest standard analyzed during the initial calibration. Lower concentration standard may be needed to meet the reporting limit requirements of state specific regulatory program. The linear range covered by this calibration is the highest concentration standard.

10.1.2 A calibration range must be constructed for each surrogate compound. Accordingly, add appropriate amounts of surrogate spiking solutions to the calibration solution to define a range similar to the target compounds.

10.1.3 Aliquot 1 mL of each calibration standard into a 2 mL crimp top vial.

10.1.4 Prior to analysis, add 10 µL of the applicable (Full scan and/or SIM) internal standard solution (Section 9.2.2) to each standard. This results in a concentration of 40 µg/mL (Full scan) and 4ug/mL (SIM) for each internal standard. For 1,4-Dioxane isotope dilution analysis, add 1mL of 20µg/mL 1,4-Dioxane-d8 prior to extraction of samples.

10.1.5 Analyze the standard solutions using the conditions established in Section 11.0. Each analyte is quantitatively determined by internal standard technique using the closest eluting internal standard and the corresponding area of the major ion. See Table 6. 1,4-Dioxane via SIM is analyzed using Isotope Dilution.

10.1.6 The Response Factor (RF) is defined in Section 13.1. Calculate the mean RF for each target analyte, using minimum of five RF values calculated from the initial calibration curve.

10.1.7 For the initial calibration to be valid, the following criteria must be met.

10.1.7.1 The percent relative standard deviation (% RSD) (see Section 13.2) of all target analytes must be less than or equal to 20%.

10.1.7.1.1 If the average response factor criteria cannot be achieved, employ an alternative calibration linearity model. Do not force the regression line through the origin and do not employ 0,0 as a sixth calibration standard. The correlation coefficient (r value) must be ≥ 0.995 or ±0.99 (for r^2 value) for each compound to be acceptable, and calibration curves using quadratic model must have minimum 6 calibration points.

10.1.7.1.2 In some cases, although the %RSD of a target analyte is≤ 20%, more suitable calibration model may be employed or “best fit” rather than average calibration or response factor. Choice of calibration model can be based on previous experience with the same analyte or knowledge of the physics of the detector on the instrument where the calibration is performed. To determine the suitability of linear or quadratic calibration, the %RE is calculated, where the calibration data is refitted back to the curve (see section 10.1.7.1.3 for calculation and criteria). The choice of calibration model must not be used to compensate for detector saturation or to avoid proper instrument maintenance.

10.1.7.1.3 The calculation of relative error (%RE) must be performed for two calibration levels, the standard at or near the mid-point of the initial calibration and the standard at the lowest level.

Relative Error is calculated using the following equation:

$$\% \text{ Relative Error} = \frac{x'i - xi}{Xi} \times 100$$

xi = True value for the calibration standard
x'i = Measured concentration of the calibration standard

The Relative Error at lowest level must be within ±50% from the true value. The RE for mid-point level must be within ±30% from the true value. Both levels after calculating %RE must be fitted back into the curve.

10.1.7.2.4 If more than 10% of the compounds included with the initial calibration exceed the 20% RSD limit and do not meet the minimum correlation coefficient for the linear calibration option, then the chromatographic system is considered too reactive for the analysis to begin. Perform corrective action and recalibrate if the calibration criteria cannot be achieved.

10.1.7.2 Below is a table containing minimum RFs that may be used as guidance in determining if the system is behaving properly and as a check to see if calibration standards are prepared correctly. The minimum RFs are determined using not only specific ions but also specific instrument conditions, which may vary from one instrument to another. It is recommended to compare the minimum RFs for target analytes from previous initial calibrations to the minimum RFs form current initial calibration on each instrument to make sure the RFs are stable.
Note: For target analyte, whose RF<0.01 (response of peak is <1/100 the response of the Internal Standard), it is recommended that its concentration in relation to other analytes be increased to make the response more comparable to other analytes

Guidance Response Factor Table for both scan and SIM mode analysis

Semivolatile Compounds	**Minimum Response Factor (RF)**
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-hloroethoxy) 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-Dinitrobenzene	0.200
Diethyl phthalate	0.010
1,2,4,5-Tetrachlorobenzene	0.010
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
1,4 Dioxane	0.010
2,3,4,6-Tetrachlorophenol	0.010

10.1.7.3.1 Due to the large number of compounds, some compounds will fail to meet the minimum response factor criteria. They may be used as qualified data or estimated values for screening purposes. Non-detects may be reported if adequate sensitivity has been demonstrated at the applicable lower quantitation limit.

10.1.7.4 The initial calibration criteria for this method apply to all additional compounds of concern specified by the client.

10.1.7.5 Structural isomers that produce very similar mass spectra are identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is more than 50% of the average of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs. The resolution must be verified on the mid - point concentration of the initial calibration (e.g., benzo(b)fluoranthene and benzo(k)fluoranthene). Print the check and keep it on file.

10.1.8 The laboratory may remove individual analyte calibration levels from the lowest and/or highest levels of the curve. Multiple levels may be removed, but removal of interior levels is not permitted.

10.1.8.1 The laboratory may remove an entire single standard calibration level from the interior of the calibration curve when the instrument response demonstrates that the standard was not properly introduced to the instrument, or an incorrect standard was analyzed. If a calibration standard was removed from the interior of the calibration, this particular standard calibration level must be removed for all analytes. Removal of calibration points from the interior of the curve is not to be used to compensate for lack of maintenance or repair to the instrument.

10.1.8.1.1The laboratory must adjust the LOQ/reporting limit and quantitation range of the calibration based on the concentration of the remaining high and low calibration standards.

10.1.8.1.2 The laboratory must ensure that the remaining initial calibration standards are sufficient to meet the minimum requirements for number of initial calibration points as mandated by the method, or regulatory requirements.

10.1.8.1.3 The laboratory may replace a calibration standard provided that:

a) the laboratory analyzes the replacement standard within twenty-four (24) hours of the original calibration standard analysis for that particular calibration level;

b) the laboratory replaces all analytes of the replacement calibration standard if a standard within the interior of the calibration is replaced; and

c) the laboratory limits the replacement of calibration standards to one calibration standard concentration.

10.1.8.1.4 The laboratory must document a technically valid reason for either removal or replacement of any interior calibration point.

10.2 Initial Calibration Verification (ICV) - Second Source Calibration Check Standard.

10.2.1 The calibration is verified with a calibration check standard at 50 μg/mL (Full scan) or 1 ug/mL (SIM) from a secondary source (Section 9.6). It must be analyzed immediately following the initial calibration.

10.2.2 The percent difference (% D) (Section 13.3) for this standard must meet the criteria of 30% for all the target compounds.

10.2.2.1 If % D is greater than 30%, reanalyze the second source check. If the criteria cannot be met upon re-injection, re-prepare the second source solution using a fresh ampoule and repeat the process.

10.2.2.2 If the %D criteria cannot be achieved after re-preparation of the second source, prepare a third source and repeat the process. Make fresh calibration standards using one of the two standard sources that match each other.

10.3 Continuing Calibration Verification Standard - CCV

10.3.1 A calibration verification standard at close mid-level concentration of the initial calibration range at 50 ug/mL for full scan, 10 ug/mL for full scan LVI, 1 ug/mL for SIM, and 0.2 ug/mL for LVI SIM must be acquired every 12 hrs. The 12-hour clock starts at the time of injection of daily CCV.

10.3.1.1 The calibration verification standard selected must be near concentration of the midpoint calibration standard or near the action level for the project specified.

10.3.2 For the continuing calibration to be valid, all of the following specified criteria must be met.

10.3.2.1 Each of the most common target analytes in the calibration verification standard must meet the minimum response factors as noted in the Minimum Response Factor Table in section 10.1.7.3.

10.3.2.2 All target compounds of interest must be evaluated using 20% D criteria. If the percent difference or percent drift for a compound is less than or equal to 20%, then the initial calibration for that compound is assumed to be valid.

10.3.2.3 Due to the large numbers of compounds that may be analyzed by this method, it is expected that some compounds will fail to meet the 20% D criterion. If the criterion is not met (i.e., greater than 20% difference or drift) for more than 20% of the compounds included in the initial calibration, then corrective action must be taken prior to the analysis of samples.

10.3.2.4 In cases where compounds fail, they may still be reported as non-detects if it can be demonstrated that there was adequate sensitivity to the compound at the applicable quantitation limits. For situation when the failed compound is present, the concentration must be reported as estimated.

10.3.2.4.1 Compounds with response factors that exceed the 20% D in the CCV compared to the initial calibration with high bias may be still reported when as non-detect, or in cases where the failed compound is present, the concentration must be reported as estimated value.

10.3.2.4.2 Compounds that do not meet the 20% D in the CCV compared to the initial calibration due to low response factors can only be reported if the low sensitivity of the instrument is still achieved. This sensitivity must be verified by running a low-level standard check at reporting limit. If a positive result for the compound is found, then adequate sensitivity has been demonstrated and the run can proceed.

10.3.2.5 The resolution check for structural isomers must be verified for each CCV standard Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 50% of the average of the two peak heights. Otherwise structural isomers are identified as isomeric pairs. Print the check and keep it on file.

10.3.3 If the first continuing calibration verification does not meet criteria, a second standard may be injected after notifying the team leader/manager and checking the system for defects.

10.3.3.1 A continuing calibration check is allowed to be repeated only once; if the second trial fails, a new initial calibration must be performed or refer to section 10.3.2.4. In situations where the first check fails to meet the criteria, the instrument logbook must have clearly documented notations as to what the problem was and what corrective action was implemented to enable the second check to pass.

10.3.4 If the verification criteria cannot be achieved, a new initial calibration must be performed or refer to section 10.3.2.4.

10.3.5 If any of the internal standard areas change by a factor of two (- 50% to + 100%) or the retention time changes by more than 30 seconds from the midpoint standard of the last initial calibration, the mass spectrometer must be inspected for malfunctions and corrections must be made, as appropriate.

10.3.5.1 Reanalyze the continuing calibration standard. New initial calibration is required if reanalyzed standard continues to fail the internal standard requirements.

10.3.5.2 All samples analyzed while the system was out of control must be reanalyzed following corrective action.

11.0 PROCEDURE

11.1 Instrument Conditions.

11.1.1 Recommended instrument conditions are listed in Table 2 and 2a (SIM only). Modifications of parameters specified with an asterisk are allowed as long as criteria of calibration are met. Any modification must be approved by team leader/manger. DFTPP, Standards, QC and samples must all be run under the exact same operating conditions, including EM voltage.

11.2 GC/MS Performance Checks.

11.2.1 Mass Spectrometer Tuning. Inject 1 μL of 50 ng/μL DFTPP solution directly on to the column.

11.2.2 The GC/MS system must be checked to verify that acceptable performance criteria are achieved (see Table 3).

11.2.3 **This performance test must be passed before every initial calibration curve.** Evaluate the tune spectrum using three mass scans from the chromatographic peak and a subtraction of instrument background.

11.2.3.1 Select the scans at the peak apex and one to each side of the apex.

11.2.3.2 Calculate an average of the mass abundances from the three scans.

11.2.3.3 Background subtraction is required. Select a single scan in the chromatogram that is absent of any interfering compound peak and acquired within no more than 20 scans to the elution of DFTPP. The background subtraction must be designed only to eliminate column bleed or instrument background ions. Do not subtract part of the tuning compound peak.

11.2.4 If all the criteria are not achieved, the analyst must retune the mass spectrometer with team leader/manager and repeat the test until all criteria are met.

11.2.4.1 Alternatively, an additional scan on each side of the peak apex may be selected and included in the averaging of the mass scans. This will provide a mass spectrum of five averaged scans centered on the peak apex. NOTE: The selection of additional mass scans for tuning may only be performed with supervisory approval on a case by case basis.

11.2.5 In order to assess GC column performance and injection port inertness, the DFTPP tune standard also contains appropriate amount of 4,4'-DDT, benzidine and pentachlorophenol.

11.2.6 All subsequent standards, samples, MS/MSDs, and blanks associated with a DFTPP analysis must use the identical mass spectrometer instrument conditions.

11.2.6.1 Injection Port Inertness Check.

11.2.6.1.1 The injection port inertness of the GC portion of the GC/MS is evaluated by the percent breakdown of 4,4'-DDT. DDT is easily degraded in the injection port. Breakdown occurs when the injection port liner is contaminated by high boiling residue from sample injection or when the injector contains metal fittings. Check for degradation problems by injecting a GC/MS tune standard containing 4,4'-DDT , regardless of whether DDT is a target analyte. The degradation of DDT to DDE and DDD must not exceed 20%, in order to proceed with calibration procedures. Refer to Section 13.7 for calculation. Print the check and keep it on file.

11.2.6.2 Column Performance Check.

11.2.6.2.1 The condition of the GC column is evaluated by the tailing of benzidine and pentachlorophenol. Benzidine and pentachlorophenol must be present at their normal responses, with no visible peak tailing, as demonstrated by the peak tailing factors. The tailing factor criteria for benzidine (base-neutral fraction) must be $\leq$ 2 and for pentachlorophenol (acid fraction) must be $\leq$ 2. Print the check daily and keep on file:

11.2.6.3 If degradation is excessive and/or poor chromatography is observed, the injector port may require cleaning. It may also be necessary to break off the first 6-12 in. of the capillary column.

11.3 Initial Calibration

11.3.1 Refer to Section 10.1.

11.4 Initial calibration Verification (ICV) - Second Source Calibration Check

11.4.1 This standard must at least be analyzed when initial calibration provided. Refer to Section 10.2.

11.5 Continuing Calibration Checks

11.5.1 Refer to Section 10.3.

11.6 Sample Analysis.

11.6.1 Allow the sample extract (preparation procedure detailed in SOP EOP001, 003 or 3546) to warm to room temperature. Spike 10 µl of the appropriate internal standard mix (4,000 µg/mL for full scan and 400ug/mL for SIM) into 1 mL of sample extract, just prior to analysis. This is equivalent to a concentration of 40 µg/mL (full scan) and 4ug/mL (SIM) of each internal standard.1,4-Dioxane-d8 is added prior to extraction for isotopic dilution. For LVI, each sample extract will be spiked with 2 µl of internal standard mixtures.

11.6.2 Inject 1 µL aliquot of the sample extract into the GC/MS system. A split injection technology is used.

11.6.3 If the responses for any of the ions of interest exceed the working range of the GC/MS system, dilute a stored extract if available and reanalyze.

11.6.4 When the extracts are not being used for the analysis, store them at -10ºC, protected from light, in sealed vials equipped with unpierced PTFE-lined septa.

11.7 Sample Dilution

11.7.1 Establish dilutions of samples in order for detected targets to fall within the calibration range or to minimize matrix interference.

- Utilize screen data (specific project only).
- Utilize acquired sample data.
- Utilize the history program or approval from client/project.
- Sample characteristics (appearance, odor).

11.7.2 If no lower dilution has been reported, the dilution factor chosen must keep the response of the largest peak for a target analyte in the upper half of the initial calibration range of the instrument.

11.7.3 Preparing Dilutions.

11.7.3.1 Prepare sample dilutions quantitatively. Dilute the sample extract with methylene chloride using logical volume to volume ratios, i.e., 1:5, 1:10, 1:50, etc. Large dilutions may require serial dilutions or the use of a Class A 10 mL volumetric flask.

11.7.3.2 Syringe dilutions. – Calibrated syringes are used to prepare dilutions. Add the appropriate amount of methylene chloride to a clean autosampler vial. Add the proper amount of sample using a calibrated syringe of the appropriate volume for the dilution. Add sufficient internal standard to maintain a concentration of 40ug/mL. Cap the vial and gently shake to disperse the sample through the solvent.

11.7.3.3 Volumetric Flask Dilutions – Large dilutions may require the use of a 10 mL or larger Class A Volumetric flask.

11.8 Establishing Search Criteria for target compounds. Search criteria for each compound listed in the method must be entered into the method quantitation/identification file in the Enviroquant software package. This activity must be performed before attempting qualitative and quantitative analysis on any acquired data file. The search criteria are based on compound retention time and the characteristic ions from the reference mass spectrum. Characteristic ions are defined as 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. The number of secondary ions displayed for each compound search varies between compounds.

11.8.1 Select the primary ion for the target compound from the characteristic ions in Table 6. If multiple characteristic ions are listed, the first ion is the major (primary) ion. Enter this ion as the search ion. Enter the relative abundance of this ion (100% for base peak ions) and set the relative abundance window at ± 30%.

11.8.1.2 Alternate primary ions may be selected when interferences exist from ion abundance contribution from close eluting compounds.

11.8.2 Enter the remaining ions as secondary ions. Secondary ions are not be used to locate peaks within the search window but are be used to support the qualitative identification of selected peaks. The number of secondary ions displayed for each compound search varies between compounds depending on the number of ions in the spectra >30% relative abundance.

11.8.3 Set the relative abundance windows for the secondary ions at ± 30%.

11.8.4 The qualitative identification of compounds determined by this method is based on retention time (RT). The RT must be within ±10 seconds of the RT for this analyte in the CCV run at the beginning of the 12-hour period (delta RT0.17 minute) or within ±10 seconds relative to the shift of the associated internal standard (delta RT of the IS±10 seconds).

11.9 Data Interpretation.

11.9.1 Executing Qualitative Searches. The target compounds shall be identified by analyst with competent knowledge in the interpretation of mass spectra by comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound.

11.9.1.1 The search procedure will identify peaks within the search window using the primary ion only. Secondary ions and the relative retention are used to determine “the best match”. If the best match contains secondary ions outside the relative abundance window, they will be flagged with a # sign.

11.9.2 Qualitative Identification. The qualitative identification of compounds determined by this method is based on retention time and on comparison of the sample mass spectrum, after background correction, with characteristic ions in a reference mass spectrum. Compounds are identified when the following criteria are met.

11.9.2.1 The intensities of the characteristic ions of a compound must maximize in the same scan or within one scan of each other.

11.9.2.2 The absolute retention time (RT)must be within ±10 seconds of the retention time for this analyte in the daily standard (CCV) run at the beginning of the 12-hour period (delta RT 0.17 minute) or within ±10 seconds relative to the shift of the associate internal standard (IS) (delta RT of the IS ± 10 seconds). If RT drift is significant, relative retention time (RRT) may be used as an alternative to delta RTs. The RRT of the analyte in the sample should be within RRT limits of the analyte in the standards.

$$\text{RRT} = \frac{\text{RT of the analyte}}{\text{RT of the IS}}$$

11.9.2.3 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%).

11.9.2.3.1 If a chromatographic peak exhibits a spectrum containing an ion with relative abundance outside the relative abundance window is selected for reporting, the analyst must annotate the spectra that the compound qualified based on his/her best judgement. This circumstance will most often occur from coeluting compounds with similar ions or background matrix interferences.

11.9.3 Quantitative Analysis.

11.9.3.1 Once a target compound has been identified, its concentration (Section 13.4) will be based on the integrated area of the quantitation ion, normally the base peak (Table 6). The compound is quantitated by internal standard technique with an average response factor generated from the initial calibration curve. 1,4-Dioxane via SIM is analyzed via Isotope Dilution.

11.9.3.2 If the sample produces interference for the primary ion, use a secondary ion to quantitate. This may be characterized by an excessive background signal of the same ion, which distorts the peak shape beyond a definitive integration. Also, interference could severely inhibit the response of the internal standard ion. The secondary ion must be used to generate a new response factor.

11.10 Library Search for Tentatively Identified Compounds.

11.10.1 If a library search is requested, the analyst must perform a forward library search of the NIST08 mass spectral library to tentatively identify 10 to 15 non-reported compounds (15 for base, 10 for acid, 25 for base/acid fraction).

11.10.2 Guidelines for making tentative identification are listed below.

11.10.2.1 These compounds must have a response greater than 10% of the nearest internal standard. The response is obtained from the integration for peak area of the Total Ion Chromatogram (TIC).

11.10.2.2 The search is to include a spectral printout of the 3 best library matches for a particular substance. The results are to be interpreted by analyst.

11.10.2.3 Molecular ions present in the reference spectrum must be present in the sample spectrum.

11.10.2.4 Relative intensities of major ions in the reference spectrum (ions > 10 % of the most abundant ion) must be present in the sample spectrum.

11.10.2.5 The relative intensities of the major ions must agree within ± 20 %. (Example: For an ion with an abundance of 50% in the standard spectrum, the corresponding sample ion abundance must between 30 and 70%).

11.10.2.6 Ions present in the sample spectrum but not in the reference spectrum must be reviewed for possible background contamination or presence of coeluting compounds.

11.10.2.7 Ions present in the reference spectrum but not in the sample spectrum must be verified by performing further manual background subtraction to eliminate the interference created by coeluting peaks and/or matrix interference.

11.10.3 Quantitation of the tentatively identified compounds is obtained from the total ion chromatogram based on a response factor of 1 and is to be tabulated on the library search summary data sheet.

11.10.4 The resulting concentration must be reported indicating: (1) that the value is estimate, and (2) which internal standard was used to determine concentration. Quantitation is performed on the nearest internal standard.

11.10.5 Peaks that are suspected to be aldol-condensation reaction products (i.e., 4-methyl-4-hydroxy-2-pentanone and 4-methyl-3-pentene-2-one) shall be searched and reported but not counted towards the total TIC count.

11.10.6 Any peak naming as “System artifact” (from the column bleedings) or “Internal Standard” (added by lab for other test, like SIM analysis) shall be searched and reported but not counted towards the total TIC count.

11.11 Selected Ion Monitoring (SIM) Option

NOTE: The use of SIM is not allowed by the SCDHEC for samples from South Carolina.

11.11.1 Instrument Set-Up: Modify the method for SIM analysis and define ion groups with retention times, ions and dwell times to include base peak ion for the target compounds of interest, surrogates, and internal standards (Table 2a, Table 8a). Select a mass dwell time of 50 milliseconds for all compounds.

11.11.2 Calibration: Calibrate the mass spectrometer in the selected ion monitoring mode using 7 calibration standards of 0.02, 0.05, 0.10, 0.20, 1.0, 2.5, 5.0 µg/ml. Use 0.02, 0.05, 0.1, 0.2, 0.5, 1.0, 2.5, 5.0, 10.0, 20.0 ug/ml for calibration of 1,4-Dioxane by SIM isotopic dilution. Spike each standard with the SIM specific internal standard solution at 4ug/mL (1,4-Dioxane-d8 is calibrated using 20ug/mL). Calculate individual response factors and response factor RSDs using the procedures and criteria described in Section 10.1.6, 10.1.7.3 and 10.1.7.4.

11.11.3 Initial Calibration Verification. Verify the initial calibration after its completion using a 1.0 µg/mL calibration standard purchased or prepared from a second standards reference materials source. The initial calibration verification must meet the criteria of Section 10.2.2.

11.11.4 Continuing Calibration Verification. Verify the initial calibration every 12 hours using a 1.0 or 0.5 µg/mL calibration. The continuing calibration verification must meet the criteria of Section 10.3.

11.11.5 Sample Extract Analysis: Each extract has been previously spiked with the SIM internal standard at 4µg/mL. Analyze the sample extracts for the compounds of interest using the SIM scan parameters employed for the calibration standards.

11.11.6 Surrogate Standard Calculation. Report surrogate spike accuracy for the surrogates spiked for the full scan GC/MS analysis at 50µg/ml.

12.0 QUALITY CONTROL

12.1 QC Requirements Summary.

Daily GC/MS Performance Checks	Before initial calibration
Initial Calibration	Whenever needed.
Second Source Calibration Check	Following initial calibration
Continuing Calibration Verification	Every 12 hours.
Method Blank	One per extraction batch*.
Blank Spike	One per extraction batch*.
Matrix Spike	One per extraction batch*.
Matrix Spike Duplicate	One per extraction batch*.
Surrogate	Every sample extract and standard.
Internal Standard	Every sample extract and standard.

*The maximum number of samples per batch is twenty or per project specification.

12.2 Daily GC/MS Performance Checks.

12.2.1 Refer to Section 11.2.

12.3 Initial Calibration.

12.3.1 Refer to Section 10.1.

12.4 Initial Calibration Verification (ICV) - Second Source Calibration Check.

12.4.1 Refer to Section 10.2.

12.5 Continuing Calibration Verification.

12.5.1 Refer to section 10.3.

12.6 Method blank.

12.6.1 The method blank is either reagent water or anhydrous sodium sulfate (depending on the sample matrix) which must be extracted with each set of 20 or less samples. For a running batch, a new method blank is required for each different extraction day. The method blank is then extracted and carried through all stages of the sample preparation and measurement.

12.6.2 If the method blank contains a target analyte above its MDL, the entire batch must be re-extracted and re-analyzed.

12.6.2.1 A method blank may be acceptable if it is less than 5% (20x) of the sample result for the same analyte.

12.6.3 Surrogate compounds are added to the method blank prior to extraction. If the surrogate accuracy in the method blank does not meet in house criteria, it must be reanalyzed. If the reanalysis confirms the original data, the entire batch must be re-extracted.

12.7 Blank Spike

12.7.1 A blank spike must be extracted with each set of 20 or less samples. For a running batch, a new blank spike is required for each different extraction day. The blank spike consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same volume. It is spiked with the same analytes at the same concentrations as the matrix spike/matrix spike duplicate.

12.7.2 The blank spike recoveries must be assessed using laboratory in house limits.

12.7.3 If a blank spike is out of control, the following corrective actions must be taken, and all the associated samples must be re-extracted and reanalyzed. The exception is if the blank spike recovery is high and no hits reported in associated samples and QC batch. In that case, the sample results can be reported with footnote (remark) and no further action is required.

12.7.3.1 Check to be sure that there are no errors in the calculations, or spike solutions. If errors are found, recalculate the data accordingly.

12.7.3.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample batch.

12.7.3.3 If no problem is found, re-extract and reanalyze the sample batch.

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

12.8.1 One sample is randomly selected from each extraction batch and spiked in duplicate to assess the performance of the method as applied to a particular matrix and to provide information on the homogeneity of the matrix. Both the MS and MSD are carried through the complete sample preparation, and determinative procedures.

12.8.2 Matrix spikes are prepared by spiking an actual sample at a concentration of 50 μg/l for both base/neutral and acids.

12.8.3 Assess the matrix spike recoveries (% R) (Section 13.5) and relative percent difference (RPD) (Section 13.6) against the in-house control limits.

12.8.4 If the matrix spike accuracy of any individual compound is out of control, the accuracy for the compound in the blank spike must be within control. In such case, matrix interference is assumed, and the data is reported with footnote (e.g., spike recovery indicates possible matrix interference). No further corrective action is required.

12.9 Surrogates

12.9.1 All standards, blanks, sample extracts, and matrix spikes contain surrogate compounds which are used to monitor the performance of the extraction and analytical system.

12.9.2 The recoveries (Section 13.5) of the surrogates must be evaluated to determine whether or not they fall within surrogate control limits developed by the laboratory annually.

12.9.3 If the recovery of any surrogate compound does not meet the control limits, the calculation must be checked for possible error. The surrogate solution must be checked for degradation. Contamination and instrument performance must also be reviewed.

12.9.3.1 Reanalyze the extract if no calculation errors are detected. If the surrogate recoveries for the reanalyzed extract are in control, report the data from the reanalysis only.

12.9.3.2 If the data from the reanalysis is also out of control, re-extract and reanalyze the sample. The testing of concrete or gravel samples may result in low acid fraction surrogate recovery and re-extraction is not necessary. Surrogates will be properly footnoted in the report to reflect this.

12.9.3.3 If, upon reanalysis, the surrogate recoveries are acceptable, report the reanalysis data. If the holding time has expired prior to the reanalysis, report both the original and reanalysis results and note the holding time problem.

12.9.3.4 If the recovery is again not within limits, the problem is considered to be matrix interference. Submit both data sets with the original analysis being reported.

12.9.4 If the sample exhibits matrix interference, defined as excessive signal where target or non-target responses are greater than the response of the internal standards. In this case, reanalysis may not be required following team leader/manager approval; the surrogates will be qualified as outside the limits due to matrix interference. Alternatively, sample may be reanalyzed on dilution, if the reanalysis is again not within the limit, the sample must be reported with a footnote indicating that there was possible matrix interference.

12.9.5 If any two or more surrogates for any one fraction (base-neutral or acid) are outside of recovery limits or if any one surrogate recovers at <10%, the sample must be re-extracted and re-analyzed to confirm matrix interference. If a surrogate is diluted to a concentration below that of the lowest calibration standard, no corrective active is necessary.

12.10 Internal Standards.

12.10.1 Retention time for all internal standards must be within ± 30 seconds of the corresponding internal standard in the latest continuing calibration or 50 μg/mL standard of initial calibration.

12.10.2 The area (Extracted Ion Current Profile) of the internal standard in all analyses must be within 50 to 200 % of the corresponding area of the latest calibration standard (12 hr. time period).

12.10.3 If the area of internal standard does not meet control limits, the calculations must be checked. If a problem is not discovered, the sample must be reanalyzed.

12.10.4 If the areas are acceptable upon reanalysis, the reanalysis data is reported.

12.10.5 If the areas are unacceptable upon reanalysis, then both sets of data are submitted with the original analysis reported.

12.11 Refer to Project Specific Bench Notes (MS8270) for additional program or client specific QC Requirements

13.0 CALCULATION

13.1 Response Factor (RF).

$$RF = \frac{A_s \times C_{is}}{A_{is} \times C_s}$$

where:
A_s = Area of the characteristic ion for the compound being measured.
A_{is} = Area of the characteristic ion for the specific internal standard.
C_s = Concentration of the compound being measured (μg/mL).
C_{is} = Concentration of the specific internal standard (μg/mL).

13.2 Percent Relative Standard Deviation (%RSD).

$$\%RSD = \frac{SD}{RF_{av}} \times 100$$

where:
SD = Standard Deviation.
RF_{av} = Average response factor from initial calibration.

13.3 Percent Difference (%D).

$$\% D = \frac{| RF_{av} - RF_{cv} |}{RF_{av}} \times 100$$

where: RF_{cv} = Response factor from Calibration Verification Standard.

13.4 Concentration (Conc.).

13.4.1 for water:

$$\text{Conc. } (\mu g/l) = \frac{A_s \times C_{is} \times V_f \times D \times 1000}{A_{is} \times RF_{av} \times V_i}$$

13.4.2 for soil/sediment (on a dry weight basis):

$$\text{Conc. } (\mu g/kg) = \frac{A_s \times C_{is} \times V_f \times D \times 1000}{A_{is} \times RF_{av} \times W_s \times S}$$

where:
V_f = Final Volume of total extract (mL).
D = Secondary dilution factor.
V_i = Initial volume of water extracted (mL).
W_s = Weight of sample extracted (g).
S = (100 - % moisture in sample) / 100.

13.5 Percent Recovery (%R).

$$\% R = \frac{\text{Concentration found}}{\text{Concentration spiked}} \times 100$$

13.6 Relative Percent Difference (RPD).

$$RPD = \frac{\left| MSC - SDC \right|}{(1/2)(MSC+MSDC)} \times 100$$

where:

MSC = Matrix Spike Concentration.
MSDC = Matrix Spike Duplicate Concentration.

13.7 Percent Breakdown.

$$\% \text{ Breakdown for DDT} = \frac{\text{Total DDT degradation peak area}}{\text{Total DDT peak area}} \times 100$$

where:
Total DDT degradation peak area = DDE + DDD
Total DDT peak area = DDT + DDE + DDD.

13.8 Linear regression by the internal standard technique.

$$C_s = \left(\frac{\frac{A_s}{A_{is}} - b}{a} \right) \times C_{is}$$

Where:
Cs = concentration of target analyte
As = Area of target analyte
Cis = concentration of the internal standard
b = Intercept
a = slope of the line

$$a = \frac{N\,\Sigma xy - \Sigma x\,\Sigma y}{N\,\Sigma x^2 - (\Sigma x)^2}$$

$$b = \frac{\Sigma y - a\,\Sigma x}{N}$$

N = number of points
x = amount of analyte
y = response of instrument

13.9 Quadratic curve with internal standard technique

$$C_s = \frac{-b \pm \sqrt{b^2 - 4a\left(c - \frac{A_s \times C_{is}}{A_{is}}\right)}}{2a}$$

Where:
Cs = concentration of target analyte
As = Area of target analyte
Cis = concentration of the internal standard
b = Intercept
a = slope of the line

13.10 Correlation Coefficient

$$r = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma(x - \bar{x})^2\,\Sigma(y - \bar{y})^2}}$$

Where r = correlation coefficient
x = amount of analyte
y = response of instrument

$\bar{x}$ = average of x values

$\bar{y}$ = average of y values

14.0 DOCUMENTATION

14.1 The Analytical Logbook is a record of the analysis sequence; the logbook must be completed daily. Each instrument will have a separate logbook.

14.1.1 If samples require reanalysis, a brief explanation of the reason must be documented in this log.

14.1.2 Overwriting of data files is never allowed.

14.2 The Standard Preparation Logbook must be completed for all standard preparations. All information requested must be completed; the page must be signed and dated by the respective person.

14.2.1 The SGS Lot Number must be cross-referenced on the standard vial.

14.3 The Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. Each instrument has a separate log.

14.4 Any corrections to laboratory data must be done using a single line through the error. The initials of the person and date of correction must appear next to the correction.

14.5 Unused blocks of any form must be X'ed or Z'ed out by the analyst before submitting the data for review.

14.6 Supervisory (or peer) personnel must routinely review (at least once per month) all laboratory logbooks to ensure that information is being recorded properly. Additionally, the maintenance of the logbooks and the accuracy of the recorded information must also be verified during this review.

15.0 DATA REVIEW AND REPORTING

15.1 Initial and continuing calibration check. Verify that all calibration and continuing calibration criteria have been achieved. If the criteria had not been achieved, corrective action must be performed to bring the system in control before analyzing any samples.

15.1.1 If samples had been analyzed under non-compliant calibration criteria, all sample extracts must be re-analyzed once the system is brought into control.

15.2 Quality Control Data Review. Review all QC data. If QC criteria were not achieved, perform corrective action before proceeding with analysis.

15.2.1 In some situation, corrective action may demand that the entire sample batch be re-extracted and re-analyzed before processing data.

15.3 Chromatogram Review. The chromatogram of each sample is evaluated for target analytes.

15.3.1 Each sample may require the reporting of different target analytes. Review the login to assure that the correct target compounds are identified.

15.3.2 Manual integration of chromatographic peaks must be identified by the analysts. Upon review, the supervisor will initial and date the changes made to the report.

15.4 Transfer to LIMS. Following the initial screen review, transfer the processed data to the LIMS.

15.4.1 Compare the printed values to the original values to verify transfer accuracy.

15.4.2 If transfer errors occurred, the errors must be corrected before the data is re-submitted.

16.0 POLLUTION PREVENTION & WASTE MANAGEMENT

16.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 16.2.

16.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

16.2.1 Non-hazardous aqueous wastes.
16.2.2 Hazardous aqueous wastes
16.2.3 Chlorinated organic solvents
16.2.4 Non-chlorinated organic solvents
16.2.5 Hazardous solid wastes
16.2.6 Non-hazardous solid wastes

Table 1 – Target Compounds by SW846 8270E			
Benzenethiol	4-Bromophenyl phenyl ether	Di-n-octyl phthalate	5-Nitro-o-toluidine
Benzoic Acid	Butyl benzyl phthalate	Diethyl phthalate	Naphthalene
2-Chlorophenol	Benzyl Alcohol	Dimethyl phthalate	Nitrobenzene
4-Chloro-3-methyl phenol	1,1'-Biphenyl	2,3-Dichloroaniline	n-Nitrosodimethylamine

2,4-Dichlorophenol	Butyl Stearate	Decane	4-Nitroquinoline 1-Oxide
2,4-Dimethylphenol	2-Chloronaphthalene	Octadecane	N-Nitroso-di-n-propylamine
2,4-Dinitrophenol	4-Chloroaniline	bis(2-Ethylhexyl)phthalate	N-Nitrosodi-n-butylamine
2,6-Dichlorophenol	Carbazole	Ethyl methanesulfonate	N-Nitrosodiethylamine
4,6-Dinitro-2-methylphenol	Caprolactam	Famphur	N-Nitrosodiphenylamine
Dinoseb	Chlorobenzilate	Fluoranthene	N-Nitrosomethylethylamine
2-Methylphenol	Chrysene	Fluorene	N-Nitrosomorpholine
3&4-Methylphenol	Cumene	Hexachlorobenzene	N-Nitrosopiperidine
2-Nitrophenol	bis(2-Chloroethoxy)methane	Hexachlorobutadiene	N-Nitrosopyrrolidine
4-Nitrophenol	bis(2-Chloroethyl)ether	Hexachlorocyclopentadiene	O,O,O-Triethyl phosphorothioat
Pentachlorophenol	bis(2-Chloroisopropyl)ether	Hexachloroethane	2-Picoline
Phenol	4-Chlorophenyl phenyl ether	Hexachlorophene	Parathion
2,3,4,6-Tetrachlorophenol	1,2-Dichlorobenzene	Hexachloropropene	Pentachloroethane
2,4,5-Trichlorophenol	1,2-Diphenylhydrazine	Indene	Pentachlorobenzene
2,4,6-Trichlorophenol	1,3-Dichlorobenzene	Indeno(1,2,3-cd)pyrene	Pentachloronitrobenzene
2-Acetylaminofluorene	1,4-Dichlorobenzene	Isodrin	Phenacetin
4-Aminobiphenyl	2,4-Dinitrotoluene	Isophorone	Phenanthrene
Acenaphthene	2,6-Dinitrotoluene	Isosafrole	Phorate
Acenaphthylene	3,3'-Dichlorobenzidine	Kepone	Pronamide
Acetophenone	3,3'-Dimethylbenzidine	1-Methylnaphthalene	Pyrene
Aniline	1,4-Dioxane	2-Methylnaphthalene	Pyridine
Anthracene	7,12-Dimethylbenz(a)anthracene	3-Methylcholanthrene	p-Phenylenediamine
Aramite	Dimethylnaphthalenes (total)	4,4'-Methylenebis(2-chloroaniline)	Quinoline
Atrazine	Diallate	Methapyrilene	Safrole
alpha-Terpineol	Dibenz(a,h)acridine	Methyl methanesulfonate	1,2,4,5-Tetrachlorobenzene
A,A-Dimethylphenethylamine	Dibenzo(a,h)anthracene	Methyl parathion	1,2,4-Trichlorobenzene
Benzidine	Dibenzofuran	6-Methyl Chrysene	1,2,3-Trichlorobenzene
Benzaldehyde	Dimethoate	1,4-Naphthoquinone	1,3,5-Trichlorobenzene
Benzo(a)anthracene	Diphenylamine	1-Naphthylamine	Thionazin
Benzo(a)pyrene	Disulfoton	2-Naphthylamine	o-Toluidine
Benzo(b)fluoranthene	m-Dinitrobenzene	2-Nitroaniline	sym-Trinitrobenzene
Benzo(g,h,i)perylene	p-(Dimethylamine) azobenzene	3-Nitroaniline	Tetraethyl dithiopyrophosphate
Benzo(k)fluoranthene	Di-n-butyl phthalate	4-Nitroaniline	

Table 2 – RECOMMENDED OPERATING CONDITIONS: Gas Chromatograph/ Mass Spectrometer	
Injection Type	Splitless
Carrier Gas (linear velocity)	Helium at 30 cm/sec*
Mass range	35-500 AMU
Electron Energy	70 volts (nominal)
Scan time	not to exceed 1 sec. per scan
Injection port temperature	200-300 °C
Source temperature	220-270 °C
Transfer line temperature	250-300 °C
Analyzer temperature	220-250 °C
Injection volume	1 ul (5 ul for LVI)
Gas Chromatograph Temperature Program*	
Initial temperature	40-50 °C*
Time 1	2-4 minutes*
Column temperature rate	8-25 degrees/min*
Final temperature	290-320 °C according to column type*
Total run time	*20-40 minutes*

***** Parameter modification allowed for performance optimization as long as QC criteria are achieved.

Table 2a – SIM Group Parameters		
Group No.	**Retention Time (minutes)**	**Ions**
1	0 – 7.8	150, 64, 93, 82, 152, 99, 63, 128, 112, 42, 95, 88, 58
2	7.8 – 11	150, 128, 225, 142, 172, 152, 129, 223, 141, 171, 122, 127, 227, 115, 170
3	11 – 13.8	172, 152, 166, 182, 334, 266, 176, 153, 165, 330, 284, 264, 174, 154, 77, 332, 286, 268
4	13.8 – 18	266, 179, 202, 122, 268, 212, 203, 284, 178, 213, 244, 286
5	18 – 22	244, 229, 167, 122, 226, 202, 228, 149, 203
6	22 – 34.7	264, 149, 253, 278, 263, 150, 250, 139, 265, 252, 276, 138

Table 3 - DFTPP KEY IONS AND ION ABUNDANCE CRITERIA	
Mass	**Ion Abundance Criteria**
51	30-60 of mass 198
68	<2 % of mass 69
70	<2 % of mass 69
127	40-60 % of mass 198
197	<1 % of mass 198
198	Base peak, 100 % relative abundance
199	5-9 % of mass 198
275	10-30 % of mass 198
365	>1 % of mass 198
441	Present but less than mass 443
442	>40 % of mass 198
443	17-23 % of mass 442

Table 4 – INTERNAL STANDARDS	
Internal Standard (Full Scan)	**Prim/Sec. ions**
1,4-Dichlorobenzene-d4	152 / 150, 115
Naphthalene-d8	136 / 68
Acenaphthene-d10	164 / 162, 160
Phenanthrene-d10	188 / 94, 80
Chrysene-d12	240 / 120, 236
Perylene-d12	264 / 260, 265
Internal Standard (SIM)	**Prim/Sec. ions**
1,2-Dichlorobenzene-d4	152/ 150
1-Methylnaphthalene-d10	150/ 152, 122
Fluorene-d10	174/ 176
Fluoranthene-d10	212/ 213
Benzo(a)pyrene- d12	264/ 263, 265
1,4-Dioxane-d8	96/ 64

Table 6 – Full Scan Semivolatile Internal Standards with Corresponding Analytes Assigned for Quantitation			
1,4-Dichlorobenzene-d4	**Ions**	**Acenaphthene-d10**	**Ions**
Aniline	(93/66,65)	Acenaphthene	(154/153,152)
Benzaldehyde	(105)	Acenaphthylene	(152/151,153)
Benzenethiol	(110)	1-Chloronaphthalene	(162/127,164)
Benzyl alcohol	(108/79,77)	2-Chloronaphthalene	(162/127,164)
Bis(2-chloroethyl)ether	(93/63,95)	4-Chlorophenylphenyl ether	(204/206,141)
Bis (2-chloroisopropyl)ether	121	Dibenzofuran	(168/139)
2-Chlorophenol	(128/64,130)	Diethyl phthalate	(149/177,150)
Cumene	(105,120)	Dimethyl phthalate	(163/149,164)
Decane	(43)	m-Dinitrobenzene	(168)
1,3-Dichlorobenzene	(146/148,111)	2,4-Dinitrophenol	(184/63,154)
1,4-Dichlorobenzene	(146/148,111)	2,4-Dinitrotoluene	(165/63,89)
1,2-Dichlorobenzene	(146/148,111)	2,6-Dinitrotoluene	(165/63,89)
1,4 Dioxane	(88, 58)	Fluorene	(166/165,167)
Ethyl methanesulfonate	(79/109,97)	Hexachlorocyclopentadiene	(295/237,142)
2-Fluorophenol (SURR.)	(112)	1,4 – Naphthoquinone	(158)
Hexachloroethane	(117/201,199)	1- Naphthylamine	(143/115,116)
Indene	(116)	2- Naphthylamine	(143/115,116)
Methyl methanesulfonate	(80/79,64)	2-Nitroaniline	(65/92,138)
2-Methylphenol	(108/107,79)	3-Nitroaniline	(138/108,92)
4-Methylphenol	(108/107,79)	4-Nitroaniline	(138/108,92)
N-Nitrosodiethylamine	(102)	4-Nitrophenol	(139/109,65)
N-Nitrosodimethylamine	(74/42)	5 Nitro-o-toluidine	(152)
N-Nitroso-di-n-propylamine	(70/101,130)	Pentachlorobenzene	(250/252,248)
N-Nitrosomethyethylamine	(42)	Pentachloronitrobenzene	(237/235,272)
N-Nitrosomorpholine	(56)	Phenacetin	(108/109,179)
N-Nitrosoptrrolidine	(41)	Phorate	(75)
O-Toluidine	(106)	Pronamide	(173/175,145)
Petachloroethane	(167)	1,2,4,5-Tetrachlorobenzene	(216/214,218)
Phenol	(94)	2,3,4,6-Tetrachlorphenol	(232/230,131)
Phenol-d5 (SURR.)	(99)	Tetraethyldithiopyrophosphate	(322)
2-Picoline	(93/66,92)	Thioazin	(143)
Pyridine	(79)	2,4,6-Trichlorophenol	(196/198,200)
		2,4,5-Trichlorophenol	(196/198,200)

Table 6 (cont'd) – Full Scan Semivolatile Internal Standards with Corresponding Analytes Assigned for Quantitation

Naphthalene-d8	**Ions**	**Phenanthrene-d10**	**Ions**
A,A-Dimethylphenethylamine	(58)	4-Aminobiphenyl	(169/168,170)
Acetophenone	(105/77,51)	Anthracene	(178/176,179)
Benzoic acid	(184/92,185)	Atrazine	(58)
Bis(2-chloroethoxy)methane	(93/95,123)	4-Bromophenyl phenyl ether	(248/250,141)
Caprolactam	(55)	Carbazole	(167)
4-Chloroaniline	(127)	Diallate	(86)
4-Chloro-methylphenol	(107/144)	Dimethoate	(87)
2,3 Dichloroaniline	(161)	Di-n-Butyl phthalate	(149/150)
2,4-Dichlorophenol	(162/164,98)	4,6-Dinitro-2-methylphenol	(198/51,105)
2,6-Dichlorophenol	(162/164,98)	Dinoseb	(211)
Dimethylnaphthalene	(156)	Diphenylamine	(169/168,167)
2,4-Dimethylphenol	(122/107)	1,2-Diphenylhydrazine	(77/105)
a,a-Dimethyl-phenethylamine	(58/91,42)	Disulfoton	(88)
Hexachlorobutadiene	(225/223,227)	Fluoranthene	(202/101,203)
Hexachloroprene	(213)	2-Fluorobiphenyl (SURR)	(172)
Isophorone	(82/95,138)	Hexachlorobenzene	(284/142,249)
Isosafrole	(127)	Isodrin	(193)
1-Methylnaphthalene	(142)	Methapyriline	(58)
2-Methylnaphthalene	(142/141)	Methyl Parathion	(125)
Naphthalene	(128/129,127)	N-Nitrosodiphenylamine	(169/168,167)
Nitrobenzene	(77/123,65)	4-Nitroquinoline 1-oxide	(190)
Nitrobenzene-d5 (SURR.)	(82)	Octadecane	(57)
N-Nitroso-di-n-butylamine	(84/57/41)	Parathion	(109)
2-Nitrophenol	(139/109,65)	Pentachlorophenol	(266/264,268)
Quinoline	(129)	Phenanthrene	(178/179,176)
N-Nitrosopiperidine	(42/114,55)	Pronamide	(173)
p-Phenylenediamine	(108)	sym- Trinitrobenzene	(213)
O,O,O-Triethylphosphorthioat	(198)	2,4,6 Tribromophenol (SURR)	(330)
Safrole	(162)		
alpha –Terpineol	(128)	**Perylene-d12**	**Ions**
1,2,3-Trichlorobenzene	(180/182,145)	Benzo(b)fluoranthene	(252/125)
1,2,4-Trichlorobenzene	(180/182,145)	Benzo(k)fluoranthene	(252/125)
1,3,5-Trichlorobenzene	(180/182,145)	Benzo(g.h.i)perylene	(276/138,277)
		Benzo(a)pyrene	(252/253,125)
Chrysene-d12	**Ions**	Dibenz(a,j)acridine	(279/280)
2 –Acetylaminofluorene	(181)	Dibenz(a,h)anthracene	(278/139,279)
Aramite	(194)	7,12-Dimethylbenz(a)anthracene	(256/241,257)
Benzidine	(184)	Di-n-Octyl Phthalate	(149)
Benzo(a)anthracene	(228/229/226)	Hexachlorophene	(196)
Bis(2-ethylhexyl)phthalate	(149/167,279)	Indeno(1,2,3-d)pyrene	(276)
Butylbenzyl phthalate	(149/91)	3-Methylchloanthrene	(268/253)
Chlorobenzilate	(251)		
Chrysene	(228/226,229)		
3,3'-Dichlorobenzidine	(252/254,126)		
p-Dimethylaminoazobenzene	(120/225,77)		
3,3 Dimethylbenzidine	(212)		
Famphur	(218)		
Kepone	(272)		
Methyl Chrysene	(242)		
Pyrene	(202/200,203)		
Terphenyl-d14 (SURR.)	(244)		

Table 6a – SIM Semivolatile Internal Standards with Corresponding Analytes Assigned for Quantitation

1,4-Dichlorobenzene-d4	**Ions**	**Fluoranthene-d10**	**Ions**
2-Fluorophenol (Surr)	(112)	Fluoranthene	202, 101, 203
Phenol-d5 (Surr)	(99)	Pyrene	202, 203

Bis-(2-chloro-ethyl)ether	93, 63, 95	Terphenyl-d14 (Surr)	(244)
Nitrobenzene-d5 (Surr)	(82)	Benzo(a)anthracene	228, 229, 226
		Chrysene	228, 226, 229
1-Methylnaphthalene-d10	**Ions**	Bis(2-ethylhexylphthalate	149, 167, 279
1,4-Dioxane	88, 58		
Naphthalene	128, 129, 127		
Hexachlorobutadiene	225, 223, 227	**Benzo(a) pyrene-d12**	**Ions**
2-Methyl Naphthalene	142, 141, 115	Di-n-octyl phthalate	149, 150, 43
2-Fluorobiphenyl (Surr)	(172)	Benzo(b)fluoranthene	252, 253
		Benzo(k)fluoranthene	252, 125
Fluorene-d10	**Ions**	Benzo(a)pyrene	252, 253, 125
Acenaphthylene	152, 151, 153	Indeno(1,2,3-cd)pyrene	276, 277, 138
Acenaphthene	153, 152, 154	Dibenzo(a,h)anthracene	278, 139, 279
Fluorene	166, 165, 167	Benzo(g,h,i)perylene	276, 138, 277
1,2-Diphenylhydrazine	77, 105, 182		
2,4,6-Tribromophenol (Surr)	(330)	**1,4-Dioxane-d8**	**Ions**
Hexachlorobenzene	284, 286	**1,4-Dioxane**	**88, 58**
Pentachlorophenol	266, 264		
Phenanthrene	178, 179, 176		
Anthracene	178, 176, 179		

Table 7 STANDARD PREPARATION

Table 7A – Intermediate Calibration Standard Solution

Stock Solution	Stock Conc., μg/mL	Volume Added, μl	Final Vol. in $MeCl_2$, mL	Final Conc. μg/mL
Semivolatile Standard Mix # 1	2,000	500	10	100
Semivolatile Standard Mix # 2	2,000	500	10	100
Semivolatile Standard Mix # 4	2,000	500	10	100
Semivolatile Standard Mix # 5	2,000	500	10	100
Semivolatile Standard Mix # 6	2,000	500	10	100
Semivolatile Standard Mix # 7	2,000	500	10	100
PAH Mixture #2	2,000	500	10	100
Semivolatile Standard Mix # 8	2,000	500	10	100
Additional Requested Compound(s) Mix	2,000	500	10	100
Pyridines Mixture	2,000	500	10	100
1,2,3-Trichlorobenzene	1,000	1,000	10	100
1,3,5-Trichlorobenzene	1,000	1,000	10	100
Butyl Stearate	10,000	200	10	200
Pentachlorophenol	1,000	1,000	10	100
B/N Surrogate Standard Mix	5,000	200	10	100
Acid Surrogate Standard Mix	7,500	134	10	100.5

Table 7B – Intermediate Calibration Standard Solution -SIM

Stock Solution	Stock Conc., μg/mL	Volume Added, μl	Final Vol. in MeCl$_2$, mL	Final Conc. μg/mL
Semivolatile Standard Mix # 1	2,000	50	10	10
Semivolatile Standard Mix # 2	2,000	50	10	10
Toxic #2	2,000	50	10	10
PAH Mixture #2	2,000	50	10	10
Semivolatile Standard Mix # 8 (Acids)	2,000	250	10	50
1-Methynaphthalene	1,000	100	10	10
B/N Surrogate Standard Mix	5,000	100	10	50
Acid Surrogate Standard Mix (Full Scan)	7500	67	10	50

Table 7C – Initial Calibration Standards Prep Scheme

Standard Solution	Intermediate Conc., μg/mL	Intermediate added, μl Full Scan	Final Volume in MeCl$_2$, mL	Final Conc., μg/mL – Full Scan
STD 1	100	1,000	1	100
STD 2	100	800	1	80
STD 3	100	500	1	50
STD 4	100	250	1	25
STD 5	100/10 (SIM)	100	1	10
STD 6	100	50	1	5
STD 7	100	20	1	2
STD8	100	10	1	1

Table 7D Initial Preparation Standards Prep Scheme - SIM

Standard Solution	Intermediate Conc., μg/mL	Intermediate added, μl SIM	Final Volume in MeCl$_2$, mL	Final Conc., μg/mL – SIM Scan
STD 1	10/50	500	1	5 BN / 25 Acids
STD 2	10/50	250	1	2.5 BN / 12.5 Ac
STD 3	10/50	100	1	1 BN / 5 Acids
STD 4	1	200	1	0.2 BN / 1 Acids
STD 5	1	100	1	0.1 BN / 0.5 Acids
STD7	0.1	500	1	0.05 BN / 0.25 AC
STD 6	0.1	200	1	0.02 BN / 0.1 AC

Table 7E– ICV -Second Source Calibration Check Standard

Intermediate	Intermediate Conc., μg/mL	Volume Used, μl (Full/SIM)	Final Volume in Acetone, mL	Final Conc., μg/mL (Full/SIM)
Base Neutrals Mixture	100	500/ 50	1	50/ 5
Acid Mixture	100	500/ 50	1	50/ 5

Table 7F Initial Preparation Standards Prep Scheme – 1,4-DioxaneSIM isotopic dilution

Standard Solution	Intermediate Conc., μg/mL	Intermediate added, μl SIM	Final Volume in $MeCl_2$, mL	Final Conc., μg/mL – SIM Scan
STD 1	20	1000	1	20
STD 2	20	500	1	10
STD 3	20	250	1	5
STD 4	5	500	1	2.5
STD 5	5	200	1	1
STD7	1	500	1	0.5
STD 6	1	200	1	0.2
STD 7	1	100	1	0.1
STD 8	0.1	500	1	0.05
STD9	0.1	200	1	0.02

Table 7G – Initial Calibration Standards Prep Scheme - LVI

Standard Solution	Intermediate Conc., μg/mL	Intermediate added, μl Full Scan	Final Volume in $MeCl_2$, mL	Final Conc., μg/mL – Full Scan
STD 1	100	200	1	20
STD 2	80	200	1	16
STD 3	50	200	1	10
STD 4	25	200	1	5
STD 5	10	200	1	2
STD 6	5	200	1	1
STD 7	2	200	1	0.4
STD8	1	200	1	0.2

Table 7H Initial Preparation Standards Prep Scheme – SIM LVI

Standard Solution	Intermediate Conc., μg/mL	Intermediate added, μl SIM	Final Volume in $MeCl_2$, mL	Final Conc., μg/mL – SIM Scan
STD 1	5/25	200	1	1 BN / 5 Acids
STD 2	2.5/12.5	200	1	0.5 BN / 2.5 Acids
STD 3	1/5	200	1	0.2 BN / 1 Acids
STD 4	0.2/1	200	1	0.04 BN / 0.2 Acids
STD 5	0.1/0.5	200	1	0.02 BN / 0.1 Acids
STD7	0.05/0.25	200	1	0.01 BN / 0.05 Acids
STD 6	0.02/0.1	200	1	0.004 BN / 0.02 Acids

Table 8a –Selected Ion Monitoring: Masses and Dwell Times

Compound	Mass Ion (m/z)	Dwell Time (ms)
Acenaphthene	153, 152, 154	50
Acenaphthylene	152, 151, 153	50
Anthracene	178, 176, 179	50
Benzo(a)anthracene	228, 229, 226	50
Benzo(a)pyrene	252, 253, 125	50
Benzo(b)fluoranthene	252, 253	50
Benzo(g,h,i)perylene	276, 138, 277	50
Benzo(k)fluoranthene	252, 125	50
Chrysene	228, 226, 229	50
Dibenzo(a,h)anthracene	278, 139, 279	50
Fluoranthene	202, 101, 203	50
Fluorene	166, 165, 167	50
Indeno(1,2,3-cd)pyrene	276, 277, 138	50
Naphthalene	128, 129, 127	50
Phenanthrene	178, 179, 176	50
Pyrene	202, 203	50
2-Methyl Naphthalene	142, 141, 115	50
Bis-(2-chloro-ethyl)ether	93, 63, 95	50
Pentachlorophenol	266, 264	50
Hexachlorobutadiene	225, 223, 227	50
1,2-Diphenylhydrazine	77, 105, 182	50
Bis(2-ethylhexyl)phthalate	149, 167, 279	50
Di-n-octyl phthalate	149, 150, 43	50
Hexachlorobenzene	284, 286	50
2-Fluorophenol	112, 64, 63	50
Phenol-d5	99, 42	50
Nitrobenzene-d5	82, 128	50
2-Fluorobiphenyl	172, 171, 170	50
2,4,6-Tribromophenol	330, 332, 334	50
1,4 Dioxane	88, 58	50
4,6-dinitro-2-methylphenol	198, 51,105	50
Terphenyl-d14	244, 122	50

Table 9 REPORTING LIMITS

Compound	Water	Soil	Compound	Water	Soil
	µg/l	µg/kg		µg/l	µg/kg
Benzoic Acid	20	667	Chlorobenzilate	5	167
2-Chlorophenol	5	167	Chrysene	1	33
4-Chloro-3-methylphenol	5	167	bis(2-Chloroethoxy)methane	2	67
2,4-Dichlorophenol	5	167	bis(2-Chloroethyl)ether	2	67
2,4-Dimethlyphenol	5	167	Bis(2-Chloroisopropyl)ether	2	67
2,4-Dinitrophenol	20	667	4-Chlorophenyl phenyl ether	2	67
4,6-Dinitro-o-cresol	20	667	1,2-Dichlorobenzene	2	67
Dinoseb	5	167	1,3-Dichlorobenzene	2	67
2-Methylphenol	2	67	1,4-Dichlorobenzene	2	67
4-Methylphenol	2	67	2,4-Dinitrotoluene	2	67
2-Nitrophenol	5	167	2,6-Dinitrotoluene	2	67
4-Nitrophenol	10	333	3,3'-Dichlorobenzidine	5	167
Pentachlorophenol	10	333	3,3’-Dimethylbenzidine	5	167
Phenol	2	67	7,12-Dimethylbenz(a)anthracene	5	167
2,3,4,6-Tetrachlorophenol	5	167	Diallate	5	167
2,4,5-Trichlorophenol	5	167	Dibenzo(a,h)anthracene	1	33
2,4,6-Trichlorophenol	5	167	Dibenzofuran	2	67
2-Acetylaminofluorene	5	167	Dimethoate	5	167
4-Aminobiphenyl	5	167	Diphenylamine	5	167
Acenaphthene	1	33	Disulfuton	5	167
Acenaphthylene	1	33	m-Dinitrobenzene	5	167
Acetophenone	5	167	p-(Dimethylamine)azobenzene	5	167
Aniline	2	67	Di-n-butyl phthalate	2	67
Anthracene	1	33	Di-n-octyl phthalate	2	67
Aramite	5	167	Diethyl phthalate	2	67
A,A-Dimethylphenethylamine	5	167	Dimethyl phthalate	2	67
Benzo(a)anthracene	1	33	bis(2-Ethylhexyl)phthalate	2	67
Benzo(a)pyrene	1	33	Ethyl methansulfonate	5	167
Benzo(b)fluoranthene	1	33	Famphur	30	1000
Benzo(g,h,i)perylene	1	33	Fluoranthene	1	33
Benzo (k)fluoranthene	1	33	Fluorene	1	33
4-Bromophenyl phenyl ether	2	67	Hexachlorobenzene	2	67
Butyl benzyl phthalate	2	67	Hexachlorobutadiene	1	33
Benzyl Alcohol	2	67	Hexachlorocyclopentadiene	20	667
2-Chloronaphthalene	2	67	Hexachloroethane	5	167
4-Chloroaniline	5	167	Hexachlorophene	50	1700
Carbazole	1	67	Hexachloropropene	5	167

Table 9 (Cont'd)

Compound	Water	Soil	Compound	Water	Soil
	µg/l	µg/kg		µg/l	µg/kg
Indeno(1,2,3-cd)pyrene	1	33	N-Nitrosomethylethylamine	5	167
Isodrin	5	167	N-Nitrosomorpholine	5	167
Isophorone	2	67	N-Nitrosopiperidine	5	167
Isosafrole	5	167	N-Nitrosopyrrolidine	5	167
Kepone	30	1000	O,O,O Triethylphosphorothioat	5	167
2-Methylnaphthalene	2	667	2-Picoline	5	167
3-Methylcholanthene	5	167	Parathion	5	167
Methapyrilene	5	167	Pentachlorobenzene	5	167
Methyl Methanesulfonate	5	167	Pentachloroethane	5	167
Methyl Parathion	5	167	Pentachloronitrobenzene	5	167
1,4 Naphthoquinone	5	167	Phenacetin	5	167
1-Naphthylamine	5	167	Phenanthrene	1	33
2-Naphthylamine	5	167	Phorate	5	167
2-Nitroaniline	5	167	Pronamide	5	167
3-Nitroaniline	5	167	Pyrene	1	33
4-Nitroaniline	5	167	Pyridine	2	67
5-Nitro-o-toluidine	5	167	p-Phenylenediamine	5	167
Naphthalene	1	33	Safrole	5	167
Nitrobenzene	2	67	1,2,4,5 Tetrachlorobenzene	5	167
n-Nitrosodimethylamine	2	67	1,2,4-Trichlorobenzene	2	67
4-Nitroquinoline-1-Oxide	10	333	Thionazin	5	167
N-Nitroso-di-n-propylamine	2	67	o-Toluidine	5	167
N-Nitrosodi-n-butylamine	5	167	sym-Trinitrobenzene	5	167
N-Nitrosodiethylamine	5	167	Tetraethyl dithiopyrophosphate	5	167
N-Nitrosodiphenylamine	5	167	Quinoline	5	167
Benzenethiol	20	667	Indene	5	167
1,4-Dioxane	1	33			

Table 10 Selected Ion Monitoring Reporting Limits

Compound	Water	Soil	Compound	Water	Soil
	µg/l	µg/kg		µg/l	µg/kg
Pentachlorophenol	0.3	17	Fluoranthene	0.1	3.3
Acenaphthene	0.1	3.3	Fluorene	0.1	3.3
Acenaphthylene	0.1	3.3	Hexachlorobenzene	0.02	3.3
Anthracene	0.1	3.3	Hexachlorobutadiene	0.1	3.3
Benzo(a)anthracene	0.1	3.3	Indeno(1,2,3-cd)pyrene	0.1	3.3
Benzo(a)pyrene	0.1	3.3	2-Methylnaphthalene	0.1	3.3
Benzo(b)fluoranthene	0.1	3.3	Naphthalene	0.1	3.3
Benzo(g,h,i)perylene	0.1	3.3	Phenanthrene	0.1	3.3
Benzo (k)fluoranthene	0.1	3.3	Pyrene	0.1	3.3
Chrysene	0.1	3.3	bis(2-Chloroethyl)ether	0.2	6.6
Dibenzo(a,h)anthracene	0.1	3.3	Bis (2-ethylhexyl) phthalate	0.2	6.6
1,2-Diphenylhydrazine	0.2	6.6	Di-n-octyl phthalate	0.2	6.6
4,6-dinitro-2-methylphenol	0.5	16.7	1,4 Dioxane	0.1	3.3
			1,4 Dioxane by Isotopic Dilution	0.3	

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
9.5.1.1	Added 2 ppm to the SIM LVI curve
10.1.1	Added 2 ppm to the SIM LVI curve

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added

History of Revisions

Version #	Date of Revision	Revised By
01	03/31/2021	Olga Azarian
02	9/15/2022	Jason Savoie
03	4/13/2023	Jason Savoie
04	8/11/2023	Olga Azarian
05	9/21/2023	Olga Azarian

END OF DOCUMENT

LAB SUPERVISOR: ______________________

QA OFFICER: ______________________

EFFECTIVE DATE: 5-14-2021

TITLE: METALS BY INDUCTIVELYCOUPLED PLASMA ATOMIC EMISSION SPECTROMETRY (ICP) USING SOLIDS STATE ICP

REFERENCE: SW846 6010D, Rev.5, July2018

REVISED SECTIONS: reference,4.0, 6.1, 12.2

1.0 SCOPE AND APPLICATION

1.1 This method is applicable for the determination of metals in water, wipes, sludges, sediments, and soils. Sample matrices are pretreated following SW846 methods for digestion of soil, sediment, sludge, wipe or water samples. Refer to specific digestion SOP's for more information on digestion techniques.

1.2 A variety of metals can be analyzed by ICAP. These include, but are not limited to, Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, V, Zn, Li P and Pd W S Bi Zr

2.0 SUMMARY

2.1 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.

2.2 This SOP describes operation of the ICAP 6500 and ICAP 7000 Spectrometer following method SW846 6010D.

2.2.1 This inductively coupled argon plasma optical emission spectrometers (ICP-OES) uses an Echelle optical design and a Charge Injection Device (CID) solid-state detector to provide elemental analysis. Control of the spectrometer is provided by PC based iTEVA software.

2.2.2 In the instrument, samples are nebulized, and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by a radiofrequency inductively coupled plasma. The spectra are dispersed by a spectrometer, and the intensities of the emission lines are monitored the solid-state detector.

2.2.3 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. Interferences which cannot be addressed with background correction must be corrected using the appropriate interelement correction factors.

3.0 REPORTING LIMIT AND METHOD DETECTION LIMIT

3.1 Reporting Limit. The normal reporting limits for this method have been established at the concentrations listed in Table 1. Reporting limits may vary depending on client needs and lab protocols, but the reporting limits must always be verified with a low check which meets the criteria outlined in this SOP. In addition, the reporting limits must always be greater than the MDL. Refer to the scheduling sheets and check with the metal's supervisor for further information.

3.2 Method Detection Limit. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B. This value represents the lowest reportable concentration of an individual compound that meets the method qualitative identification criteria.

3.2.1 Experimental MDLs must be determined annually for this method. Refer to SGS SOP EQA075

4.0 DEFINITIONS

BATCH: A group of samples which behave similarly with respect to the sampling or the testing procedures being employed, and which are processed as a unit. For QC purposes, if the number of samples in a group is greater than 20, then each group of 20 samples or less will all be handled as a separate batch.

CALIBRATION CHECK STANDARD. The calibration check standard is a mid-range calibration standard.

EXTERNAL CHECK STANDARD. The external check standard is a standard from a separate source than the calibration curve that is used to verify the accuracy of the calibration standards.

SPIKE BLANK SAMPLE. Digest and analyze a laboratory control sample (Soil LC) or spike blank with each set of samples.

MATRIX: The component or substrate (e.g., water, soil) which contains the analyte of interest.

MATRIX SPIKE DUPLICATE: A matrix spike duplicate sample is digested at a minimum of 1 in 20 samples. The relative percent difference (RPD) between the matrix spike duplicate and the matrix spike must be assessed.

$$\frac{(|\text{Matrix Spike Result} - \text{Matrix Spike Duplicate Result}|) \times 100}{(\text{Matrix Spike Result} + \text{Matrix Spike Duplicate Result})/2} = \text{Duplicate RPD}$$

MATRIX SPIKE: The laboratory must add a known amount of each analyte to a minimum of 1 in 20 samples. The matrix spike recovery is calculated as shown below

$$\frac{(\text{Spiked Sample Result} - \text{Sample Result})}{(\text{Amount Spiked})} \times 100 = \text{Matrix Spike Recovery}$$

METHOD BLANK. The laboratory must digest and analyze a method blank with each set of samples. A minimum of one method blank is required for every 20 samples. For a running batch, a new method blank is required for each different digestion day. If no digestion step is required, then the method blank is equivalent to the reagent blank.

METHOD DETECTION LIMITS (MDLS). The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is distinguishable from method blank results.

REAGENT BLANK: The reagent blank is a blank that has the same matrix as the samples, i.e., all added reagents, but did not go through sample preparation procedures. The reagent blank is an indicator for contamination introduced during the analytical procedure. (Note: for methods requiring no preparation step, the reagent blank is equivalent to the method blank.)

REAGENT GRADE: Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents which conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.

REAGENT WATER: Water that has been generated by any method which would achieve the performance specifications for ASTM Type II water.

STANDARD CURVE: A plot of concentrations of known analyte standards versus the instrument response to the analyte. Calibration standards are prepared by successively diluting a standard solution to produce working standards which cover the working range of the instrument. Standards must be prepared at the frequency specified in the appropriate section. The calibration standards must be prepared using the same type of acid or solvent and at the same concentration as will result in the samples following sample preparation. This is applicable to organic and inorganic chemical analysis.

LOW LEVEL CALIBRATION VERIFICATION (CRI or LLCCV). The LLCCV or CRI standard is a check standard containing the elements of interest at (or below) the reporting level for each element.

HIGH STANDARD/LINEAR RANGE: The high standard is a check standard containing elements of the interest at the instrument linear range. The linear range establishes the highest concentration that may be reported without diluting the sample. The acceptance criteria are +/-10 of the true value.

5.0 HEALTH & SAFETY

5.1 The analyst must follow normal safety procedures as outlined in the SGS Health and Safety Plan and Personal Protection Policy, which include the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents must be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets must be made available to all personnel involved in these analyses.

6.0 PRESERVATION & HOLDING TIME

6.1 All water samples must be preserved with nitric acid to a pH of 2 or less. All solid samples must be stored in a refrigerator at ≤6°C.

6.2 All samples must be analyzed within 6 months of the date of collection.

7.0 INTERFERENCES

7.1 Several types of interferences can cause inaccuracies in trace metals determinations by ICP. These interferences are discussed below.

7.2 Spectral interferences are caused by overlap of a spectral line from another element, unresolved overlap of molecular band spectra, background contribution from continuous or recombination phenomena, and background contribution from stray light from the line emission of high concentration elements. Corrections for these interferences can be made by using interfering element corrections, by choosing an alternate analytical line, and/or by applying background correction points.

7.3 Physical interferences can be caused by changes in sample viscosity or surface tension, by high acid content in a sample, or by high dissolved solids in a sample. These interferences can be reduced by using an internal standard, by making sample dilutions or by analyzing a sample using the method of standard additions.

7.4 Chemical interferences are not pronounced with ICAP due to the high temperature of the plasma, however if they are present, they can be reduced by optimizing the analytical conditions (i.e. power level, torch height, etc.).

8.0 EQUIPMENT AND SUPPLIES

8.1 Currently there are five solid state ICPs available for use in the lab. They are Thermo 6500 and 7000 ICP units. These units have been optimized to obtain low detection limits for a wide range of elements. Since they are solid state systems, different lines may be included for elements to obtain the best analytical results. However, the lines which are normally included in the normal analysis program are shown in Table 2.

8.2 Instrument auto-samplers. For random access during sample analysis.

8.3 Class A volumetric glassware and pipets.

8.3.1 All glassware must be washed with soap and tap water and then soaked in a 10% nitric acid bath for a minimum of 2 hours. It must then be rinsed at least 3 times with deionized water.

8.4 Glass autosampler tubes

8.4.1 Autosampler tubes must be washed with soap and tap water and then soaked in a 10% nitric acid bath for a minimum of 2 hours. They must then be rinsed at least 3 times with deionized water.

8.5 Autopipettes with tips. These must be calibrated and checked as outlined in the autopipette SOP, EQA004.
8.6 ASXPRESS PLUS Valve system from CETAC
8.7 Argon humidifier

9.0 REAGENTS

9.1 All chemicals listed below are reagent grade unless otherwise specified. Deionized water must be used whenever water is required. The expiration date for standards and reagents is the date supplied by the manufacturer or if no expiration date is given, a default of 6 months is used. For acid solutions (nitric, sulfuric, hydrochloric) the expiration date is 2 years from the date of preparation of the solution.

9.2 Hydrochloric acid, trace metals grade.

9.3 Nitric Acid, Baker instra-analyzed or equivalent.

9.4 Standard stock solutions available from Absolute, Inorganic Ventures, CPI, Ultra Scientific or equivalent.
Note: All standards must be ICP quality standards.
Calibration Standards: These are made up by diluting the stock solutions to the appropriate concentrations. Fresh calibration standards must be prepared every day.

9.4.1 Standards must be approximately matrix matched to the samples. For most samples, a 5 percent nitric acid and 5 percent hydrochloric acid will approximate the acid matrix of the sample and limit nebulization problems. If it is known that the samples contain a significantly different acid matrix, then the matrix of the standards must be modified, or the samples must be diluted so that they are in a similar matrix to the curve.

9.4.2 Standards must be prepared so that there is minimal spectral interference between analytes. See Table 10 for the make-up and concentrations of standards and stock solutions being used to calibrate the ICP. The standard curve consists of a blank and 1 non-zero standard at the levels shown in Table 10.

9.5 Calibration/Rinse Blank. The calibration blank is prepared by diluting a mixture of 50 ml of concentrated nitric acid and 50 ml of concentrated hydrochloric acid to a final volume of 1 liter with deionized water.

9.6 Analytical Quality Control Solutions. All the solutions below are prepared by adding either mixed or single element metals solutions to a solution containing 5 percent nitric acid and 5 percent hydrochloric acid and diluting to a fixed final volume with this acid mixture. These solutions must be placed in FEP fluorocarbon or previously unused polyethylene or polypropylene bottles for long term storage.

9.7.1 Initial Calibration Verification solution (ICV). This standard solution must be made from a different source than the calibration curve. The values for each element must be near the midpoint of the calibration curve. This solution is used to verify the accuracy of the initial calibration. See Table 4 for suggested ICV concentrations.

9.7.2 Continuing Calibration Verification solution (CCV): The metals concentrations for this standard must be at approximately the mid-point of the calibration curve for each element. This standard must be prepared from the same source that is used for the calibration curve. See Table 4 for suggested CCV concentrations.

9.7.3 Interference Element Check Solutions. These solutions must be used on a periodic basis to check the interfering element corrections on the instruments and interfering element solutions may be modified. Two acceptable solutions are outlined below.

9.6.1.1 ICSA Solution <u>(Interference Check Standard)</u> This is a QC standard used to verify the accuracy of the interferents (Al, Ca, Fe, and Mg) and the accuracy of the inter-element correction factors applied in the absence of analyte. The recommended concentrations are shown below. If the linear ranges on a given instrument are lower than these levels, the concentrations may be set near the top of the linear range for those elements.

Al	500 mg/L
Ca	400 mg/L
Fe	200 mg/L
Mg	500 mg/L

9.6.1.2 ICSAB Solution (Interference Check Standard with analytes): The ICSAB solution contains both the interferents and the analytes of interest. The recommended concentrations are shown below. If the linear ranges on a given instrument are lower than these levels, the concentrations may be set near the top of the linear range for those elements

Ag	1.0 mg/L	Zn	1.0 mg/L
Ba	0.50 mg/L	As	1.0 mg/L
Be	0.50 mg/L	Se	1.0 mg/L
Cd	1.0 mg/L	Sb	1.0 mg/L
Co	0.50 mg/L	Tl	1.0 mg/L
Cr	0.50 mg/L	Mo	0.5 mg/L
Cu	0.50 mg/L	P	0.5 mg/L
Mn	0.50 mg/L	Al	500 mg/L
Ni	1.0 mg/L	Ca	400 mg/L
Pb	1.0 mg/L	Fe	200 mg/L
V	0.50 mg/L	Mg	500 mg/L
W	0.50 mg/L	Zr	0.50 mg/L

Li	0.50 mg/l	Sr	0.5 mg/l
Bi	0.50 mg/l	Ti	0.5 mg/l
B	0.50 mg/l	S	0.5 mg/l
Sn	0.50 mg/l	Si	0.5 mg/l

9.6.2 CRI Standards (also referred to as LLCCV). The CRI standard must contain the elements of interest at (or below) the reporting limit for each element. The CRI level is at the reporting limit as shown in Table 1. This solution is to be prepared at the reporting limit level for each element. They must be made in the same matrix as the calibration standards. Note: The CRI must be verified at the RL before any dilutions are applied

9.7 Matrix Spike and Spike Blank Solution: The final concentrations suggested for the matrix spike and spike blank solutions are shown in Table 5. Refer to METALS SPIKING SOLUTION AND STANDARDS PREPARATION SOP EMP 202 Table 1,1A, and 3 for preparation/concentration and amount of spiking solutions. Appropriate amount of the resulting stock solution is added to the matrix spike and blank spike samples before they are digested.

9.8 Matrix Spike and Spike blank (For aqueous samples and TCLP leachates).

9.8.1 The final concentrations suggested for the matrix spike are shown in Table 5. Spiking solutions, they are prepared by adding either mixed or single element metals solution. Refer to METALS SPIKING SOLUTION AND STANDARDS PREPARATION SOP EMP 202 Table 1,1A, and 3 for preparation/concentration and amount of spiking solutions. Resulting stock solution is added to the matrix spike and blank spike samples before they are digested.

9.8.2 The Spike blank sample must be digested and analyzed for every batch of 20 samples or less. The Blank spike prepared by adding either mixed or single element metals solutions to DI water and bringing up to a fixed final volume. For TCLP samples, the blank spike must be made using blank leachate solution rather than DI water. 50 ml of this solution is digested and brought to a final volume of 50 ml.

9.9 Liquid Argon or Argon Gas. Argon is provided by Air Products in the large outdoor tank. No lab monitoring of the tank is normally necessary

9.10 Internal Standard Solution (with matrix modifier). To a 2-liter flask containing approximately 1500 ml of DI water, add 40 ml of 10,000 mg/l Cesium solution, 10 ml of 10000 mg/l indium, and 2 ml of 10000 mg/l yttrium. Add 100 ml concentrated nitric acid and 100 ml concentrated hydrochloric acid and bring to a final volume of 2000 ml and mix well. This solution is added to all samples and standards as the instrument is running using a split line on the peristaltic pump.

10.0 PROCEDURE

10.1 General procedure on how to operate the SS Trace is described below. Refer to the Thermo 6500-7000 operation manual for further details.

10.2 Before bringing up the instrument, make sure that the lines, the torch, the nebulizer, and the spray chamber are clean, the dehumidifier is filled with DI water up to the level between Minimum and Maximum, and that there are no leaks in the torch area.

10.3 Turn on the recirculating cooler. Verify that the liquid argon is turned on.

10.4 Set up the pump tubing and engage the peristaltic pump.

10.5 Put a new solution of acid rinse into the rinse reservoir. (Note: the composition of the rinse solution may be periodically changed to minimize sample introduction problems and sample carryover.) If internal standard is being used, make sure that sufficient internal standard solution is prepared.

10.6 Start up the instrument following the sequence shown below.

10.6.1 Double click the **iTEVA Control Center** Icon on desktop. Type ***admin*** in User Name field, and then click OK.

10.6.2 Once the iTEVA Control Center window is opened, click on **Plasma** Icon at status bar area. Then click on **Instrument Status** to check the interlock indicators (torch compartment, purge gas supply, plasma gas supply, water flow and exhaust must be in green; drain flow and busy must be in gray) and the Optics Temperature. (It needs to be around 38°C.) Click on the Close box.

10.6.3 Click **Plasma On**. After the plasma is on, close the Status window and let the instrument warm to up for 15 to 20 minutes before starting the analysis. New tubing may take an hour to stabilize.

10.7 Torch Alignment and Auto Peak

10.7.1 If the torch has been cleaned, then it must be realigned after it is replaced

10.7.1.1 Open the method and then click on **Sequence** tab, and then click on List View Icon until you reach rack display.

10.7.1.2 Send probe to the cup which is filled with 2 ppm Zn solution in Autosampler program. eg. Go to S-6 position (you can assign any position in the rack for torch alignment) which is filled with 2 ppm Zn solution.

10.7.1.3 Click on **Analysis** tab and then select **Torch Alignment** from **Instrument** drop down menu. There will be a popup dialog box present. Click RUN. Then there will be another dialog box pop up (This is a reminder for Torch Alignment Solution (2 ppm Zn)), let the solution to pass through the plasma and click Ok. Now, the instrument is initiating an automated torch alignment. It takes about 7 minutes to complete this step. Progress is indicated in the progress bar.

10.7.1.4 After Torch Alignment is done, click Close. Click on **Sequence** tab and then follow by **List View** Icon.

10.7.1.5 Go to Rinse position at rack display, right click to select Go to rinse and let it rinse for 2 minutes.

10.7.2 Perform Auto Peak.

10.7.2.1 It is recommended that the Auto Peak Adjust procedure be performed monthly or whenever the peak shape has shifted for any element. A standard that contains all of the lines of interest is used and the system automatically makes the appropriate fine adjustment. (CCV solution is used for this process.)

10.7.2.1.1 A shift in peak shape can be defined as when the peak is no longer in the middle of the defined viewing window. The window must be set so that the peak is approximately centered and there is a sufficient area measured so that reproducible, consistent data can be obtained at reporting limit levels. This is done as part of the automatic process, but the window size can be adjusted manually in the method based on the shape of the peak to obtain the best fit for the peak. A wider peak may need a broader integration window for the best analysis. In general, the window must cover at least the top 1/3 of the peak.

10.7.2.2 Click **Sequence** tab and then click on **List View** Icon till the rack is displayed.

10.7.2.3 Send the probe to the cup which is filled with CCV solutions using Autosampler program (you can assign any position in the rack which has CCV solution filled for auto peak adjust) then click on **Analysis** tab. All elements' result is showed in the display area. From **Instrument** drop down menu, select **Perform Auto Peak**. There will be a popup dialog box present. Highlight _All Elements, then click RUN. Then there will be another dialog box pop up (This is a reminder for Perform Auto Peak Solution), click Ok. Now, the instrument is performing auto peak adjust. It takes about 5 minutes to complete this process. The Auto Peak dialog box will show a green " √" in front of All Elements, which indicates Auto Peak is completed.

10.8 Open the method and start up the run.

10.8.1 Click on **Analyst** Icon at the workspace. Go the Method and choose Open from the drop-down menu. Select the method with a Revision (usually select the last revision used).

10.8.2 Go to **Method** tab at the bottom of left-hand corner to click on **Automated Output** at the workspace area. Type a filename in Filename field in the data display area (i.e.: SA073107M1: starts with SA, then follow by MM-DD, then M1; M1 indicates the first analytical run for that day, then follow by M2, M3 and so on for the second and third runs).

10.8.3 Click on **Sequence** tab at the bottom of left-hand corner. From **Auto-Session** drop down menu bar, click on **New Autosampler** to create a sequence. This will pop up a dialog box, then click on **New** and fill number of samples (i.e.: 100) in the Number of Samples field and the sample ID (usually leave this field empty) in Sample Name field. Type a sequence name (i.e.: SEQ073107M1: starts with SEQ, then MM-DD-YY, then M1; M1 indicates the first analytical run for that day, then follow by M2, M3 and so on for the second and third runs) in the Sequence Name field. Click OK, then put in "0" on Settle Time between the Sequences box, click OK.

10.8.4 Right click on **Untitled** (CETAC ASX-520 Enviro 5 Named Rack is the rack that currently using) at the workspace area, click on **Auto-Locate ALL** to locate all samples.

10.8.5 Double click on **Untitled** again, then click on the sequence name (i.e.: SEQ073107M1), on the data display area, type the sequence in Sample name column, dilution factor (if needed) in CorrFact column, check the box in front of Check column, and select an appropriate check table.

10.8.6 Once done with creating sequence, go to **Method** drop down menu and save all changes as **Save As**. There will be a Save a Method dialog box present, go to Save Option to check on "Overwrite Method and bump revision number" box, then click OK.

10.8.7 Go to **Sequence** tab, click on **List View** Icon from tool bar, then click on **Connect Autosampler to PC and Initialize** Icon. (Now, the autosampler tip is up and sits on the top of the rinse cup.)

10.8.8 The sequence includes the calibration and run quality control.

10.8.8.1 Calibrate the instrument as outlined below using the standards shown in Table 3. This calibration procedure is done a minimum of once every 24 hours. The calibration standards may be included in the autosampler program or they may be run separately.

10.8.8.2 Analyze ICV and ICB after the calibration is completed and before any samples are analyzed.

10.8.8.3 For mixed runs (EPA 200.7 and SW846 6010D), the first CCV is designated the ICCV. For samples and quality control, insert the list pointer after a space after the sample. Check with the metal's supervisors for additional information on the use of list pointers. In general, list pointer 7 refers to the SW846 6010D method and list pointer 1 refers to EPA 200.7 method.

10.8.8.4 Low Level Calibration Verification (Low checks or LLCCV) Run low checks at reporting limit levels after ICCV and CCB. The low checks are named as CRI (or CRIB for DOD run), CRID and CRIA. The levels for each low check are listed in Table 6, Table 7 and Table 8.

10.8.8.4.1 Muti-level low check solutions must be analyzed for default reporting limits and special client reporting limits.

10.8.8.4.2 Method limits of 80 to 120% are applied to the CRI low check standard.

10.8.8.5 Before analyzing any real samples, an interference check solution (ICSA-ICSAB) must be checked. For all spiked elements, the analyzed results must be within 20 percent of the true results. For unspiked elements, the interfering element solutions must contain **less than** the absolute value of the reporting limit for each element.

10.8.8.6 If the interfering element solution is not within specifications and that element must be reported, then new interfering element correction (IEC) factors will need to be generated following the procedure outlined in Section 11 below. If new IEC's are generated, then the run must be restarted from the ICSA, ICSAB quality control samples and new CCV checks must be run before any samples can be reported.

10.8.8.7 After the initial analytical quality control has been analyzed, the samples and the preparation batch quality control must be analyzed. Each sample including calibration standards and QC needs at least 3 replicates using at least 5 seconds integration time, this time can be modified. For samples containing levels of elements greater than approximately 5 times the reporting limits, the relative standard deviations for the replicates must be less than 5%. If not, reanalyze the sample. Upon reanalysis, the RSDs are acceptable then report the data from the reanalysis. If RSD's are not acceptable on reanalysis, then the results for that element must be evaluated by the data reviewer and footnoted if necessary. In some cases, an additional dilution analysis may be needed. Check with the area supervisor or manager for additional information.

10.8.8.8 Between each sample, flush the nebulizer and solution uptake system with a blank rinse solution for 60-120 seconds to ensure that analyte memory effects are not occurring. A time of 60-120 seconds is recommended for most analyses. When using Sprint valve and ASX EXPRESS Plus unit the uptake and rinse timing are being controlled by the valve configurator, Follow the manufacturer guideline. Normal timing for the valve configurator is as follow.

Loop Evacuation Delay: 1-3 Sec
Loop Load: 5-11 Sec
Time to Evacuate: 1-3 Sec
Rinse Station Fill: 5-10 Sec

Rinse Evacuation Delay: 1-3 sec
Equalization Delay: 1-3 Sec
Probe Rinse: 5-10 Sec

10.8.8.9 Analyze the continuing calibration verification solution and the continuing calibration blank after every tenth samples during an analysis run, whichever is more frequent, and at the end of the sample run.

10.8.8.10 If the CCV solution is not within 10 percent of the true value, no samples can be reported in the area bracketed by the failing CCV for the failing element. Additionally, for the elements with a CCV greater than 5 times the reporting limit, the relative standard deviation for the replicates must be less than 5 percent.

10.8.8.11 The CCB results must be less than the reporting limit or limit of quantitation for each desired target analyte. If these criteria are not met, then no samples can be reported in the area bracketed by the failing CCB for the failing element and all samples must be submitted for reanalysis.

10.8.8.11.1 However, if the samples are high relative to the CCB (> 10 X the CCB level) and a higher reporting limit is acceptable for the final end use of the data, then the samples may be evaluated using a higher reporting limit to meet the CCB criteria. This must be clearly documented on the run if a higher reporting limit is applied.

10.8.8.11.2 In addition, at the reviewer’s discretion, samples that are < RL may be reported when the CCB is biased high. Analysts must assume that samples bracketed by a failing CCB must be reanalyzed unless instructed otherwise.

10.8.8.11.3 If a CCB fails, if possible, the analyst must stop the run and run a new CCV, CCB pair before proceeding with the analysis of any additional samples.

10.8.8.12 For one sample per preparation batch a serial dilution must be prepared. Normally the sample used for the serial dilution is the sample that is used for the matrix spike and matrix spike duplicate. For the serial dilution, a 1:5 dilution must be made on the sample.

10.8.8.13 When matrix spike or matrix spike duplicate is out of acceptable limits, then post-digest spikes be prepared to determine potential interferences.

10.8.8.14 For any readings that exceed the linear range for a given element, a dilution is required. After a high reading, the sample following the high one must be examined for possible carryover. The verifications may be necessary by rinsing the lines with an acid solution and then rereading the sample. A limit check table may be built into the autosampler file so that samples exceeding the linear range are flagged on the raw data.

10.8.8.15 For the interelement spectral interference corrections to remain valid during sample analysis, the interferent concentration must not exceed its linear range. If the interferent exceeds its linear range or its correction factor is big enough to affect the element of interest even at a lower concentration, sample dilution with reagent blank and reanalysis is required. In these circumstance analyte detection limits are raised.

10.8.8.16 Anytime that the interference is large relative to the sample, dilution may be required.

10.8.8.17 For any readings where the internal standard is outside of the range of 70 to 130% of the internal standard level in the calibration blank, then the sample must be diluted until the internal standard is within that range. See Table 11 for the assigned Internal Standard for each element.

10.8.9 This method does not require the analysis of an interfering element check solution at the end of the run. However, this may be required to meet other method and/or client requirements. Run the ICSA and ICSAB solutions as instructed by the Metals lab supervisor or manager or as noted in the program code instructions.

10.8.10 After the instrument is optimized, click **Run Auto-Session** Icon to start the run.

10.8.11 If you need to add or delete samples once the run is started, follow the steps shown below.

10.8.11.1 Adding Samples.

10.8.11.1.1 Click on **Sequence** tab, then click on **List View** Icon at the tool bar. There is the sequence table on the data display area.

10.8.11.1.2 Click on **Add Samples** Icon. This will pop up the dialog box, then fill number of samples that need to add in field. Click OK. By doing this, samples will be added at the end of sequence without a location the rack.

10.8.11.1.3 Go to the added samples, on the To position ID column, assign a number for each sample. This number will be the position in the rack. On the Samplename column, type in sample IDs, fill in Corr Fact (if needed) and Check Table.

10.8.11.1.4 The added samples will be analyzed at the end of the original sequence run order unless you assign them to run under different order.

10.8.11.2 Deleting Samples.

10.8.11.2.1 Click on **Sequence** tab, then click on **List View** Icon under the sequence display area.

10.8.11.2.2 To the sample that need to be deleted, on the to position ID column, change the number to "0". By doing this, that sample will be unlocated in the rack and the autosampler tip will go to the next sample.

10.9 When the analysis is completed export the data to LIMS following the procedure outlined below.

10.9.1 Double click on **ePrint** Icon on desktop. There will be a LEADTOOLS ePRINT dialog box pop up, then click **Finish Jobs** and **OK** boxes.

10.9.2 Double click the **PDF** Icon on desktop, the PDF file will present as Document_#. Right click on that file, select **Rename** to change the file name to an assigned analytical run ID. (i.e.: MA8324). This is the raw data for MA8324.

10.9.3 Drop the raw data to LIMS.

10.9.4 By completing above steps, the raw data (i.e.: MA8324) can be pulled up in the Raw Data Search function.

10.9.5 For any Thallium hit found during the data review or analysis, the sample will be rerun to confirm. If the hit is confirmed, check the thallium spectrum of that sample to determine if the hit is caused by the matrix interference or true. If the spectrum indicates any matrix interference, then the sample will be rerun on dilutions to bring the thallium result to <RL

10.10 The data must be reviewed in the LIMS as outlined in the inorganic data review SOP, EQA034. Calculations for water samples are done automatically in the LIMS using the equation shown below.

$$\text{original sample concentration of metal } (\mu g/l) = \frac{(\text{conc. in the digestate } (\mu g/l)) \times (\text{final digestate volume (ml)})}{(\text{Initial sample volume (ml)})}$$

10.11 Aft the end of the analysis day, the ICP must be brought down using the following sequence:

10.11.1 Place the autosampler tip in rinse cup and rinse in a mixed solution of 5% nitric acid and 5% hydrochloric acid for 10 minutes and in DI water for 20 minutes. **Note**: A stronger acid may be needed depending on the matrix of the samples that were analyzed.

10.11.2 Turn off the plasma by click on the **Plasma** Icon and click on **Plasma Off**.

10.11.3 Close all iTEVA programs/ windows.

10.11.4 Release the tension on the sample pump platen.

10.11.5 Switch off recirculating chiller.

11.0 PROCEDURE FOR GENERATION OF INTERFERING ELEMENT CORRECTION FACTORS

11.1 All IEC's must be verified and updated a minimum of once every 6 months or whenever instrument conditions change significantly. It is recommended that elements with frequent high concentrations or with large IEC's must be checked more frequently.

11.2 Calculate the IEC correction factors and enter them into the method. Verify that the recalculated sample results are within QC limits. Calculate the correction factor using the equation shown below. This correction factor must be added to the correction factor already in place in the method for a given element.

$$\text{IEC} = \frac{\text{Concentration Result of the element with the interference}}{\text{Concentration result of the interfering element}}$$

11.3 Analyze the ICSA/ICSAB solutions and/or SIE solutions and verify that the combined standards are within QC limits. If they are not, make additional changes to the IEC factors and then re-verify both the individual and combined solution values.

11.4 Save and update the method.

11.5 Interfering element correction factors saved as raw data along with the run printouts daily so that the IEC's for a given run are traceable.

12.0 QC REQUIREMENTS

12.1 This section outlines the minimum QA/QC operations necessary to satisfy the analytical requirements for method SW846 6010D.

12.2 Method Detection Limits (MDLs). Initial MDL must be verified quarterly and re-calculated once every thirteen months. Refer to SGS SOP EQA075.

12.3 Instrument Detection Limits (IDLs). Instrument Detection Limits (IDLs). It is required that IDL's be completed **ANNUALLY** or after major instrument maintenance or by project specifications. The Instrument Detection Limits (in ug/L) are determined by analyzing 10 replicates of a reagent blank solution. The IDL is defined as 3 times the standard deviation of 10 reps added to the mean of the replicates; as long as it is 0 or positive (Use zero for the mean if the mean is negative.). IDLs shall be determined and reported for each wavelength used in the analysis of the samples.

12.4 Linear Calibration range: The linear range establishes the highest concentration that may be reported without diluting the sample. Following calibration, analyze a standard at a higher concentration than the high standard in the calibration. The standard must recover within 10% of the true value, and if successful, establishes the linear range. The linear range standards must be analyzed in the same instrument run as the calibration they are associated with (i.e., on a daily basis) but may be analyzed anywhere within that run. If a linear range standard is not analyzed for any specific element.

12.5 Initial Calibration Verification (ICV) and Initial Calibration Blank (ICB). After every new calibration, an ICV must be analyzed. The analysis of the ICV may be followed by the analysis of the ICB,

12.5.1 For the ICV, all elements to be reported must be within 10 percent of the true value and the replicates that exceed 5 times the reporting limit must have a relative standard deviation of less than 5 percent. The ICV must be from a different source than the calibration standards and must be near the mid-point of the calibration curve. If the ICV does not meet criteria, then the problem must be identified and corrected before samples can be run and reported for the element(s) that are outside of criteria. Correction of the problem can be verified by rerunning the check standard and showing that it meets QC criteria.

12.5.2 If an ICB is analyzed, then all elements to be reported must be less than ½ of the RL (LLOQ). If the ICB is outside of criteria, then the problem must be identified and corrected before samples can be run and reported for the element(s) that are outside of criteria. Correction of the problem can be verified by rerunning the check standard and showing that it meets QC criteria.

12.6 Continuing Calibration Verification (CCV) and Continuing Calibration Blank (CCB). Analyze the continuing calibration verification solution and the continuing calibration blank after every tenth sample and at the end of the sample run.

12.6.1 For the CCV, all elements to be reported must be within 10 percent of the true value and the replicates that are greater than 5 times the reporting limit must have a relative standard deviation of less than 5 percent. The CCV must be made from the same source as the calibration standards at a concentration near the mid-level of the calibration curve. If an element does not meet the recovery criteria of the CCV (90 to 110%), then no samples can be reported for that element in the area bracketed by the CCV. Relative Error (%RE) must be 10% for CCV (See section 12.20 for calculation)

12.6.1.1 If the replicate RSD is high, but all replicates are within the recovery limits, then the results can be accepted at the discretion of the reviewer.

12.6.2 For the CCB, all elements to be reported must be less than the reporting limit (LLOQ). If an element does not meet this criterion then no samples can be reported for that element in the area bracketed by the CCB.

12.7 Interference Check Standard (ICSA-ICSAB). An interference check standard must be analyzed at the beginning of each analytical run. For all spiked elements, the analyzed results must be within 20 percent of the true values. For unspiked elements, the interfering element solutions must contain less than the absolute value of the reporting limit for each element. If these criteria are not met, then no samples containing the elements in question can be reported in the area bracketed by this QC unless the samples contain no significant interferents.

12.8 Low Level Calibration Verification (CRI, CRIB, CRID, CRIA or LLCCV). These are the low-level calibration verification standards containing the elements of interest at (or below) the reporting level for each element. A low-level check standard at or below the RL/LOQ must be analyzed at the beginning of each calibration (analysis) batch. The acceptance criterion for these checks is 80 to 120% recovery. Relative Error (%RE) must be 20% for LLCCV (See section 12.20 for calculation).

12.8.1 The low-level calibration verification is initially verified by the analysis of at least 7 replicate samples, spiked at the RL/LOQ and processed through all preparation and analysis steps of the method. The mean recovery and relative standard deviation of these samples provide an initial statement on precision and accuracy at the LLOQ. In most cases the mean recovery must be +/- 35% of the true value and RSD must be < 20%. Ongoing quarterly verification is required.

12.8.2 More frequent LLCCV checks may be analyzed during the course of the run if system stability at the low end of the calibration is questionable or if the lab wants to ensure that fewer samples will have to be submitted for reanalysis if there is a failed low check at the end of a run.

12.9 Method Blank: The laboratory must digest and analyze a method blank with each set of samples. A minimum of one method blank is required for every 20-sample batch. All elements to be reported must be less than ½ of the RL (LLOQ). if the samples are high relative to the Method blank (> 10 X of the level), then the samples may be reported. If the method blank does not contain target analytes at a level that interferes with the project specific DQOs, then the method blank is considered acceptable.

12.9.1 The default 6010D method limit for the method blank is that is must be less than one half of the reporting limit.

12.9.2 If the method blank does not meet criteria, then it can be reanalyzed along with any associated samples. If it is still unacceptable, then all associated samples must be redigested and reanalyzed along with the other appropriate batch QC samples

12.10 Spike Blank: The laboratory must digest and analyze a spike blank with each set of samples. A minimum of one lab control sample or spike blank is required for every 20-sample batch. The laboratory must assess laboratory performance of the spike blank against recovery limits of 80 to 120 percent. In house spike blank limits may also be generated to support these default limits. If the spike blank is outside of the control limits for a given element, all samples must be redigested and reanalyzed for that element.

12.10.1 If solid lab controls are used, then the manufacturer’s QC Performance Acceptance Limits must be applied.

12.11 Matrix Spike: The laboratory must add a known amount of each analyte to a minimum of 1 in 20 samples. The matrix spike recovery is calculated as shown below. Recoveries must be assessed against default limits of 75 to 125 percent. In house limits may be generated for this method for informational purposes only Note: Both the matrix spike amount and the sample amount are calculated to the IDL for any given element. Any value less than the IDL is treated as zero.

((Spiked Sample Result - Sample Result) / Amount Spiked) x 100 = matrix spike recovery

12.11.1 Post-digest spike must be performed when matrix spike is out of the limits of 75 to 125 percent.

12.12 Matrix Spike Duplicate (MSD) or Matrix Duplicate DUP). The laboratory must digest a matrix spike duplicate or matrix duplicate sample for a minimum of 1 in 20 samples. The relative percent difference (RPD) between the MSD and the MS or between the DUP and the sample must be assessed. The RPD is calculated as shown below. The control limit for the duplicate RPD is method defined as 20%. If the sample and the duplicate are less than 5 times the reporting limits and are within a range of ± the reporting limit, then the duplicate is considered to be in control. Note: Both the duplicate amount and the sample amount are calculated to the IDL for any given element. Any value less than the IDL is treated as zero.

12.12.1 If an MSD or duplicate is out of control, then the data must be checked carefully to confirm that the high rpd for a given element is not a result of an analytical problem. If an analytical problem is suspected, the MSD or duplicate must be reanalyzed for confirmation. If the initial and reanalysis are in agreement (within 20%), then the high rpd is a result of preparation or sample issues and further analysis of the initial preparation is not required. If the initial and reanalysis are not in agreement due to an analytical problem, then any affected samples in the associated batch must also be reanalyzed for that element.

12.12.2 If more than 50% of the elements in a sample (that have levels of at least 5 times the reporting limit) have a high RPD, then the MSD or duplicate must be redigested for confirmation, unless the sample matrix is such that the non-homogeneity of the sample is visually apparent. If the results confirm, the results from the original MSD or duplicate must be flagged as indicative of possible sample non-homogeneity. If the results do not confirm, then the whole batch must be digested and reanalyzed.

12.12.3 If 50% or less of the elements in a sample (that have levels of at least 5 times the reporting limit) have a high rpd, then the high rpd(s) must be footnoted as indicating possible sample non-homogeneity unless other problems are suspected. If problems are suspected, the reviewer will initiate redigestion and reanalysis of the batch.

12.12.4 The calculations used to calculate RPD are shown below.

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

$$\frac{(|\text{Sample Result - Duplicate Result}|) \times 100}{(\text{Sample Result + Duplicate Result})/2} = \text{Duplicate RPD}$$

12.13 Serial Dilution. A serial dilution is required on a frequency of one in 20 samples. For one sample per preparation batch, or whenever matrix interferences are suspected for a batch of samples, a serial dilution must be prepared. Normally the sample used for the serial dilution is the sample that is used for the matrix spike and matrix spike duplicate. For the serial dilution, a 1:5 dilution must be made on the sample. The results of the 1:5 dilution must agree within 20 percent of the true value as long as the sample is greater than 25 times the reporting limit for that element before dilution and the sample results are within the linear range. If not, an interference effect must be suspected, and the serial dilution result for the element with the suspected interference must be footnoted. The serial dilution is calculated as shown below.

$$\frac{100 \times ((\text{Sample result – Serial dilution result}))}{\text{Sample result}} = \text{Serial dilution percent difference}$$

12.14 Post Digestion Spike: Post-digest spikes used to determine potential interferences. The test only needs to be performed for the specific elements that failed original matrix spike limits, and only if the spike concentration added was greater than the concentration determined in the unspiked sample.
Using unspiked QC sample, spike with a known quantity of target elements. Post spike concentration is at matrix spike concentration. See TABLE 5 for suggested concentrations of Metals in the Post digestion spike and Table 18 for preparation of post spike. The recovery of the post-digestion Spike must fall within 75 to 125 % acceptance range, relative to the known true value. If the post-digestion MS recovery fails to meet the acceptance criteria, the sample results must be reported as estimated values.
((Post spiked Sample Result - Sample Result) / Amount Spiked) x 100 = Post spike recovery

12.15 For TCLP samples, a post-digest spike for any element where the matrix spike recovery is less than 50% and the sample concentration for that element is within 20% of the appropriate regulatory level and not over the regulatory level. If the post-digest spike passes within limits of 75 to 125% recovery, the low recovery will be attributed to a sample matrix effect at digestion and no further analyses will be required. If the post-digest spike fails, then a second post-digest spike will be prepared on a sample dilution. If this spike passes, all samples will be rerun at this dilution level to confirm the sample results. If the post-digest spike fails again on the diluted sample, then Method of Standard Additions (MSA) will be performed for this sample.

12.16 IEC Correction Factor Generation. All interfering element correction factors (IEC's), must be verified and updated a minimum of once every 6 months or whenever instrument conditions change significantly. The result of <2 times RL (LLOQ) is required on IEC.

12.17 Lower Limit of Quantitation check sample (LLQC). The LLQC is a sample at the reporting limit that is taken through the entire preparation and analytical process. This standard must be analyzed when reporting limits are initial established and on an as needed basis after that. The LLQC is equivalent to the LOQ (Limit of quantitation) standard which must be analyzed quarterly for the DOD QSM program. The limits of quantitation are verified when all analytes in the LLQC sample are detected within 20% of their true value. If the limits cannot be verified at the spiked level, then the quantitation limit must be adjusted to a level where verification is successful.

12.18 Calibration Curve. The calibration curve must be prepared daily using a minimum of a calibration blank and one non-zero. The calibration must be verified with LLCCV/CRI and an ICV before any samples can be analyzed. If the curve is not verified as described in section 12.5 or 12.8, then no results can be reported for those elements which did not meet quality control criteria.

12.19 HIGH STANDARD: The high standard is required in run and acceptance criteria are +/-10 of the true value. See HSTD table 14 for preparation and true value.

12.20 Measurement the Relative Error (%RE):

Relative error is calculated using the following equation:

$$\% \text{ Relative Error} = \frac{x'i - xi}{xi} \times 100$$

xi = True value for the standard
x'i = Measured concentration of the standard
The Relative Error for the CCV is 10% and for LLCCV (CRI) is 20%

13.0 CALCULATIONS

13.1 For water samples, the following calculations must be used. Refer to the QC section for the calculations to be used for the QC samples.

$$\text{original sample concentration of metal } (\mu g/l) = \frac{(\text{conc. in the digestate } (\mu g/l)) \times (\text{final digestate volume (ml)})}{(\text{Initial sample volume (ml)})}$$

13.2 For soil samples, the following calculations must be used.

$$\text{concentration of the metal in the dry sample (mg/kg)} = \frac{(\text{conc. in the digestate (mg/l)} \times \text{final digestate volume(L)})}{(\text{sample wt. (kg)}) \times (\text{\% solids}/100)}$$

14.0 DOCUMENTATION REQUIREMENTS

14.1 If any samples or QC checks require reanalysis, a brief explanation of the reason must be documented in the raw data. All instrument data must be exported to the LIMS system and a copy of the run log must be included in the logbook by the instrument.

14.2 The Standard Preparation Logbook must be completed for all standard preparations. All information requested must be completed. The SGS Lot Number must be cross-referenced on the standard vial.

14.3 The Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. A copy of any outside maintenance reports must also be kept in the log. In addition to the maintenance, the maintenance log must also contain daily information on such items as the profile intensity. Each instrument has a separate log.

14.4 Any corrections to laboratory data must be done using a single line through the error and a reason for the correction. The initials of the person and date of correction must appear next to the correction.

14.5 Supervisory (or peer) personnel must routinely review (at least once per month) all laboratory logbooks to ensure that information is being recorded properly. Additionally, the maintenance of the logbooks and the accuracy of the recorded information must also be verified during this review.

15.0 INSTRUMENT MAINTENANCE

15.1 Recommended periodic maintenance includes the items outlined below.

15.1.1 Change the pump tubing weekly or as needed.

15.1.2 Clean the filter on the recirculating pump approximately once a month and dust off the power supply vents every one to two weeks.

15.1.3 Clean the radial view quartz surface weekly or more often if needed.

15.1.4 Clean the nebulizer, torch, and injector tube every two to four weeks or more often as needed.

15.1.5 Change the sampler tip as needed (every one to two months).

15.1.6 Clean the recirculating pump lines every 3 months or more often if needed.

15.1.7 Clean the slides on the autosampler with methanol and wipe them with a Kim Wipe saturated with Teflon spray a minimum of once per day.

16.0 POLLUTION PREVENTION & WASTE MANAGEMENT

16.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 16.2.

16.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

16.2.1 Nonhazardous aqueous wastes.
16.2.2 Hazardous aqueous wastes
16.2.3 Chlorinated organic solvents
16.2.4 Non-chlorinated organic solvents
16.2.5 Hazardous solid wastes
16.2.6 Non-hazardous solid wastes

17.0 ADDITIONAL REFERENCES

17.1 Refer to other SOP’s for ICP analysis (CLP, and EPA 200.7 for both DW and WW).

	TABLE 1: NORMAL REPORTING LIMITS BY ELEMENT			
ANALYTE	**WATER & WIPE REPORTING LIMIT(µg/l)**	**SOIL REPORTING LIMIT (mg/kg)**	**SOIL REPORTING LIMIT (ug/l)**	**TCLP REPORTING LIMIT**
Aluminum	200	50	500	
Antimony	6	2	20	
Arsenic	3	2	20	0.50
Barium	200	20	200	1.0
Beryllium	1	0.2	2	
Cadmium	3	0.5	5	0.025
Calcium	5000	500	5000	
Chromium	10	1	10	0.05
Cobalt	50	5	50	
Copper	10	2.5	25	
Iron	100	50	500	
Lead	3	2	20	0.50
Magnesium	5000	500	5000	
Manganese	15	1.5	15	
Nickel	10	4.0	40	
Potassium	10000	1000	10000	
Selenium	10	2	20	0.50
Silver	10	0.5	5	0.05
Sodium	10000	1000	10000	
Thallium	10	1	10	
Vanadium	50	5	50	
Zinc	20	5	50	
Boron	100	10	100	
Molybdenu	20	1	10	
Palladium	50	5.0	50	
Sulfur	50	10	100	
Silicon	200	20	200	
Strontium	10	5	50	
Tin	10	10	200	
Titanium	10	1	10	
Tungsten	50	5	50	
Zirconium	10	2	20	
Bismuth	20	2	20	
Lithium	50	5	50	
Phosphorus	50	10	100	
Cerium	100	10	100	

Cerium is being calibrated to monitor IEC factor only.

TABLE 2: ANALYTICAL LINES ON THE SSTRACE			
ELEMENT	**WAVELENGTH**	**PLASMA VIEW**	**WAVELENGTH RANGE SELECTION**
Al	396.1	Radial	High
As	189.0	Axial	Low
Ca	317.9	Radial	High
Fe	259.9	Radial	High
Mg	279.0	Radial	High
Mn	257.610	Axial	High
Pb	220.3	Axial	Low
Se	196.0	Axial	Low
Tl	190.8	Axial	Low
V	292.4	Axial	High
Ag	328.0	Axial	High
Ba	455.4	Radial	High
Be	313.0	Radial	High
Cd	228.8	Axial	Low
Co	228.6	Axial	Low
Cr	267.7	Axial	High
Cu	324.7	Axial	High
K	766.4	Radial	High
Na	589.5	Radial	High
Ni	231.6	Axial	Low
Sb	206.8	Axial	Low
Zn	206.2	Axial	Low
B	208.9	Axial	Low
Mo	202.0	Axial	Low
P	177.4	Axial	Low
S	182.0	Axial	Low
Sr	407.7	Radial	High
Sn	189.9	Axial	Low
Ti	334.9	Axial	High
Si	212.4	Axial	Low
W	207.9	Axial	Low
Zr	339.1	Axial	High
Bi	223.0	Axial	Low
Li	670.7	Radial	High
Ce	404.0	Axial	High

TABLE 3: CALIBRATION STANDARD LEVELS in ug/l		
Element	**STD A (Blank)**	**STD B**
Aluminum	0	80000
Antimony	0	4000
Arsenic	0	4000
Barium	0	4000
Beryllium	0	4000
Cadmium	0	4000
Calcium	0	80000
Chromium	0	4000
Cobalt	0	4000
Copper	0	4000
Iron	0	80000
Lead	0	4000
Magnesium	0	80000
Manganese	0	4000
Nickel	0	4000
Potassium	0	80000
Selenium	0	4000
Silver	0	500
Sodium	0	80000
Thallium	0	4000
Vanadium	0	4000
Zinc	0	4000
Boron	0	4000
Molybdenum	0	4000
Phosphorus	0	4000
Sulfur	0	4000
Silicon	0	**10000**
Strontium	0	4000
Tin	0	4000
Titanium	0	4000
Tungsten	0	4000
Zirconium	0	4000
Bismuth	0	4000
Lithium	0	4000
Cerium	0	4000

TABLE 4: ICV, and CCV LEVELS		
Element	**ICV Suggested Level in ug/l**	**CCV Suggested Level in ug/l**
Aluminum	40000	40000
Antimony	2000	2000
Arsenic	2000	2000
Barium	2000	2000
Beryllium	2000	2000
Cadmium	2000	2000
Calcium	40000	40000
Chromium	2000	2000
Cobalt	2000	2000
Copper	2000	2000
Iron	40000	40000
Lead	2000	2000
Magnesium	40000	40000
Manganese	2000	2000
Nickel	2000	2000
Potassium	40000	40000
Selenium	2000	2000
Silver	250	250
Sodium	40000	40000
Thallium	2000	2000
Vanadium	2000	2000
Zinc	2000	2000
Boron	2000	2000
Molybdenum	2000	2000
Phosphorus	2000	2000
Sulfur	2000	2000
Silicon	5000	5000
Strontium	2000	2000
Tin	2000	2000
Titanium	2000	2000
Tungsten	2000	2000
Zirconium	2000	2000
Bismuth	2000	2000
Lithium	2000	2000
Cerium	N/A	2000

TABLE 5: SUGGESTED CONCENTRATIONS OF METALS IN THE MATRIX SPIKE, SPIKE BLANK AND POST SPIKE FOR AQ, SOIL AND TCLP MATRIX

ELEMENT	SOILS FINAL CONCENTRATION IN mg/kg	AQUEOUS/SOIL FINAL CONCENTRATION IN µg/l	
Aluminum	2500	25000	
Antimony	200	2000	
Arsenic	200	2000	
Barium	200	2000	
Beryllium	200	2000	
Cadmium	200	2000	
Calcium	2500	25000	
Chromium	200	2000	
Cobalt	200	2000	
Copper	200	2000	
Iron	2500	25000	
Lead	200	2000	
Magnesium	2500	25000	
Manganese	200	2000	
Nickel	200	2000	
Potassium	2500	25000	
Selenium	200	2000	
Silver	25	250	
Sodium	2500	25000	
Thallium	200	2000	
Vanadium	200	2000	
Zinc	200	2000	
Boron	200	2000	
Molybdenum	200	2000	
Phosphorus	200	2000	
Sulfur	200	2000	
Silicon	500	5000	
Strontium	200	2000	
Tin	200	2000	
Titanium	200	2000	
Tungsten	200	2000	
Zirconium	200	2000	
Bismuth	200	2000	
Lithium	200	2000	
Cerium	N/A	N/A	

TABLE 6: SUGGESTED CONCENTRATIONS OF METALS IN THE QUALITY CONTROL SAMPLE LOW CHECK (CRI or CRIB) SOLUTION

ELEMENT	FINAL CONCENTRATION IN µg/l
Sb	6
As	8
Ba	200
Be	2
Cd	3
Cr	10
Co	50
Cu	10
Pb	3
Mn	15
Ni	10
Se	10
Tl	10
V	50
Zn	20
B	100
Bi	20
Li	50
Mo	20
P	50
Sr	10
S	50
Sn	10
Ti	10
W	50
Zr	10
Ag	5
Si	200
Al	200
Ca	5000
Fe	100
Mg	5000
K	5000
Na	5000
Ce	N/A

TABLE 7: SUGGESTED CONCENTRATIONS OF METALS IN THE QUALITY CONTROL SAMPLE LOW CHECK (CRID) SOLUTION

Element	Final Concentration in μg/l
Sb	
As	3
Ba	4
Be	1
Cd	1
Cr	2
Co	3
Cu	
Pb	
Mn	3
Ni	4
Se	5
Tl	
V	2
Zn	10
B	
Bi	
Li	
Mo	
Pd	
Sr	
S	
Sn	
Ti	
W	
Zr	
Ag	
Si	
Al	100
Ca	1000
Fe	
Mg	100
K	2000
Na	1000
Ce	N/A

TABLE 8: SUGGESTED CONCENTRATIONS OF METALS IN THE QUALITY CONTROL SAMPLE LOW CHECK (CRIA) SOLUTION	
ELEMENT	**FINAL CONCENTRATION IN µg/l**
Sb	20
As	20
Ba	
Be	
Cd	
Cr	
Co	
Cu	
Pb	20
Mn	
Ni	
Se	20
Tl	
V	
Zn	
B	
Bi	
Li	
Mo	
Pd	
Sr	
S	
Sn	200
Ti	
W	
Zr	
Ag	
Si	
Al	500
Ca	2000
Fe	500
Mg	2000
K	
Na	
Ce	

Solution shown in Table 8 is not the part of the routine run but can be used as needed for higher detection limit.

TABLE 9: INTERNAL STANDARDS				
ELEMENTS	**Y 3600**	**Y 3710**	**Y 2243**	**In 2306**
Sb			X	
As			X	
Ba		X		
Be		X		
Cd			X	
Cr	X			
Co				X
Cu	X			
Pb				X
Mn	X			
Ni				X
Se			X	
Tl				X
V	X			
Zn			X	
B			X	
Bi			X	
Li		X		
Mo			X	
P			X	
Sr		X		
S			X	
Sn			X	
Ti	X			
W			X	
Zr	X			
Ag	X			
Si			X	
Al		X		
Ca		X		
Fe		X		
Mg		X		
K		X		
Na		X		
Ce	X			

TABLE 10: PREPARATION AND CONCENTRATION OF ICP DAILY CALIBRATION AND INTERNAL STANDARD

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expira-tion Date	Acid Matrix	Acid Manu-facturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Exp. Date	Date	Analyst (Initials)
MA-__________ STDA	None	N/A		N/A	N/A	__% HNO3 __% HCl			0.000	0.000	1000	0.000			
MA-__________ STDA	None	N/A		N/A	N/A	__% HNO3 __% HCl			0.000	0.000	1000	0.000			
MA-__________ STDA	None	N/A		N/A	N/A	__% HNO3 __% HCl			0.000	0.000	1000	0.000			
MA-__________ STDA	None	N/A		N/A	N/A	__% HNO3 __% HCl			0.000	0.000	1000	0.000			
MA-__________ STDA	None	N/A		N/A	N/A	__% HNO3 __% HCl			0.000	0.000	1000	0.000			
MA-___________ - STDB	B,Ba,Be,Cd,Co, Cr3,Cu,Mn,Ni,P, Pb,Se,Sr,TL,V, Zn	Inorganic Ventures	Accutest-13 REV1			__% HNO3 __% HCl			1000	0.80	200	4.00			
	As,Mo,Sb,Sn,Ti, W,Zr	Inorganic Ventures	Accutest-14 REV1						1000	0.80		4.00			
	Ag	In house							125	0.80		0.50			
	Bi								1000	0.80		4.00			
	Li								1000	0.80		4.00			
	S								1000	0.80		4.00			
	Si								1000	2.00		10.00			
	Al.Na,K,Fe,Mg, Ca	Inorganic Ventures	Metals Mix						5000	3.20		80.00			
	Ce								1000	0.80		4.00			
MA-___________ - IS	Y					__% HNO3 __% HCl			10000	2.00	2000	10.00			
	Cs								10000	40.00		200.00			
	In								10000	10.00		50.00			
MA-___________ - IS	Y					__% HNO3 __% HCl			10000	2.00	2000	10.00			
	Cs								10000	40.00		200.00			
	In								10000	10.00		50.00			

TABLE 11: PREPARATION AND CONCENTRATION OF CCV

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expira-tion Date	Acid Matrix	Acid Manu-facturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Exp. Date	Date	Analyst (Initials)
MA-___________ - CCV	B,Ba,Be,Cd,Co, Cr3,Cu,Mn,Ni,P, Pb,Se,Sr,TL,V, Zn	Inorganic Ventures				__% HNO3 __% HCl			1000	2.00		2.00			
	As,Mo,Sb,Sn,Ti, W,Zr	Inorganic Ventures							1000	2.00		2.00			
	Ag	In house							125	2.00		0.25			
	Bi								1000	2.00		2.00			
	Li								1000	2.00		2.00			
	S								1000	2.00		2.00			
	Si								1000	5.00		5.00			
	Al.Na,K,Fe,Mg, Ca	Inorganic Ventures	Mineral Mix						5000	8.00		40.00			
	Ce								1000	2.00		2.00			

TABLE 12: PREPARATION AND CONCENTRATION OF ICV

Standard Name	Elements	Vendor Name	Name (for multi-elements)	Stock Lot #	Exp. Date	Acid Matrix	Acid Manu-facturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc (mg/l)	Exp. Date	Analyst (Initials)	Date
	Ba								1000	2.0	1000	2.00			
	Be								1000	2.0		2.00			
	Cd								1000	2.0		2.00			
	Co								1000	2.0		2.00			
	Cr								1000	2.0		2.00			
	Cu								1000	2.0		2.00			
	Mn								1000	2.0		2.00			
	Ni								1000	2.0		2.00			
	V								1000	2.0		2.00			
	Zn								1000	2.0		2.00			
	As								1000	2.0		2.00			
	TL								1000	2.0		2.00			
	Pb								1000	2.0		2.00			
	Se								1000	2.0		2.00			
	Sb								1000	2.0		2.00			
	B								1000	2.0		2.00			
	Mo								1000	2.0		2.00			
	Sn								1000	2.0		2.00			
	Sr								1000	2.0		2.00			
	Ti								1000	2.0		2.00			
	W								1000	2.0		2.00			
	Zr								1000	2.0		2.00			
	S								1000	2.0		2.00			
	Bi								1000	2.0		2.00			
	Li								1000	2.0		2.00			
	P								1000	2.0		2.00			
	Ag								1000	0.250		0.25			
	Si								1000	5.00		5.00			
	Al								10000	4.0		40.00			
	Ca								10000	4.0		40.00			
	Fe								10000	4.0		40.00			
	Mg								10000	4.0		40.00			
	K								10000	4.0		40.00			
	Na								10000	4.0		40.00			

TABLE 13: PREPARATION AND CONCENTRATION OF ICSA AND ICSAB SOLUTIONS.

ICSA:

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expiration Date	Acid Matrix	Acid Manufacturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Expiration Date	Analyst (Initials)	Date
MA-___-____ - ICSA	Mg		N/A			____% Nitric ____% HCl			10000	50.0	1000	500			
	Al		N/A						10000	50.0	1000	500			
	Ca		N/A						10000	40.0	1000	400			
	Fe		N/A						10000	20.0	1000	200			

ICSAB:

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expiration Date	Acid Matrix	Acid Manufacturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Expiration Date	Analyst (Initials)	Date
MA-___-____ - ICSAB	Ag,Cd,Ni,Pb,Zn		CLP ILM 03.0 Analytes B			____% HNO3 ____% HCl			100	10	1000	1.00			
	Ba,Be,Cr,Co,Cu,Mn,V								50	10	1000	0.50			
	Al								10000	50.0	1000	500			
	Ca								10000	40.0	1000	400			
	Fe								10000	20.0	1000	200			
	Mg								10000	50.0	1000	500			
	Sb								1000	1.0	1000	1.00			
	As								1000	1.0	1000	1.00			
	Se								1000	1.0	1000	1.00			
	Tl								1000	1.0	1000	1.00			
	Mo								1000	0.5	1000	0.50			
	W								1000	0.5	1000	0.50			
	Zr								1000	0.5	1000	0.50			
	B								1000	0.5	1000	0.50			
	Sr								1000	0.5	1000	0.50			
	Sn								1000	0.5	1000	0.50			
	Ti								1000	0.5	1000	0.50			
	Si								1000	0.5	1000	0.50			
	S								1000	0.5	1000	0.50			
	Bi								1000	0.5	1000	0.50			
	Li								1000	0.5	1000	0.50			
	P								1000	0.5	1000	0.50			

TABLE 14: PREPARATION AND CONCENTRATION OF HIGH STANDARD

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expira-tion Date	Acid Matrix	Acid Manu-facturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Exp. Date	Date	Analyst (Initials)
MA-__________ - HSTD (Regular)	B,Ba,Be,Cd,Co, Cr3,Cu,Mn,Ni,P, Pb,Se,Sr,TL,V, Zn	Inorganic Ventures	Accutest-13 REV1			__% HNO3 __% HCl			1000	8.00	1000	8.00			
	As,Mo,Sb,Sn,Ti, W,Zr	Inorganic Ventures	Accutest-14 REV1						1000	8.00		8.00			
	Ag	In house							125	5.00		0.625			
	Bi								1000	8.00		8.00			
	Li								1000	8.00		8.00			
	S								10000	10.00		100.00			
	Si								10000	2.50		25.00			

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expira-tion Date	Acid Matrix	Acid Manu-facturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Exp. Date	Date	Analyst (Initials)
MA-__________ - HSTD (Minerals)	Al					__% HNO3 __% HCl			10000	30.00	1000	300.00			
	Mg								10000	30.00		300.00			
	K								10000	20.00		200.000			
	Na								10000	20.00		200.00			
	Ca								10000	20.00		200.00			
	Fe								10000	20.00		200.00			

TABLE 15: PREPARATON AND CONCENTRATION OF CRI SOLUTION

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expira-tion Date	Acid Matrix	Acid Manu-facturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Expira-tion Date	Analyst (Initials)	Date
MA-__________ - CRI	Sb	Inorganic Ventures	ACCUTEST-20A			____% HNO3 ____% HCl			6.00	1.00	1000	0.006			
	Mo								20.00			0.020			
	Sn								10.00			0.010			
	Ti								10.00			0.010			
	W								50.00			0.050			
	Zr								10.00			0.010			
	Al	Inorganic Ventures	ACCUTEST-20B						200.00	1.00		0.200			
	As								8.00			0.008			
	Ba								200			0.200			
	Be								2.00			0.002			
	B								100.00			0.100			
	Cd								3.00			0.003			
	Ca								5000			5.000			
	Cr								10.0			0.010			
	Co								50.00			0.050			
	Cu								10.0			0.010			
	Fe								100.0			0.100			
	Pb								3.0			0.003			
	Mg								5000			5.000			
	Mn								15.0			0.015			
	Ni								10.0			0.010			
	P								50.0			0.050			
	K								5000			5.000			
	Se								10.0			0.010			
	Na								5000.0			5.000			
	Sr								10			0.010			
	TL								10			0.010			
	V								50			0.050			
	Zn								20			0.020			
	Bi	In house	Intermediate						20	1.00		0.020			
	Li	In house	Intermediate						50	1.00		0.05			
	S	In house	Intermediate						50	1.00		0.05			
	Zr	In house	Intermediate						10	1.00		0.01			
	Si								1000	0.20		0.20			
	Ag	In house	Intermediate						10	0.50		0.005			

TABLE 16: PREPARATION AND CONCENTRATION OF CRID SOLUTION

Standard Name	Elements	Vendor Name	Item Name (for multi-elements)	Stock Lot #	Expiration Date	Acid Matrix	Acid Manufacturer	Acid Lot #	Stock Conc. (mg/l)	Vol. Added (ml)	Total Vol. (ml)	Std Conc. (mg/l)	Expiration Date	Analyst (Initials)	Date
MA-__________ - CRID	Al	Inorganic Ventures	ACCUTEST-21			____% HNO3 ____% HCl			100.00	1.00	1000	0.100			
	As								3.00			0.003			
	BA								4.00			0.004			
	Be								1.00			0.001			
	Cd								1.00			0.001			
	Ca								1000.00			1.000			
	Cr								2.00			0.002			
	Co								3.00			0.003			
	Mg								100			0.100			
	Mn								3.00			0.003			
	Ni								4.00			0.004			
	K								2000.00			2.000			
	Se								5			0.005			
	Na								1000.0			1.000			
	TL								2.00			0.002			
	V								2.0			0.002			
	ZN								10.0			0.010			

TABLE 17: PREPARATION AND CONCENTRATION OF POST SPIKE SOLUTION

SGS					Date		Analyst		MP #	
Post spike for ICP Method 6010D					**QC sample #**					
Spiking solution	Elements	Spike added (Y/N)	Vendor	Intermediate Lot #	Exp. Date	Conc. (mg/l)	Amt of Spike added (ml)	Digestate sample volume (ml)	Final Digestate volume in ml (Spike+ Sample)	Final Conc at the instrument (mg/l)
Mixed ICP intermediate Metals Solution (ACCUTEST-13A-REV1)	Ba,Be,B Cd,Cr,Co,Cu,Pb ,Mn,Ni,P,Se,Sr, TL,V,Zn					200	0.2			2
Mixed ICP intermediate Metals Solution (ACCUTEST-14A-REV1)	Sb,As,Mo,Sn,Ti, W,Zr					200	0.2		20	2
Ag Spike Intermediate	Ag					20	0.25			0.25
Metals Mix	Ca,Al,Fe,Mg,K, Na					5000	0.1			25
S spike	S					200	0.2			2
Bi Spike	Bi					200	0.2			2
Li Spike	Li					200	0.2			2
Si spike	Si					1000	0.1			5

For preparations of post spike Intermediate solutions follow the ICP Intermediate preparation book.

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
reference	Added revision and year
4.0	Updated MDL definition
6.1	Revised preservation temperature
12.2	Updated MDL procedure requirement

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added

History of Revisions

Version #	Date of Revision	Revised By

END OF DOCUMENT

LAB SUPERVISOR: ______________________

QA OFFICER: Olga L. Azarian

EFFECTIVE DATE: 12-14-2020

TITLE:TOTAL SEMI-VOLATILE PETROLEUM HYDROCARBONS
REFERENCES: SW846 8015D (Revision 4, June, 2003)
REVISED SECTIONS: deleted reference to Appendix I

1.0 SCOPE AND APPLICATION

1.1 This method is based on a solvent extraction and gas chromatographic procedure utilizing a flame ionization detector (FID). The method may be utilized to detect hydrocarbons in the Diesel Range Organics (DRO), where the C8 to C44 hydrocarbon range corresponds to a boiling point range between approximately 170°C and 430°C. However, the routine reporting range is C10 to C28.

1.2 The method is suitable for the analysis of the extracts prepared from all types of solid waste matrices, soils, and water samples.

2.0 SUMMARY

2.1 The sample is extracted with methylene chloride, pentane, hexane, or other suitable solvent and concentrated. The extract is analyzed by capillary GC column equipped with a flame ionization detector. The chromatogram is integrated within the C8 to C44 range, or client specified range and quantified with a calibration factor.

3.0 REPORTING LIMIT AND METHOD DETECTION LIMIT

3.1 Reporting Limit. The reporting limit for this method is established at the lowest concentration standard in the calibration curve (1 µg/ml for LVI waters, 25 µg/ml for waters and 10 mg/kg for soils).

3.2 Method Detection Limit. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B, Revision 2. This value represents the lowest reportable concentration of an individual compound that meets the method qualitative identification criteria.

3.2.1 Experimental MDLs must be determined according to the SOP EQA075.

4.0 DEFINITIONS

BLANK. An analytical sample designed to assess specific sources of laboratory contamination. See individual types of Blanks: Method Blank; Instrument Blank, Storage Blank, and Sulfur Blank.

BLANK SPIKE. A blank matrix (reagent water or clean sand) is spiked with the targeted parameters and analyzed using the same method used for samples. Accuracy data is compared to laboratory derived limits to determine if the method is in control.

CALIBRATION FACTOR (CF). A measure of the gas chromatographic response of a target analyte to the mass injected. The calibration factor is analogous to the Relative Response Factor (RRF) used in the Volatile and Semi-volatile fractions.

CONTINUING CALIBRATION. Analytical standard run every 12 hours to verify the initial calibration of the system.

INITIAL CALIBRATION. Analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the flame ionization detector to the target compounds.

MATRIX. The predominant material of which the sample to be analyzed is composed. For the purpose of this SOP, a sample matrix is either water or soil/sediment. Matrix is not synonymous with phase (liquid or solid).

MATRIX SPIKE. Aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

MATRIX SPIKE DUPLICATE. A second aliquot of the same matrix as the matrix spike (above) that is spiked in order to determine the precision of the method.

METHOD BLANK. An analytical control consisting of all reagents, internal standards and surrogate standards, which is carried throughout the entire analytical procedure. The method blank is used to define the level of laboratory, background and reagent contamination.

METHOD DETECTION LIMITS (MDLs). The minimum concentration of a substance that can be measured and reported with 99% confidence that the measured concentration is distinguishable from method blank results.

PERCENT DIFFERENCE (%D). As used in this SOP and elsewhere to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero (In contrast, see relative percent difference).

PERCENT MOISTURE. An approximation of the amount of water in a soil/sediment sample made by drying an aliquot of the sample at 105°C. The percent moisture determined in this manner also includes contributions from all compounds that may volatilize at or below 105° C, including water. Percent moisture may be determined from decanted samples and from samples that are not decanted.

REAGENT WATER. Water in which an interferant is not observed at or above the minimum detection limit of the parameters of interest.

RELATIVE PERCENT DIFFERENCE (RPD). As used in this SOP and elsewhere to compare two values, the relative percent difference is based on the mean of the two values, and is reported as an absolute value, i.e., always expressed as a positive number or zero (In contrast, see percent difference).

RELATIVE RESPONSE FACTOR (RRF). A measure of the instrument response of an analyte. Response Factors are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples.

RETENTION TIME (RT). The time required (in minutes) for a standard compound to elute from a chromatographic column.

INSTRUMENT BLANK. A system evaluation sample containing lab reagent grade water with internal standards and surrogate standards added. An instrument blank is used to remove and/or evaluate residual carryover from high level standards, spike samples and field samples.

5.0 HEALTH & SAFETY

5.1 The analyst must follow normal safety procedures as outlined in the SGS Laboratory Safety Manual which includes the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents must be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets must be made available to all personnel involved in these analyses.

5.3 Primary standards of toxic compounds must be prepared in a hood. A NIOSH/Mass approved toxic gas respirator must be worn when the analyst handles high concentrations of these toxic compounds.

6.0 COLLECTION, PRESERVATION, & HOLDING TIMES

6.1 Collection & Preservation

6.1.1 Aqueous samples are collected in 1 liter or 300mL amber glass bottles with Teflon lined cap. Samples must be preserved with 5 ml of 50% HCl at the time of collection(acid must be added to the bottle prior to adding the sample)

6.1.2 Soil samples are collected in glass containers with Teflon lined cap.

6.1.3 The samples must be protected from light and refrigerated at 0 to < 6°C from the time of receipt until extraction and analysis.

6.1.4 Sample extracts are stored at 0 to < 6°C, protected from light.

6.2 Holding Time

6.2.1 Aqueous sample must be extracted within 7 days of sampling.Aqueous sample extract by 3511 must be extracted within 7 days of sampling, samples with acid preservation must be extracted within 14 days of sampling.

6.2.2 Soil sample must be extracted within 14 days of sampling.

6.2.3 All extracts must be analyzed within 40 days following extraction.

7.0 APPARATUS & MATERIALS

7.1 Microsyringes - 10 ul, 25 ul, 100 ul, 500 ul, and 1000 ul.

7.2 Volumetric flasks - 10 ml, , 25 ml, 50 ml, 100 ml.

7.3 Disposable pasteur pipets.

7.4 10 ul graduated syringe, manually held (Hamilton or equiv.).

7.5 10 ul graduated syringe, auto sampler (Hamilton or equiv.).

7.6 50ul graduated syringe, auto sampler (Hamiltion or equiv.)

7.7 Gas Chromatograph, equipped with a flame ionization detector, capable of temperature programming.

7.8 Autosampler

7.9 GC column - 30m x 0.25mm ID, DB-5, 0.5u film or equivalent

7.10 GC Column (Large Volume Injection) – 15-30m x 25mm ID w/ 5-10m Integrated Guard, ZB 5MSPlus 0.25u film or equivalent

7.11 Data Integrator - Data system capable of summing peaks, re-analyzing data files after revising integration parameters, and manually drawing chromatographic baselines as necessary. The ENVIROQUANT (PC) data system is capable of quantitation using multi-point calibration.

8.0 STANDARDS & REAGENTS

8.1 Solvents - Ultra pure, chromatography grade methylene chloride, pentane, or hexane.

8.2 Diesel stock standard - 50,000 ppm of Absolute Standards or equivalent.

8.3 Surrogate Solution – o-Terphenyl, Tetracosane-d50, 5 α-Androstane 1000 ug/ml, Restek or equivalent.

8.4 Spike solution - Diesel stock standard - 20,000 ppm of Absolute Standards or equivalent.
8.5 C8-C40 Standard Solution 500µg/ml each of the Restek or equivalent.

8.6 Unopened stock must be stored according to manufacturer’s documented holding time and storage temperature recommendations.

8.7 Retention time window standard – Restek FL TRPH Std. 500ppm or equivalent.

8.8 C44 standard – Sigma-Aldrich neat or equivalent

8.9 After opened, stock standards must be replaced after 6 months or sooner if manufacturer expiration date comes first or comparison with quality control check samples indicates degradation.

9.0 INTERFERENCES

9.1 The data from all blanks, samples, and spikes must be evaluated for interferences.

9.2 Method interferences may be caused by contaminants in solvents, reagents, glassware, and other stages of sample processing. Refer to "Preparation of Glassware for Extraction of Organic Contaminants" SOP for practices utilized in the extraction department.

9.3 Contamination from "carry over" may occur when high and low level samples are sequentially analyzed. The sample syringe must be rinsed with reagent water, or a suitable solvent in between samples. When an unusually concentrated sample is encountered, a solvent-blank should be analyzed to check for cross contamination. Low level samples immediately following high level samples should be verified.

9.4 Most polar interferences (animal fats, glycerides, “leaf hydrocarbons”, etc.) may be removed with the silica clean up. This is performed at the client’s request.

9.5 Sample should be taken with care, to prevent any portion of the collected sample coming in contact with the sampler's gloves. Since this can result in phthalate contamination.

9.6 Siloxane contamination can occur when the septa cap on the extract vial is repeatedly punctured. These contaminants are more noticeable in Large Volume Injection techniques and can be avoided by minimizing the number of times the sample extract is punctured.

10.0 PROCEDURE

10.1 INITIAL CALIBRATION.

10.1.1 A minimum of five calibration standards are required although ten are generally used. The concentrations for the conventional analysis are 25*, 50*, 100, 250, 500, 1000, 2000, 5000, 10,000, 50,000 µg/ml (*25 & 50 are used for all water calibrations); the concentration for the Large Volume Injection analysis are 1, 2, 4, 10, 20, 40, 100, 200, 400, 2000 ug/ml. The standards are prepared in Methylene chloride, pentane, or hexane depending on the anaytical technique. Refer to the standards preparation logbook for procedure.

10.1.2 The initial calibration is performed with the alkane standard C8 - C44 to identify hydrocarbon range for client requirements and for retention marker (see section 10.4 for detail).

10.1.3 The method reporting limit is established by the concentration of the lowest standard analyzed during initial calibration. The linear range covered by this calibration is equal to the highest concentration standard.

10.1.4 Aliquot proper amount of each calibration standard into a 2 ml vial.

10.1.5 Analyze the standard solutions using the conditions established in Section 10.5. Establish the calibration factor for each standard solution by dividing the total area of each standard by the total concentration as defined in Section 11.9.

10.1.6 For the initial calibration to be valid, the percent relative standard deviation (% RSD) (Section 11.9) must be less than 20%. If the average calibration factor criteria cannot be achieved, corrective action must be taken.

10.1.7 If the problem is associated with a single standard, reanalyze the standard and recalculate the RSD

10.1.7.1 Alternately, the laboratory may remove individual analyte calibration levels from the lowest and/or highest levels of the curve. Multiple levels may be removed, but removal of interior levels is not permitted.

10.1.7.2 The laboratory may remove an entire single standard calibration level from the interior of the calibration curve when the instrument response demonstrates that the standard was not properly introduced to the instrument, or an incorrect standard was analyzed. If a calibration standard was removed from the interior of the calibration, this particular standard calibration level must be removed for all analytes. Removal of calibration points from the interior of the curve is not to be used to compensate for lack of maintenance or repair to the instrument.

10.1.7.3 The laboratory must adjust the LOQ/reporting limit and quantitation range of the calibration based on the concentration of the remaining high and low calibration standards.

10.1.7.4 The laboratory must ensure that the remaining initial calibration standards are sufficient to meet the minimum requirements for number of initial calibration points as mandated by the method, or regulatory requirements.

10.1.7.5 The laboratory may replace a calibration standard provided that:

10.1.7.5.1 the laboratory analyzes the replacement standard within twenty-four (24) hours of the original calibration standard analysis for that particular calibration level;

10.1.7.5.2 the laboratory replaces all analytes of the replacement calibration standard if astandard within the interior of the calibration is replaced; and

10.1.7.5.3 the laboratory replaces all analytes of the replacement calibration standard if a standard within the interior of the calibration is replaced; and

10.1.7.6 The laboratory must document a technically valid reason for either removal or replacement of any interior calibration point.

10.2 INITIAL CALIBRATION VERIFICATION (ICV) – SECOND SOURCE CALIBRATION CHECK

10.2.1 A second source calibration check prepared at the concentration of 1000 μg/ml for conventional analysis / 40 ug/ml for LVI analysis, and must be run immediately after the initial calibration.

10.2.2 The percent different (%D) (Section 11.9) for this standard must meet the criteria of 20% used for the calibration verification.

10.2.2.1 If the %D is greater than 20%, reanalyze the second source check. If the criteria cannot be met upon re-injection, re-prepare the second source solution using a fresh ampoule and repeat the process.

10.2.2.2 If the %D criteria cannot be achieved after re-preparation of the second source, prepare a third source and repeat the process. Make fresh calibration standards by using one of the two standard sources that matches each other.

10.3 CONTINUING CALIBRATION CHECK VERIFICATION (CCV)

10.3.1 The initial calibration curve must be verified by a calibration check standard every 10 injections(not to exceed 12-hrs). The concentration of the calibration check solution is alternated between concentrations of 500/20 μg/ml and 1000/40 μg/ml.

10.3.2 C8-C44 hydrocarbon standard is injected everyday to identify the retention window for integration of DRO range. If the retention time of the daily marker standard is outside the window established in section 10.4 refer to section 10.3.6.

10.3.3 For the continuing calibration to be valid, the percent difference (%D) must be within 20% of the initial calibration factor. Calculate the percent difference (%D) using the formula in Section11.9.

10.3.4 Each sample analysis must be bracketed by analyses of acceptable calibration verification standards. If %D criteria fails during a mid-sequence calibration check or at the end of the analysis sequence, a continuing calibration check is allowed to be repeated only once; if the second trial fails, a new initial calibration must be performed and the samples may need to be reanalyzed. In situations where the first check fails to meet the criteria, the instrument logbook should have clear documented notations as to what the problem was and what corrective action was implemented to enable the second check to pass.

10.3.5 When a calibration verification standard fails to meet the QC criteria at the end of the analysis sequence, all samples injected after the last standard that last met the QC criteria must be evaluated to prevent mis-quantitations, and re-injection of the sample extracts may be required.

10.3.5.1 When the calibration standard response is above the initial calibration response and if an analyte was not detected in the specific samples analyzed during the analytical shift, then the extracts for those samples do not need to be reanalyzed.

10.3.5.2 Whether the analyte was detected in the specific samples analyzed during the analytical shift, or the calibration standard response is below the initial calibration response, then the extracts for those samples need to be reanalyzed.

10.3.6 Each subsequent injection of a continuing calibration standard must be checked against the retention time windows established in Section10.4. 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.

10.4 RETENTION TIME WINDOWS

10.4.1 The retention time range for DROs is defined during initial calibration. The range is established from the retention times of the C10 and C28 alkanes (the standard however contains C8 –C44 hydrocarbons to cover for any special requirement needed). Use the following procedure to establish the retention time window from retention time studies performed using these two compounds. The retention time range is then calculated based on the lower limit of the RT window for the first eluting component and the upper limit of the RT window for the last eluting component.

10.4.2 Retention Time Determination

10.4.2.1 Perform initial retention time study using alkane markers. Analyze three calibration studies over a 72 hour period to maximize the retention time variability.

10.4.2.2 Calculate the average retention time and standard deviation of the retention time for the C10 and C28 alkane marker compounds.

10.4.2.2.1 Establish the low end of the retention window for the DRO range using the lower extreme of the C10 alkane. Calculate this value at -3 times the standard deviation of the mean absolute retention time from the analysis conducted during the 72-hour period.

10.4.2.2.1.1 If the standard deviation is less than 0.01 minutes, employ a default minimum standard deviation of 0.01 minutes. If the default standard is used, the width of the window will be 0.03 minutes.

10.4.2.2.2 Establish the high end of the retention window for the DRO range using the higher extreme of the C28 alkane. Calculate this value at +3 times the standard deviation of the mean absolute retention time from the analysis conducted during the 72-hour period.

10.4.2.2.2.1 If the standard deviation is less than 0.01 minutes, employ a default minimum standard deviation of 0.01 minutes. If the default standard is used, the width of the window will be 0.03 minutes.

10.4.2.2.3 Document the retention time study and retain the retention time data as paper copy at the instrument.

10.4.2.3 Apply retention window data to the marker compound standards injection following initial calibration, using the lower extreme value for the low molecular weight compound and the higher extreme value for the higher molecular weight compound.

10.4.3 Check the window on calibration verification with the marker compound standard.

10.4.3.1 Update the retention time data in the quantitation method file using the new information. Use this window for the qualitative identification of diesel range organics in samples, standards, and quality control samples.

10.4.3.2 If the retention time of the daily marker standard is outside the acceptance window of +/- 0.03 minutes, recalibrate the instrument.

10.4.3.3 Retain documented records of all retention time information. Documentation may include paper file maintained next to each instrument or electronic data files that are archived for future use.

10.5 PROCEDURE

10.5.1 Instrument conditions. Recommended instrument conditions are listed in Table 1. Modifications are allowed as long as criteria of calibration are met and approved by team leader/manager.

10.5.2 Sample Preparation.

10.5.2.1 Aqueous samples are solvent extracted using liquid/liquid extraction procedures following EPA method 3510C – Separatory Funnel (DAYT-EXT-0155). Aqueous samples analyzed by large volume injection are extracted using liquid/liquid extraction procedures following EPA method SW-846 3511 (Microextraction).

10.5.2.2 Soil/Sediment samples are solvent extracted using liquid/solid extraction procedure following EPA methods 3550C (EOP003 Sonication Extraction) and/or 3546 (EOP3546 Microwave Extraction).

10.5.2.3 Refer to SGS Organic Preparation SOPs referenced above for procedural details.

10.5.3 Initial Calibration. See Section 10.1.

10.5.4 ICV -Independent source calibration check. See Section 10.2.

10.5.5 Continuing calibration checks. See Section 10.3.

10.5.6 Instrument Blank.

10.5.6.1 An instrument blank is a volume of clean methylene chloride spiked with 5α-Androstane between 25-50ppm or 1 – 2 ppm for LVI

10.5.6.2 At the beginning of each 12-hour shift or immediately after the continuing calibration check, an instrument blank is injected to demonstrate that interferences from the analytical system are under control.

10.5.6.3 Acceptance Criteria

10.5.6.3.1 The DRO concentration in the instrument blank must be less than 25µg/ml and less than1 – 2 ug/mL (depending on specified reporting limits) for LVI.

10.5.6.4 If the instrument blank does not meet the acceptance criteria above, then corrective action must be taken to locate and reduce the source of contamination. An acceptable instrument blank must be run before the analysis can be proceeded.

10.5.7 Sample analysis.

10.5.7.1 Inject 1ul or 25ul for LVIof the sample extract

10.5.7.2 The DRO concentration (Section 11.9.5) is based on the total area of all peaks eluting between C10 and C28 minus the surrogate area and is calculated by external standard technique. If the concentration is greater than full scale of highest standard, then dilute and reanalyze the extract.

10.5.7.3 Preparing Dilutions.

10.5.7.3.1 Prepare sample dilutions quantitatively. Dilute the sample extract with methylene chloride or suitable solvent using logical volume to volume ratios, i.e.,1:2, 1:5, 1:10, 1:50, etc. See Table 2 for dilution sequence. All dilutions must be made with a calibrated 1ml syringe.

10.5.8 Baseline correction for gas chromatography hydrocarbon methods is employed for GC methods that quantify total or fractional hydrocarbon ranges by integrating a retention time range that extends over several minutes. The potential for interfering peaks can occur from column bleed or common laboratory fragments, which can result in a positive bias in samples.

10.5.8.1 Minimize column bleed or chromatographic baseline rise by conditioning and replacing columns when necessary (i.e. when bleed becomes evident that may contribute to a positive bias in samples).

10.5.8.2 Integrate samples at a baseline that corresponds with the chromatographic profile of the associated instrument batch's instrument blanks.

10.5.8.3 If the instrument blanks display a chromatogram profile that cannot be isolated or may impact the area of associated samples, corrective action must be taken to correct issue and samples must be re-run.

10.5.9 Corrected concentrations are edited on the quantitaion before transferring data into the laboratory database (LIMS). Comparisons must be made between quantitation reports and LIMS to eliminate transcription errors.

11.0 QUALITY CONTROL

11.1 QC Requirements Summary.

ICV	Following initial calibration.
Calibration Verification Standards	Every 12 hours or 10 injections not to exceed 12 hours per project request.
Instrument Blank	At the beginning of each 12- hour shift or right after CCV
Method Blank	One per extraction batch
Matrix Spike	One per extraction batch*
Matrix Spike Duplicate	One per extraction batch*
Blank Spike	One per extraction batch*
Surrogate	Every sample and standard

* The maximum number of samples per extraction batch is twenty.

11.2 Initial Calibration Verification (ICV)

11.2.1 Refer to Section 10.2.

11.3 Calibration Verification Standards.

11.3.1 Refer to Section 10.3.

11.4 Instrument Blank.

11.4.1 Refer to Section 10.5.6.

11.5 Method Blank

11.5.1 A method blank is a volume of a clean reference matrix (reagent water for water samples, or purified sodium sulfate for soil/sediment samples) that is carried through the entire analytical procedure. The volume or weight of the reference matrix must be approximately equal to the volume or weight of samples associated with the blank. The purpose of a method blank is to determine the levels of contamination associated with the processing and analysis of samples.

11.5.2 A method blank must be extracted each time samples are extracted. The number of samples extracted with each method blank shall not exceed 20 field samples.

11.5.3 Acceptance Criteria

11.5.3.1 The concentration of each target compound in the method blank must be less than its MDL.

11.5.3.2 Surrogate recoveries must fall within the established acceptance criteria for the analysis.

11.5.4 Corrective Action

11.5.4.1 If a method blank does not meet the acceptance criteria, the system is out of control.

11.5.4.1.1 If contamination is a problem, then the source of the contamination must be investigated and appropriate corrective measures must be taken and documented before further sample analysis proceeds. All samples associated with a contaminated method blank must be re-extracted and reanalyzed.

11.5.4.1.2 If the surrogate recoveries in the method blank do not meet the acceptance criteria, first reanalyze the method blank. If surrogate recoveries do not meet the acceptance criteria after reanalysis, the method blank and all samples associated with that method blank must be re extracted and reanalyzed.

11.6 Blank Spike

11.6.1 A blank spike must be extracted with each set of 20 or less samples. The blank spike consists of an aliquot of a clean matrix (deionized water for aqueous samples or sodium sulfate for soil samples) similar to the sample and of the same weight or volume. It is spiked at the concentration of 1000 μg/ml / 50 ug/ml for aqueous samples or 33.3mg/kg for soils and is extracted and run through analytical procedures along with the other samples to monitor the efficiency of the extraction.

11.6.2 The blank spike recoveries and surrogates (Section11.9) should be assessed using in house limits. These limits are determined annually, hard wired into the LIMS and used for QC decision purposes. If a blank spike is out of control, the following corrective action must be taken and all the associated samples may be re-extracted and reanalyzed. The exception is if the blank spike recovery is high and no hits reported in associated samples and QC batch. In that case, the sample results can be reported with footnote (remark) and no further action is required.

11.6.2.1 Check to be sure that there are no errors in the calculations, or spike solutions. If errors are found, recalculate the data accordingly.

11.6.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample batch.

11.6.2.3 If no problem is found, re-extract and reanalyze the sample batch.

11.7 Matrix Spikes /Matrix Spike Duplicates.

11.7.1 Documenting the effect of the matrix should include the analysis of at least one matrix spike/matrix spike duplicate (MS/MSD) pair, a matrix spike to assess the impact of sample matrix on spike recovery, and a matrix spike duplicate to evaluate the precision associated with analysis of the matrix. The matrix spikes and matrix spike duplicates are spiked at a concentration in the mid-range of the calibration curve (1000 ug/ml / 50 ug/ml or 33.3 mg/kg).

11.7.2 The acceptance range for matrix spike recoveries (Section11.9) and relative percent difference (RPD) (Section11.9) are statistically determined using in-house data. These limits are determined annually, hard wired into the LIMS and used for QC decision purposes.

11.7.3 If matrix spike recovery does not meet acceptance criteria, the laboratory must assess the batch data to determine whether the spike results are attributable to matrix affect, or the result of other problems in the analytical process. If the blank spike is in control, and if there is no evidence that spiking was not properly performed, matrix interference is assumed and the data is reportable. No further corrective action is required. Otherwise, the method is out of control and the matrix spike sample(s) must be re-processed through the entire analytical sequence.

11.8 Surrogates.

11.8.1 All blanks, samples, QC samples, and calibration standards contain surrogate compounds to monitor the efficiency of the extraction and analytical procedures.

11.8.2 The recoveries (Section11.9) of the surrogates must be evaluated versus the surrogate control limits developed by the laboratory.

11.8.3 If surrogate recovery is not within established control limits, corrective action must be performed.

11.8.3.1 Check the surrogate calculations for calculation or integration errors and perform corrections if detected. Reanalyze the extract if calculation errors are not detected.

11.8.3.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the extract.

11.8.3.3 If the surrogate recoveries for the reanalyzed extract are in control, report data from the reanalysis only.

11.8.3.4 If data from the reanalysis is also out of control, re-extract and reanalyze the sample.

11.8.3.5 If, upon reanalysis, the surrogate recoveries are acceptable, report the reanalysis data. If the holding time has expired prior to the reanalysis, report both the original and reanalysis results and note the holding time problem.

11.8.3.6 If the recovery is again not within limits, the problem is considered to be matrix interference. Submit both data sets with the original analysis being reported.

11.8.4 The retention time shift for surrogate must be evaluated after the analysis of each sample. The sample should be reanalyzed when the retention time of any surrogate compound is outside the retention window.

11.8.4.1 If the sample exhibits visible matrix interference, defined as excessive signal levels from target or non-target interfering peaks. In this case, reanalysis may not be required following team leader/manager approval.

11.9 CALCULATIONS

11.9.1 Sum the areas of all the peaks eluting between the hydrocarbon range of C10 to C28. Do not include the area of the surrogate and internal standard, if applicable. Consult the supervisor for any integration questions.

11.9.2 Calibration Factor (CF).

$$CF = \frac{A_s}{C_s}$$

where:
A_s = Total Area within Retention Time Range minus the Surrogate area.
C_s = Concentration of the compound being measured (μg/ml).

11.9.3 Percent Relative Standard Deviation (% RSD).

$$\%RSD = \frac{SD}{CF_{av}} \times 100$$

where:
SD = Standard Deviation
CF_{av} = Average calibration factor from initial calibration.

11.9.4 Percent Difference (%D).

$$\% D = \frac{|CF_{av} - CF_c|}{CF_{av}} \times 100$$

where:
CF_c = Calibration factor from continuing calibration check standard.

11.9.5 Concentrations (Conc.):

11.9.5.1 Aqueous Samples:

$$\frac{As \times Vf \times D}{CF_{av} \times Vi} = \text{Sample Conc. mg/l}$$

where:
As = Area for sample hydrocarbon range of C10 to C28 (corrected for surrogate)
Vf = Final Volume of total extract (ml).
D = Secondary dilution factor.
Vi = Initial volume of water extracted (ml).

11.9.5.2 Soil Samples:

$$\frac{As \times Vf \times D}{CFav \times Wt \times \%SOL \times Vi} = \text{Sample Conc. in mg/kg}$$

where:
As = Area for sample (corrected for surrogate)
Wt = sample wt in grams

11.9.6 Percent Recovery (% R).

$$\% R = \frac{\text{Concentration found}}{\text{Concentration spiked}} \times 100$$

11.9.7 Relative Percent Difference (% RPD).

$$\% RPD = \frac{|C_{ms} - C_{msd}|}{(1/2)(C_{ms} + C_{msd})} \times 100$$

Where:
C_{ms} = Matrix Spike Concentration.

C_{msd} = Matrix Spike Duplicate Concentration.

12.0 DOCUMENTATION

12.1 Analytical Logbooks are used to record the analysis sequence; the logbook must be completed daily. Each instrument will have a separate logbook.

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12.1.1 If samples require reanalysis, a brief explanation of the reason must be documented in the Comments section. For consistency, if surrogates are high or low indicate it as (↑) for high and (↓) for low

12.2 The Standards Preparation Logbook must be completed for all standard preparations. All information must be completed, the page must be signed and dated by the appropriate person.

12.2.1 The SGS lot number must be cross referenced on the standard vial.

12.3 The Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. Each instrument will have a separate log.

12.4 Any corrections to laboratory data must be done using a single line cross off through the error. The initials of the person and date of correction must appear next to the correction.

12.5 Unused blocks of any form must be x’ed or z’ed by the analyst before submitting the data for review.

12.6 Supervisory (or peer) personnel must routinely review (at least once per month) all laboratory logbooks to ensure that the information is being recorded properly. Additionally, the maintenance of the logbooks and the accuracy of the recorded information must also be verified during this review.

13.0 DATA REPORTING

13.1 Initial and continuing calibration check. Verify that all calibration and continuing calibration criteria have been achieved. If the criteria has not been achieved, corrective action must be performed to bring the system in control before analyzing samples.

13.2 Quality Control Data Review. Review all QC data. If QC criteria were not achieved, perform corrective action before proceeding with analysis.

13.2.1 In some instances , corrective action may demand that the entire sample batch be re-extracted and reanalyzed before processing data.

13.3 Chromatogram Review. The chromatogram of each sample is evaluated for target compounds.

13.3.1 Check specific retention time windows for each target compound for the presence of the target compound in each chromatogram.

13.3.1.1 Projects may require the reporting of different hydrocarbon ranges. Review the login to assure that the correct hydrocarbon range is reported.

13.3.2 Manual integration of chromatographic peaks must be identified by the analysts by electronic signature and dating the changes made to the report.

13.4 Transfer to LIMS. Following the initial screen review, transfer the processed data to the LIMS.

14.0 POLLUTION PREVENTATION & WASTE MANAGEMENT

14.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 14.2.

14.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

14.2.1 Non hazardous aqueous wastes.
14.2.2 Hazardous aqueous wastes
14.2.3 Chlorinated organic solvents
14.2.4 Non-chlorinated organic solvents
14.2.5 Hazardous solid wastes
14.2.6 Non-hazardous solid wastes

15.0 REFERENCES

15.1 Not Applicable

TABLE 1
Instrument Operating Conditions

The conditions listed are a guideline, and must be optimized for the instrument and column in use.

GC Conditions	
Instrument	HP 6890 or 7890
Column	30m x 0.25mm DB-5, 0.5μm film
Carrier	Helium @ 12 psig, 6 mi/min
Temp. Program	35°C for 5 min., 10/min. to 310°C (hold 15mins)
Detector	Flame Ionization
Make-up Gas	Nitrogen @ 25 mi/min
Hydrogen	10 ml/min. Air: 300 ml/min
Injector Temp	280°C
Detector Temp	320°C

TABLE 1A
Large Volume Injection Instrument Operating Conditions

The conditions listed are a guideline, and must be optimized for the instrument and column in use, detailed information can be found in the acquisition method.

GC Conditions	
Instrument	HP 6890 or 7890
Column	15-30m x 0.25mm w/ 5-10m guard ZBMSplus, 0.25μm film
Carrier	Hydrogen @ 3.5 ml/min
Temp. Program	50°C for 2 min., 30°C /min. to 275°C for 0min; then 20°C/min to 350°C for 5.5 min
Detector	Flame Ionization
Make-up Gas	Nitrogen @ 35 ml/min
Hydrogen	40 ml/min. Air: 450 ml/min
Injector Temp	35°C for 0.3 min then 700°C/min to 330°C
Detector Temp	350°C

Table 2
Sample Dilution Table

All dilutions must be made using a 1ml calibrated syringe.

Dilution	*Intact Sample*	*Solvent*
1:2	500ul	500ul
1:5	200ul	800ul
1:10	100ul	900ul
1:20	50ul	950ul
1:25	40ul	960ul
1:50	20ul	980ul

Two Step dilution

Diution	**Step 1**		**Step 2**	
	Intact Sample	*Solvent*	*Sample Aliquot from Step 1*	*Solvent*
1:100	100ul	900ul	100ul	900ul
1:200	100ul	900ul	50ul	950ul
1:250	100ul	900ul	40ul	960ul
1:500	100ul	900ul	20ul	980ul

Three Step Dilution

Diution	**Step 1**		**Step 2**		**Step 3**	
	Intact Sample	*Solvent*	*Sample Aliquot from Step 1*	*Solvent*	*Sample Aliquot from Step 2*	*Solvent*
1:1000	100ul	900ul	100ul	900ul	100ul	900ul
1:2000	100ul	900ul	100ul	900ul	50ul	950ul
1:2500	100ul	900ul	100ul	900ul	40ul	960ul
1:5000	100ul	900ul	100ul	900ul	20ul	980ul

Four Step Dilution

Diution	**Step 1**		**Step 2**		**Step 3**		**Step 4**	
	Intact Sample	*Solvent*	*Sample Aliquot from Step 1*	*Solvent*	*Sample Aliquot from Step 2*	*Solvent*	*Sample Aliquot from Step 3*	*Solvent*
1:10,000	100ul	900ul	100ul	900ul	100ul	900ul	100ul	900ul
1:20,000	100ul	900ul	100ul	900ul	100ul	900ul	50ul	950ul
1:25,000	100ul	900ul	100ul	900ul	100ul	900ul	40ul	960ul
1:50,000	100ul	900ul	100ul	900ul	100ul	900ul	20ul	980ul

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
	Deleted reference to Appendix I (control limits)

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added

History of Revisions

Version #	Date of Revision	Revised By
00	10/04/2018	Wahied Bayoumi
01	02/11/2020	Olga Azarian
02	03/25/2020	Maria Ruschke
03	12/14/2020	Olga Azarian

END OF DOCUMENT

LAB SUPERVISOR: ____________________

QA OFFICER: Olga E. Azarian

EFFECTIVE DATE: 5/5/2020

TITLE: TOTAL VOLATILE PETROLEUM HYDROCARBONS
REFERENCES: SW846 8015D/8000D
REVISED SECTIONS: 10.1.5.2, 10.1.5.2.1
ADDED SECTIONS: 10.1.5.2.2 through 10.1.5.2.6

1.0 Scope and Application

1.1 This method is based on a purge and trap gas chromatographic procedure utilizing a flame ionization detector (FID). The method may be utilized to detect hydrocarbons in the Gasoline Range Organics (GRO) in aqueous, soil and waste matrices, which the C6 to C10 hydrocarbon range corresponds to a boiling point range between approximately 60 ° C and 170 ° C.

2.0 Summary

2.1 The sample is introduced onto the GC column by purge and trap technique. A temperature program is used to separate the compounds. The peaks are detected by the flame ionization detector (FID).

3.0 Reporting Limit and Method Detection Limit

3.1 Reporting Limit. The reporting limit for this method is established at the lowest concentration standard in the calibration curve (0.2 µg/ml for both soils and waters)

3.2 Method Detection Limit. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B, Revision 2. This value represents the lowest reportable concentration of an individual compound that meets the method qualitative identification criteria.

3.2.1 Experimental MDLs must be determined following SOP EQA075, Procedure for development and application of experimental MDL.

4.0 Definitions

BLANK (Instrument Blank) - an analytical sample designed to assess specific sources of laboratory contamination.

BLANK SPIKE - a blank matrix (reagent water or clean sand) is spiked with the targeted parameters and analyzed using the same method used for samples. Accuracy data is compared to laboratory derived limits to determine if the method is in control.

CALIBRATION FACTOR (CF) - a measure of the gas chromatographic response of a target analyte to the mass injected.

CONTINUING CALIBRATION - analytical standard run at the beginning of the 12-hour analytical shift after every 10 injections and at the end of the analytical sequence to verify the initial calibration.

INITIAL CALIBRATION - analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the flame ionization detector to the target compounds.

MATRIX - the predominant material of which the sample to be analyzed is composed. For the purpose of this SOP, a sample matrix is either water or soil/sediment. Matrix is <u>not</u> synonymous with phase (liquid or solid).

MATRIX SPIKE - aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure to indicate the appropriateness of the method for the matrix by measuring recovery.

MATRIX SPIKE DUPLICATE - a second aliquot of the same matrix as the matrix spike (above) that is spiked to determine the precision of the method.

METHOD BLANK - an analytical control consisting of all reagents and surrogate standards, which is carried throughout the entire analytical procedure. The method blank is used to define the level of laboratory, background and reagent contamination.

METHOD DETECTION LIMITS (MDLs) - The minimum concentration of a substance that can be measured and reported with 99% confidence that the measured concentration is distinguishable from method blank results.

PERCENT DIFFERENCE (%D) - As used in this SOP and elsewhere to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference.)

PERCENT MOISTURE - an approximation of the amount of water in a soil/sediment sample made by drying an aliquot of the sample at 105^oC. The percent moisture determined in this manner also includes contributions from all compounds that may volatilize at or below $105\,^oC$, including water. Percent moisture may be determined from decanted samples and from samples that are not decanted.

REAGENT WATER - water in which an interferant is not observed at or above the minimum detection limit of the parameters of interest.

RELATIVE PERCENT DIFFERENCE (RPD) - As used in this SOP and elsewhere to compare two values, the relative percent difference is based on the mean of the two values, and is reported as an absolute value, i.e., always expressed as a positive number or zero. (In contrast, see percent difference.)

RELATIVE RESPONSE FACTOR (RRF) - a measure of the instrument response of an analyte. Response Factors are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples.

RETENTION TIME (RT) – the time required (in minutes) for a standard compound to elute from a chromatographic column.

INSTRUMENT BLANK – a system evaluation sample containing lab reagent grade water with internal standards and surrogate standards added. An instrument blank is used to remove and/or evaluate residual carryover from high level standards, spike samples and field samples.

5.0 Health and Safety

5.1 The analyst must follow normal safety procedures as outlined in the SGS- Dayton Laboratory Safety Manual which includes the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents must be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets must be made available to all personnel involved in these analyses.

5.3 Primary standards of toxic compounds must be prepared in a hood. A NIOSH/Mass approved toxic gas respirator must be worn when the analyst handles high concentrations of toxic compounds,

6.0 Collection and Preservation

6.1 Aqueous samples are collected in 40 ml VOA vials, and preserved with 4 drops of HCl. The sample is stored at <6°C (not frozen) and must be analyzed within 14 days of sampling.

6.2 Soils, Sediments, and Sludges are collected as follows:

6.2.1 for medium level samples in a wide mouth 4 oz. jar and stored at< 6°C (not frozen), refer to SOP for SW846 Method 5030. The sample must be analyzed within 14 days of sampling.

6.2.2 for medium level samples in Encore™ units are transferred to preservative solution within 48 hours of collection, Refer to the SOP for SW846 Method 5035 for preservation requirement of non-aqueous solids. The sample must be analyzed within 14 days of sampling.

7.0 Apparatus and Materials

7.1 Syringes - 5 ml luerlock gastight syringe.

7.2 Microsyringes - 10 μl, 25 μl, 100 μl, 500 μl, and 1000 μl.

7.3 Volumetric flasks - 10 ml, 50 ml, 100 ml.

7.4 Grade A cylinder

7.5 Disposable pasteur pipets.

7.6 Glass vials - 40 ml screw-cap VOA vials with Teflon-faced silicone septum.

7.7 Top - loading balance, capable of weighing 0.1g.

7.8 Gas Chromatograph, equipped with a flame ionization detector, capable of temperature programming.

7.9 GC column –105m x 0.53mm ID x 3um film RTX 502.2, or equivalent. The column selected must resolve 2-methlypentane from the methanol solvent front.

7.10 Autosamplers

7.10.1 O.I. 4560 sample concentrator with 4552 Water/Soil Multi sampler provides unattended automation for up 51 samples, constant heat times mode of operation. O.I. 4560 sample concentrator with 4551A Water/Soil Multi sampler provides unattended automation for up 51 samples. The gas tight vials followed by direct injection onto GC column. The syringe is baked and flushed with helium after injection.

7.11 Data Integrator - Data system capable of summing peaks, re-analyzing data files after revising integration parameters, and manually drawing chromatographic baselines as necessary. The ENVIROQUANT data system is capable of quantitation using multi-point calibration.

8.0 Standards and Reagents

8.1 De-ionized water, organic free - Reagent water is generated by using a multi-element deionizing system consisting of a particulate filter, twin mixed bed ion exchange resin columns, and a carbon-polishing column.

8.2 Solvent - Methanol, purge and trap grade. Burdick and Jackson or equivalent.

8.3 Stock standards

8.3.1 Commercially prepared standards used.

8.3.1.1 Accustandard Gasoline Mixture (or equivalent): 20,000 μg/ml,

8.3.1.2 Restek Gasoline Mixture (or equivalent): 50,000 μg/ml.

8.3.1.3 Surrogate standard - α,α,α -Trifluorotoluene, 2000 μg/ml, Sigma Aldrich neat, or equivalent.

8.3.1.4 Retention Time Window Solution - 2-methylpentane, 1000 ug/ml, Absolute; n-Hexane, 1000 ug/ml, Absolute; n-Dodecane, 1000 ug/ml, Absolute; 1,2,4-trimethylbenzene, 1000 ug/ml, Restek

8.3.2 Unopened stock must be stored according to manufacturer’s documented holding time and storage temperature recommendations.

8.3.3 After opened, stock standards must be replaced after 6 months or sooner if manufacture expiration date come first or comparison with quality control check samples indicates degradation.

8.4 Working standards - Refer to the Volatile Standard Logbook for the preparations of working standards.

8.4.1 Two solutions at 8 μg /ml and 4 μg /ml are utilized as the continuing calibration check standards. Another 8 μg /ml working standard from different source is used as the independent source calibration check and blank spike.

9.0 Interferences

9.1 High levels of heavier petroleum fractions may contain some volatile components within the range of retention times for gasoline. Other volatile organic components may elute in this range as well. As defined by the method, gasoline range organics (GRO) include these compounds.

9.2 Samples may become contaminated by diffusion of volatile organics through the container septum during shipment and storage. A reagent water trip blank may serve as a check on shipping and storage conditions.

9.3 Contamination from "carry over" may occur when high and low-level samples are sequentially analyzed. The sample syringe and purging device must be rinsed with reagent water, or a suitable solvent (methanol) between samples. When an unusually concentrated sample encountered, a reagent water-blank must be analyzed to check for cross contamination. Low level samples immediately following high level samples must be verified.

10.0 Calibration

10.1 Initial calibration. Calibration standards, at a minimum of five concentrations. The calibration range covered by the standards is 0.2, 0.8, 4, 8, 20, (30) and 40 μg/ml.

10.1.1 To establish a one-point retention window, use a spike solution of 10ul of marker mixture (250 ug/ml) into a final volume of 50 ml for a final concentration of 50 ug/L 2-methylpentane and 50 ug/L1,2,4 trimethylbenzene.

10.1.2 The preparation of initial calibration

Using DI water bring to 50- or 100-ml final volume: Transferring each standard into a 40 ml VOA vials.

Standard / Surrogate Concentration	GRO Mix (20000 ppm)	Surrogate Mix (2000ppm)	Final Volume (ml)
200 / s 100 ppb	1 µl	5 µl	100
800 / s 200 ppb	2.0 µl	5 µl	50
4000 / s 300 ppb**	10 µl	7.5 µl	50
*** 8000 /** s 300 ppb**	20 µl	7.5 µl	50
20000 / s 400 ppb	50 µl	10 µl	50
30000 / s 500 ppb	75 µl	12.5 µl	50
40000 / s 600 ppb	100 µl	15 µl	50

**for continuing calibration check
* second source calibration check and BS

10.1.3 Place the vials in the autosampler tray. Program the autosampler to add 1 µl of 1500 µg/ml surrogate solution automatically to each standard prior to analysis.

10.1.4 Analyze the standard solutions using the conditions established in Section 12.0. Establish the calibration factor for each standard solution by dividing the total area of each standard by the total concentration as defined in Section 14.2.

10.1.5 For the initial calibration to be valid, the percent relative standard deviation (% RSD) (Section 14.3) must be less than 20 %. If the average calibration factor criteria cannot be achieved, corrective action must be taken.

10.1.5.1 If the problem is associated with specific standards, reanalyze the standards and recalculate the RSD.

10.1.5.2 Alternatively, the laboratory may remove and replace calibration standards if the following requirements are met:

10.1.5.2.1The laboratory may remove individual analyte calibration levels from the lowest and/or highest levels of the curve. Multiple levels may be removed, but removal of interior levels is not permitted.

10.1.5.2.2 The laboratory may remove an entire single standard calibration level from the interior of the calibration curve when the instrument response demonstrates that the standard was not properly introduced to the instrument, or an incorrect standard was analyzed. If a calibration standard was removed from the interior of the calibration, this particular standard calibration level must be removed for all analytes. Removal of calibration points from the interior of the curve is not to be used to compensate for lack of maintenance or repair to the instrument.

10.1.5.2.3 The laboratory must adjust the LOQ/reporting limit and quantitation range of the calibration based on the concentration of the remaining high and low calibration standards.

10.1.5.2.4 The laboratory must ensure that the remaining initial calibration standards are sufficient to meet the minimum requirements for number of initial calibration points as mandated by the method, or regulatory requirements.

10.1.5.2.5 The laboratory may replace a calibration standard provided that:

a) the laboratory analyzes the replacement standard within twenty-four (24) hours of the original calibration standard analysis for that particular calibration level;
b) the laboratory replaces all analytes of the replacement calibration standard if a standard within the interior of the calibration is replaced; and
c) the laboratory limits the replacement of calibration standards to one calibration standard concentration.

10.1.5.2.6 The laboratory must document a technically valid reason for either removal or replacement of any interior calibration point.

10.2 Initial Calibration Verification (ICV)

10.2.1 A second source calibration check prepared at the concentration of 8 μg/ml must be run immediately after the initial calibration.

- Standard preparation refers to section10.1.1

10.2.2 The percent different (%D) (Section 14.4) for this standard must meet the criteria of 20% used for the calibration verification.

10.2.2.1 If the %D is greater than 20%, reanalyze the second source check. If the criteria cannot be met upon re-injection, re-prepare the second source solution using a fresh ampoule and repeat the process.

10.2.2.2 If the %D criteria cannot be achieved after re-preparation of the second source, prepare a third source and repeat the process. If the third source passes, then the calibration is verified. If not, make fresh calibration standards by using one of the two standard sources that matches each other.

10.3 Continuing Calibration Verification (CCV)

10.3.1 Continuing calibration verification standards are prepared at concentrations of 4 μg/ml and 8 μg/ml. Alternate the use of these standards for calibration verification at the beginning of each run, after 10 samples, (or 10 injections for certain client requirements) not to exceed 12 hours, and at the end of the sequence to verify that the initial calibration is still valid.

- Standard preparations refer to section 10.1.1

10.3.2 For the continuing calibration to be valid, the percent difference (% D) (Section 14.4) must be less than 20%.

10.3.3 If the first continuing calibration verification (CCV) does not meet criteria, a second standard can be analyzed immediately or after the corrective action is performed. If the second CCV trial fails, the lab must demonstrate acceptable performance after corrective action with two consecutive passing calibration verifications OR a new calibration. In situations where the checks fail to meet the criteria, the instrument logbook must have clearly documented notations as to what the problem is and what corrective action is implemented to enable the analysis go forward.

10.3.3.1 If the calibration standard analyzed at the end of the sequence does not meet the criteria, the samples bracketed by the previous CCV must be evaluated. If the CCV recoveries are biased high and the samples do not have target compounds detected, then the sample results can be reported. If the CCV recoveries are biased low or the samples have target compounds detected, then the samples must be re-analyzed.

10.3.4 Each subsequent injection of a continuing calibration standard must be checked against the retention time windows established in Section 11.0. 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, and the samples must be reanalyzed.

11.0 Retention Time Windows

11.1 The retention time range for GROs is defined during initial calibration. Two specific gasoline components are used to establish the range. The GRO retention time window is defined as beginning with 2-methylpentane and ending with 1,2,4-trimethyl benzene. The data must be retained in the laboratory.

11.2 Retention Time Determination: Employ the following approach to establish retention time windows.

11.2.1 Analyze three calibration standard studies over a 72-hour period to maximize the retention time variability.

11.2.2 Calculate the average retention time and standard deviation of the retention time for beginning with 2-methylpentane and ending with 1,2,4-trimethyl benzene.

11.2.2.1 Establish the low end of the retention window for the GRO range using the lower extreme of 2-methylpentane. Calculate this value at -3 times the standard deviation of the mean absolute retention time from the analysis conducted during the 72-hour period.

11.2.2.1.1 If the standard deviation is less than 0.01 minutes, employ a default minimum standard deviation of 0.01 minutes. If the default standard is used, the width of the window will be 0.03 minutes.

11.2.2.2 Establish the high end of the retention window for the GRO range using the higher extreme of 1,2,4-trimethyl benzene. Calculate this value at +3 times the standard deviation of the mean absolute retention time from the analysis conducted during the 72-hour period.

11.2.2.2.1 If the standard deviation is less than 0.01 minutes, employ a default minimum standard deviation of 0.01 minutes. If the default standard is used, the width of the window will be 0.03 minutes.

11.2.2.3 Document the retention time study and retain the retention time data as paper copy at the instrument.

11.2.3 Update the retention time data in the quantitation method file using the new information. Use this window for the qualitative identification of target compounds in samples, standards, and quality control samples.

11.2.4 Retain documented records of all retention time information. Documentation may include paper file maintained next to each instrument or electronic data files that are archived for future use.

11.3 Check the window on calibration verification with the marker compound standard. The marker standard must be run prior to analyzing the CCV.

11.3.1 Update the retention time data in the quantitation method file using the new information. Use this window for the qualitative identification of gasoline range organics in samples, standards, and quality control samples.

11.3.2 If the retention time of the VPH daily marker standard is outside the window, recalibrate the instrument.

11.3.3 Retain documented records of all retention time information. Documentation may include paper file maintained next to each instrument or electronic data files that are archived for future use.

12.0 Procedure

12.1 Instrument conditions. Recommended instrument conditions are listed in Table 1. Modifications of parameters specified with an asterisk are allowed as long as criteria of calibration are met. Any modification must be approved by team leader/manager.

12.2 Initial Calibration. See Section 10.1.

12.3 Second source calibration check (LCS). See section 10.2.

12.4 Continuing calibration checks. See section 10.3.

12.5 Method blank (reagent water):

12.5.1 A method blank must be analyzed every 12-hours or sooner. The method blank is analyzed immediately following the continuing calibration standards and before any field or QC samples are analyzed.

12.5.2 No target compound can be present above the ½ the RL of 0.2 ug/ml.

12.5.3 Surrogates must meet recovery criteria specified LIMS.

12.5.4 If a method blank does not meet the acceptance criteria, the system is out of control. The following corrective actions must be taken:

12.5.4.1 If contamination is a problem, then the source of the contamination must be investigated, and appropriate corrective measures must be taken and documented before further sample analysis proceeds. All samples associated with a contaminated method blank must be reanalyzed.

12.5.4.2 If the surrogate recoveries in the method blank do not meet the acceptance criteria, first reanalyze the method blank. If surrogate recoveries do not meet the acceptance criteria after reanalysis, the method blank and all samples associated with that method blank must be reanalyzed.

12.6 Sample Analysis

12.6.1 Aqueous Samples

12.6.1.1 Load the 40 ml sample vials to the autosampler tray. Program the autosampler to add 1 μl of 1500 μg/ml surrogate automatically to each sample before analysis.

12.6.1.2 Program the autosampler and GC system to analyze the loaded samples.

12.6.1.3 Reanalyze any samples that require dilutions. Target the dilution to approximate the mid-range concentration of the calibration curve.

12.6.1.4 Once the sample analysis is completed or before preparing sample dilution, the pH of the sample must be determined to ensure that all samples were properly preserved in the field. Put one or two drops of sample directly on a piece of pH paper. Check the pH. Any sample with a pH greater than 2 will be recorded accordingly on the instrument run log and will be reported with a footnote indicating the sample preservation deficiency.

12.6.2 Soil/Sediment Samples (Intact Sample - SW-5030C)

12.6.2.1 Weigh a 40 ml VOA vial with 10ml methanol inside on a properly calibrated top loading balance. Set the tare to zero.

12.6.2.2 Open the sample container and remove the top 3-5 ml of sample and discard. Quickly weigh 10 ± 0.5 grams of the sample to the nearest 0.1 grams.

12.6.2.3 Cap the sample container.

12.6.2.4 Select a methanol aliquot of appropriate volume (see Table 2) and transfer to 40 ml of reagent water.

12.6.2.4.1 NOTE: The area around the balance must remain clean and free of sample spillage and residues, as volatile analytes will contaminate the air and subsequent samples.

12.6.3 Sediment/Soil Samples (SW5035A)

12.6.3.1 <u>Medium-level soil method</u>

12.6.3.1.1 Collect the sample using the procedures detailed in the SOP for SW846 Method 5035 medium - level soil samples.

12.6.3.1.2 Select a methanol aliquot of appropriate volume (see Table 2) and transfer to 40 ml of reagent water.

12.6.4 Sample dilutions

If the concentration of GRO in any sample exceeds the initial calibration range, a new aliquot of that sample must be diluted and re-analyzed. Until the diluted sample is in a sealed sample vial, all steps in the dilution procedure must be performed without delay.

12.6.4.1 Water Samples.

12.6.4.1.1 Prepare all dilutions of water samples in volumetric flasks (10 ml to 100 ml) or grade A cylinders (50ml). Intermediate dilutions may be necessary for extremely large dilutions.

12.6.4.1.2 Calculate the approximate volume of reagent water, which will be added to the volumetric flask or grade A cylinder and add slightly less than this quantity to the flask or grade A cylinder. Refer to Table 2 for dilution guideline.

12.6.4.1.3 Inject the proper sample aliquot from a syringe into the volumetric flask or grade A cylinder. Dilute the flask or grade A cylinder to the volume mark with reagent water. Cap the flask or grade A cylinder and invert the flask or grade A cylinder three times.

12.6.4.1.4 Fill a 40 ml sample vial and seal with a Teflon- baked- silicon septa, load the diluted sample into the autosampler and analyze according to Section 12.6.

12.7 Data Interpretation

12.7.1 Qualitative Identification

12.7.1.1 The sample hydrocarbons must fall within the retention time range established during the initial calibration.

12.7.2 Quantitative Analysis

12.7.2.1 The GRO concentration (Section 14.5) is based on the total area of all peaks eluting between 2-methylpentane and 1,2,4-trimethyl benzene and calculated by external standard technique.

13.0 Quality Control

13.1 QC Requirements Summary.

Ind. Source Calibration Check Std.	Following initial calibration
Calibration Verification Standards	Every 10 samples or 10 injections not to exceed 12 hours
Method Blank	Every 10 samples or 10 injections not to exceed 12 hours
Matrix Spike	One per analytical batch*
Matrix Spike Duplicate or Sample Duplicate	One per analytical batch*
Blank Spike	One per analytical batch*
Surrogate	Every sample and standard

* The maximum number of samples per analytical batch is twenty.

13.2 Initial Calibration Verification.

13.2.1 Refer to Section 10.2.

13.3 Calibration Verification Standards.

13.3.1 Refer to Section 10.3.

13.4 Method Blank.

13.4.1 Refer to Section 12.5.

13.5 Blank Spike.

13.5.1 One blank spike from the second source is analyzed with each batch of 20 or less samples. It consists of an aliquot of a clean (control) matrix similar to the sample matrix and of the same weight or volume. The blank spike is spiked with the target analytes at a detectable concentration, usually the mid-point concentration of the calibration range (8 μg/ml).

13.5.2 The percent recovery (Section 14.6) must fall within the control limits in LIMS complied by the lab annually. If the blank spikes are not within that range, then the entire batch must be re-analyzed. The exception is if the blank spike recovery is high and no hits reported in associated samples and QC batch. In that case, the sample results can be reported with footnote (remark) and no further action is required.

13.6 Matrix Spike/Matrix Spike Duplicate.

13.6.1 One sample is selected at random from each analytical batch of similar matrix types and spiked in duplicate to check precision and accuracy.

13.6.2 The matrix spikes and matrix spike duplicates are spiked at a concentration in the mid-range of the calibration curve (8 µg/ml)

13.6.2.1 The matrix spike duplicate is allowed to be replaced with sample duplicate if limited sample vials are provided.

13.6.3 Assess the matrix spike recoveries (Section 14.6) and relative percent difference (RPD) (Section 14.7) against the control limits in LIMS.

13.6.4 If the matrix spike recoveries do not meet the criteria, check the blank spike recovery to verify that the method is in control. If the blank spike meets criteria, matrix interference is assumed, and the data is reportable. No further corrective action is required.

13.7 Surrogate

13.7.1 All standards, blanks, samples, and matrix spikes contain surrogate compound, which is used to monitor method performance.

13.7.2 The surrogate recoveries (Section 14.6) must fall within in-house control limits in LIMS for the results to be acceptable.

13.7.3 If the recovery does not meet the control limits, the following corrective actions must be performed.

13.7.3.1 Check to be sure that there are no errors in the calculations, or surrogate solutions. If errors are found, recalculate the data accordingly.

13.7.3.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

13.7.3.3 If surrogate recoveries are acceptable upon reanalysis, the data from the reanalysis is reported. If the reanalysis date did not meet the hold time, then report both the original and reanalysis results and note the holding time problem.

13.7.3.4 If surrogates are still outside control limits upon reanalysis, the problem is matrix interference. Submit both sets of data with the first analysis being reported.

14.0 Data Handling and Calculations

14.1 Sum the areas of all peaks eluting from the low end of the retention window of 2-methylpentane to the high end of the retention window of 1,2,4-trimethyl benzene. Do not include the area of the surrogate or internal standard, if applicable, in the area sum. Consult supervisor with any questions.

14.2 Calibration Factor (CF).

$$CF = \underline{\quad A_s \quad}$$

$$\overline{C_s}$$

where:
A_s = Total Area within Retention Time Range.
C_s = Concentration of the compound being measured (μg/ml).

14.3 Percent Relative Standard Deviation (% RSD).

$$\%RSD = \frac{SD}{CF_{av}} \times 100$$

where:
SD = Standard Deviation
CF_{av} = Average calibration factor from initial calibration.

14.4 Percent Difference (%D).

$$\%\ D = \frac{|\ CF_{av} - CF_c\ |}{CF_{av}} \times 100$$

where: CF_c = Calibration factor from continuing calibration check standard.

14.5 Concentration (Conc.).

14.5.1 Aqueous Samples

$$\frac{As}{CF_{av} \times Vol} = \text{Sample Conc. mg/l}$$

where:
As = Area for sample (corrected for surrogate)
Vol = sample volume in ml

14.5.2 Soil Samples

$$\text{Conc. } (\mu g/kg) = \frac{Ac \times Vp \times Vt}{CF \times Vme \times Ws \times M}$$

Where:
Ac = Area of compound being measured.
CF = Response factor of compound being measured (from initial calibration)
Vi = Initial volume of water purged (ml)
Vp = 5 ml (Total Purge Volume)
Vme = Volume of Methanol aliquot
Vt = Ml Solvent + ((100-% solid)/100 x Ws)
Ws = Weight of sample extracted (g).
M = (100 - % moisture in sample) / 100 or % solids / 100

14.6 Percent Recovery (% R).

$$\% R = \frac{\text{Concentration found}}{\text{Concentration spiked}} \times 100$$

14.7 Relative Percent Difference (% RPD).

$$\% \text{ RPD} = \frac{\left| C_{ms} - C_{msd} \right|}{(1/2)\,(C_{ms} + C_{msd})} \times 100$$

Where:
C_{ms} = Matrix Spike Concentration.
C_{msd} = Matrix Spike Duplicate Concentration.

15.0 Documentation

15.1 Analytical Logbooks are used to record the analysis sequence; the logbook must be completed daily. Each instrument will have a separate logbook.

15.1.1 If samples require reanalysis, a brief explanation of the reason must be documented in the comments section.

15.2 The Standards Preparation Logbook must be completed for all standard preparations. All information must be completed, the page must be signed and dated by the appropriate person.

15.2.1 The Accutest lot number must be cross-referenced on the standard vial.

15.3 The Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. Each instrument will have a separate log.

16.0 Pollution Prevention and Waste Management

16.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 16.2.

16.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

16.2.1 Non-hazardous aqueous wastes.

16.2.2 Hazardous aqueous wastes

16.2.3 Chlorinated organic solvents

16.2.4 Non-chlorinated organic solvents

16.2.5 Hazardous solid wastes

16.2.6 Non-hazardous solid wastes.

17.0 Data Review & Reporting

17.1 Initial and continuing calibration check. Verify that all calibration and continuing If samples had been analyzed under non-compliant calibration criteria, all sample extracts must be re-analyzed once the system is brought into control.

17.2 Quality Control Data Review. Review all QC data. If QC criteria were not achieved, perform corrective action before proceeding with analysis.

17.2.1 In some situation, corrective action may demand that the entire sample batch be re-extracted and reanalyzed before processing data.

17.3 Chromatogram Review. The chromatogram of each sample is evaluated for target compounds.

17.3.1 Check specific retention time windows for each target compound for the presence of the target compound in each chromatogram.

17.3.1.1 Projects may require the reporting of different hydrocarbon ranges. Review the login to assure that the correct hydrocarbon range is reported.

17.3.2 Manual integration of chromatographic peaks must be identified by the analysts by electronic signature and dating the changes made to the report.

17.4 Transfer to LIMS. Following the initial screen review, transfer the processed data to the LIMS.

17.4.1 Print the processed data and compare the printed values to the original values to verify transfer accuracy.

17.4.2 If transfer errors occurred, the errors must be corrected before the data is re-submitted.

TABLE 1 RECOMMENDED OPERATING CONDITION	
Gas Chromatograph	
Instrument	HP 6890
Column	105m x 0.53mm x 3um film RTX 502.2 or equivalent
Carrier	Helium or Nitrogen, 5-6 mi/min
Temp.Program	* 50°C for 6 min., 60/min. to 220°C (hold 8 min), post run 250□C for 3 min.
Detector	Flame Ionization
Make-up Gas	Helium or Nitrogen @ 10-30 ml/min
Hydrogen	30 ml/min. Air: 350 ml/min
Injector Temp	220°C
Detector Temp	260°C
Purge and Trap Device	
Purge Gas	Helium or Nitrogen @ 30 - 40 ml/min.
Trap	Tenax/Silica Gel/ cms
Sample Temp	Aqueous-Ambient,
Trap Temp	<35°C
Purge Time	8 min.
Desorb	1.5 min. @ 190°C.
Bake	11 min. @ 210°C,

* Parameter modification allowed for performance optimization provided operational and QC criteria is achieved.

Table 2 GUIDELINE FOR DILUTION PREPARATION

Water Sample

Dilution	**Sample amount taken**	**Final volume A (volumetric)**	**Take from final volume A**	**Final volume B (volumetric)**
1:2	25 ml	50 ml		
1:5	10 ml	50 ml		
1:10	5 ml	50 ml		
1:20	2.5 ml	50 ml		
1: 25	2 ml	50 ml		
1:50	1 ml	50 ml		
1:100	0.5 ml	50 ml		
1:200	250 µl	50 ml		
1:250	200 µl	50 ml		
1:500	100 µl	50 ml		
1:1000	50 µl	50 ml		
1:2000	25 µl	50 ml		
1:2500	20 µl	50 ml		
1:5000	10 µl	50 ml		
1:10000	0.5 ml	50 ml	0.5 ml	50 ml
1:20000	0.5 ml	50 ml	250 µl	50 ml
1:25000	0.5 ml	50 ml	200 µl	50 ml
1:50000	0.5 ml	50 ml	100 µl	50 ml
1:100000	0.5 ml	50 ml	50 µl	50 ml

Soil-medium level

Additional Dilution	Sample in Methanol amount taken	Final volume (volumetric)
1:1	1 ml	50 ml
1:2	0.5 ml	50 ml
1:5	200 µl	50 ml
1:10	100 µl	50 ml
1:20	50 µl	50 ml
1: 25	40 µl	50 ml
1:50	20 µl	50 ml
1:100	10 µl	50 ml
1:200	5 µl	50 ml
1:250	4 µl	50 ml
1:500	4 ul	100ml

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
10.1.5.2	Added TNI procedure for removal of cal points
10.1.5.2.1	Added TNI procedure for removal of cal points

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added
10.1.5.2.2-10.1.5.2.6	TNI procedure for removal of cal points

History of Revisions

Version #	Date of Revision	Revised By
00	10/2/18	Owen McKenna
01	01/07/2020	Jessica Reitan

END OF DOCUMENT

LAB SUPERVISOR:

QA OFFICER: Olga Y. Azarian

EFFECTIVE DATE: 9-27-2021

TITLE: PREPARATION OF SEMI-VOLATILE EXTRACTABLES IN AQUEOUS SAMPLES (BASE, NEUTRAL, ACID ORGANICS; PESTICIDES, POLYCHLORINATED BIPHENYLS, DIESEL RANGE ORGANICS, EXTRACTABLE PETROLEUM HYDROCARBONS)

REFERENCES: SW846 3510C (Revision 3, December 1996)
ADDED SECTIONS: 10.3.9.1.1.1

1.0 SCOPE AND APPLICATION

1.1 This method describes the extraction procedure of semi-volatile organic compounds in various water sources for analysis by gas chromatography (GC) or gas chromatography/mass spectrometry (GC/MS).

2.0 SUMMARY

2.1 Extract a measured volume of sample, usually 1 liter, with an immiscible organic solvent (methylene chloride or hexane) using a separatory funnel. Serial extractions are performed at specified pHs. The extract is concentrated by evaporation/distillation by a factor of 100 – 1,000 prior to analysis to increase the apparent concentration of target analytes and improve the sensitivity of the instrumental technique. This method is applicable for EPA methods 608, 625, and SW846 8081, 8082, 8270, 8015C, EPH, and NJ OQA 25.

2.2 An option for preparing aqueous samples using a reduced initial volume (~250ml) for analysis by a large volume injection (LVI) technique is also described.

3.0 REPORTING LIMIT AND METHOD DETECTION LIMIT

3.1 See determinative method.

4.0 DEFINITIONS

BLANK - an analytical sample designed to assess specific sources of laboratory contamination. Types of Blanks may include: Method Blank, Instrument Blank, Storage Blank, and Leachate Blank.

BLANK SPIKE (BS) - An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

BATCH - A group of samples and associated quality control samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples.

CLASS A GLASSWARE - Volumetric laboratory glass that has been manufactured, calibrated and certified to established ASTM volume standards. Under normal laboratory conditions, Class A Glassware does not require volume calibration or verification.

EXTRACTION – The process of removing a desired compound from a matrix using chemical or mechanical procedures. The process is used to isolate and concentrate targeted constituents for instrumental analysis

HOLDING TIME - The maximum time that samples may be held prior to preparation and/or analysis and still are considered valid.

KUDERNA DANISH (K-D) – A three-stage glass solvent concentration device consisting of a large volume receiving flask (250 or 500mL), a small volume receiver and a three-ball air cooled condenser (Snyder column). This device is used to evaporate large volumes of solvent used for organic extractions to increase the concentration of the analyte in the solvent.

MATRIX - The predominant material of which a sample is composed. For the purpose of this method, a sample matrix is either water or soil/sediment. Matrix is not synonymous with phase (liquid or solid).

MATRIX SPIKE (MS) - aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

MATRIX SPIKE DUPLICATE (MSD) - a second aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

METHOD BLANK (MB) - an analytical control consisting of all reagents, internal standards, and surrogate standards that is carried throughout the entire analytical procedure. The method blank is used to define the level of laboratory, background, and reagent contamination.

REAGENT WATER – Purified water in which an interferant is not observed at or above the minimum reporting limit of the parameters of interest.

SEPARATORY FUNNEL – A large volume (500, 1000 or 2000mL) closed funnel used for separating immiscible liquids from each other. The device is used for shaking samples with solvent to extract organic constituents. One of the phases of the mixture is removed through the stopcock opening in the base to effect the separation.

SURROGATE - An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Surrogates are used to measure the extraction efficiency.

WATER BATH – A waterbath equipped with an evaporation collection system. The system collects the extraction solvent which is then disposed via the appropriate waste stream.

5.0 HEALTH & SAFETY

5.1 The analyst must follow normal safety procedures as outlined in the SGS Laboratory Safety Manual and SGS Safety Policy, which includes the use of safety glasses and lab coats. Handle all acids, which are corrosive with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, treat each chemical as a potential health hazard. Reduce exposure to these reagents to the lowest possible level. The laboratory is responsible for maintaining a current file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets is available to all personnel involved in these analyses.

6.0 INTERFERENCES

6.1 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. Demonstrate that these materials are free from interferences under the conditions of the analysis by analyzing method blanks.

6.2 Interferences co-extracted from the samples will vary considerably from source to source. If interferences prevent the analysis of an extracted sample, further cleanup of the sample extract may be necessary.

6.3 Phthalate esters contaminate many products commonly used in the laboratory. Avoid plastics in particular because they contain phthalates, used as plasticizers, which can leach from these materials. Practice sound, consistent materials control to avoid phthalate contamination, which may occur at any time.

6.4 Soap residue (e.g. sodium dodecyl sulfate), which results in a basic pH on glassware surfaces, may cause degradation of certain analytes. Specifically, Aldrin, Heptachlor, and most organophosphorus pesticides will degrade in this situation. This occurs in glassware that is difficult to rinse. Carefully hand-rinse these items to avoid this problem.

7.0 COLLECTION, PRESERVATION AND HOLDING TIMES

7.1 Collect EPA 608, 625, SW-846 8081, 8082, 8270 samples in 1-liter amber glass bottles without preservatives. Collect SW-846 8015 and BNJEPH samples in 1-liter amber glass bottles preserved with hydrochloric acid. Samples for NJ OQA25 are preserved with HCl upon collection.

7.2 1 liter (nominal) or 250ml-LVI of unpreserved sample is required for extraction with the exception of NJ OQA 25 samples. Additional sample volume is necessary for any samples used for matrix duplicates and matrix spikes. Therefore, submit 3 liters of at least one sample in every group of 20 field samples for analysis to accommodate all quality control requirements.

7.3 The samples must be protected from light and refrigerated at 0 to <6° C from the time of receipt until extraction and analysis.

7.4 For methods EPA 625; SW-846 8081, 8082, 8270 & 8015C. Extract aqueous samples within 7 days of sampling and analyze within 40 days of the extraction.

7.5 For method 608, check the sample pH and adjust to 5-9 if necessary. Extract samples within 7 days of sampling and analyze within 40 days of the extraction. If the sample pH cannot be adjusted between 5 - 9, the sample must be extracted within 72 hours.

7.6 For Methods 608 and 625, check the sample for residual chlorine using test paper. If the sample tests positive add 80mg of sodium thiosulfate per liter of sample.

8.0 APPARATUS & MATERIALS

8.1 Amber Glass Bottle- 1000mL, 250mL

8.2 Separatory funnels - 2 liter with Teflon stopcocks.

8.3 Class A Volumetric Flasks: 1mL, 5mL, 10mL, 100mL volumes

8.4 One (1) ml volumetric pipettes or pre-calibrated 1ml syringes

8.5 Graduated cylinder- 10mL & 1000mL, Class A

8.6 Beaker- 250mL

8.7 4 position Automatic Separatory Funnel Shaker

8.8 Drying column – used for removing aqueous fraction from organic fraction. Composed of funnel (large or small) containing glass wool or filter paper and sodium sulfate

8.9 Waterbath with solvent evaporation collection system- large volume concentrator capable of capturing evaporated solvent. Composed of waterbath, chiller, and solvent collector

8.10 Porous Boiling Chips or Glass Beads

8.11 Kuderna-Danish sample collection setup- for waterbath with solvent evaporation collection system. Composed of Kuderna-Danish flask (500mL or 250mL), receiver (10mL, Class A calibration), and retaining clip

8.12 Snyder Column- three ball

8.13 Buchi Concentrator System- solvent concentrator capable of capturing evaporated solvent. Composed of Syncore Unit, Vacuum Pump, Chiller, & Recirculating Pump

8.14 Buchi tube, Class A- for Buchi concentrator system.

8.15 N-VAP Concentrator- small volume concentrator. Composed of waterbath and Nitrogen gas blow down apparatus.

8.16 Microsnyder Concentrator- small volume concentrator. Composed of waterbath and microsnyder column.

8.17 Vortex Mixer

8.18 2mL graduated amber glass vial and associated PTFE lined cap (screw top or crimp)

8.19 Refrigerator & Freezer- for sample and backup storage

8.20

9.0 REAGENTS

9.1 Reagent water - deionized and carbon filtered water prepared to ASTM Type II specifications.

9.2 Solvents - reagent grade for trace organic analysis. Each solvent lot must be checked for interferences prior to use. Refer to SOP EOP013 for the procedure regarding solvent lot approval.

9.2.1 Methylene chloride

9.2.2 Hexane

9.2.3 Acetone

9.2.4 Hydrochloric Acid

9.3 Solutions- generated from reagent grade for trace organic analysis solvents listed above or shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.

9.3.1 Sodium hydroxide solution (10N) - purchase as a commercially prepared solution. Alternatively, dissolve 40g of NaOH in reagent water and dilute to 100 ml.

9.3.2 Sulfuric acid (1:1)- purchase as a commercially prepared solution (50% v/v). Alternatively prepare a 50% solution from equal parts concentrated sulfuric acid and reagent water.

9.4 Sodium sulfate - granular anhydrous, refer to EOP029 for preparation instructions.

9.5 Nitrogen Gas – High Purity Grade.

9.6 Surrogate and Matrix Spiking Solutions. See the analytical SOP for target compound specifications. See the extraction SOP for target compound amounts. Refer to the most current version of Form: OP026 for details on Standard and Spike preparation.

Note: Unopened stock solutions must be stored according to the manufacturers documented holding time and storage temperature recommendations. After opening, stock standards must be replaced after 6 months or sooner if manufacturer’s expiration date comes first or comparison with quality control check samples indicate degradation.

9.7 pH indicator paper – wide range, minimum of pH 2 – pH 11.

9.8 Wide range residual and total chlorine test paper.

10.0 PROCEDURE

10.1 Assemble all needed apparatuses and rinse prior to use.

10.1.1 Separatory Funnel Preparation

10.1.1.1 Prepare previously washed 2L (or 500 ml for 3510C LVI) separatory funnel by closing valve and adding 5-10mL of DCM. Cap and shake until all inner surfaces have come in contact with the DCM. Discard methylene chloride by opening valve and decanting into chlorinated solvent waste container.

10.1.1.1.1 If water is present in separatory funnel, rinse with 5-10mL of acetone prior to methylene chloride prep.

10.1.1.1.2 Hexane rinse, if needed, may also be performed after the methylene chloride rinse.

10.1.2 Drying Column Preparation

10.1.2.1 Prepare a drying column by adding approximately 30-35g of baked sodium sulfate into a funnel lined with glass wool or filter paper. Rinse with 5-10 mL of methylene chloride, collecting excess into a waste container, and discard in chlorinated solvent waste.

10.1.3 Kuderna-Danish Sample Collection Setup Preparation

10.1.3.1 Rinse assembled Kuderna-Danish flask and receiver with 5-10mL of methylene chloride. Discard methylene chloride into chlorinated solvent waste.

10.1.3.2 Place a drying column on top of K-D flask to complete Kuderna-Danish Sample Collection Setup.

10.1.4 Snyder Column Preparation

10.1.4.1 Pass approximately 3-5mL of methylene chloride from top to bottom of Snyder Column and on the joints to rinse and prime. Collect excess methylene chloride and discard into chlorinated solvent waste.

10.1.5 Buchi Tube Sample Collection Setup Preparation

10.1.5.1 Prepare previously washed and dry Buchi Tubes by adding 5-10mL of DCM and shaking/swirling until all inner surfaces have come in contact with the DCM. Discard methylene chloride by pouring off into chlorinated solvent waste container.

10.1.5.1.1 If water is present, rinse with 5-10mL of acetone prior to methylene chloride prep.

10.1.5.1.2 Hexane rinse, if needed, may also be performed after the methylene chloride rinse.

10.1.5.2 Place a drying column on top of Buchi tube to complete Buchi Tube Sample Collection Setup

10.2 Turn on all equipment, check for proper operating conditions, and allow to reach operating temperatures prior to use.

10.2.1 Waterbath with Evaporation Collection System. System is composed of 2 parts: Waterbath and Condensation System (Chiller and Condensers). Each part will need to be checked prior to use.

10.2.1.1 Chiller

10.2.1.1.1 Check coolant level in chiller and top-up as needed.

10.2.1.1.2 Turn on chiller. Temperature of coolant should show up on digital display, and flowmeter will register rate of coolant flow in gallons per minute (gpm).

10.2.1.1.3 Check coolant lines for leaks. If any are noted, turn off chiller and notify team lead, supervisor, or manager.

10.2.1.1.4 Adjust flowrate of chiller to exceed flow rate listed on chiller operating parameter card.

10.2.1.1.5 Monitor coolant temperature and ensure it falls below the maximum chiller temperature listed on chiller operating parameter card. If it will not fall below maximum temperature, notify team lead, supervisor, or manager.

10.2.1.1.6 Continue to monitor coolant temperature throughout use. At any point of operation, if chiller temperature exceeds listed maximum, remove all samples and suspend use of the associated waterbath(s) until temperature falls below maximum. If it doesn’t fall below maximum temperature, notify team lead, supervisor, or manager.

10.2.1.2 Waterbath

10.2.1.2.1 Check water level in waterbath. If water level is below ¾” of sample holding deck, top up with water.

10.2.1.2.2 Turn on waterbath. If waterbath will not turn on, notify team lead, supervisor, or manager.

10.2.1.2.3 Temperature of water in waterbath should show up on digital display. Check and adjust to ensure temperature is set to 75.0±5.0°C. Water set point temperature is never allowed to exceed 75.0°C. Water temperature is never allowed to exceed 80.0°C. Calibration of waterbath temperature occurs on a quarterly basis. Check calibration date- if expired, do not use. If waterbath will not turn on or out of calibration, notify team lead, supervisor, or manager.

10.2.1.2.4 Continue to monitor water temperature throughout use to ensure heating elements are operating normally and maintain water set point temperature. If waterbath does not maintain the water set point temperature, notify team lead, supervisor, or manager.

10.2.2 Buchi Concentrator System. System is composed of 2 parts: Buchi and Condensation System (Chiller and Condenser). Each part will need to be checked prior to use.

10.2.2.1 Refer to OP030 for proper Buchi Concentrator System Start-up instructions.

10.2.2.2 If any issues, notify a team lead, supervisor, or manager.

10.2.3 Microsnyder. System is composed of waterbath and microsnyder column. Waterbath will need to be checked prior to use.

10.2.3.1 Check water level in waterbath. If water level is below ¾” of sample holding deck, top up with water.

10.2.3.2 Turn on waterbath. If waterbath will not turn on, notify team lead, supervisor, or manager.

10.2.3.3 Temperature of water in waterbath should show up on digital display. Check and adjust to ensure temperature is set to 85.0±5.0°C. Microsnyder waterbath set point is higher due to lower volume of water. If full size waterbath is used, set point temperature is never allowed to exceed 75.0°C and water temperature is never allowed to exceed 80.0°C. If waterbath will not turn on, notify team lead, supervisor, or manager.

10.2.3.4 Continue to monitor water temperature throughout use to ensure heating elements are operating normally and maintain water set point temperature. If waterbath does not maintain the water set point temperature, notify team lead, supervisor, or manager.

10.2.4 N-VAP Concentrator. System is composed of 2 parts: Waterbath and Nitrogen Flow System. Each part will need to be checked prior to use.

10.2.4.1 Waterbath

10.2.4.1.1 Check water level in waterbath. If water level is below ¾” of top, top up with water.

10.2.4.1.2 Turn on waterbath. If waterbath will not turn on, notify team lead, supervisor, or manager.

10.2.4.1.3 Digital Display Waterbath. Temperature of water in waterbath should show up on digital display. Check and adjust to ensure temperature is set to 35.0±2.0°C. Water set point temperature is never allowed to exceed 37.0°C. If waterbath will not turn on, notify team lead, supervisor, or manager.

10.2.4.1.4 Manual Knob Waterbath. Temperature of water in waterbath will need to be manually calibrated and proper setting noted. Check and adjust to ensure temperature is set to 35.0±2.0°C. Water temperature is never allowed to exceed 37.0°C. If waterbath will not turn on or maintain proper temperature, notify team lead, supervisor, or manager.

10.2.4.1.5 Continue to monitor water temperature throughout use to ensure heating elements are operating normally and maintain water set point temperature. If waterbath does not maintain the water set point temperature, notify team lead, supervisor, or manager.

10.2.4.2 Nitrogen Flow System

10.2.4.2.1 Turn on flow of Nitrogen to system. Check to assure the incoming pressure does not exceed 30 pounds per square inch (psi) on pressure gauge.

10.2.4.2.2 Adjust flow rate to 10 liters per minute (lpm) on flow rotometer.

10.2.4.2.3 Check to ensure all needles are in good working order and clean.

10.2.4.2.4 If any issues, notify team lead, supervisor, or manager.

10.3 Pesticides/PCBs by EPA Method 608, SW846 Method 8081, SW846 Method 8082 (Sep Funnel, Water Bath, Buchi Concentrator, & N-VAP).

10.3.1 Confirm all samples present and delivered, listed on the LIMS batch sheet, and listed on preparation log. If any discrepancies, check with schedulers, team leads, supervisors, or managers.

10.3.2 If no discrepancies, document custody of samples in Internal Chain program and change status of batch to “ASN” reflecting the initiation of extraction in LIMS.

10.3.3 Label all apparatuses with the correct sample identification. Sample labels may transfer from one apparatus to the next.

10.3.4 Measure two 1- liter aliquots of deionized water for a method blank and blank spike into separate 1L amber glass bottles. For samples testing for both Pesticide and PCB (known as “shared batches”), two separate sets of spikes must be prepared. Therefore, measure four 1- liter aliquots of deionized water for 2 method blanks and 2 blank spikes into separate 1L amber glass bottles. Initial extraction pH must be 5 – 9. If pH is outside of the range adjust using sulfuric acid or sodium hydroxide.

10.3.5 Mark level of sample on outside of glass bottle. For samples filled to completion, a mark is placed on the cap.

10.3.6 Mix the sample thoroughly by shaking.

Note: Samples which do not homogenize, are multiphasic, have a gasoline or oil odor, thick aqueous sludges, visible oil layer, or gels may not be appropriate for this extraction.

These may require a reduced sample amount, alternate extraction technique, and comments to be added. Check with the team leads, supervisors, or managers for further instructions.

10.3.7 After mixing the sample, decant ¾" to 1" of sample into respective 2L separatory funnel. This is to allow for the addition of surrogate and/or spike.

10.3.8 Record the bottle number, sample description, and pH and chlorine (if needed) in the logbook.

10.3.9 Spiking & Surrogating. For proper execution protocols refer to EOP027.

10.3.9.1 Spiking Amounts. The test being requested will dictate the spike that will need to be added. Using a calibrated 1mL syringe, add spike to blank spike, matrix spike, and matrix spike duplicate (if present).

10.3.9.1.1 For Pesticide add 1mL of pesticide target compound spike.

10.3.9.1.1.1 For Pesticides by EPA 608.3, prepare additional spike with Toxaphene and Chlordane with every batch of 20 samples or less by adding 0.5 ml of the spike.

10.3.9.1.2 For Pesticide Low Level ("LL") add 0.1mL of pesticide target compound spike.

10.3.9.1.3 For PCB add 1mL of PCB target compound spike.

10.3.9.1.4 For PCB Low Level ("LL") add 1mL of PCB target compound spike.

10.3.9.1.5 For samples testing for both Pesticide and PCB (known as "shared batches"), two separate sets of blanks and spikes must be prepared. One for Pesticides and one for PCBs.

Note: Check the expiration date for all spiking materials to verify that the solution is valid. Do not use expired solutions for spiking.

Note: Other special spikes may be needed. Check the special spike section of the logbook for additional information.

10.3.9.2 Surrogate Amounts. The test being requested will dictate the amount of surrogate that will need to be added.

10.3.9.2.1 For Pesticide or PCB regular samples (not "LL"), add 1mL of the pesticide/PCB surrogate (labeled as "TCMX" on surrogate bottle) using a calibrated 1mL syringe to all samples, blanks, and spikes.

10.3.9.2.2 For Pesticide or PCB Low Level ("LL") samples, add 0.1mL of the pesticide/PCB surrogate (labeled as "TCMX" on surrogate bottle) using a calibrated 1mL syringe to all samples, blanks, and spikes

Note: Check the expiration date for all surrogating materials to verify that the solution is valid. Do not use expired solutions for surrogating.

Note: Other special surrogates maybe needed. Check the logbook for additional information.

10.3.10 Pour samples into their respective 2L separatory funnel.

10.3.11 Rinse the sample bottle with 60mL of methylene chloride. Transfer the 60mL methylene chloride rinse from the sample container into the separatory funnel containing the sample.

10.3.12 To determine the initial sample volume in the sample bottle, fill the empty sample jar with tap water to the mark on the jar. Pour the contents of the jar into a graduated cylinder and measure the volume. This is the sample volume that is recorded on the extraction log.

10.3.13 Hand shake the funnel vigorously for 15-20 seconds. Release excess pressure by venting the funnel into the hood by opening and closing the Teflon stopcock.

10.3.14 Extract the sample by shaking the funnel vigorously for 2 minutes either using the automatic shaker or by hand. Allow the aqueous solvent layers to separate for a minimum of 10 minutes.

10.3.15 Collect the methylene chloride layer (the bottom layer) by passing through the drying column into the assembled Kuderna-Danish.

Note: Additional sodium sulfate may be added as needed to prevent trace amounts of aqueous fraction present in methylene chloride layer from passing through.

Important: Do not allow the sodium sulfate to become dry between solvent extracts.

10.3.16 Rinse drying column with methylene chloride. This ensures quantative recovery of analytes of interest.

10.3.17 Add a second 60mL volume of methylene chloride to the separatory funnel. Seal and shake the separatory funnel and repeat the extraction/collection procedure described in Section 10.3.13 to 10.3.15. Perform a third extraction/collection in the same manner.

10.3.18 If needed, once all three 60mL volumes of methylene chloride have been added, centrifuge the solvent layer to break emulsions.

10.3.19 Once the three extraction steps are completed, perform a final rinse of the drying column with an additional 10mL of methylene Chloride. Allow the methylene chloride to drain through until dripping stops.

10.3.20 Remove drying column and discard sodium sulfate, glass wool or filter paper into solid sulfate waste.

10.3.21 Add in boiling chip and Snyder column. The sample is now ready to be concentrated.

10.3.22 Sample Concentration Procedure. Document the procedure in the extraction logbook.

10.3.22.1 Water Bath with Evaporation Collection System

Note: Fill in waterbath information, chiller information, and flow rates once samples have been loaded.

Note: If a sample ruptures into the waterbath, immediately close the hood, allow the boiling action of the water to subside, fumes to dissipate, and notify a team lead, supervisor, or manager. Do not attempt glassware removal or cleanup by yourself.

10.3.22.1.1 Position K-D flask in the waterbath. Immersing the 10mL concentrator tube into the waterbath. Concentrate samples to about 5-7mL.

10.3.22.1.2 Allow the K-D flask, receiver, and Snyder column to cool. During this process, approximately 1mL of methylene chloride will re-condense and flow down the side of the K-D flask removing most of the extract remaining in the flask and joints.

10.3.22.1.3 Remove Snyder column and slowly add 0.5-1mL of methylene chloride to the tilted K-D flask while rotating the flask. This is a final rinse of the flask and joint. Tilt upright to allow the methylene chloride to drain into the receiver.

10.3.23 Solvent Exchange. A solvent exchange to hexane is required for Pest/PCB samples.

10.3.23.1 Add 50mL of hexane into K-D setup and swirl to contact all surfaces.

10.3.23.2 Transfer sample by pouring from K-D setup into Buchi tube.

10.3.23.3 Buchi Concentrator System

Note: In logbook, fill in Buchi concentrator information, chiller information, and flow rates once samples have been loaded

10.3.23.3.1 Load Buchi tubes into Buchi Concentrator. Use yellow plugs to close any Buchi tube slots that are not being used.

10.3.23.3.2 Select program “Pest/PCB Hexane X”, and press “Start” on the vacuum controller. Turn rotation knob until digital display reads 250 rotations per minute. The extract is concentrated to approximately 1mL.

10.3.23.3.3 Once program is finished, press “Stop” on vacuum controller and turn rotation knob to 0 rotations per minute.

10.3.23.3.4 Unload Buchi tubes from Buchi Concentrator and allow to cool.

10.3.24 Final volume adjustment. Samples may require further concentration to reach proper volumes.

10.3.24.1 For Methods 608, final volume is 5mL. For Methods 8081 and 8082, final volume is 10mL. For 608 Low Level (“608 LL”), 8081 Low Level (“8081 LL”), and 8082 Low Level ("8082 LL), final volume is 1mL. If samples will not concentrate to final volumes or if they change states (i.e. liquid to gel), notify team lead, supervisors, and managers for further instructions. These may require a modified sample amount, alternate concentration technique, and comments to be added.

10.3.24.2 N-VAP Method. Immerse the nipple of the Buchi tube in the waterbath of the N-VAP. Direct a gentle stream of nitrogen gas onto the extract by adjusting height of needle until small dimple appears on surface. Evaporate the solvent until the desired volume is reached. Occasionally rinse the sidewalls of the concentrator tubes with methylene chloride during the evaporation step.

10.3.25 Vialing

10.3.25.1 Sample Vial Labeling

10.3.25.1.1 For 608 Low Level ("608 LL"), 8081 Low Level ("8081 LL"), and 8082 Low Level ("8082 LL), sample, label one 2mL graduated amber vials with Sample number and Batch number. No backup vial is created for this test.

10.3.25.1.2 For Methods 608, 8081, and 8082, sample, label two 2mL graduated amber vials with Sample number and Batch number. One for analysis and one for backup.

10.3.25.1.3 For "Shared Batch" 608 Low Level ("608 LL"), "Shared Batch" 8081 Low Level ("8081 LL"), and "Shared Batch" 8082 Low Level ("8082 LL) sample. Label two 2mL graduated amber vials with Sample number and Batch number. One for PCB analysis and one for pesticide analysis. No backup vial is created for this test.

10.3.25.1.4 For "Shared Batch" sample. Label three 2mL graduated amber vials with Sample number and Batch number. One for PCB analysis, one for pesticide analysis, and one for backup.

10.3.25.2 Bring sample to final volume. Top up and vial each sample individually. This prevents evaporation of solvent and concentration of sample.

10.3.25.2.1 For all Low-Level samples (608 LL, 8081 LL, 8082 LL, Shared Batch LL), final volume is 1mL.

10.3.25.2.2 For method 608, bring to 5mL volume by adding additional 4mL of hexane using a graduated cylinder. Mix using the vortex mixer for 10 seconds minimum.

10.3.25.2.3 For Methods 8081, 8082, and "Shared Batch", bring final volume to 10mL by adding additional 9mL of Hexane using a graduated cylinder. Mix using the vortex mixer for 10 seconds minimum.

10.3.25.3 Vialing Backup. For Methods 608, 8081, 8082, and “Shared Batch”, vial 2mL into 2mL amber vial as a backup and do not add copper. Backup samples for pesticide and PCB are vialed prior to appropriate cleanup.

10.3.25.4 Vialing Sample.

10.3.25.4.1 For method 608 and 608 LL, place 1mL into 2mL amber vial and copper cleanup following EOP011.

10.3.25.4.2 For Methods 8081, 8082, 8081 LL, 8082 LL, place 1mL into 2mL amber vial and copper cleanup following EOP011.

10.3.25.4.3 For “Shared Batch”, vial two separate 1mL aliquots of extract into 2mL amber vials and copper cleanup both following EOP011. For “Shared Batch LL”, vial two separate 0.5mL aliquots of extract into 2mL amber vials and copper cleanup both following EOP011. One for Pesticide and one for PCB.

10.3.25.5 Discard unvialed remainder of the extract into hexane wastes.

10.3.25.6 Protect the extracts from light and store them in the designated freezer at -10^{o}C.

10.3.26 Upon completion of extraction and vialing, account for all samples by matching to logbook entry and confirm the following information is complete and present. This information must be noted in real-time and not after completion.
10.3.26.1 Method. Start date and time, stop date and time, and method used
10.3.26.2 Sample. Matrix type and weights
10.3.26.3 Extract. Colors, final volumes, and cleanup procedures
10.3.26.4 Reagent. Reagents used, lot numbers, and volumes used
10.3.26.5 Spikes and surrogates. Lot numbers, concentration, and volumes used
10.3.26.6 Equipment. Equipment used, flow rates, and temperatures
10.3.26.7 Personnel. Document all personnel that have assisted in the extraction of the batch by having that person initial the logbook.
Note: It is not permissible under any circumstances to have another person initial for another person or take credit for work not performed.

10.3.27 In LIMS program, update status of samples to “DONE”, using associated batch number, date of extraction, department, select samples being updated using “X”, and saving changes. Document completion of sample extraction in Internal Chain program by changing status of batch to “OPEXT”.

10.3.28 Present samples and logbook to team leads, supervisors, or managers for final review.

10.3.29 Deliver samples for analysis. Protocols and expectations for delivery are dictated by analytical department and are expected to be adhered to.

10.4 Acid-Base Neutrals by Methods EPA 625 & SW846 8270 (Sep Funnel, Water Bath, & Microsnyder or N-VAP).

Note: The sample preparation procedure for aqueous samples contains two options: standard volume extraction (1000ml) and reduced volume extraction (250ml) for large volume injection (LVI) analysis.

10.4.1 Confirm all samples present and delivered, listed on the LIMS batch sheet, and listed on preparation log. If any discrepancies, check with schedulers, team leads, supervisors, or managers.

10.4.2 If no discrepancies, document custody of samples in Internal Chain program and change status of batch to "ASN" reflecting the initiation of extraction in LIMS.

10.4.3 Label all apparatuses with the correct sample identification. Sample labels may transfer from one apparatus to the next.

10.4.4 Measure two 1-liter (or 250-ml for 3510C LVI) aliquots of deionized water for a method blank and blank spike into separate 1L or 250 ml amber glass bottles.

10.4.5 Mark level of sample on outside of glass bottle. For samples filled to completion, a mark is placed on the cap.

10.4.6 Mix the sample thoroughly by shaking.

Note: Samples which do not homogenize, are multiphasic, have a gasoline or oil odor, thick aqueous sludges, visible oil layer, or gels may not be appropriate for this extraction. These may require a reduced sample amount, alternate extraction technique, and comments to be added. Check with the team leads, supervisors, or managers for further instructions.

10.4.7 After mixing the sample, decant ¾" to 1" of sample into respective 2L separatory funnel. This is to allow for the addition of surrogate and/or spike.

10.4.8 Record the bottle number, sample description, and pH and chlorine (if needed) in the logbook.

10.4.9 Spiking & Surrogating. For proper execution protocols refer to EOP027.

10.4.9.1 Spiking Amounts. The test being requested will dictate the spikes that will need to be added. Using a calibrated 1mL syringe, add spike to blank spike, matrix spike, and matrix spike duplicate (if present).

10.4.9.1.1 For Base-Neutral ("BN") add 1.0mL (or 0.2ml for 3510C LVI) of each of the base neutral target compound spikes: BN1, BN2, & Aniline.

10.4.9.1.2 For Acid ("A") add 1.0mL (or 0.2ml for 3510C LVI) of the acid target compound spike.

10.4.9.1.3 For Acid Base-Neutral ("ABN") add 1.0mL (or 0.2ml for 3510C LVI) each of the Base-Neutral (BN1, BN2, Aniline) and Acid target compound spikes.

10.4.9.1.4 For SIM ("BS12SIM"), add 0.1 mL of acid target compound spike and 1.0 mL of Base-Neutral SIM ("BSIM") target compound spike.

Note: Check the expiration date for all spiking materials to verify that the solution is valid. Do not use expired solutions for spiking.

Note: Other special spikes may be needed. Check the special spike section of the logbook for additional information.

10.4.9.2 Surrogate Amounts. Add 1.0mL of the acid-base neutral surrogate using a calibrated 1mL syringe (or add 0.2ml for 3510C LVI) to all samples, blanks, and spikes. For SIM 1,4-Dioxane samples, add 1.0mL of 1,4-Dioxane-d8 solution.

Note: Check the expiration date for all surrogate materials to verify that the solution is valid. Do not use expired solutions for surrogating.

Note: Other special surrogates maybe needed. Check the logbook for additional information.

10.4.10 Pour samples into their respective 2L separatory funnel.

10.4.11 Rinse the sample bottle with 60 mL (or 15ml for 3510C LVI) of methylene chloride. Transfer the 60 mL methylene chloride rinse from the sample container into the separatory funnel containing the sample.

10.4.12 To determine the initial sample volume in the sample bottle, fill the empty sample jar with tap water to the mark on the jar. Pour the contents of the jar into a graduated cylinder and measure the volume. This is the sample volume that is recorded on the extraction log.

10.4.13 pH adjustment. pH will need to be adjusted based upon analysis type requested. Acid extraction (if requested) will take precedent over Base-Neutral extraction. If Acid extraction is not requested, proceed directly to Base-Neutral extraction.

10.4.13.1 For Acid only, Acid Base-Neutral, or SIM Samples. Adjust the pH of the sample to <2 using 1mL of the 50% sulfuric acid solution. Check the pH of the sample with pH test paper to verify the correct pH, adding more acid if needed, and document amount added in the extraction logbook.

10.4.13.1.1 Hand shake the funnel vigorously for 15-20 seconds. Release excess pressure by venting the funnel into the hood by opening and closing the Teflon stopcock.

10.4.13.1.2 Extract the sample by shaking the funnel vigorously for 2 minutes either using the automatic shaker or by hand. Allow the aqueous solvent layers to separate for a minimum of 10 minutes.

10.4.13.1.3 Collect the methylene chloride layer (the bottom layer) by passing through the drying column into the assembled Kuderna-Danish.

Note: Additional sodium sulfate may be added as needed to prevent trace amounts of aqueous fraction present in methylene chloride layer from passing through.

Important: Do not allow the sodium sulfate to become dry between solvent extracts.

10.4.13.1.4 Add a second 60-ml volume (or 15ml for 3510C LVI) of methylene chloride to the separatory funnel. Seal and shake the separatory funnel and repeat the extraction procedure described in Section 10.4.11.1.2 to 10.4.11.1.3. Perform a third extraction in the same manner.

10.4.13.1.5 If needed, once all three 60mL volumes (or 15ml for 3510C LVI) of methylene chloride have been added, centrifuge the solvent layer to break emulsions.

10.4.13.2 For Base-Neutral only, Acid Base-Neutral, BSIM, or SIM Samples. Adjust the pH to >11 with 4mL of the 10N sodium hydroxide solution, Check the pH of the sample with pH test paper to verify the correct pH, adding more base if needed, and document amount added in the extraction logbook. Add in 60mL of methylene chloride and repeat the shaking technique described in Sections 10.4.13.1.1 through 10.4.13.1.5.

Note: For Acid Base-Neutral or SIM Samples, pass the Base-Neutral extractions through the drying column and Kuderna-Danish setup utilized in the Acid extractions.

10.4.14 Once the three extractions or six extractions are completed, perform a final rinse of the drying column with an additional 10 mL of methylene Chloride. Allow the methylene chloride to drain through until dripping stops.

10.4.15 Remove drying column and discard sodium sulfate, glass wool or filter paper into solid sulfate waste.

10.4.16 Add in boiling chip and Snyder column. The sample is now ready to be concentrated.

10.4.17 Sample Concentration Procedure. Document the procedure in the extraction logbook.

10.4.17.1 Water Bath with Evaporation Collection System

Note: Fill in waterbath information, chiller information, and flow rates once samples have been loaded.

Note: If a sample ruptures into the waterbath, immediately close the hood, allow the boiling action of the water to subside, fumes to dissipate, and notify a team lead, supervisor, or manager. Do not attempt glassware removal or cleanup by yourself.

10.4.17.1.1 Position K-D flask in the waterbath. Immersing the 10mL concentrator tube into the waterbath. Concentrate samples to about 5-7mL.

10.4.17.1.2 Allow the K-D flask, receiver, and Snyder column to cool. During this process, approximately 1mL of methylene chloride will recondense and flow down the side of the K-D flask removing most of the extract remaining in the flask and joints.

10.4.17.1.3 Remove Snyder column and slowly add 0.5-1mL of methylene chloride to the tilted K-D flask while rotate the flask. This is a final rinse of the flask and joint. Tilt upright to allow the methylene chloride to drain into the receiver.

10.4.17.1.4 Disassemble the K-D flask from the receiver.

10.4.18 Final volume adjustment. Samples may require further concentration (using the N-VAP or Micro Snyder methods) or addition to reach the desired final volume.

10.4.18.1 For Methods 8270, 625, and SIM, final volume is 1mL. For LVI extractions blow the extract directly down to a final volume of 2 ml on the N-Evap. If samples will not concentrate to final volumes or change states (i.e. liquid to gel), notify team lead, supervisors, and managers for further instructions. These may require a modified sample amount, alternate concentration technique, and comments to be added.

10.4.18.2 N-VAP Concentration Method. Immerse the nipple of the Buchi tube in the waterbath of the N-VAP. Direct a gentle stream of nitrogen gas onto the extract by adjusting height of needle until small dimple appears on surface. Evaporate the solvent until the desired volume is reached. Occasionally rinse the sidewalls of the concentrator tubes with methylene chloride during the evaporation step.

10.4.18.3 Micro Snyder Concentration Method. Attach a microsnyder column to the 10mL concentrator tube and immerse into the waterbath. Concentrate to the desired volume.

10.4.19 Vialing

10.4.19.1 For each sample, label a 2mL graduated amber vial with Sample number and Batch number. No backup vial is created for this test.

10.4.19.2 Bring final volume to 1mL with methylene chloride in receiver and mix with a Pasteur pipet. Transfer all sample extract to the vial.

10.4.19.3 Adjust the vial volume to 1mL with methylene chloride.

10.4.19.4 Protect the extracts from light and store them in the designated freezer at -10^{o}C.

10.4.20 Upon completion of extraction and vialing, account for all samples by matching to logbook entry and confirm the following information is complete and present. This information must be noted in real-time and not after completion.

10.4.20.1 Method. Start date and time, stop date and time, and method used
10.4.20.2 Sample. Matrix type and weights
10.4.20.3 Extract. Colors, final volumes, and cleanup procedures
10.4.20.4 Reagent. Reagents used, lot numbers, and volumes used
10.4.20.5 Spikes and surrogates. Lot numbers, concentration, and volumes used

10.4.20.6 Equipment. Equipment used, flow rates, and temperatures.

10.4.20.7 Personnel. Document all personnel that have assisted in the extraction of the batch by having that person initial the logbook.

Note: It is not permissible under any circumstances to have another person initial for another person or take credit for work not performed.

10.4.21 In LIMS program, update status of samples to “DONE”, using associated batch number, date of extraction, department, select samples being updated using “X”, and saving changes. Document completion of sample extraction in Internal Chain program by changing status of batch to “OPEXT”.

10.4.22 Present samples and logbook to team leads, supervisors, or managers for final review.

10.4.23 Deliver samples for analysis. Protocols and expectations for delivery are dictated by analytical department and are expected to be adhered to.

10.5 DRO - Diesel Range Organics for method SW846-8015C (Sep Funnel, Water Bath, & Microsnyder or N-VAP).

10.5.1 Confirm all samples present and delivered, listed on the LIMS batch sheet, and listed on preparation log. If any discrepancies, check with schedulers, team leads, supervisors, or managers.

10.5.2 If no discrepancies, document custody of samples in Internal Chain program and change status of batch to “ASN” reflecting the initiation of extraction in LIMS.

10.5.3 Label all apparatuses with the correct sample identification. Sample labels may transfer from one apparatus to the next.

10.5.4 Measure two 1-liter aliquots of deionized water for a method blank and blank spike into separate 1L amber glass bottles. For fingerprint (“FING”) samples, only one method blank is required.

10.5.5 Add 1mL of HCl to blanks to match preservation method of the samples.

10.5.6 Mark level of sample on outside of glass bottle. For samples filled to completion, a mark is placed on the cap.

10.5.7 Mix the sample thoroughly by shaking.

Note: Samples which do not homogenize, are multiphasic, have a gasoline or oil odor, thick aqueous sludges, visible oil layer, or gels may not be appropriate for this extraction. These may require a reduced sample amount, alternate extraction technique, and comments to be added. Check with the team leads, supervisors, or managers for further instructions.

10.5.8 After mixing the sample, decant ¾” to 1” of sample into respective 2L separatory funnel. This is to allow for the addition of surrogate and/or spike.

10.5.9 Record the bottle number, sample description, and pH and chlorine (if needed) in the logbook.

10.5.10 Spiking & Surrogating. For proper execution protocols refer to EOP027.

10.5.10.1 Spiking Amounts. The test being requested will dictate the spikes that will need to be added. Add spike to blank spike, matrix spike, and matrix spike duplicate (if present).

10.5.10.1.1 Add 1mL of the DRO target compound spike using a calibrated 1mL syringe to the samples selected for matrix spikes.

10.5.10.1.2 "FING" samples do not have blank spikes, matrix spike, or matrix spike duplicates. Therefore, no target compound spike is necessary.

Note: Check the expiration date for all spiking materials to verify that the solution is valid. Do not use expired solutions for spiking.

10.5.10.2 Surrogate Amounts. Add 1mL of the DRO surrogate using a calibrated 1mL syringe to all samples, blanks, and spikes. "FING" samples require 4mL of DRO surrogate to be added using a calibrated 1mL syringe to all samples and method blank.

Note: Check the expiration date for all surrogating materials to verify that the solution is valid. Do not use expired solutions for surrogating.

10.5.11 Pour samples into their respective 2L separatory funnel.

10.5.12 Rinse the sample bottle with 60mL of methylene chloride. Transfer the 60mL methylene chloride rinse from the sample container into the separatory funnel containing the sample.

10.5.13 To determine the initial sample volume in the sample bottle, fill the empty sample jar with tap water to the mark on the jar. Pour the contents of the jar into a graduated cylinder and measure the volume. This is the sample volume that is recorded on the extraction log.

10.5.14 Hand shake the funnel vigorously for 15-20 seconds. Release excess pressure by venting the funnel into the hood by opening and closing the Teflon stopcock.

10.5.15 Extract the sample by shaking the funnel vigorously for 2 minutes either using the automatic shaker or by hand. Allow the aqueous solvent layers to separate for a minimum of 10 minutes.

10.5.16 Collect the methylene chloride layer (the bottom layer) by passing through the drying column into the assembled Kuderna-Danish.

Note: Additional sodium sulfate may be added as needed to prevent trace amounts of aqueous fraction present in methylene chloride layer from passing through.

Important: Do not allow the sodium sulfate to become dry between solvent extracts.

10.5.17 Add a second 60mL volume of methylene chloride to the separatory funnel. Seal and shake the separatory funnel and repeat the extraction procedure described in Section 10.5.13 to 10.5.14. Perform a third extraction in the same manner.

10.5.18 If needed, once all three 60mL volumes of methylene chloride have been added, centrifuge the solvent layer to break emulsions.

10.5.19 Once the three extraction steps are completed, perform a final rinse of the drying column with an additional 10mL of methylene chloride. Allow the methylene chloride to drain through until dripping stops.

10.5.20 Remove drying column and discard sodium sulfate, glass wool or filter paper into solid sulfate waste.

10.5.21 Add in boiling chip and Snyder column. The sample is now ready to be concentrated.

10.5.22 Sample Concentration Procedure. Document the procedure in the extraction logbook.

10.5.22.1 Water Bath with Evaporation Collection System

Note: Fill in waterbath information, chiller information, and flow rates once samples have been loaded.

Note: If a sample ruptures into the waterbath, immediately close the hood, allow the boiling action of the water to subside, fumes to dissipate, and notify a team lead, supervisor, or manager. Do not attempt glassware removal or cleanup by yourself.

10.5.22.1.1 Position K-D flask in the waterbath. Immersing the 10mL concentrator tube into the waterbath. Concentrate samples to about 5-7mL.

10.5.22.1.2 Allow the K-D flask, receiver, and Snyder column to cool. During this process, approximately 1mL of methylene chloride will recondense and flow down the side of the K-D flask removing most of the extract remaining in the flask and joints.

10.5.22.1.3 Remove Snyder column and slowly add 0.5-1mL of methylene chloride to the tilted K-D flask while rotate the flask. This is a final rinse of the flask and joint. Tilt upright to allow the methylene chloride to drain into the receiver.

10.5.22.2 Disassemble the K-D flask from the receiver.

10.5.23 Final volume adjustment. Samples may require further concentration using the N-VAP or Micro Snyder methods to reach the desired final volume.

10.5.23.1 For Methods 8015 and “FING”, final volume is 1mL. If samples will not concentrate to final volumes or change states (i.e. liquid to gel), notify team lead, supervisors, and managers for further instructions. These may require a modified sample amount, alternate concentration technique, and comments to be added.

10.5.23.2 N-VAP Method. Immerse the nipple of the receiver in the waterbath of the N-VAP. Direct a gentle stream of nitrogen gas onto the extract by adjusting height of needle until small dimple appears on surface. Evaporate the solvent until the desired volume is reached. Occasionally rinse the sidewalls of the concentrator tubes with methylene chloride during the evaporation step.

10.5.23.3 Micro Snyder Method. Attach a micro-snyder column to the receiver and immerse into a waterbath. Concentrate to the desired volume.

10.5.24 Vialing

10.5.24.1 For each sample, label a 2mL graduated amber vial with Sample number and Batch number. No backup vial is created for this test.

10.5.24.2 Bring final volume to 1mL with methylene chloride in receiver and mix with a Pasteur pipet. Transfer all sample extract to the vial.

10.5.24.3 Adjust the vial volume to 1mL with methylene chloride.

10.5.24.4 Protect the extracts from light and store them in the designated freezer at -10°C.

10.5.25 Upon completion of extraction and vialing, account for all samples by matching to logbook entry and confirm the following information is complete and present. This information must be noted in real-time and not after completion.
10.5.25.1 Method. Start date and time, stop date and time, and method used
10.5.25.2 Sample. Matrix type and weights
10.5.25.3 Extract. Colors, final volumes, and cleanup procedures
10.5.25.4 Reagent. Reagents used, lot numbers, and volumes used
10.5.25.5 Spikes and surrogates. Lot numbers, concentration, and volumes used
10.5.25.6 Equipment. Equipment used, flow rates, and temperatures.
10.5.25.7 Personnel. Document all personnel that have assisted in the extraction of the batch by having that person initial the logbook.

Note: It is not permissible under any circumstances to have another person initial for another person or take credit for work not performed.

10.5.26 In LIMS program, update status of samples to “DONE”, using associated batch number, date of extraction, department, select samples being updated using “X”, and saving changes. Document completion of sample extraction in Internal Chain program by changing status of batch to “OPEXT”.

10.5.27 Present samples and logbook to team leads, supervisors, or managers for final review.

10.5.28 Deliver samples for analysis. Protocols and expectations for delivery are dictated by analytical department and are expected to be adhered to.

10.6 NJ EPH- Extractable Petroleum Hydrocarbons (Sep Funnel, Water Bath, & Micro Snyder or N-VAP).

10.6.1 Confirm all samples present and delivered, listed on the LIMS batch sheet, and listed on preparation log. If any discrepancies, check with schedulers, team leads, supervisors, or managers.

10.6.2 If no discrepancies, document custody of samples in Internal Chain program and change status of batch to “ASN” reflecting the initiation of extraction in LIMS.

10.6.3 Label all apparatuses with the correct sample identification. Sample labels may transfer from one apparatus to the next.

10.6.4 Measure three 1-liter aliquots of deionized water for a method blank, blank spike (BS1), and second blank spike (labeled as “BS11”) into separate 1L amber glass bottles.

10.6.5 Add 1mL of HCl to blanks to match preservation method of the samples.

10.6.6 Mark level of sample on outside of glass bottle. For samples filled to completion, a mark is placed on the cap.

10.6.7 Mix the sample thoroughly by shaking.

Note: Samples which do not homogenize, are multiphasic, have a gasoline or oil odor, thick aqueous sludges, visible oil layer, or gels may not be appropriate for this extraction. These may require a reduced sample amount, alternate extraction technique, and comments to be added. Check with the team leads, supervisors, or managers for further instructions.

10.6.8 After mixing the sample, decant ¾” to 1” of sample into respective 2L separatory funnel. This is to allow for the addition of surrogate and/or spike.

10.6.9 Record the bottle number, sample description, and pH and chlorine (if needed) in the logbook.

10.6.10 Spiking & Surrogating. For proper execution protocols refer to EOP027.

10.6.10.1 Spiking Amounts. The test being requested will dictate the spikes that will need to be added. Add spike to blank spike, matrix spike, and matrix spike duplicate (if present).

Note: EPH spike in use must be stored at room temperature. If inadvertently placed into the refrigerator or freezer, remove and allow to return to room temperature.

10.6.10.1.1 Add 1mL of the EPH target compound spike using a calibrated 1mL syringe to the blank spike (BS1), matrix spike (MS), matrix spike duplicate (MSD) and blank spike duplicate (BSD) if present.

10.6.10.1.2 Add 0.5mL of the DRO target compound spike using a calibrated 1mL syringe to the second blank spike (BS11).

Note: Check the expiration date for all spiking materials to verify that the solution is valid. Do not use expired solutions for spiking.

10.6.10.2 Surrogate Amounts. Add 1mL of the EPH surrogate using a calibrated 1mL syringe to all samples, blanks, and spikes.

Note: Check the expiration date for all surrogating materials to verify that the solution is valid. Do not use expired solutions for surrogating.

10.6.11 Pour samples into their respective 2L separatory funnel.

10.6.12 Rinse the sample bottle with 60mL of methylene chloride. Transfer the 60mL methylene chloride rinse from the sample container into the separatory funnel containing the sample.

10.6.13 To determine the initial sample volume in the sample bottle, fill the empty sample jar with tap water to the mark on the jar. Pour the contents of the jar into a graduated cylinder and measure the volume. This is the sample volume that is recorded on the extraction log.

10.6.14 Hand shake the funnel vigorously for 15-20 seconds. Release excess pressure by venting the funnel into the hood by opening and closing the Teflon stopcock.

10.6.15 Extract the sample by shaking the funnel vigorously for 2 minutes either using the automatic shaker or by hand. Allow the aqueous solvent layers to separate for a minimum of 10 minutes.

10.6.16 Collect the methylene chloride layer (the bottom layer) by passing through the drying column into the assembled Kuderna-Danish.

Note: Additional sodium sulfate may be added as needed to prevent trace amounts of aqueous fraction present in methylene chloride layer from passing through.

Important: Do not allow the sodium sulfate to become dry between solvent extracts.

10.6.17 Add a second 60mL volume of methylene chloride to the separatory funnel. Seal and shake the separatory funnel and repeat the extraction procedure described in Section 10.5.13 to 10.5.14. Perform a third extraction in the same manner.

10.6.18 If needed, once all three 60mL volumes of methylene chloride have been added, centrifuge the solvent layer to break emulsions.

10.6.19 Once the three extraction steps are completed, perform a final rinse of the drying column with an additional 10mL of methylene chloride. Allow the methylene chloride to drain through until dripping stops.

10.6.20 Remove drying column and discard sodium sulfate, glass wool or filter paper into solid sulfate waste.

10.6.21 Add in boiling chip and Snyder column. The sample is now ready to be concentrated.

10.6.22 Sample Concentration Procedure. Document the procedure in the extraction logbook.

10.6.22.1 Water Bath with Evaporation Collection System

Note: Fill in waterbath information, chiller information, and flow rates once samples have been loaded.

Note: If a sample ruptures into the waterbath, immediately close the hood, allow the boiling action of the water to subside, fumes to dissipate, and notify a team lead, supervisor, or manager. Do not attempt glassware removal or cleanup by yourself.

10.6.22.1.1 Position K-D flask in the waterbath. Immersing the 10mL concentrator tube into the waterbath. Concentrate samples to about 5-7mL.

10.6.22.1.2 Allow the K-D flask, receiver, and Snyder column to cool. During this process, approximately 1mL of methylene chloride will recondense and flow down the side of the K-D flask removing most of the extract remaining in the flask and joints.

10.6.22.1.3 Remove Snyder column and slowly add 0.5-1mL of methylene chloride to the tilted K-D flask while rotate the flask. This is a final rinse of the flask and joint. Tilt upright to allow the methylene chloride to drain into the receiver.

10.6.22.2 Disassemble the K-D flask from the receiver.

10.6.23 Final volume adjustment. Samples may require further concentration using the N-VAP or Micro Snyder methods to reach the desired final volume.

10.6.23.1 For NJ EPH final volume is 1mL. If samples will not concentrate to final volumes or change states (i.e. liquid to gel), notify team lead, supervisors, and

managers for further instructions. These may require a modified sample amount, alternate concentration technique, and comments to be added.

10.6.23.2 N-VAP Method. Immerse the nipple of the receiver in the waterbath of the N-VAP. Direct a gentle stream of nitrogen gas onto the extract by adjusting height of needle until small dimple appears on surface. Evaporate the solvent until the desired volume is reached. Occasionally rinse the sidewalls of the concentrator tubes with methylene chloride during the evaporation step.

10.6.23.3 Micro Snyder Method. Attach a micro-snyder column to the receiver and immerse into a waterbath. Concentrate to the desired volume.

10.6.24 Vialing

10.6.24.1 For each sample, label a 2mL graduated amber vial with Sample number and Batch number. No backup vial is created for this test.

10.6.24.2 Bring final volume to 1mL with methylene chloride in receiver and mix with a Pasteur pipet. Transfer all sample extract to the vial.

10.6.24.3 Adjust the vial volume to 1mL with methylene chloride.

10.6.24.4 Protect the extracts from light and store them in the designated freezer at -10^{o}C.

10.6.25 Upon completion of extraction and vialing, account for all samples by matching to logbook entry and confirm the following information is complete and present. This information must be noted in real-time and not after completion.

10.6.25.1 Method. Start date and time, stop date and time, and method used
10.6.25.2 Sample. Matrix type and weights
10.6.25.3 Extract. Colors, final volumes, and cleanup procedures
10.6.25.4 Reagent. Reagents used, lot numbers, and volumes used
10.6.25.5 Spikes and surrogates. Lot numbers, concentration, and volumes used
10.6.25.6 Equipment. Equipment used, flow rates, and temperatures.
10.6.25.7 Personnel. Document all personnel that have assisted in the extraction of the batch by having that person initial the logbook.

Note: It is not permissible under any circumstances to have another person initial for another person or take credit for work not performed.

10.6.26 In LIMS program, update status of samples to "DONE", using associated batch number, date of extraction, department, select samples being updated using "X", and saving changes. Document completion of sample extraction in Internal Chain program by changing status of batch to "OPEXT".

10.6.27 Present samples and logbook to team leads, supervisors, or managers for final review.

10.6.28 Deliver samples for analysis. Protocols and expectations for delivery are dictated by analytical department and are expected to be adhered to.

10.7 NJ OQA-QAM-025 (NJ Semi-VOA Petroleum Hydrocarbon) (Sep Funnel, Water Bath, & Micro Snyder or N-VAP).

10.7.1 Confirm all samples present and delivered, listed on the LIMS batch sheet, and listed on preparation log. If any discrepancies, check with schedulers, team leads, supervisors, or managers.

10.7.2 If no discrepancies, document custody of samples in Internal Chain program and change status of batch to "ASN" reflecting the initiation of extraction in LIMS.

10.7.3 Label all apparatuses with the correct sample identification. Sample labels may transfer from one apparatus to the next.

10.7.4 Measure two 1-liter aliquots of deionized water for a method blank and blank spike into separate 1L amber glass bottles.

10.7.5 Mark level of sample on outside of glass bottle. For samples filled to completion, a mark is placed on the cap.

10.7.6 Mix the sample thoroughly by shaking.

Note: Samples which do not homogenize, are multiphasic, have a gasoline or oil odor, thick aqueous sludges, visible oil layer, or gels may not be appropriate for this extraction.

These may require a reduced sample amount, alternate extraction technique, and comments to be added. Check with the team leads, supervisors, or managers for further instructions.

10.7.7 After mixing the sample, decant ¾" to 1" of sample into respective 2L separatory funnel. This is to allow for the addition of surrogate and/or spike.

10.7.8 Record the bottle number, sample description, and pH and chlorine (if needed) in the logbook.

10.7.9 Spiking & Surrogating. For proper execution protocols refer to EOP027.

10.7.9.1 Spiking Amounts. The test being requested will dictate the spikes that will need to be added. Using a calibrated 1mL syringe or 1 mL volumetric pipette, add spike to blank spike, matrix spike, and matrix spike duplicate (if present).

10.7.9.1.1 Add 1mL of the DRO target compound spike using a calibrated 1mL syringe to the samples selected for matrix spikes.

Note: Check the expiration date for all spiking materials to verify that the solution is valid. Do not use expired solutions for spiking.

Note: Other special spikes maybe needed. Check the special spike section of the logbook for additional information.

10.7.9.2 Surrogate Amounts. Add 1mL of the OQA surrogate using a calibrated 1mL syringe to all samples, blanks, and spikes.

Note: Check the expiration date for all surrogate materials to verify that the solution is valid. Do not use expired solutions for surrogating.

Note: Other special surrogates maybe needed. Check the logbook for additional information.

10.7.10 Pour samples into their respective 2L separatory funnel.

10.7.11 Rinse the sample bottle with 60mL of methylene chloride. Transfer the 60mL methylene chloride rinse from the sample container into the separatory funnel containing the sample.

10.7.12 To determine the initial sample volume in the sample bottle, fill the empty sample jar with tap water to the mark on the jar. Pour the contents of the jar into a graduated cylinder and measure the volume. This is the sample volume that is recorded on the extraction log.

10.7.13 Hand shake the funnel vigorously for 15-20 seconds. Release excess pressure by venting the funnel into the hood by opening and closing the Teflon stopcock.

10.7.14 Extract the sample by shaking the funnel vigorously for 2 minutes either using the automatic shaker or by hand. Allow the aqueous solvent layers to separate for a minimum of 10 minutes.

10.7.15 Collect the methylene chloride layer (the bottom layer) by passing through the drying column into the assembled Kuderna-Danish.

Note: Additional sodium sulfate may be added as needed to prevent trace amounts of aqueous fraction present in methylene chloride layer from passing through.

Important: Do not allow the sodium sulfate to become dry between solvent extracts.

10.7.16 Add a second 60mL volume of methylene chloride to the separatory funnel. Seal and shake the separatory funnel and repeat the extraction procedure described in Section 10.6.12 to 10.6.13. Perform a third extraction in the same manner.

10.7.17 If needed, once all three 60mL volumes of methylene chloride have been added, centrifuge the solvent layer to break emulsions.

10.7.18 Once the three extraction steps are completed, perform a final rinse of the drying column with an additional 10mL of methylene Chloride. Allow the methylene chloride to drain through until dripping stops.

10.7.19 Remove drying column and discard sodium sulfate, glass wool or filter paper into solid sulfate waste.

10.7.20 Add in boiling chip and Snyder column. The sample is now ready to be concentrated.

10.7.21 Sample Concentration Procedure. Document the procedure in the extraction logbook.

10.7.21.1 Water Bath with Evaporation Collection System

Note: Fill in waterbath information, chiller information, and flow rates once samples have been loaded.

Note: If a sample ruptures into the waterbath, immediately close the hood, allow the boiling action of the water to subside, fumes to dissipate, and notify a team lead, supervisor, or manager. Do not attempt glassware removal or cleanup by yourself.

10.7.21.1.1 Position K-D flask in the waterbath. Immersing the 10mL concentrator tube into the waterbath. Concentrate samples to about 5-7mL.

10.7.21.1.2 Allow the K-D flask, receiver, and Snyder column to cool. During this process, approximately 1mL of methylene chloride will recondense and flow down the side of the K-D flask removing most of the extract remaining in the flask and joints.

10.7.21.1.3 Remove Snyder column and slowly add 0.5-1mL of methylene chloride to the tilted K-D flask while rotate the flask. This is a final rinse of the flask and joint. Tilt upright to allow the methylene chloride to drain into the receiver.

10.7.21.2 Disassemble the K-D flask from the receiver.

10.7.22 Final volume adjustment. Samples may require further concentration using the N-VAP or Micro Snyder methods to reach the desired final volume.

10.7.22.1 For NJ OQA 25, final volume is 1mL. If samples will not concentrate to final volumes or if they change states (i.e. liquid to gel), notify team lead, supervisors, and managers for further instructions. These may require a modified sample amount, alternate concentration technique, and comments to be added.

10.7.22.2 N-VAP Method. Immerse the nipple of the receiver in the waterbath of the N-VAP. Direct a gentle stream of nitrogen gas onto the extract by adjusting height of needle until small dimple appears on surface. Evaporate the solvent until the desired volume is reached. Occasionally rinse the sidewalls of the concentrator tubes with methylene chloride during the evaporation step.

10.7.22.3 Micro Snyder Method. Attach a micro-snyder column to the receiver and immerse into a waterbath. Concentrate to the desired volume.

10.7.23 Vialing

10.7.23.1 For each sample, label a 2mL graduated amber vial with Sample number and Batch number. No backup vial is created for this test.

10.7.23.2 Bring final volume to 1mL with methylene chloride in receiver and mix with a Pasteur pipet. Transfer all sample extract to the vial.

10.7.23.3 Adjust the vial volume to 1mL with methylene chloride.

10.7.23.4 Protect the extracts from light and store them in the designated freezer at -10°C.

10.7.24 Upon completion of extraction and vialing, account for all samples by matching to logbook entry and confirm the following information is complete and present. This information must be noted in real-time and not after completion.

10.7.24.1 Method. Start date and time, stop date and time, and method used
10.7.24.2 Sample. Matrix type and weights
10.7.24.3 Extract. Colors, final volumes, and cleanup procedures
10.7.24.4 Reagent. Reagents used, lot numbers, and volumes used
10.7.24.5 Spikes and surrogates. Lot numbers, concentration, and volumes used
10.7.24.6 Equipment. Equipment used, flow rates, and temperatures.
10.7.24.7 Personnel. Document all personnel that have assisted in the extraction of the batch by having that person initial the logbook.

Note: It is not permissible under any circumstances to have another person initial for another person or take credit for work not performed.

10.7.25 In LIMS program, update status of samples to “DONE”, using associated batch number, date of extraction, department, select samples being updated using “X”, and saving changes. Document completion of sample extraction in Internal Chain program by changing status of batch to “OPEXT”.

10.7.26 Present samples and logbook to team leads, supervisors, or managers for final review.

10.7.27 Deliver samples for analysis. Protocols and expectations for delivery are dictated by analytical department and are expected to be adhered to.

11.0 CALCULATIONS

11.1 Not applicable.

12.0 QUALITY ASSURANCE

12.1 Extract a method blank and blank spike at a rate of one per day or every twenty (20) samples, whichever is more frequent.

12.2 A matrix spike / matrix spike duplicate (MS/MSD) is required per every 20 samples of similar matrix. If there is insufficient sample volume in the batch for MS/MSD pair, a BS/BSD will be used in place of a MS/MSD to evaluate accuracy and precision.

12.3 For pest/PCBs a separate MB, BSP, and MS/MSD set are needed if the sample requires PCBs, Toxaphene and/or chlordane. Therefore, if a sample is to be extracted for pesticides and PCBs, 2 sets of MB, BS, MS, and MSD are needed.

12.4 Refer to Project Specific Bench Notes (GC8081, GC8082, MS8270) for additional program or client specific QC requirements.

13.0 DOCUMENTATION

13.1 All sample preparation activities and related information must be documented in the respective extraction logbook. Complete all information required for the extraction summary logbook.

13.1.1 Errors must be stricken with a single line, initialed and dated. The correct information must be written adjacent to the erroneous information.

13.1.2 The individual with custody responsibility must sign the extraction log.

13.1.3 The individuals involved in the processing of the batch must initial in the appropriate respective locations.

13.1.4 All spikes, surrogates, reagents, solutions, and applicable manufacturer and lot information must be filled in the appropriate respective locations.

13.1.5 All equipment, equipment identifiers, and the operating parameters at time of use must be filled in the appropriate respective locations.

13.1.6 The logbooks and/or e-logs must be reviewed and initialed by a team leader or supervisor. The approved page is copied and given to the Report Generation Dept.

13.2 Sample custody must be updated according to proper Chain of Custody protocols.

13.3 All standards preparation must be documented in the standards preparation logbook.

13.4 Equipment maintenance logs must be maintained.

14.0 POLLUTION PREVENTION & WASTE MANAGEMENT

14.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. Follow all safety practices that limit the escape of vapors, liquids, or solids to the environment. All method users must be familiar with the waste management practices described in section 14.2.

14.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, EHS004. This document describes the proper disposal of all waste materials generated during the testing of samples as follows:

14.2.1 Non-hazardous aqueous wastes.

14.2.2 Hazardous aqueous wastes

14.2.3 Chlorinated organic solvents

14.2.4 Non-chlorinated organic solvents

14.2.5 Hazardous solid wastes

14.2.6 Non-hazardous

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
12.2	Added BS/BSD when MS/MSD cannot be prepped

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added

History of Revisions

Version #	Date of Revision	Revised By
22	9/12/18	Thomas Gabriel
23	9/17/19	Olga Azarian
24	10/29/19	Wahied Bayoumi
25	8/13/20	Wahied Bayoumi
26	3/12/21	Adrian Lee
27	9/27/21	Olga Azarian

END OF DOCUMENT

LAB SUPERVISOR: Raj

QA OFFICER: Olga S. Agaian

EFFECTIVE DATE: 01/04/2024

TITLE: ANALYSIS OF PER- AND POLYFLUORINATED ALKYL SUBSTANCES (PFAS) IN AQUEOUS AND SOLID SAMPLES BY LC/MS/MS

REFERENCES: EPA 4th DRAFT METHOD 1633, July 2023

REVISED SECTIONS: TABLE 3

ADDED SECTIONS: 6.3.3

1.0 SCOPE AND APPLICATION

1.1 This method is used to determine the concentrations of select Per- and Polyfluorinated Alkyl Substances (PFAS) in aqueous, solid (soil, sediment, biosolids) and tissue matrices utilizing an HPLC equipped with a tandem mass spectrometer (MS/MS).

1.2 Analytes that may be reported under this method are listed in TABLE 1. Translations between analytes names and acronyms used in EPA 1633 versus the laboratory report and raw data are listed in TABLE 4.

1.3 This method is "performance-based," meaning that modifications may be made without additional EPA review to improve performance (e.g., overcome interferences, or improve the sensitivity, accuracy, or precision of the results) provided that all performance criteria in this method are met.

2.0 SUMMARY OF METHOD

2.1 This method is adapted from draft EPA Method 1633 for the analysis of environmental water and soil samples. This SOP is not designed to be used to analyze aqueous and solid samples by the laboratory's in-house LCMSMS method.

2.2 Samples are received, stored, and extracted within the appropriate holding times.

2.3 Sample preparation is performed in accordance with SGS-Dayton SOP EOP040 and EOP041.

2.4 Samples known to be high in PFAS (such as AFFF or AFFF impacted waters) should be screened by serial dilution and direct injection onto the LC/MS/MS in order to determine the appropriate subsample size. High level water and soil samples require that a smaller sample aliquot be used so that the analytes fall within the instrument calibration range. For definitive analysis AFFF samples must be subcontracted to a laboratory certified for AFFF analysis by QSM 5.4.

2.5 Per- and Polyfluorinated Alkyl Analytes are separated, detected and quantitated using an LC/MS/MS. After HPLC separation and ionization, the specific Perfluorinated compound is isolated in the first mass spectrometer and transferred to a collision cell for fragmentation.

The resulting fragments are introduced into the second mass spectrometer where they are detected and quantified.

2.6 Per- and Polyfluorinated Alkyl Analytes may exist in branched and/or linear form. Fluorotelomer production results in linear isomers only but electrochemical fluorination results in branched and linear isomers. The branched isomers may account for up to 30% of the total analyte. The branched isomers will elute just before the linear isomer. A qualitative branched/linear RT standard with additional branched isomers is used to help establish transition windows.

2.7 Manual integrations are performed in accordance with SOP EQA044.

3.0 REPORTING LIMIT AND METHOD DETECTION LIMIT

3.1 The Lower Limit of Quantitation (LLOQ) or Reporting limits (RL) are based on the extraction procedure and the lowest calibration standard. LLOQs may vary depending on matrix complications and volumes. LLOQs for this method are 0.002-0.050 ug/l for aqueous samples and 0.2-50 ug/kg for solid samples. Solid matrices are reported on a dry weight basis.

3.2 **MeFOSA, EtFOSA, MeFOSE, and EtFOSE** tend to recover erratically by SPE cartridge. These analytes may also be lost during the evaporative step. Data for these analytes should be reviewed carefully.

3.3 The Method Detection Limit (MDL). Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B, Revision 2. Experimental MDLs must be determined in accordance with SGS SOP EQA075

3.4 Compounds detected at concentrations between the LLOQ and MDL are quantitated and qualified as estimated values and reported with a “J” qualifier. Some program or project specifications may require that no values below the LLOQ be reported.

4.0 DEFINITIONS

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or 12 hours whichever comes first.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known number of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

4.3 Low Level Blank Spike (LLBS): An analyte-free matrix spiked with a known number of analyte(s) at 2x LLOQ, processed simultaneously with the samples through all the steps of the analytical procedure. Low-Level Blank Spike Recoveries are used to document laboratory performance at the LLOQ for a given method. This may also be called a Low Level Laboratory Control Sample (LLLCS) or the Low-Level Ongoing Precision And Recovery Standard (LLOPR).

4.4 Extracted Internal Standards (EIS): A standard containing isotopically labelled versions of the native target analytes. These isotopes are usually labelled with C13, d2, or O18 atoms. Isotope Dilution Standards are used to measure the extraction efficiency and to correct the concentrations of the native analytes based on the recovery of their isotopically labelled analogs.

4.5 Field Blank (FB): An aliquot of reagent water that is placed in a sample container in the laboratory and treated as a sample in all respects, including shipment to the sampling site, exposure to sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the FB is to determine if method analytes or other interferences are present in the field environment.

4.6 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and are still considered valid.

4.7 Matrix Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.8 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.9 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.10 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.11 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

5.0 HEALTH & SAFETY

5.1 The analyst must follow normal safety procedures as outlined in the SGS Laboratory Safety Manual which includes the use of Safety glasses, gloves and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 Safety Data Sheets (SDS) are available for all reagents and solvents used in the lab. Technicians should review the SDS prior to using any new reagents or solvents.

5.3 Methanol is an inhalation hazard. Use in well ventilated area.

5.4 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical must be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory maintains a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets is available to all personnel involved in these analyses.

6.0 COLLECTION, PRESERVATION, AND HOLDING TIME

6.1 Collection

6.1.1 Aqueous samples should be collected in 500mL high density polyethylene bottles (HDPE). Caps must not have Teflon liners. Alternate size bottles may be used depending on project requirements. Additional bottles should be provided for solids determination, dilutions, and pre- screening of samples.

6.1.2 Solid samples shall be collected in 4oz or 2oz HDPE wide mouth jars. Caps must not have Teflon liners.

6.1.3 The samples must be chilled to ≤ 6°C from the time of collection until arrival at the laboratory.

6.2 Storage

6.2.1 Samples may be stored in the dark at either ≤ 6°C or ≤ -20°C.

6.2.1.1 Issues were observed with MeFOSE, EtFOSE, MeFOSAA and EtFOSAA after 7 days when stored at ≤ 6°C. 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.

6.2.2 The extracts should be stored in the dark at ≤ 6°C. All extracts must be allowed to come to room temperature and vortexed just prior to transfer to the autosampler vials.

6.3 Holding Time

6.3.1 Aqueous and solid samples must be extracted and analyzed within 28 days of collection if stored at ≤ 6°C.

6.3.2 Aqueous and solid samples must be extracted and analyzed within 90 days of collection if stored at ≤ -20°C.

6.3.3 Leachates must be leached within 28 days of collection and extracted and analyzed within 28 days from leaching date.

7.0 APPARATUS AND MATERIALS

7.1 HPLC – Agilent Technologies 1260 or 1290

7.1.1 Suitable HPLC equipped with an autosampler, pump, and column compartment. System may have a membrane degasser if shown to not adversely affect the analysis.

7.2 MS/MS – Agilent Technologies 6470A or 6495B

7.2.1 LC/MS/MS must be capable of negative ion electrospray ionization near the required flow rate of the HPLC Column. The system must be capable of performing MS/MS to produce unique precursor and product ions for the PFAS method analytes within the specified retention time segments. A minimum of 10 scans across each peak is required to ensure adequate precision.

7.3 Data System – Agilent Technologies Mass Hunter B10.0x

7.3.1 A computer system interfaced to the HPLC/MS/MS that allows for the continuous acquisition and storage of all data obtained throughout the duration of the chromatographic program.

7.3.2 The software must allow for the viewing of the specific MS/MS Spectra acquired over the analytical run. Comparisons can then be made between spectra from standards and samples.

7.3.3 Data is archived to a backup server for long term storage.

7.4 Columns: Agilent Poroshell 120 EC C18 2.7um, 100 x 2.1 mm ID or equivalent

7.5 Delay Columns: Agilent Poroshell or Eclipse C18 50 x 4.6 mm ID or equivalent

7.6 Disposable polyethylene transfer pipettes

7.7 15ml Centrifuge tubes

7.8 HDPE or Polypropylene screw cap and autosampler vials

7.9 Volumetric Pipettors and volumetric “plasticware” for dilutions of standards and extracts.

7.10 Class A volumetric flasks.

7.11 HDPE bottles – various sizes, shown to be PFAS free.

8.0 STANDARDS AND REAGENTS

8.1 Acetonitrile – HPLC grade or equivalent (Eluent A)

8.2 Water – HPLC grade or equivalent

8.3 Ammonium Acetate – LCMS grade or equivalent

8.4 Ammonium Hydroxide – Fisher A669-212 or equivalent (28-30% Aqueous Ammonia)

8.5 Eluent A - Acetonitrile

8.6 Eluent B – 2mM Ammonium Acetate in 95:5 Water: Acetonitrile

Dissolve 0.154 grams of ammonium acetate in 950ml of water and 50ml of acetonitrile.

8.7 Dilution Mix - Methanol with 4% water, 1% ammonium hydroxide and 0.625% acetic acid

Add ammonium hydroxide (3.3ml of 30%), reagent water (1.7ml) and acetic acid (0.625ml) to methanol (92ml). Store at room temperature, replace after 1 month.

8.8 Nitrogen – various grades

8.9 Per fluorinated Alkyl Substances stock standards – Traceable to Certificate of Analysis.

8.10 Mass labeled – Non-Extracted Internal Standards

$^{13}C_3$-PFBA	$^{13}C_4$-PFOA	$^{13}C_2$-PFDA	$^{13}C_4$-PFOS
$^{13}C_2$-PFHxA	$^{13}C_5$-PFNA	$^{18}O_2$-PFHxS	

8.11 Mass labeled – Extracted Internal Standards

$^{13}C_4$-PFBA	$^{13}C_9$-PFNA	$^{13}C_3$-PFBS	$^{13}C_2$-8:2 FTS	D_5-NEtFOSAA
$^{13}C_5$-PFPeA	$^{13}C_6$-PFDA	$^{13}C_3$-PFHxS	$^{13}C_8$-PFOSA	D_7-NMeFOSE
$^{13}C_5$-PFHxA	$^{13}C_7$-PFUnA	$^{13}C_8$-PFOS	D_3-NMeFOSA	D_9-NEtFOSE
$^{13}C_4$-PFHpA	$^{13}C_2$-PFDoA	$^{13}C_2$-4:2 FTS	D_5-NEtFOSA	$^{13}C_3$-HFPO-DA
$^{13}C_8$-PFOA	$^{13}C_2$-PFTeDA	$^{13}C_2$-6:2 FTS	D_3-NMeFOSAA	

9.0 INTERFERENCES

9.1 Data from all blanks, samples, and spikes must be evaluated for interferences. Method interferences may be caused by contaminants in solvents, reagents, or glassware. The analytes in this method can also be found in many common laboratory supplies and equipment, such as PTFE (polytetrafluoroethylene) or Teflon products, HPLC solvent lines, methanol, aluminum foil, SPE transfer lines, bottle caps, etc. All materials must be demonstrated to be free from interferences.

9.2 Contact with glass containers, pipettes, or syringes should be minimized since the Perfuorinated compounds can potentially adsorb to glass surfaces.

9.3 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 sample. 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 the humic content of the sample. High levels of iron have been shown to reduce the d5-EtFOSAA recoveries.

9.4 When establishing the chromatographic conditions, it is important to consider the potential interference of bile salts during analyses of tissue samples. A standard containing TDCA should be injected to ensure that TDCA does not coelute with any of the target analytes, EIS, or NIS standards. Analytical conditions must be set to allow a separation of at least 1 minute between the bile salts and PFOS.

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

9.6 Water and containers used for equipment blanks or field blanks must be tested prior to use. For smaller sampling events DI water will be provided in the same type of bottle used for sample collection. For larger sampling events four-liter HDPE containers should be used. Containers should be filled with DI water and allowed to sit for several hours before testing. If the bottles are from the same lot and filled with DI on the same day, then one analysis per 10 containers should suffice. The DI water and container blanks must be free of any analytes of interest or interferences below the MDL.

9.7 A field blank should be collected with each set of samples. Each field blank consists of 4 bottles. Two bottles are filled with DI water at the lab and the other two bottles are empty. At the sampling site the sampler should open then two empty bottles and transfer the DI water from the full bottles into them. Cap the bottles, label as field blanks, and return them to the laboratory along with the samples for analysis.

10.0 PROCEDURE

10.1 Standards Preparation

10.1.1 Standards are prepared from commercially available certified neat or reference standards. All standards must be logged in the HPLC Standards Logbook. All standards shall be traceable to their original source. The standards must be stored at ≤ 6°C, or as recommended by the manufacturer. Calibration levels, spike and isotope dilution standard concentrations, preparation information, and vendor part numbers can be found in the LCMS STD Summary in the Active SOP directory. A summary of the calibration concentrations can be found in Table 3.

10.2 Stock Standard Solutions

10.2.1 Stock standards are available from some commercial vendors. All vendors must supply a “Certificate of Analysis” with the standard. The certificate will be retained by the lab. Hold time for unopened stock standards is until the vendor’s expiration date. Once opened, the hold time is reduced to one year or the vendor’s expiration date (whichever is shorter).

10.3 Intermediate Standard Solutions

10.3.1 Intermediate standards are prepared by quantitative dilution of the stock standard with methanol. The hold time for intermediate standards is six months or the vendor’s expiration date (whichever is shorter). Intermediate standards may need to be remade if comparisons to other standards indicate analyte degradation or concentration changes. Intermediate standards should be prepared using the dilution mix and stored in polyethylene vials.

10.4 Calibration Standards

10.4.1 Calibration standards for Perfluorinated analytes are prepared at a minimum of six concentration levels through quantitative dilutions of the intermediate standard. Calibration standards are prepared in methanol. The low standard is at a concentration at or below the RL and the remaining standards define the working range of the detector. Calibration standards should be prepared using the dilution mix and be stored in polyethylene vials. See Table 3 for levels.

10.4.2 Calibration standards concentrations for the sulfonates may need to be corrected for the molecular weight of the cation in the salt. Check the vendor's Certificate of Analysis to see if their nominal concentration is based on the acid or salt.

$$\text{Mass}_{acid} = \text{Mass}_{salt} \textbf{ X } \text{MW}_{acid}/\text{MW}_{salt}$$

MW_{acid} = Molecular weight of PFAA
MW_{salt} = Molecular weight of the salt

NOTE: Per fluorinated analytes may exist in branched and/or linear form. If a branched form is commercially available, then the calibration standards must contain the branched and linear form. The Quantitative standards must contain PFHxS, PFOS, PFOSA, NMeFOSAA, NEtFOSAA NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE, which are currently available in mixes of branched and linear isomers.

10.4.3 Calibration standard concentrations are verified by the analysis of an initial calibration verification (ICV) standard.

10.5 HPLC/MS/MS Conditions

10.5.1 HPLC Conditions

10.5.1.1 6-10ul autosampler injection
10.5.1.2 Gradient Program
10.5.1.3 Eluent A – Acetonitrile
10.5.1.4 Eluent B – 2mM ammonium acetate in 95:5 water: acetonitrile
10.5.1.5 Column temperature – 50.0 °C

Time (min)	A (%)	B (%)	Flow (mL/min)
0.20 min	10.0 %	90.0 %	0.350 mL/min
4.00 min	30.0 %	70.0 %	0.350 mL/min
7.00 min	55.0 %	45.0 %	0.350 mL/min
9.00 min	75.0 %	25.0 %	0.350 mL/min
10.00 min	95.0 %	5.0 %	0.400 mL/min
10.30 min	95.0 %	5.0 %	0.400 mL/min
10.40 min	2.0 %	98.0 %	0.400 mL/min

11.80 min	2.0 %	98.0 %	0.400 mL/min
13.00 min	2.0 %	98.0 %	0.350 mL/min

10.5.2 MS/MS Conditions

Parameter	Value	Parameter	Value
Gas Temp C	250	Sheath Gas Flow (l/min)	10
Gas Flow (l/min)	10	Capillary (V)	3500
Nebulizer (psi)	50	V Charging	500
Sheath Gas Heater	300	Ionization Mode	Neg ESI
Collision Cell Gas (psi)	40	Collision Cell Gas	UHP N2

Fragmentation voltages and collisions energies are optimized for each analyte and are stored in the instrument method. Precursor ions and transition masses are listed in Table 2.

LC/MS/MS conditions are optimized for each instrument. Actual conditions may vary slightly from those listed above.

10.6 Sample Preparation

10.6.1 Low Level Aqueous Samples

10.6.1.1 A 500ml aliquot of sample (entire bottle) is extracted utilizing a solid phase extraction cartridge. The cartridge is eluted with basic methanol. The extract is carbon cleaned, filtered and the final volume is adjusted to 5.0ml, and then transferred to a centrifuge tube for storage. Refer to SOP EOP041.

10.6.2 Solid Samples

10.6.2.1 A 5-gram aliquot sample is extracted with basic methanol utilizing vortex mixer and a shaker table. The extract is carbon cleaned, SPE cleaned, filtered and the final volume is adjusted to 5.0ml, and then transferred to a centrifuge tube for storage. Refer to SOP EOP040.

10.7 HPLC/MS/MS Analysis

Instrument calibration consists of four major sections:

Mass Tuning and Calibration Transition
Window Selection Initial Calibration
Procedures Continuing Calibration
Verification

10.7.1 Mass Calibration and Transition Window Selection

The instrument must have a valid mass calibration prior to any sample analysis. The mass calibration must be updated as needed. (i.e. QC failures, ion masses showing large deviations from known masses, or after major instrument maintenance is performed). It is recommended that the mass calibration be verified weekly through the analysis of a Check Tune. The Agilent Check Tune Masses range from 112.99 to 2233.91 amu for MS1 and 69.00 to 2233.91 for MS2.

The Check Tune Report may show both Positive and Negative ESI Results. Only the Negative results need to be evaluated. Unit resolution is demonstrated when the value of the peak width at half-height is within 0.5 ± 0.1 amu of the true value.

MS1 (UNIT)	MS2 (UNIT)
	69.00
112.99	112.99
302.00	302.00
601.98	601.98
1033.99	1033.99
1633.95	1633.95
2233.91	2233.91

Since masses greater than 1033.99 amu are not used for this method, the 1633.95 and 2233.91 amu masses must be present but do not need to be within 0.1 amu of the true value.

The Branched/Linear RT Check and mid-point calibration standard are used to check the analyte retention times. These retention times are used to update the transition windows. The windows must be wide enough to ensure that the branched and linear isomer PFAS analytes are completely within the transition window. The branched isomers will elute just prior to the linear isomer. If they are partially cut off, adjust the retention time of the linear isomer or the width of the transition window. Use a similar size window for the other analytes that do not have a branched standard. Later eluting peaks are broader and require a slightly wider transition windows because of peak broadening.

10.7.2 Initial Calibration Procedures

Before samples can be run, the LC/MS/MS system must be calibrated. The signal to noise ratio must be >= 3:1 for analytes with both a quant and confirmation ion and >= 10:1 for analytes with no confirmation ion.

10.7.2.1 Isotope Dilution Standard (Extracted Internal Standard) Calibration

A minimum 6-point calibration curve is created for the native PFAS compounds using an Isotope Dilution or Extracted Internal Standard technique. SGS - Dayton routinely performs an 8-point calibration to maximize the calibration range and to allow for quadratic fits. See Table 3.

The calibration standards for PFHxS, PFOS, PFOSA, NMeFOSAA, NEtFOSAA NMeFOSA, NEtFOSA, NMeFOSE, and NEtFOSE must consist of both branched and linear isomers.

The branched isomer elutes just prior to the linear isomer. These 9 PFAS are currently being reported as the sum of the branched and linear isomers so both the branched and linear isomers in the calibration standards must be integrated.

Response factors (RF) for each analyte at each calibration level are determined as follows:

$RF = (A_{analyte}\ C_{ids})/(A_{ids} \mathbf{X}\ C_{analyte})$ $A_{analyte}$

= area of the analyte
A_{ids} = area of the isotope dilution standard $C_{analyte}$
= concentration of the analyte
C_{ids} = concentration of the isotope dilution standard.

The mean RF and standard deviation of the RF are determined for each analyte and EIS. The percent relative standard deviation (%RSD) of the response factors is calculated for each analyte as follows:

%RSD = (Standard Deviation of RF X 100) / Mean RF

If the %RSD $\leq$ 20%, linearity through the origin can be assumed and the mean RF can be used to quantitate target analytes in the samples.

Alternatively, a weighted linear regression or non-linear regression may be used. If used, the regression must be weighted inversely proportional to concentration and must not be forced through zero. The correlation coefficient (r value) must be ≥ 0.995 or ± 0.99 (for r^2 value) for each compound to be acceptable. If a linear or non-linear regression is used, then the Relative Standard Error (%RSE) must be calculated.

Calculation of Relative Standard Error (%RSE)

$$RSE = 100 \times \sqrt{\sum_{i=1}^{n} \left[\frac{x_i' - x_i}{x_i}\right]^2 \Big/ (n-p)}$$

x'i = Measured amount of analyte at calibration level i, in mass or concentration units.

xi = True amount of analyte at calibration level i, in mass or *concentration units.*

p = Number of terms in the fitting equation. (average = 1,

linear = 2, quadratic = 3)

n = Number of calibration points.

If Relative Standard Error (%RSE) ≤ 20%, then the curve can be used to quantitate target analytes in the samples.

NOTE: If any EIS was removed from a specific calibration point to meet the acceptance criteria for the initial calibration, then corresponding native compound in that calibration point must be also removed.

10.7.2.2 Initial Calibration Verification (ICV)

The validity of the initial calibration curve must be verified through the analysis of an initial calibration verification (ICV) standard. The ICV must be prepared from a second source at a mid-range concentration.

NOTE: Second source standards may consist of linear isomers only.

The %D for the compound of interest must be ≤ ±30% (70-130% of True Value). If the ICV does not meet criteria, a fresh standard must be prepared. If this ICV meets criteria, proceed with sample analysis. If the ICV still does not meet criteria, make fresh calibration standards. Recalibrate the instrument.

NOTE: Analyze the branched/linear standard to identify the branched isomers. This is a qualitative standard only. Currently it should contain branched isomers of PFOA and PFNA. This standard is loaded into LIMS as an ICV.

10.7.2.3 Bile Salt Interference Check and Branched/Linear Retention Time Check.

The separation between Taurodeoxycholic Acid (TDCA) and PFOS must be verified with each ICAL.

Inject a mid-level PFAS standard that has been fortified with 1 ug/ml TDCA. The standard may also contain Taurochenodeoxycholic Acid (TCDCA) and Tauroursodeoxycholic Acid (TUDCA) as well.

TDCA must be separated by at least 1 minute from all branched and linear isomers of PFOS.

10.7.2.4 Branched/Linear RT Check. Analyze

The branched/linear RT standard to identify the branched isomers. This is a qualitative standard only. Currently, it should contain branched isomers of PFOA and PFNA. This standard is loaded into LIMS as an RT Check.

10.7.2.5 Highest Standard and Instrument Blank

Analyze an instrument blank (IBLK) immediately following the highest standard analyzed. The highest standard analyzed may be analyzed as part of the calibration curve or following the calibration curve. The highest standard may be at or above the concentration of highest level of calibration. It cannot be used to extend the calibration range.

The instrument blank must be analyzed immediately following the highest standard. The instrument blank must be free of any analytes of interest or interferences at ½ the required LOQ to be acceptable.

If the acceptance criteria is not met, the concentration of the standard should be lowered and another blank analyzed.

The highest standard and instrument blank pair are used only to document the highest concentration at which carryover does not occur. If a sample concentration exceeds this range and the sample(s) following have reportable detections for that analyte, then they must be reanalyzed.

10.7.2.6 Retention Time Windows

The retention time of each analyte and extracted internal standard must fall within **0.4 minutes** of the predicted retention times from the daily calibration verification or from the midpoint standard of the ICAL (on days when an ICAL is performed).

Establish the center of the retention time window for each analyte and surrogate by using the absolute retention time for each analyte and extracted internal standard from the calibration verification standard at the beginning of the analytical shift. For samples run during the same shift as an initial calibration, use the retention time of the mid-point standard of the initial calibration.

Initial peak identification is based on the retention time of a peak falling within the retention time window for a given analyte. Time reference peaks (extracted internal standards) are used to correct for run-to-run variations in retention times due to temperature, flow, or injector fluctuations. HPLC retention times tend to shift more than GC retention times.

The retention time of the target analyte must fall within **0.1 minutes** of the associated isotope dilution standard (for analytes that have an exact isotopic counterpart).

10.7.2.7 Ion Ratios and Signal to Noise

A minimum of two transition ions are monitored for each target analyte except for those analytes in Table 2 which only have a single transition ion.

The ratio of the primary and secondary transition masses should be updated from the initial calibration. They may be updated from the midpoint standard or from an average of all levels. Additionally, the ion ratio may be updated from the opening daily CCV.

Isotope Ratio criteria is still being developed for EPA method 1633. The MassHunter software calculates the ratio as the response of the primary transition mass divided by the response of the secondary transition mass times 100. It is set to flag the analyte if the ratio of these ions is not within ± 50% of the expected, (e.g., if the ion ratio is expected to be 50% in the standard, the ion ratio in the corresponding sample must be between 25 and 75%).

Primary and secondary transition masses must maximize within ± 2 seconds.

The signal to noise ratio for the primary transition mass must be at least 3 times that of the background and the secondary transition mass must be at least 3 times that of the background.

10.7.3 Daily Calibration and Carryover Verifications

10.7.3.1 Continuing Calibration Verification (CCV)

Continuing calibration verification standards for the Perfluorinated compounds are prepared at low and mid-range concentration. CCV standards are prepared from the same stock as the initial calibration standards.

A low level CCV must be analyzed at the beginning of each analytical sequence (prior to sample analysis) and at least once every 24 hours during the sequence to ensure accuracy at the LOQ.

The CCV must be analyzed at the beginning and end of each run to verify that the initial calibration is still valid. Additionally, the mid-point CCV must be analyzed after every 10 samples.

The percent difference (%D) for each analyte of interest will be monitored. The |%D| must be ≤ 30% for the target analytes and EIS in each CCV.

If the first continuing calibration verification does not meet criteria, a second standard may be injected. If the second standard does not meet

criteria, the system must be recalibrated. If the second standard meets criteria, then a third standard must be analyzed. If the third standard also meets criteria, then the system is considered in control and results may be reported.

If the |%D| is outside the control limits, then documented corrective action is necessary. This may include recalibrating the instrument and reanalyzing the samples, performing instrument maintenance to correct the problem and reanalyzing the samples, or qualifying the data. Qualifying the data should only be done if the sample cannot be reanalyzed. Under certain circumstances, the data may be reported,
i.e. The CCV failed high, the associated QC passed, and the samples were ND.

NOTE: Any target analytes that are detected in the samples must be bracketed by an acceptable initial calibration curve and acceptable CCV standards; otherwise, the samples must be reanalyzed, or the data must be qualified.

10.7.3.2 Carryover Verification

A high standard and an instrument blank (IBLK) must be analyzed each day prior to the analysis of samples. The high standard may be at or above the concentration of highest level of the calibration.

The instrument blank must be analyzed immediately following the high standard. The instrument blank must be free of any analytes of interest or interferences at ½ the required LOQ to be acceptable.

If the acceptance criteria are not met, the concentration of the standard should be lowered, and another blank analyzed.

The highest standard and instrument blank pair are used only to document the highest concentration at which carryover does not occur. If sample concentrations exceed this range and the sample(s) following exceed this acceptance criteria (>1/2 LOQ), they must be reanalyzed.

10.7.3.3 Continuing Calibration Blank (CCB)

An additional blank must be analyzed after each CCV to ensure no carryover from the standard. The instrument blank must be free of any analytes of interest or interferences at ½ the required LOQ to be acceptable. The CCB is loaded into LIMS as "ICCB".
If the acceptance criteria are not met, the system should be

checked. Any samples bracketed by the failing CCB must be reanalyzed.

Review the data to see if there was a high sample prior to the CCV/CCB pair that may have contaminated the system? If so, clean the system and run additional blanks to see if the system is in control.

10.7.3.4 Bile Salt Interference Check.
Inject a mid-level PFAS standard that has been fortified with 1 ug/ml TDCA. The standard may also contain Taurochenodeoxycholic Acid (TCDCA) and Tauroursodeoxycholic Acid (TUDCA) as well.

TDCA must be separated by at least 1 min relative to all of the branched and linear isomers of PFOS.

10.7.3.5 Branched.Linear RT Check

Analyze the branched/linear RT standard daily to identify the branched isomers. This is a qualitative standard only. Currently, it should contain branched isomers of PFOA and PFNA. This standard is loaded into LIMS as an RT Check

10.7.4 Sample Extract Analysis

10.7.4.1 Samples are analyzed in a set referred to as an analysis sequence or batch. A batch consists of the following:

- Initial Calibration Standards
- ICV
- Carryover Check Standard
- Instrument Blank (IBLK)
- Bile Salt Interference Check
- Branched/Linear RT
- CCV Standards:
  - Low-Level (LOQ)
  - Mid-Level
- QC Extracts
- Sample Extracts
- Bracketing CCV
- Bracketing CCB

10.7.4.2 Six to ten microliters (same amount as standards) of extract is injected into the HPLC by the autosampler. The data system then records the resultant peak responses and retention times.

10.7.4.3 Tentative identification of an analyte occurs when the peak from the sample extract falls within the retention time window of the target compound.

10.7.4.4 Positive identification is confirmed by comparing the ion ratio in the sample to the ion ratio of the standards. For the linear isomer, the primary and secondary transition masses must both be present. For the branched isomers the primary and secondary transition masses should both be present. In rare circumstances a particular branched peak may only exhibit the primary transition ion. These should be omitted from the quantitation.

The MassHunter software is set to flag the analyte if the ratio of these ions is not within ± 30% of the expected, (e.g., if the ion ratio is expected to be 50% in the standard, the ion ratio in the corresponding sample must be between 20 and 80%).

The signal to noise ratio for the primary transition mass must be at least 3 times that of the background and the secondary transition mass must be at least 3 times that of the background.

10.7.4.5 Some of the PFASs may have multiple chromatographic peaks due to the presence of linear and branched isomers. This is prevalent in PFHxS and PFOS. The areas of all the linear and branched isomers peaks must be included and the concentrations reported as a total for each of these analytes.

NOTE: The branched isomers for PFOA and PFNA must be included in the quantitation even if the calibration is based on just the linear isomer.

10.7.4.6 If the compound identification does not confirm, then the result should be reported as ND.

10.7.4.7 If the analyte response exceeds the linear range of the system, the extract must be diluted and reanalyzed. It is recommended that extracts be diluted so that the response falls into the middle of the calibration curve.

Dilutions for this method are performed differently depending on the concentration of the target analytes in the extract. For dilutions in the 2x to 10x range, the extract is diluted with the dilution mix. No additional EIS nor NIS are added. NIS concentrations in the diluted samples are normalized by multiplying calculated concentration by dilution factor.

If the responses for each EIS in the diluted extract meet the S/N requirements in Section 10.7.2 and retention time requirements in Section 10.7.2.6, 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 (i.e., if the EIS recovery of the affected analyte in the undiluted analysis is 50%, then the sample cannot be diluted more than 10:1; if the if the EIS recovery of the affected analyte in the undiluted analysis is 30%, then the sample cannot be diluted more than 6:1).

For dilutions greater than 10-fold, a smaller aliquot should be extracted for soil samples. The estimated analyte concentration from below can be used to determine the best aliquot size. The method requires the collection of a smaller sample size for aqueous samples in such cases (i.e., 125 mL). If aliquoting of an aqueous sample is necessary, the client must be notified prior to subsampling.

If no additional sample is available, then additional EIS and NIS are added, and the sample re-analyzed. The theoretical concentration of the isotope dilution standards in the extract will need to be entered into MassHunter so that the software can correctly calculate the native analyte concentration. This result is estimated based on an internal standard approach. The results should be footnoted as such.

10.7.4.8 If peak identification is prevented by the presence of interferences, further cleanup may be required, or the extract must be diluted so that the interference does not mask any analytes.

10.8 Maintenance and Trouble Shooting

10.8.1 All instrument maintenance must be documented in the appropriate “Instrument Repair and Maintenance” log. The log will include such items as problem, action taken, correction verification, date, and analyst.

10.8.2 Repairs performed by outside vendors must also be documented in the log. The analyst or Department Supervisor responsible for the instrument must complete the log if the repair technician does not.

10.8.3 PC and software changes must be documented in the “Instrument Repair and Maintenance” log. Software changes may require additional validation.

11.0 METHOD PERFORMANCE

11.1 Method performance is monitored through the routine analysis of negative and positive control samples. These control samples include method blanks (MB), blank spikes (BS), low-level blank spikes (LLBS), matrix spikes (MS), matrix spike duplicates (MSD) and sample duplicates (DUP). The MB, BS, LLBS are used to monitor overall method performance, while the MS and MSD or DUP are used to evaluate the method performance and reproducibility in a specific sample matrix.

11.2 The QC sample recoveries for water samples are compared to the required QC acceptance limits in table 5 and 6. The same limits must be used for soil samples until in-house limits can be developed by the laboratory.

12.0 QC REQUIREMENTS

Accuracy and matrix bias are monitored by the use of isotope dilution standards and by the analysis of a QC set that is prepared with each batch (maximum of 20 samples) of samples. The QC set consists of a method blank (MB), blank spike (BS), matrix spike (MS), matrix spike duplicate (MSD) or sample duplicate (DUP). All control limits are updated annually and are listed in the LIMS.

12.1 Non-Extracted Internal Standards (NIS)

12.1.1 The analytes listed in section 5.10 are used as the Non-Extracted Internals Standards for this method. The response of the NIS in all subsequent runs must be 30-200% of the average response from the initial calibration.

12.1.2 If the NIS responses are not within limits, the following are required.

12.1.2.1 Check to be sure that there are no errors in calculations, integrations, or internal standards solutions. If errors are found, recalculate the data accordingly.

12.1.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem, and reanalyze the sample. If no problem is found, prepare a second aliquot of extract, and reanalyze the sample.

12.1.2.3 If upon reanalysis, the responses are still not within limits reanalyze the sample at a dilution.

12.1.2.4 If upon analysis of the dilution the responses are within limits, then the sample or select analytes may need to be reported from the dilution or qualified.

12.2 Extracted Internal Standard (EIS)

12.2.1 The analytes listed in section 5.11 are used as the Extracted Internal Standards for this method.

A known amount of isotope dilution standard is added to each sample including the QC set prior to extraction. The recovery (corrected for dilution) for each isotope dilution standard must follow the limits in Table 6 for water and soil matrices.

The % recovery is calculated from the calculated concentrations.

% Recovery = (Sample Amount / Amount Spiked) X 100

Only those isotope dilution standards that directly link to the native analytes being reported need to pass. For example, 13C4-PFBA only needs to pass if PFBA is being reported.

12.2.2 If any isotope dilution standard response/recovery is not within the established control limits, the following are required.

12.2.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, isotope dilution standard solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re- inject the extract to verify.

12.2.2.2 Check instrument performance. It may be necessary to re-vial and re- inject the extract in order to verify performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

12.2.2.3 Check for instrument suppression or enhancement by reanalyzing the sample at a dilution.

12.2.2.4 If no problem is found re-extract and reanalyze the sample. **NOTE:** If the recoveries are high and the sample is non-detect, then re-extraction may not be necessary. If there is insufficient sample for re-extraction, reanalyze the sample and footnote this on the report.

12.2.2.5 If upon reanalysis, the recovery is still not within control limits, the problem is considered matrix interference . Isotope dilution standards from both sets of analysis must be reported on the final report.

12.3 Method Blank

12.3.1 The method blank is either HPLC water or cleaned sand (depending upon sample matrix). The method blank is then taken through all procedures along with the other samples to determine any contamination from reagents, glassware, or high- level samples. The method blank must be free of any analytes of interest or interferences at ½ the required LOQ to be acceptable. If the method blank is not acceptable, corrective action must be taken to determine the source of the contamination. Samples associated with a contaminated method blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples, re-extracting and reanalyzing the samples or qualifying the results with a “B” or “V” qualifier.

12.3.2 If the MB is contaminated but the samples are non-detect, then the source of contamination must be investigated and documented. The samples may need to be re-extracted and reanalyzed for confirmation. If there is insufficient sample to re-extract, or if the sample is re-extracted beyond hold time, the appropriate footnote and qualifiers must be added to the results. This must be approved by the department supervisor.

12.3.3 If the MB is contaminated but the samples results are > 10 times the contamination level, the source of the contamination must be investigated and documented. The samples results may be reported with the appropriate “B” or “V” qualifier. This must be approved by the department supervisor.

12.3.4 If the MB is contaminated but the samples results are < 10 times the contamination level, the source of the contamination must be investigated and documented. The samples must be re-extracted and reanalyzed for confirmation. If there is insufficient sample to re-extract, or if the sample is re-extracted beyond hold time, the appropriate footnote and qualifiers must be added to the results. This must be approved by the department supervisor.

12.4 Blank Spike

12.4.1 The blank spike is either HPLC water or cleaned sand (depending upon sample matrix) to which the spike standard has been added. The blank spike is then taken through all procedures along with the other samples to monitor the efficiency of the extraction procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = (Blank Spike Amount / Amount Spiked) X 100

The percent recovery for each analyte of interest must fall within the established control limits for the results to be acceptable (see Table 5). As additional analytes are added to this method, the recoveries will need to be carefully evaluated.

12.4.2 If the blank spike recoveries are not within the established control limits, the following are required.

12.4.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, or spike solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re-inject the extract to verify.

12.4.2.2 Check instrument performance. It may be necessary to re-vial and re- inject the extract in order to verify performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

12.4.2.3 If the recovery of an analyte in the BS is high and the associated sample is non-detect, the data may be reportable.

12.4.2.4 If no problem is found, the department supervisor shall review the data and determine what further corrective action is best for each particular sample. That may include reanalyzing the samples, re-extracting and reanalyzing the samples, or qualifying the results as estimated.

12.4.2.5 If there is insufficient sample to re-extract, or if the sample is re-extracted beyond hold time, the appropriate footnote and qualifiers must be added to the results. This must be approved by the department supervisor.

12.5 Low-Level Blank Spike

12.5.1 The low-level blank spike is either HPLC water or cleaned sand (depending upon sample matrix) to which the spike standard has been added at no more than 2 times the LLOQ. The low-level blank spike is then taken through all procedures along with the other samples to monitor the efficiency of the extraction procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = (Blank Spike Amount / Amount Spiked) X 100

The percent recovery for each analyte of interest must fall within the established control limits for the results to be acceptable (see table 5). As additional analytes are added to this method, the recoveries will need to be carefully evaluated.

12.5.2 If the low-level blank spike recoveries are not within the established control limits, the following are required. Check to be sure that there are no errors in calculations, dilutions, integrations, or spike solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re-inject the extract to verify.

12.5.2.1 Check instrument performance. It may be necessary to re-vial and re- inject the extract in order to verify performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

12.5.2.2 If the recovery of an analyte in the BS is high and the associated sample is non-detect, the data may be reportable.

12.5.2.3 If no problem is found, the department supervisor shall review the data and determine what further corrective action is best for each particular sample. That may include reanalyzing the samples, re-extracting and reanalyzing the samples, or qualifying the results as estimated.

12.5.2.4 If there is insufficient sample to re-extract, or if the sample is re-extracted beyond hold time, the appropriate footnote and qualifiers must be added to the results. This must be approved by the department supervisor.

12.6 Matrix Spike and Matrix Spike Duplicate

12.6.1 Matrix spike and spike duplicates are second samples to which the spike standard has been added. The matrix spike and spike duplicate are then taken through all procedures along with the other samples to monitor the precision and accuracy of the procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = [(Spike Amount – Sample Amount) / Amount Spiked] X 100

The percent recovery for each analyte of interest must fall within the established control limits for the results to be acceptable (see table 5).

12.6.2 If the matrix spike recoveries are not within the established control limits, the following are required.

12.6.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, or spike solutions. If errors are found, recalculate the data accordingly. If errors are suspected, re-vial and re-inject the extract to verify.

12.6.2.2 Check instrument performance. It may be necessary to re-vial and re- inject the extract in order to verify performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

12.6.2.3 If no problem is found, compare the recoveries to those of the blank spike. If the blank spike recoveries indicate that the problem is sample related, document this on the run narrative. Matrix spike recovery failures are not grounds for re-extraction but are indications of the sample matrix effects.

12.6.3 Precision

Matrix spike and spike duplicate recoveries for each analyte OR sample result and duplicate result are used to calculate the relative percent difference (RPD) for each compound.

RPD = [| MS Result – MSD Result | / Average Result] X 100

The RPD for each Perfluorinated compound must be less than 30%. If the RPDs fall outside of the established control limits, the MS/MSD should be reanalyzed to ensure that there was no injection problem. If upon reanalysis the RPDs are still outside of the control limits, the department supervisor shall review the data and determine if any further action is necessary. RPD failures are generally not grounds for re-extraction.

The RPD for each Per fluorinated compound must be less than 30%. If the RPDs fall outside of the established control limits, the DUP should be reanalyzed to ensure that there was no injection problem. If upon reanalysis the RPDs are still outside of the control limits, the department supervisor shall review the data and determine if any further action is necessary. RPD failures are generally not grounds for re-extraction.

13.0 CALCULATIONS

The concentration of each Per fluorinated compound in the original sample is calculated as follows:

Water (ug/l) = $(CONC_{inst}) \times (V_F / V_I) \times DF$

Soil (ug/kg) = $[(CONC_{inst}) \times (V_F / W_I) \times DF] / \%solids$

$CONC_{inst}$ = Instrument concentration calculated from the initial calibration using mean CF or curve fit (ppb)
DF = Dilution Factor
V_F = Volume of final extract (ml)
V_I = Volume of sample extracted (ml)
W_I = Weight of sample extracted (g)
% solids = Dry weight determination in decimal form

14.0 DOCUMENTATION

14.1 The Analytical Logbook is a record of the analysis sequence; the logbook must be completed daily. Each instrument will have a separate logbook.

14.1.1 If samples require reanalysis, a brief explanation of the reason must be documented in this log.

14.1.2 Overwriting of data files is never allowed.

14.2 The Standard Preparation Logbook must be completed for all standard preparations. All information requested must be completed; the page must be signed and dated by the respective person.

14.2.1 The SGS Lot Number must be cross-referenced on the standard vial.

14.3 The Instrument Maintenance Logbook must be completed when any type of maintenance is performed on the instrument. Each instrument has a separate log.

14.4 Any corrections to laboratory data must be done using a single line through the error. The initials of the person and date of correction must appear next to the correction.

14.5 Unused blocks of any form must be X'ed or Z'ed out by the analyst before submitting the data for review.

14.6 Supervisory (or peer) personnel must routinely review (at least once per month) all laboratory logbooks to ensure that information is being recorded properly. Additionally, the maintenance of the logbooks and the accuracy of the recorded information must also be verified during this review.

15.0 DATA REVIEW AND REPORTING

15.1 Initial and continuing calibration check. Verify that all calibration and continuing calibration criteria have been achieved. If the criteria had not been achieved, corrective action must be performed to bring the system in control before analyzing any samples.

15.1.1 If samples had been analyzed under non-compliant calibration criteria, all sample extracts must be re-analyzed once the system is brought into control.

15.2 Quality Control Data Review. Review all QC data. If QC criteria were not achieved, perform corrective action before proceeding with analysis.

15.2.1 In some situation, corrective action may demand that the entire sample batch be re-extracted and re-analyzed before processing data.

15.3 Chromatogram Review. The chromatogram of each sample is evaluated for target analytes.

15.3.1 Each sample may require the reporting of different target analytes. Review the login to assure that the correct target compounds are identified.

15.3.2 Manual integration of chromatographic peaks must be identified by the analysts. Upon review, the supervisor will initial and date the changes made to the report.

15.4 Transfer to LIMS. Following the initial screen review, transfer the processed data to the LIMS.

15.4.1 Compare the printed values to the original values to verify transfer accuracy.

15.4.2 If transfer errors occurred, the errors must be corrected before the data is re-submitted.

16.0 POLLUTION PREVENTATION & WASTE MANAGEMENT

16.1 Wastewater and acetonitrile from the instrument are collected in waste storage bottles and are eventually transferred to the non-chlorinated waste drum.

16.2 Sample Extracts are archived and stored for 30 days after analysis. Old extracts and standards are disposed of in the waste vial drum.

17.0 REFERENCES

17.1 4th Draft EPA Method 1633, Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS, July 2023.

Table 1 : Target Analytes

PFAS Analyte	Acronym	CAS #
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	PFTriA	72629-94-8
Perfluorotetradeconoic acid	PFTeA	376-06-7
Perfluorobutane sulfonate	PFBS	29240-43-3
Perfluoropentane sulfonate	PFPeS	2706-91-4
Perfluorohexane sulfonate	PFHxS	108427-53-8
Perfluoroheptane sulfonate	PFHpS	375-92-8
Perfluorooctane sulfonate	PFOS	1763-23-1
Perfluorononane sulfonate	PFNS	68259-12-1
Perfluorodecane sulfonate	PFDS	67906-42-7
Perfluorododecanesulfonate	PFDoDS	79780-39-5
4:2 Fluorotelomer sulfonate	4:2 FTS	757124-72-4
6:2 Fluorotelomer sulfonate	6:2 FTS	27619-97-2
8:2 Fluorotelomer sulfonate	8:2 FTS	39108-34-4
3:3 Fluorotelomer carboxylate	3:3 FTCA	356-02-5
5:3 Fluorotelomer carboxylate	5:3 FTCA	914637-49-3
7:3 Fluorotelomer carboxylate	7:3 FTCA	812-70-4
N-ethyl perfluorooctanesulfonamido acetic acid	EtFOSAA	2991-50-6
N-methyl perfluorooctanesulfonamido acetic acid	MeFOSAA	2355-31-9
Perfluorooctane sulfonamide	PFOSA	754-91-6
N-Ethyl perfluorooctane sulfonamide	EtFOSA	4151-50-2

N-Methyl perfluorooctane sulfonamide	MeFOSA	31506-32-8
N-Ethyl perfluorooctane sulfonamidoethanol	EtFOSE	1691-99-2
N-Methyl perfluorooctane sulfonamidoethanol	MeFOSE	24448-09-7
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6
11-chloroicosafluoro-3-oxaundecade-1-sulfonic acid	11Cl-	763051-92-9
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1
4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6
Perfluoro(2-ethoxyethane) sulfonic acid	PFEESA	113507-82-7
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5

TABLE 2: Precursor and Primary Transition Masses

Analyte	Type	RT	Primar y	Secondary Transition	Reference Compound
13C3-PFBA	NIS	3.34	216.0 -> 172.0		
13C4-PFBA	EIS	3.34	216.8 -> 171.9		13C3-PFBA
PFBA	Target	3.34	212.8 -> 168.9		13C4-PFBA
PFMPA	Target	3.99	229.0 -> 84.9		13C5-PFPeA
3:3FTCA	Target	4.32	241.0 -> 177.0	241.0 -> 117.0	13C5-PFPeA
13C5-PFPeA	EIS	4.93	268.3 -> 223.0		13C2-PFHxA
PFPeA	Target	4.93	263.0 -> 219.0		13C5-PFPeA
PFMBA	Target	5.38	279.0 -> 85.1		13C5-PFPeA
13C2-4:2FTS	EIS	5.85	329.1 -> 80.9		18O2-PFHxS
4:2FTS	Target	5.85	327.1 -> 307.0	327.1 -> 80.9	13C2-4:2FTS
NFDHA	Target	6.08	295.0 -> 201.0	295.0 -> 84.9	13C5-PFHxA
13C3-PFBS	EIS	6.15	302.1 -> 79.9		18O2-PFHxS
PFBS	Target	6.15	298.7 -> 79.9	298.7 -> 98.8	13C3-PFBS
13C2-PFHxA	NIS	6.20	315.1 -> 270.0		
13C5-PFHxA	EIS	6.20	318.0 -> 273.0		13C2-PFHxA
PFHxA	Target	6.20	313.0 -> 269.0	313.0 -> 118.9	13C5-PFHxA
13C3-HFPO- DA	EIS	6.59	286.9 -> 168.9		13C2-PFHxA
HFPO-DA	Target	6.59	284.9 -> 168.9	284.9 -> 184.9	13C3-HFPO- DA
PFEESA	Target	6.71	314.8 -> 134.9	314.8 -> 82.9	13C5-PFHxA
5:3FTCA	Target	6.82	341.0 -> 237.1	341.0 -> 217.0	13C5-PFHxA
13C4-PFHpA	EIS	7.14	367.1 -> 322.0		13C2-PFHxA

PFHpA	Target	7.14	363.1 -> 319.0	363.1-> 169.0	13C4-PFHpA
PFPeS	Target	7.22	349.1 -> 79.9	349.1 -> 98.9	13C3-PFHxS
ADONA	Target	7.40	376.8 -> 250.9	376.8 -> 84.8	13C3-HFPO- DA
13C2-6:2FTS	EIS	7.56	429.1 -> 80.9		18O2-PFHxS
6:2FTS	Target	7.56	427.1 -> 407.0	427.1 -> 80.9	13C2-6:2FTS
13C4-PFOA	NIS	7.81	417.1 -> 172.0	417.1 -> 372.0	
13C8-PFOA	EIS	7.81	421.0 -> 376.0		13C4-PFOA
PFOA	Target	7.81	413.0 -> 369.0	413.0 -> 169.0	13C8-PFOA
PFHxS	Target	7.96	398.9 -> 79.9	398.9 -> 98.9	13C3-PFHxS
18O2-PFHxS	NIS	7.97	403.0 -> 83.9		
13C3-PFHxS	EIS	7.97	402.1 -> 79.9		18O2-PFHxS
7:3FTCA	Target	8.27	441.0 -> 316.9	441.0 -> 336.9	13C5-PFHxA
13C5-PFNA	NIS	8.40	468.0 -> 427.0		
13C9-PFNA	EIS	8.40	472.1 -> 427.0		13C5-PFNA
PFNA	Target	8.40	463.0 -> 419.0	463.0 -> 219.0	13C9-PFNA
PFHpS	Target	8.58	449.0 -> 79.9	449.0 -> 98.8	13C8-PFOS
13C2-8:2FTS	EIS	8.69	529.1 -> 80.9		18O2-PFHxS
8:2FTS	Target	8.70	527.1 -> 507.0	527.1 -> 80.8	13C2-8:2FTS
13C2-PFDA	NIS	8.95	515.1 -> 470.1		
13C6-PFDA	EIS	8.95	519.1 -> 474.1		13C2-PFDA
PFDA	Target	8.95	512.9 -> 469.0	512.9 -> 219.0	13C6-PFDA
d3-MeFOSAA	EIS	8.97	573.2 -> 419.0		13C4-PFOS
MeFOSAA	Target	8.97	570.1 -> 419.0	570.1 -> 483.0	d3-MeFOSAA
13C4-PFOS	NIS	9.14	503.8 -> 79.9		
13C8-PFOS	EIS	9.13	507.1 -> 79.9		13C4-PFOS
PFOS	Target	9.14	498.9 -> 79.9	498.9 -> 98.8	13C8-PFOS
d5-EtFOSAA	EIS	9.19	589.2 -> 419.0		13C4-PFOS
EtFOSAA	Target	9.20	584.2 -> 419.1	584.2 -> 526.0	d5-EtFOSAA
13C7-	EIS	9.44	570.0 -> 525.1		13C2-PFDA
PFUnDA	Target	9.44	563.1 -> 519.0	563.1 -> 269.1	13C7-PFUnDA
9Cl-PF3ONS	Target	9.49	530.8 -> 351.0	532.8 -> 353.0	13C3-HFPO- DA
PFNS	Target	9.63	548.8 -> 79.9	548.8 -> 98.8	13C8-PFOS
13C2-	EIS	9.87	615.1 -> 570.0		13C2-PFDA
PFDoDA	Target	9.87	613.1 -> 569.0	613.1 -> 319.0	13C2-PFDoDA
PFDS	Target	10.05	599.0 -> 79.9	599.0 -> 98.8	13C8-PFOS
13C8-FOSA	EIS	10.23	506.1 -> 77.8		13C4-PFOS
FOSA	Target	10.23	498.1 -> 77.9	498.1 -> 478.0	13C8-FOSA
PFTrDA	Target	10.26	663.0 -> 619.0	663.0 -> 168.9	13C2-PFDoDA
11Cl-	Target	10.32	630.9 -> 451.0	632.9 -> 453.0	13C3-HFPO- DA
13C2-PFTeDA	EIS	10.60	715.1 -> 670.0		13C2-PFDA
PFTeDA	Target	10.60	713.1 -> 669.0	713.1 -> 168.9	13C2-PFTeDA

PFDoDS	Target	10.75	699.1 -> 79.9	699.1 -> 98.8	13C8-PFOS
d7-MeFOSE	EIS	11.21	623.1 -> 58.9		13C4-PFOS
MeFOSE	Target	11.22	616.1 -> 58.9		d7-MeFOSE
d3-MeFOSA	EIS	11.30	515.0 -> 219.0		13C4-PFOS
MeFOSA	Target	11.30	512.0 -> 219.0	512.0 -> 169.0	d3-MeFOSA
d9-EtFOSE	EIS	11.45	639.1 -> 58.9		13C4-PFOS
EtFOSE	Target	11.46	630.0 -> 58.9		d9-EtFOSE
d5-EtFOSA	EIS	11.53	531.1 -> 219.0		13C4-PFOS
EtFOSA	Target	11.53	526.0 -> 219.0	526.0 -> 169.0	d5-EtFOSA

TABLE 3: Standard Levels (Targets), ng/ml

Compound	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**	**CS7**	**CS8**
Perfluoroalkyl carboxylic acids								
PFBA	0.8	1.6	5.0	10	20	50	100	250
PFPeA	0.4	0.8	2.5	5	10	25	50	125
PFHxA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFHpA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFOA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFNA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFDA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFUnA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFDoA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFTrDA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
PFTeDA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
Perfluoroalkyl sulfonic acids								
PFBS	0.177	0.354	1.109	2.218	4.435	11.087	22.17	55.438
PFPeS	0.188	0.376	1.176	2.353	4.705	11.762	23.52	58.813
PFHxS	0.183	0.366	1.143	2.285	4.570	11.425	22.85	57.125
PFHpS	0.191	0.382	1.191	2.383	4.765	11.912	23.82	59.563
PFOS	0.186	0.372	1.160	2.320	4.640	11.600	23.20	58.000
PFNS	0.192	0.384	1.203	2.405	4.810	12.025	24.05	60.125
PFDS	0.193	0.386	1.206	2.413	4.825	12.062	24.12	60.313
PFDoS	0.194	0.388	1.213	2.425	4.850	12.125	24.25	60.625
Fluorotelomer sulfonic acids								
4:2FTS	0.750	1.500	4.688	9.375	18.75	46.87	93.75	234.37
6:2FTS	0.760	1.520	4.750	9.500	19.00	47.50	95.00	237.50
8:2FTS	0.768	1.536	4.800	9.600	19.20	48.00	96.00	240.00
Perfluorooctane sulfonamides								
PFOSA	0.4	0.8	2.5	5	10	25	50	125
NMeFOSA	0.4	0.8	2.5	5	10	25	50	125
NEtFOSA	0.4	0.8	2.5	5	10	25	50	125
Perfluorooctane								
NMeFOSAA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
NEtFOSAA	0.2	0.4	1.25	2.5	5.0	12.5	25	62.5
Perfluorooctane sulfonamide								
NMeFOSE	1	2.0	6.25	12.5	25	62.5	125	312.5
NEtFOSE	1	2.0	6.25	12.5	25	62.5	125	312.5
Per- and polyfluoroether								
HFPO-DA	0.8	1.6	5.0	10	20	50	100	250

ADONA	0.756	1.512	4.725	9.45	18.9	47.25	94.5	236.25
PFMPA	0.4	0.8	2.5	5.0	10	25	50	125
PFMBA	0.4	0.8	2.5	5.0	10	25	50	125
NFDHA	0.4	0.8	2.5	5.0	10	25	50	125
Ether sulfonic acids								
9Cl-PF3ONS	0.748	1.496	4.675	9.35	18.7	46.75	93.5	233.75
11Cl-PF3OUdS	0.756	1.512	4.725	9.45	18.9	47.25	94.5	236.25
PFEESA	0.356	0.712	2.225	4.45	8.90	22.25	44.5	111.25
Fluorotelomer carboxylic acids								
3:3FTCA	0.9984	1.997	6.24	12.48	25.0	62.4	124.8	312.0
5:3FTCA	4.992	9.984	31.20	62.4	124.8	312.0	624.0	1560
7:3FTCA	4.992	9.984	31.20	62.4	124.8	312.0	624.0	1560
Extracted Internal Standard (EIS)								
13C4-PFBA	10	10	10	10	10	10	10	10
13C5-PFPeA	5	5	5	5	5	5	5	5
13C5-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C4-PFHpA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C8-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C9-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
13C6-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
13C7-PFUnA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
13C2-PFDoA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
13C2-PFTeDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
13C3-PFBS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C3-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C8-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C2-4:2 FTS	5	5	5	5	5	5	5	5
13C2-6:2 FTS	5	5	5	5	5	5	5	5
13C2-8:2 FTS	5	5	5	5	5	5	5	5
13C8-PFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D5-NEtFOSA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
D3-NMeFOSAA	5	5	5	5	5	5	5	5
D5-NEtFOSAA	5	5	5	5	5	5	5	5
D7-NMeFOSE	25	25	25	25	25	25	25	25
D9-NEtFOSE	25	25	25	25	25	25	25	25
13C3-HFPO-DA	10	10	10	10	10	10	10	10
Non-extracted Internal Standard								
13C3-PFBA	5	5	5	5	5	5	5	5
13C2-PFHxA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C4-PFOA	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C5-PFNA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
13C2-PFDA	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25
18O2-PFHxS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
13C4-PFOS	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

TABLE 4 : Method Names vs Lab Names

METHOD		LABORATORY		
ANALYTE NAME	**ACRONYM**	**LIMS REPORT NAME**	**RAW DATA NAME**	**RAW DATA EIS as ISTD**
Perfluorobutanoic acid	PFBA	Perfluorobutanoic acid	PFBA	
Perfluoropentanoic acid	PFPeA	Perfluoropentanoic acid	PFPeA	
Perfluorohexanoic acid	PFHxA	Perfluorohexanoic acid	PFHxA	
Perfluoroheptanoic acid	PFHpA	Perfluoroheptanoic acid	PFHpA	
Perfluorooctanoic acid	PFOA	Perfluorooctanoic acid	PFOA	
Perfluorononanoic acid	PFNA	Perfluorononanoic acid	PFNA	
Perfluorodecanoic acid	PFDA	Perfluorodecanoic acid	PFDA	
Perfluoroundecanoic acid	PFUnA	Perfluoroundecanoic acid	PFUnDA	
Perfluorododecanoic acid	PFDoA	Perfluorododecanoic acid	PFDoDA	
Perfluorotridecanoic acid	PFTrDA	Perfluorotridecanoic acid	PFTrDA	
Perfluorotetradecanoic acid	PFTeDA	Perfluorotetradecanoic acid	PFTeDA	
Perfluorobutanesulfonic acid	PFBS	Perfluorobutanesulfonic acid	PFBS	
Perfluoropentanesulfonic acid	PFPeS	Perfluoropentanesulfonic acid	PFPeS	
Perfluorohexanesulfonic acid	PFHxS	Perfluorohexanesulfonic acid	PFHxS	
Perfluoroheptanesulfonic acid	PFHpS	Perfluoroheptanesulfonic acid	PFHpS	
Perfluorooctanesulfonic acid	PFOS	Perfluorooctanesulfonic acid	PFOS	
Perfluorononanesulfonic acid	PFNS	Perfluorononanesulfonic acid	PFNS	
Perfluorodecanesulfonic acid	PFDS	Perfluorodecanesulfonic acid	PFDS	
Perfluorododecanesulfonic acid	PFDoS	Perfluorododecanesulfonic acid	PFDoDS	
1H ,1H ,2H ,2H -Perfluorohexane sulfonic acid	4:2FTS	4:2 Fluorotelomer sulfonate	4:2FTS	
1H ,1H ,2H ,2H -Perfluorooctane sulfonic acid	6:2FTS	6:2 Fluorotelomer sulfonate	6:2FTS	
1H ,1H ,2H ,2H -Perfluorodecane sulfonic acid	8:2FTS	8:2 Fluorotelomer sulfonate	8:2FTS	
Perfluorooctanesulfonamide	PFOSA	PFOSA	FOSA	
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	EtFOSAA	EtFOSAA	
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	MeFOSAA	MeFOSAA	
N-ethyl perfluorooctanesulfonamide	NEtFOSA	EtFOSA	EtFOSA	
N-methyl perfluorooctanesulfonamide	NMeFOSA	MeFOSA	MeFOSA	
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	EtFOSE	MeFOSE	
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	MeFOSE	EtFOSE	
Hexafluoropropylene oxide dimer acid	HFPO-DA	HFPO-DA (GenX)	HFPO-DA	
4,8-dioxa-3H-perfluorononanoic acid	ADONA	ADONA	ADONA	
9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	9Cl-PF3ONS (F-53B Major)	9Cl-PF3ONS	
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	11Cl-PF3OUdS (F-53B Minor)	11Cl-PF3OUdS	
Perfluoro-3-methoxypropanoic acid	PFMPA	PFMPA	PFMPA	
Perfluoro-4-methoxybutanoic acid	PFMBA	PFMBA	PFMBA	

Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	NFDHA	NFDHA	
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	PFEESA	PFEESA	
3-Perfluoropropyl propanoic acid	3:3FTCA	3:3 Fluorotelomer carboxylate	3:3FTCA	
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	5:3 Fluorotelomer carboxylate	5:3FTCA	
3-Perfluoroheptyl propanoic acid	7:3FTCA	7:3 Fluorotelomer carboxylate	7:3FTCA	
Perfluoro-n-[13C4]butanoic acid	13C4-PFBA	13C4-PFBA	13C4-PFBA	M4-PFBA
Perfluoro-n-[13C5]pentanoic acid	13C5-PFPeA	13C5-PFPeA	13C5-PFPeA	M5-PFPeA
Perfluoro-n-[1,2,3,4,6-13C5]hexanoic acid	13C5-PFHxA	13C5-PFHxA	13C5-PFHxA	M5-PFHxA
Perfluoro-n-[1,2,3,4-13C4]heptanoic acid	13C4-PFHpA	13C4-PFHpA	13C4-PFHpA	M4-PFHpA
Perfluoro-n-[13C8]octanoic acid	13C8-PFOA	13C8-PFOA	13C8-PFOA	M8-PFOA
Perfluoro-n-[13C9]nonanoic acid	13C9-PFNA	13C9-PFNA	13C9-PFNA	M9-PFNA
Perfluoro-n-[1,2,3,4,5,6-13C6]decanoic acid	13C6-PFDA	13C6-PFDA	13C6-PFDA	M6-PFDA
Perfluoro-n-[1,2,3,4,5,6,7-13C7]undecanoic acid	13C7-PFUnA	13C7-PFUnDA	13C7-PFUnDA	M7-PFUnDA
Perfluoro-n-[1,2-13C2]dodecanoic acid	13C2-PFDoA	13C2-PFDoDA	13C2-PFDoDA	M2-PFDoDA
Perfluoro-n-[1,2-13C2]tetradecanoic acid	13C2-PFTeDA	13C2-PFTeDA	13C2-PFTeDA	M2-PFTeDA
Perfluoro-1-[2,3,4-13C3]butanesulfonic acid	13C3-PFBS	13C3-PFBS	13C3-PFBS	M3-PFBS
Perfluoro-1-[1,2,3-13C3]hexanesulfonic acid	13C3-PFHxS	13C3-PFHxS	13C3-PFHxS	M3-PFHxS
Perfluoro-1-[13C8]octanesulfonic acid	13C8-PFOS	13C8-PFOS	13C8-PFOS	M8-PFOS
1H,1H,2H,2H-Perfluoro-1-[1,2-13C2]hexanesulfonic acid	13C2-4:2FTS	13C2-4:2FTS	13C2-4:2FTS	M2-4:2FTS
1H,1H,2H,2H-Perfluoro-1-[1,2-13C2]octanesulfonic acid	13C2-6:2FTS	13C2-6:2FTS	13C2-6:2FTS	M2-6:2FTS
1H,1H,2H,2H-Perfluoro-1-[1,2-13C2]decanesulfonic acid	13C2-8:2FTS	13C2-8:2FTS	13C2-8:2FTS	M2-8:2FTS
Perfluoro-1-[13C8]octanesulfonamide	13C8-PFOSA	13C8-FOSA	13C8-FOSA	M8-FOSA
N-ethyl-d5-perfluoro-1-octanesulfonamide	D5-NEtFOSA	d5-EtFOSA	d5-EtFOSA	M5-EtFOSA
N-methyl-d3-perfluoro-1-octanesulfonamide	D3-NMeFOSA	d3-MeFOSA	d3-MeFOSA	M3-MeFOSA
N-ethyl-d5-perfluoro-1-octanesulfonamidoacetic acid	D5-NEtFOSAA	d5-EtFOSAA	d5-EtFOSAA	M5-EtFOSAA
N-methyl-d3-perfluoro-1-octanesulfonamidoacetic acid	D3-NMeFOSAA	d3-MeFOSAA	d3-MeFOSAA	M3-MeFOSAA
N-methyl-d7-perfluorooctanesulfonamidoethanol	D7-NMeFOSE	d7-MeFOSE	d7-MeFOSE	M7-MeFOSE
N-ethyl-d9-perfluorooctanesulfonamidoethanol	D9-NEtFOSE	d9-EtFOSE	d9-EtFOSE	M9-EtFOSE
Tetrafluoro-2-heptafluoropropoxy-13C3-propanoic acid	13C3-HFPO-DA	13C3-HFPO-DA	13C3-HFPO-DA	M3-HFPO-DA
Perfluoro-n-[2,3,4-13C3]butanoic acid	13C3-PFBA	13C3-PFBA	13C3-PFBA	
Perfluoro-n-[1,2,3,4-13C4]octanoic acid	13C4-PFOA	13C4-PFOA	13C4-PFOA	
Perfluoro-n-[1,2-13C2]decanoic acid	13C2-PFDA	13C2-PFDA	13C2-PFDA	
Perfluoro-n-[1,2,3,4-13C4]octanesulfonic acid	13C4-PFOS	13C4-PFOS	13C4-PFOS	
Perfluoro-1-hexane[18O2]sulfonic acid	18O2-PFHxS	18O2-PFHXS	18O2-PFHxS	
Perfluoro-n-[1,2-13C2]hexanoic acid	13C2-PFHxA	13C2-PFHXA	13C2-PFHxA	
Perfluoro-n-[1,2,3,4,5-13C5]nonanoic acid	13C5-PFNA	13C5-PFNA	13C5-PFNA	

Table 5. Acceptance QC limits for wastewater and soil samples

Compounds	iDOC		BS/BS-LL Recovery (%)
	Recovery (%)	RSD (%)	
PFBA	70-135	21	70-140
PFPeA	70-135	23	65-135
PFHxA	70-135	24	70-145
PFHpA	70-135	28	70-150
PFOA	65-155	27	70-150
PFNA	70-140	28	70-150
PFDA	65-140	26	70-140
PFUnA	70-135	29	70-145
PFDoA	70-130	21	70-140
PFTrDA	60- 145	29	65-140
PFTeDA	70-145	27	60-140
PFBS	70-140	23	60-145
PFPeS	70-135	25	65-140
PFHxS	70-135	27	65-145
PFHpS	70-140	30	70-150
PFOS	70-140	29	55-150
PFNS	70-135	29	65-145
PFDS	70-135	30	60-145
PFDoS	45-135	35	50 – 145
4:2FTS	70 – 135	27	70-145
6:2FTS	70-135	32	65-155
8:2FTS	70-140	33	60-150
PFOSA	70-135	22	70-145
NMeFOSA	70-135	30	60-150
NEtFOSA	70-130	26	65 – 145
NMeFOSAA	65-140	32	50-140
NEtFOSAA	70-135	28	70-145
NMeFOSE	70-135	29	70-145
NEtFOSE	70-130	21	70-135
HFPO-DA	70 – 135	23	70-140
ADONA	70-135	23	65-145
PFMPA	60-140	23	55-140
PFMBA	65 – 145	27	60-150
NFDHA	65-140	37	50-150
9Cl-PF3ONS	70-145	30	70-155

Compounds	iDOC		
	Recovery (%)	**RSD (%)**	**BS/BS-LL Recovery (%)**
11Cl-PF3OUdS	50-150	35	55-160
PFEESA	70-135	25	70-140
3:3FTCA	70-130	23	65-130
5:3FTCA	70 – 130	24	70-135
7:3FTCA	55 – 130	34	50 – 145

Table 6. QC Acceptance Limits for EIS Recoveries in wastewater and soil samples

EIS Compound	Recovery Range (%)
13C$_4$-PFBA	5 – 130 *
13C$_5$-PFPeA	40-130
13C5-PFHxA	40-130
13C$_4$-PFHpA	40-130
13C$_8$-PFOA	40-130
13C$_9$-PFNA	40-130
13C$_6$-PFDA	40-130
13C$_7$-PFUnA	30 – 130
13C$_2$-PFDoA	10 – 130
13C$_2$-PFTeDA	10 – 130
13C$_3$-PFBS	40-135
13C$_3$-PFHxS	40-130
13C$_8$-PFOS	40-130
13C$_2$-4:2FTS	40 – 200
13C$_2$-6:2FTS	40 – 200
13C$_2$-8:2FTS	40-300
13C$_8$-PFOSA	40 – 130
D$_3$-NMeFOSA	10 – 130
D$_5$-NEtFOSA	10 – 130
D$_3$-NMeFOSAA	40-170
D$_5$-NEtFOSAA	25-135
D$_7$-NMeFOSE	10 – 130
D$_9$-NEtFOSE	10 – 130
13C$_3$-HFPO-DA	40-130
13C3-PFBA	50-200
13C2-PFHxA	
13C4-PFOA	
13C5-PFNA	
13C2-PFDA	
18O2-PFHxS	
13C4-PFOS	

* Recovery of 13C4-PFBA can be problematic in some field samples. Although the lower limit for recovery for this EIS is set below 10%, laboratories should routinely track recovery of this EIS and take reasonable steps to ensure that recovery is at least 10% in the majority of samples.

Current Version Revision Information

Changes / Edits made (this should include added or deleted information within a sentence or paragraph only):

Section / Subsection	Detailed description of what was revised
Table 3	Standard levels changed for few compounds.

Sections or Subsections deleted:

Section / Subsection	Reason section or subsection was removed

Sections or Subsections added:

Section / Subsection	Reason section or subsection was added
6.3.3	Leachates holding time

History of Revisions

Version #	Date of Revision	Revised By
00	01/05/2023	Anita Jagtap
01	05/22/2023	Olga Azarian
02	06/20/2023	Olga Azarian
03	07/21/2023	Olga Azarian
04	8/8/2023	Olga Azarian
05	01/04/2023	Olga Azarian

END OF DOCUMENT

EXHIBIT E-3 – SAMPLING, ANALYSIS, AND ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) UNDER NYSDEC'S PART 375 REMEDIAL PROGRAMS, NYSDEC, APRIL 2023

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

Table of Contents

April 2023

New York State of Opportunity | Department of Environmental Conservation

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	

April 2023

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

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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]

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[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

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[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. <u>All necessary forms will be supplied by the Bureau of Ecosystem Health.</u> 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 **<u>and signed</u>** 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 **<u>and signed</u>** 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 <u>each</u> **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 <u>each</u> 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. **<u>The Bureau of Ecosystem Health will supply the bags.</u>** 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.

page ______ of ______

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

EXHIBIT E-4 – RAMBOLL PROJECT TEAM CVS

TIMOTHY J. OLEAN

Tim has over 30 years of experience in environmental remediation project management including estimating, design, scheduling, and implementation oversight. He has managed in excess of $400M of complex remediation projects. He specializes in remedial strategy, remedy selection and evaluation, constructability review, project cost estimating, design and construction management (CM) on environmental projects focusing on former industrial sites including over 50 manufactured gas plants (MGPs) as well as refineries, railroads and manufacturing facilities. He has provided corporate level construction management and coordination, developed CM policies and project cost estimating procedures, and coordinated and directed CM services on large remediation projects throughout the United States. He has worked closely with clients and both national and state regulators to plan and implement sensitive site clean-up projects.

PROJECTS

Expert Witness Support Insurance Recovery, Antigo, WI. Providing expert services in support of our client for insurance litigation case to recover site remediation costs at a former industrial site in northern Wisconsin. Provided expert opinions and expert report rebuttal related to the appropriateness of the selected remedy and the associated estimated implementation costs.

Expert Testimony MGP Project Mediation, IN. Provided expert testimony in support of our client to defend against a multimillion-dollar contractor claim related to in-situ solidification on a former MGP site. Knowledge of the process, bidding and typical ISS contractor site operations helped the client successfully defend the claim and avoid incurring most of the original claim value.

Former Manufactured Gas Plant, Chicago, IL. Managed the planning, design, costing and construction procurement of the USEPA selected remedy for a 20-acre former industrial site west of downtown Chicago. Currently providing construction oversight for the $45 million project implementation.

Impacted Urban Waterway, Brooklyn/Queens, NY. Project lead of effort to plan, design and implement full scale project to assess viability of dredging, innovative sediment cap placement and in place solidification of impacted sediments. Directing large, national, multidisciplinary team to develop design, permitting and contractor bidding packages to implement the $10,000,000 project. Provides input on remedial selection and design input to client, legal and technical team to evaluate potential sediment remedial options and related infrastructure impacts for this highly visible urban waterway.

SPECIAL COMPETENCIES

MGP Remediation
Remedial alternative cost estimating
Expert Testimony
Remedial action construction management
Client/account management
Regulatory negotiation
Subcontractor management & cost control for remediation construction
Remedial alternative development, review & selection
Remedial design
Impacted sediment remediation
Constructability review of remedial designs

TOTAL YEARS OF EXPERIENCE

31

OFFICE LOCATION

Boston, MA

EDUCATION

BS, Engineering Management

COURSES/CERTIFICATIONS

OSHA HAZWOPER 40-hour and 8-hour Refresher Training

Northeast Utility, Former Manufactured Gas Plant, Brooklyn, NY. Project Manager for the construction oversight for the installation of an 800ft steel sheet pile bulkhead and sub surface environmental barrier wall along a former MGP located in a heavily industrialized area on the Gowanus Canal.

Former Manufactured Gas Plant, Haverstraw, NY. Project Manager leading the design, permitting and construction for remediation of coal tar impacted soils at this former MGP facility. The site is located in a heavily populated residential area and directly adjacent to a community pre-school program. The focus of the design was to achieve environmental goals while minimizing impacts to the community noise, dust odors, vapors and vibration. The design called for all impacted soil removal to be performed under a temporary fabric structure and an excavation support system to be installed using an innovative steel sheet hydraulic press in system. Coordinated design approval from the NYSDEC. Provided oversight for engineer's representative services during remediation implementation completed in Winter of 2019.
Former Solvay Coking Plant, Milwaukee, WI. Led the completion of Time Critical Removal Action for the upland and for the remediation of a former coking site along the waterfront in Milwaukee to facilitate time critical redevelopment of the parcel.

Former Manufactured Gas Plant, Manitowoc, WI. Led the completion of Feasibility Studies for the upland and sediment operable units at a former MGP site. Led the design, costing and construction procurement of the USEPA selected upland remedy. Currently providing construction oversight for the $6 million project implementation.

ISS Pilot Study Task Leader, Gowanus Canal, Brooklyn NY. Task leader and provided senior constructability input to client, legal and technical team to evaluate potential sediment remedial options for this highly visible urban waterway. Developed and implemented treatability study to assess viability of in place solidification of impacted sediments. Developed and managed innovative pilot study to perform ISS on in-place canal sediments from a barge. Developed and reviewed cost estimates, phasing and conceptual designs for dredging and capping options. Provided construction oversite of pilot implementation. This technology s now being used as a full-scale remedy in the canal based on the pilot performance.

Former Manufactured Gas Plant, Nyack NY. Project Manager for pre-design investigation, design and permitting for remediation of the intertidal zone and sediments at this former MGP facility on the shore of the Hudson River. The complex project included the treatability and design of an ISS remedy for upland impacts and dredging of over 6,000 cubic yards of impacted sediments. Coordinated permitting for USACE, New York state and local authorities. Provided senior construction oversight during remediation implementation.

Southern Utility Company, Multi-Site Utility Remediation Outsource Program., Georgia & Florida. Managed all field construction and remediation for $85,000,000 outsource program for Georgia utility. Project involved multi-site cleanup at various former manufactured gas plants throughout Georgia and Florida. Remediation technologies included excavation, in-situ treatment, In-Situ Solidification, sediment dredging and capping. Coordinated remedy selection, budgeting, design completion efforts, bidding, contractor negotiation, field staffing and site management. Negotiated with contractors to reduce original bid costs by over 25% by understanding the scope of work and by completing detailed cost estimates independent of the contractor. Successfully completed remediation fieldwork with minimal change orders and no claims. Overhauled company design and bid packages for clarity and claims avoidance. Established project controls guidelines implemented during construction including the creation and roll-out of a Web-based daily report and cost tracking function. Acted as a senior member of the program management team to set strategy and provide planning. Worked closely with client's counsel in developing access and remediation agreements with impacted landowners.

Multi-Site Superfund Clean Up Project, Syracuse NY. Provides technical support, strategy input, design support and field observation to develop in situ solidification remedies for several operable units at this large former manufacturing site.

Former Manufactured Gas Plant, Sag Harbor, NY. Provided senior construction oversight and constructability review for remediation of a former MGP site located in a densely urbanized and sensitive community in NY. Provided on-going constructability throughout design, including the development of an in-situ solidification (ISS) wall concept. Responsible for developing contractor bidding strategy and assisting client in reviewing contractor bids and negotiating final costs. Provided review, screening and negotiation of potential change orders and claims. Monitored cost and schedule and reviewed monthly contractor invoices. The multimillion-dollar contract included managing an integrated project team for community management, design, construction management, natural resources, vibration monitoring, and air monitoring services. Community management included developing a unified team—one common goal approach with regulatory and municipality authorities resulting in reduction of construction schedule from two years to one year, year-long street closure permits, and public access for staging areas. **The p**roject involved conducting an extensive dewatering and water management evaluation to manage approximately 1MGPD of water discharge for 6 months. A 3,700-foot subaqueous pipeline was designed and installed to prevent treated groundwater (1MGPD) from lowering the salinity in the local marine environment of the harbor.

Former Manufactured Gas Plant – Suffern NY. Project Manager for pre-design investigation, design and permitting for remediation of coal tar impacted soils at this former MGP facility. The site sites between an active commuter rail line and four community drinking water wells. Close coordination with the railroad and with the host community was required to insure the implementation of the remedy was protective of surrounding community and other stakeholders. Communicated regularly with the NYSDEC which lead to expedited approval of the required regulatory submittals which included the authorization to discharge treated water to the Ramapo River under a SPDES permit. The remedy included extensive excavation support systems, excavation and disposal of impacted soils, ISS and groundwater treatment.

Wyckoff Site, Bainbridge Island WA. Task lead to develop ISS alternative for feasibility study. Site is former wood treating facility. ISS is being considered for treatment of approximately 300,000 cubic yards of impacts on the upland portion of the site.

EPRI – In-Situ Solidification of Sediments White Paper Research. Retained by the Electric Power Research Institute (EPRI) to evaluate and report on the feasibility of performing ISS on sediments impacted with MGP residuals. Research evaluated past work completed on ISS and developed a framework for performing future pilot studies to further evaluate the potential for this innovative technology. Paper published by EPRI in December 2010. Oversaw treatability and work plan development for full scale pilot study completed in 2013.

Former Manufactured Gas Plant, New Bedford MA. Lead ISS treatability and design task for this innovative sediment remediation project on the New Bedford Harbor waterfront. The project included creating an enclosed treatment cell using sheet pile to isolate an existing boat slip along the waterfront in this busy fishing city. Sediments impacted by historic upland MGP operations where then placed on top of existing impacted sediments within the slip and solidified using vertical auger ISS. Also provided constructability input and senior construction management support for the field work which included environmental dredging, extensive sheet pile installation and ISS. The project reclaimed space over the treatment call along the New Bedford waterfront to allow for future use and redevelopment.

Former MGP Remediation, Hudson River, New York. Project Manager for $10,000,000 two phase MGP remediation project on the banks of the Hudson River in southeast New York. Provided constructability throughout design, including the development of an in-situ solidification (ISS) auger mix and jet grout scope and design. Responsible for developing contractor bidding strategy and assisting client in reviewing contractor bids and negotiating final costs. Provided review, screening and negotiation of potential change orders and claims. Monitored cost and schedule and reviewed monthly contractor invoices. Work included in situ solidification (ISS) of MGP impacts close to the river and excavation and off-site thermal desorption of impacted soils in upland areas. The project was the first major ISS project at an MGP site in New York.

Soils were treated in place by mixing the soils with a reagent slurry consisting of water, Portland cement and bentonite. The reagent mix was determined through bench top treatability testing. The slurry was injected into the soil and mixed with a hydraulic, track mounted mixing rig. Jet grouting was also used to solidify areas where the auger rig could not access. Approximately 25,000 tons of impacted soils and several historic below grade MGP structures were removed from the upland portion of the site under a temporary fabric structure and approximately. 10,000 tons of soil was solidified through ISS. During design provided constructability input and evaluation of potential risk areas to minimize schedule impacts and the incidence of change orders and claims. The project was completed on budget and over one month ahead of schedule despite the excavation of an additional 3,000 tons of impacted soils. Environmental from Best of New York Construction 2007.

Former Manufactured Gas Plant, Sanford FL. Wrote and implemented treatability study for large ISS project in central Florida. Developed work plan and obtained approval for treatability study from USEPA. Negotiated favorable performance standards with EPA by convincing agency that non-destructive testing (TCLP & SPLP) are not appropriate and representative of actual ISS long term performance. Managed sample collection and data management and strategy for multi-phase testing program to optimize ISS mix design variables. Implemented testing and developed cost effective mix designs to allow for competitive bidding for ISS of over 100,000 cy.

Former Manufactured Gas Plant, Cambridge MA. Developed plans, specifications and subcontractor bidding documents for $10,000,000 in situ solidification (ISS) remedy to address DNAPL & LNAPL contamination, the first major ISS project on an MGP site in the northeast. The project involved the in situ blending of NAPL and native soils (> 100,000 cy) with a designed reagent mix to achieve pre-designated physical and chemical properties to insure immobilization of contaminants. Responsible for overseeing stabilization contractor’s compliance with mix parameters and compiling quality control data to demonstrate remediation goals have been met.

Former Northeast Refinery. Estimator and Project manager for a large-scale stabilization/solidification. Stabilized approximately 8,000 tons of off-specification asphalt material collected in shallow lagoons. Performed in situ stabilization using excavator mounted blender attachment and lime kiln dust reagent.

Former Manufactured Gas Plant, Huntsville AL. Project Manager and Lead Environmental Consultant for site investigation and removal action design and implementation at a former MGP facility that is now the site of a public housing project. Assisted our client, a large southeast utility to negotiate and implement a time-critical removal action at the former MGP facility. Managed all aspects of the project including investigation, design, regulatory negotiation, contractor selection and field remediation. Completed the investigation and design and had approval from USEPA to move ahead with the Removal Action field activities just seven months later and actual field work began a short two months after that. Managed contractor qualification review and selection. Close coordination and planning with the state, city, housing authority, local utilities and a major freight rail company was critical to allow for mobilization on such a tight schedule. During remediation, provided comprehensive Construction Management and oversight and acted as the primary contact with the contractor, local stakeholders and the on-site USEPA representative. The project was completed on schedule for completion prior to the deadline set in the USEPA approved project schedule and at the budget costs established at the initiation of the project.

Bay Shore NY MGP, Operable Unit 3 (OU-3) LIRR Excavation IRM. Project Manager for completion of design and construction. Provided senior construction oversight and constructability review for remediation of a former MGP site. Project included two phases and consisted of temporally relocated approximately 600 lf of an active LIRR commuter line for remediation activities. Excavation of H-fuel like material was performed in the “wet” and inside pre-designed sheet piling. Responsible for developing contractor bidding strategy and assisting client in negotiating costs. Provided review, screening and negotiation of potential change orders and claims. Monitored cost and schedule and reviewed monthly contractor invoices. Worked closely with the client project team to coordinate support services including community air monitoring, noise and vibration monitoring, structural inspections and improvements, fencing and surveying. Due to the sensitive nature of working in this community, the project required intense coordination and communication with the remediation contractor, the LIRR, NYDEC and with the client's project team, legal team and community relations personnel.

Design and Management of River Sediment Excavation in Macon, Georgia. Provided design support, constructability review and construction oversight to address sediments adjacent to the bank along a 200-foot reach of river which were impacted by coal tar from a nearby MGP site. Prepared detailed considerations of methods to isolate the area to be excavated, including water-filled plastic barriers, temporary fabric dams, excavation boxes, and driven sheet piles. Design constraints included potentially high river flows, weak sandy soil conditions, overhead high-voltage electrical lines, and an adjacent active railway bridge. A temporary fabric dam was selected to isolate the excavation area. Wet excavation was then conducted. Dry excavation was not possible because of the danger of cofferdam failure due to the weak sandy soil conditions. Continuous pumping created a hydraulic gradient to prevent release of impacted water from the excavation zone. Managed the successful excavation, sand capping, and bank restoration.

Design and Construction Management of a Stream Sediment excavation and capping in South Bend Indiana. Provided design, constructability input and construction oversight for the time critical remediation of a stream adjacent to a former MGP site. Under EPA direction the client was required to eliminate sheen generating in this urban stream that fed the ST Joseph River. Prepared a design to divert the full flow of the stream to a nearby storm water sewer system to allow for sediment excavation and capping in the dry. Design, permitting and construction was completed in the fall and winter of 2005 and 2006.

Design Support and Construction Management of a Major River Remediation in Ft. Collins CO. Provided design support, constructability input and construction oversight for the time critical remediation of the Poudre River adjacent to a former MGP site. A complete pumped bypass was designed and implemented to allow for remediation in the dry. Flows were estimated based on historical site conditions, however up stream dam release activity was unpredictable requiring careful planning and detailed contingency plans to manage unpredictable flows.

Rail Yard Remediation, Washington. Senior Constructability Reviewer for this multiyear $50,000,000 remediation of a fuel oil plume under a rural riverfront town. Provided remediation strategy, construction sequencing, design review, bid document review and contractor selection strategy. The remedy includes a large groundwater containment/funnel and gate wall, relocation of several residences and business, extensive soil excavation, sediment removal from a pristine river and riverbank and habitat restoration.

Refinery Remediation, Virginia. Senior Constructability Reviewer and Construction Oversight for a multi-phase $25,000,000 refinery remediation project. Provided remediation strategy, construction sequencing, regulatory communication, treatability design, design review, bid document review and contractor selection and negotiation. Also provided construction management support during remedial activities. The remedy includes utility relocation, Corrective Action Management Unit construction, excavation, waste solidification and relocation and final capping and restoration.

Constructability & Cost Reviews, Various Locations. Performed constructability reviews during design phase for large and small-scale remedial construction projects. Specific projects include:

River sediment removal and remediation project in Northern Indiana
Barrier wall and collection system installation at former MGP site in Northern Illinois
Barrier wall and collection system installation in Western Massachusetts
PCB Removal Project in Pennsylvania
Wood treating sludge/sediment Removal from creek in Alabama
ISS project at former wood treating site in Seattle WA
Installation of in-situ barrier wall along riverbank in York, PA

PUBLICATIONS & PRESENTATIONS:

Author/Presenter – Sustainable Sediment Solutions: Stabilization of Contaminated Sediment, SEDNET, *Dubrovnik, Croatia April 2019*

Author/Instructor - Expanding the use of In Situ Solidification/Stabilization to Provide Additional Tools for the Management of Impacted Sediments, Short Course, *Battelle Sediments Conference, New Orleans, LA, February 2019*

Author/Presenter – **Public Water Supply Protection During MGP Site Remediation**. *MGP Symposium, New Orleans, LA, October 2017*

Co-author – In Canal Stabilization/Solidification of NAPL Impacted Sediments *Remediation Journal, Summer 2016*

Author/Presenter - Gowanus Canal In-Situ Stabilization Pilot Study *Sediment Management Working Group Sponsors Forum, Washington, DC, December 2015*

Author/Presenter - Gowanus Canal In-Situ Stabilization Pilot Study *MGP Symposium, Ghent Belgium, November 2015*

Author/Presenter – Assessing the Feasibility of In situ Solidification at MGP impacted Sediment Sites *MGP Symposium 2012, Chicago, IL, March 2012*

Author – Technology Development Need for Application of In-Situ Stabilization and Solidification to Contaminated Sediments EPRI *Publication # 1021213, December 2010*

Author/Presenter - Manufactured Gas Plant Site Remediation and Redevelopment Using *In Situ* Technologies *Gasworks Europe Conference, Dresden Germany, March 2008*

Co-author – In Situ Solidification- A Case Study at a Former Manufactured Gas Plant in Macon GA. *Remediation Journal, Spring 2004*

WILLIAM H MOORE, LSRP

Senior Scientist

Mr. Moore is a Senior Scientist and New Jersey Department of Environmental Protection (NJDEP) Licensed Site Remediation Professional (LSRP) with over twenty years of experience performing environmental Site investigations, remediation and regulatory compliance.

RELEVANT PROJECT EXPERIENCE

Mount Vernon, NY, United States - Project Manager
Responsible for implementing a Site Management Plan (SMP) associated with the remediation of a Manufactured Gas Plant (MGP) Sites. SMP implementation activities include annual certifications of institutional controls and routine inspections, monitoring, optimization and maintenance of engineering controls including sub-slab depressurization systems, a composite cover system, a groundwater sump venting system and an oxygen injection system. Coordinates access coordination and routine groundwater sampling of monitoring wells. Prepares Periodic Review Reports (PRRs) in accordance with New York State Department of Environmental Conservation (NYSDEC) DER-10 requirements. The results of SMP implementation have resulted in NYSDEC approvals to reduce monitoring frequencies and requirements.

Various Locations in NJ and NY, United States – Subject Matter Expert
Responsible for developing and implementing investigations conducting per- and polyfluoroalkyl substances (PFAS) and other contaminants of emerging concern investigations at various MGP and non-MGP Sites in NJ and NY following State and Federal regulatory requirements. Also responsible for developing PFAS-specific work plans and standard operating procedures for regulatory approval and implementation.

Village of Haverstraw, NY, United States – Subject Matter Expert
Responsible for supporting remediation efforts at a former MPG Site including developing an interim Site Management Plan (ISMP) following remedial efforts. The ISMP includes an evaluation of post-remediation soil and groundwater quality; post-remedial excavation contingency work planning, long-term groundwater monitoring work planning; and institutional and engineering control monitoring and certifications. Also responsible for preparing a Supplemental Site Characterization Workplan for sediments located in an Hudson River embayment near the former MGP Site.

Hopewell Township, NJ, United States – Project Manager
Project manager for two Industrial Site Recovery Act (ISRA) investigations of two pharmaceutical manufacturing facilities in Hopewell Township, NJ. Developed a strategic roadmap to Site closure that addresses over 200 areas of concern

Special Competencies
- Investigation
- Remediation
- Regulatory Compliance

Professional Licenses
- NJDEP LSRP No. 714957

Courses and Certifications
- OSHA 40-hour HAZWOPER Certified.
- NJDEP Ecological Course
- NJDEP In-situ Technologies for Site Remediation Course
- Interstate Technology & Regulatory Council Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management Course
- NJDEP LSRP Case Study Course
- NJDEP Final Results Package Course
- University of Waterloo's Remediation Course – March 2006
- University of Waterloo's Groundwater Modeling Course – January 2006

Education
- BS/2001/Environmental Science and Geology, Susquehanna University

(AOCs) including PFAS. Provided project management and technical oversight for all phases of the ISRA investigations, including the Preliminary Assessment (PA), Site Investigation (SI), Remedial Investigation (RI) and AOC-specific Remedial Actions (RAs). The ISRA investigation resulted in the issuance of a site-wide Response Action Outcome (RAO) within the regulatory timeframes.

City of Paterson, NJ, United States - Project Manager
Responsible for RI and RA activities at a historical and complex ISRA site consisting of multiple contaminated media and multiple contaminants of concern. Project highlights include: Implementation of a full-scale air sparge/soil vapor extraction remediation system in accordance with a NJDEP approved RAW. Responsible for managing remedial process optimization; long-term monitoring; RA progress evaluations and reporting; air permit compliance; and stakeholder communications. Development of a RAW and discharge to groundwater proposal for nutrient injection to target residual areas that exhibit recalcitrant groundwater concentration trends over time. Preparation of a final RI report that summarizes 20+ years of investigation that meets updated NJDEP requirements for the PA, SI and RI. Identification of multiple separate groundwater plumes from adjacent and upgradient site(s) via the analysis of various key indicator compounds. The interpretation and presentation of the investigation data has led to regulatory acknowledgement of commingling plumes leading to groundwater delineation. Characterization of the extent of contaminated surface water and sediment along a river located adjacent to the site. Developed an approved RA that mitigates risk to ecological and human health along the river. Development of site-specific groundwater screening levels to evaluate the vapor intrusion pathway for building structures on an adjacent property. Coordinated efforts to collect additional data via soil gas sampling to further evaluate the vapor intrusion pathway. Coordinated preparation of a groundwater mathematical model that supports groundwater delineation in the bedrock aquifer. The model was used to support the limits of a classification exception area as the institutional control for groundwater.

Waterloo, NY, United States - Project Manager
Responsible for managing activities for a Resource Conservation and Recovery Act (RCRA) investigation at an active site. Project highlights include: Performed overburden groundwater, bedrock groundwater and surface water interaction study that evaluated potential impacts to an adjacent sensitive water body receptor. Characterized elevated arsenic concentrations in groundwater based on geochemical changes to groundwater (pH). Evaluated arsenic desorption/re-adsorption capacity in natural soils as the groundwater remedy. Evaluated groundwater contamination related to a former chemical transfer pit. Identified impact to groundwater pathways and hydraulic connectivity between the former pit area and surrounding groundwater aquifer. Managed delineation of off-site arsenic and cadmium concentrations in shallow soil to support development of institutional controls. Supported characterization of a former landfill located on-site. Managed site-wide long-term monitoring, data evaluation and monitored natural attenuation evaluation. Responsible for incorporating investigation results into corrective measures work plans that were approved by the New York State Department of Environmental Conservation (NYSDEC).

Cranbury Township, NJ, United States – Project Manager
Responsible for implementing optical image profiling and in-Situ chemical oxidation remediation at a former manufacturing facility in Cranbury, NJ, where access limitations and depth to groundwater (40+ feet below ground surface) presented technical challenges for identifying, delineating and treating residual Light Non-Aqueous Phase Liquid (LNAPL) in the ground surface. Responsible for remedial phase reporting including remedial action workplan, discharge to groundwater permit application and remedial action reporting.

Franklin Township, NJ, United States – Project Manager
Responsible for conducting an ISRA investigation for a radiopharmaceutical manufacturing and distribution facility in Franklin Township, NJ. Implemented all elements of the PA, which resulted in the

identification of several AOCs warranting further investigation as a SI. The ISRA investigation resulted in the issuance of a site-wide RAO within the regulatory timeframes.

City of Newark, NJ, United States - Project Manager and LSRP
Responsible for providing technical oversight, project management and LSRP services for the City of Newark's Economic Development Corporation. Project highlights include: Provided LSRP technical services for twenty-four City of Newark-owned responsible party sites that were out of compliance with NJDEP's remediation requirements. Developed strategic approaches to administrative closure, including investigation adjacent to dilapidated structures where utilizing man operated equipment would be hazardous due to potential building collapse. The SI data was collected remotely using a Tracked Robotic Excavator that can be operated remotely by sight or utilizing a video feed. The SI results will be used to demonstrate that the site's cleanup is eligible to be funded using an existing Brownfields Revolving Loan Fund grant with the USEPA. Implemented scopes of work associated with fifteen Brownfields assessment and cleanup grants with the USEPA and ensured that administrative and reporting requirements were met for the cooperative agreements. Prepared and submitted two Brownfields cleanup grant applications for targeted sites that have received significant redevelopment interest. Developed a Remedial Action Workplan (RAW) to redevelop a former chemical processing facility to an open space community park. The redevelopment will be publicly funded through USEPA Brownfields and NJ Hazardous Discharge Site Remediation Fund (HDSRF) cleanup grants. Prepared and submitted PA, SI and RI HDSRF grant applications to NJDEP for the City of Newark.

Allentown, PA, United States - Project Manager and Subject Matter Expert
Responsible for preparing a RI report and cleanup plan for a former truck manufacturing facility. The reporting deliverables received regulatory approval by the Pennsylvania Department of Environmental Protection (PADEP).

Union City, NJ, United States - Subject Matter Expert
Responsible for the implementation, monitoring and maintenance of two sub slab depressurization systems that were installed at buildings where Immediate Environmental Concern conditions were encountered following vapor intrusion investigations. Implemented system re-commissioning following repairs and prepared annual monitoring and maintenance reports for submission to NJDEP.

Piscataway, NJ, United States - Project Manager
Managed phases of work associated with the PA/SI, RI and RA implementation at an active ISRA site. Investigation activities included review of existing records dating back to the 1980s, field screening, monitoring well installation, sampling, and hydrogeological characterization. Managed development of a conceptual site model, RI report and RAW for regulatory submission.

King of Prussia, PA, United States - Project Manager
Managed remedial process optimization efforts at a USEPA Superfund site. Optimization consisted of evaluating and updating existing remedies consisting of a groundwater pump & treat system, wet soil cover and seep collection system. The proposed updates resulted in a significant long-term cost savings and shorter overall lifespan of the remedy.

Perth Amboy, NJ, United States - Investigation Lead
Responsible for preparing, managing and implementing a RI and interim remedial measures at an active ISRA site that has over 70 AOCs. Implementation efforts included LNAPL investigation; metals and polychlorinated biphenyls (PCB) delineation; and site-wide groundwater evaluation. Managed preparation of a RI report, an area of concern specific RA report and RA permit development.

Baltimore, MD, United States - Geotechnical Manager - Responsible for managing and operating an on-site laboratory that was used for the physical and geotechnical evaluation of soil and sediment samples for the purpose of defining the limits and characteristics of chromium ore processing residue (COPR).

Ancillary responsibilities included implementing a soil and groundwater investigation at a public park in the Baltimore area containing COPR material exceeding direct contact standards in shallow soils. The investigation was highly scrutinized by the regulatory agency, stakeholders and newspaper media. The results of the investigation led to the redevelopment of the park for public use.

MATT MILLER

Senior Geologist

KEY COMPETENCIES

Mr. Miller serves as an environmental remediation professional with over 6 years of progressive consulting experience. Mr. Miller has experience in due diligence and remediation with an extensive background in, project management, remedial strategy and alternatives analysis, regulatory technical reporting, field sampling, jobsite supervision, subcontractor oversight and task management.

Mr. Miller is qualified to assist and directly manage projects, perform due diligence evaluations; site and remedial investigation assessments; remedial action workplans and reports, remedial alternatives analysis; remedial excavation implementation and evaluations; soil, groundwater, surface water, and vapor intrusion field sampling and design, injection setup, design, and evaluation; geotechnical investigations; regulatory compliance and guidance interpretation; and health & safety review and oversight.

PROJECT EXPERIENCE

Confidential – Oil & Gas Client

Project Manager
Former Terminal and Retail Sites
Teterboro, Princeton, Verona, Bound Brook, New Jersey
Oceanside, New York
May 2022 – Present

Managed project scope and budget of over $500,000 for pre-planning and implementation of remedial action activities (excavation, injections, vacuum-extraction events). Provided field and remote oversight during various site investigations, remedial action events, and site restoration activities. Designed pre-characterization sampling plans. Engage and facilitate remedial objectives with external stakeholders and clients in support of regulatory closure goals. Advised and directed budgeting, forecasting, and resource management. Implemented submission of various regulatory technical reports and permits to various agencies.

Assistant Project Manager
Former Retail Sites
Princeton, Port Monmouth, Shrewsbury, New Jersey
Buffalo, Rochester, New York
August 2017 – May 2022

Provided oversight during various soil and groundwater sampling events, borehole geophysics and geotechnical investigation, bedrock monitoring well installations, and site restoration

SPECIAL COMPETENCIES

Environmental Site Investigation and Remediation, Excavation Oversight, Injections, NJDEP and NYSDEC Regulatory Compliance

TOTAL YEARS OF EXPERIENCE

6

EDUCATION

2009 - 2013
BS, Geology
University of Mount Union,
Alliance, Ohio, United States

CERTIFICATIONS

CPR and First Aid Training

OSHA 40-Hour HAZWOPER

OSHA 8-Hour Refresher

OSHA HAZWOPER Supervisor

Silica Competent Person

DOT Hazmat #1 – DOT/IATA Shipping & Transportation activities. Supported project manager in budget, forecasting, resource management. Designed and implemented pre-characterization soil sampling plan in support of pre-excavation characterization. Supported construction team in tasks to complete limited site remedial excavation events. Drafted remedial action reports and permits for regulatory submittal.

Confidential – Oil & Gas Client

Assistant Project Manager
Former Retail Service Station Sites
West Milford and Scotch Plains, New Jersey
January 2022 – Present

Support project manager in budget, forecasting, and resource management. Design subsurface investigation sampling plans. Draft and implemented conceptual site model to support remedial action and remedy development. Engage and facilitate remedial objectives with external stakeholders in support of client and regulatory closure goals.

KRISTIN A. DRUCQUER

Senior Manager, Albany, New York

Kristin A. Drucquer has over 20 years of experience in environmental consulting and six years of experience in the environmental laboratory industry including experience in data interpretation, laboratory management and report preparation. She performs United States Environmental Protection Agency (USEPA) Level II, III and IV analytical validation for federal and commercial projects. In addition, she provides technical expertise for product safety, analytical chemistry, and chemical fate and transport litigation support.

EDUCATION

BS, Environmental Science/Soil Science Emphasis
University of Minnesota Twin Cities, Minnesota, USA

COURSES/CERTIFICATIONS

40 Hour OSHA HAZWOPER Training

Monitored Natural Attenuation for Groundwater and Soil Remediation, University of California Berkeley Extension Center, June 2001

RECENT CONSULTING ACTIVITY

Kristin has worked on site assessment and monitoring projects throughout the United States including Arkansas, California, Colorado, Indiana, Kansas, Maryland, Montana, Nevada, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Texas, West Virginia, and Wyoming. She performs data validation on both organic and inorganic analyses and is well versed in USEPA SW-846 methodology for GC, GC/MS, LC/MS/MS, HPLC, HRGC/HRMS, ICP, ICP/MS, and wet chemistry (volatiles, semivolatiles, PFAS, pesticides, PCBs, herbicides, PCB congeners, dioxins, TPH, metals and conventional water quality parameters). Specialises in in-depth evaluation of environmental data, including reviewing analyte identifications, verifying laboratory calculations, evaluating laboratory specific methods, and interpreting coelution data. Kristin has written numerous project plans including sampling and analysis plans, field sampling plans, quality assurance project plans, and health and safety plans. Kristin is experienced with preparing Quality Assurance Project Plans in support of Uniform Federal Policy (UFP); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Resource Conservation and Recovery Act (RCRA); Contract Laboratory Program (CLP); U.S. Army Corps of Engineers (USACE); EPA Region specific plans; and U.S. Air Force programs. She also has experience performing statistical analyses for groundwater data following EPA's Unified Guidance.

Kristin currently provides regulatory compliance support on hazardous waste, EPCRA, Clean Water Act, and the Clean Air Act. She is involved

CONTACT INFORMATION
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Albany, NY 12203
USA

with hazardous waste tracking and reporting for large quantity generators, monthly NPDES reporting, Tier II reporting, annual Form R (TRI) reporting, and annual emissions inventory reporting.

Highlights of her project experience include:

- Assisted companies in the consumer products and food industries in evaluating and implementing compliance with California Proposition 65 requirements.
- Worked with commercial laboratories to develop sample preparation and modifying analytical methods for testing consumer products.
- Managed a group of personnel dedicated to ensuring data quality through project planning, data collection, analysis, verification and reporting for environmental projects.
- Worked with project teams to coordinate laboratory services, perform data validation, perform statistical trend analyses, evaluate laboratory capabilities, prepare cost estimates, and provide analytical sampling advice to project teams.
- Managed groundwater monitoring and water sampling projects for industrial and oil and gas clients. Tasks included technical writing for report deliverables and preparation of sampling and analysis plans, quality assurance project plans and other quality assurance/quality control (QA/QC) documents and reports. chemical
- Provided chemistry support for the refinery-wide groundwater monitoring program and groundwater monitoring projects for a former chemical company plant and pond sites in Richmond, California. Responsible for all aspects of data management and ensuring QC including coordinating with the analytical laboratory, validating data, uploading data to the Environmental Information Management (EIM) database, and working with the database administrator for the chemical SQL database.
- Provided chemistry support for a historical crude oil pipeline project by validating data, writing data usability summaries, and assisting with QA/QC tasks.
- Managed a compliance database tool used to track health and safety and environmental regulatory compliance items for projects. Wrote and maintained revisions to the project health and safety plan and assisted in preparing for client health and safety and regulatory compliance audits.
- Provided technical support for a variety of chemically impacted sites, including the investigation, monitoring and/or remediation of chlorinated solvents, petroleum products, pesticides and PCBs, rocket-fuel components (perchlorate and hydrazines) and chromium VI in the subsurface and groundwater.
- Analyzed and presented chemical and human health and ecological risk data in remedial investigation reports for sites located at Vandenberg Air Force Base.
- Managed over $750,000 of analytical chemistry and third-party data validation subcontracting services and labor budgets between $5,000 and $50,000 and ensured project schedules were met.
- Wrote QA project plans for the Air Force Center of Environmental Excellence (AFCEE), Army Corps of Engineers (USACE) and United States Environmental Protection Agency (USEPA) projects, including CERCLA and RCRA sites.
- Reviewed and validated data under the following analytical and validation protocols: USEPA CLP, USEPA SW-846, USEPA Drinking Water, USACE and AFCEE. Ensured data met the project data quality objectives (DQOs) and produced summary reports of data for final reports. Wrote health and safety plans for federal projects and assisted with field sampling.

Prior to joining Ramboll, Kristin worked in laboratories where she:

- Developed and implemented a quality assurance program to monitor and maintain the quality of laboratory performance for a water treatment laboratory, created control charts and monitored the results of quality control samples, customized laboratory information management system computer software, oversaw analysis of USEPA performance evaluation samples, maintained a log of non-compliance/corrective action reports, created and revised standard operating procedures.
- Extracted environmental samples by certified USEPA methods for analysis by gas chromatography (GC), GC/mass spectrometry (MS) and high performance liquid chromatography; analyzed samples for pesticides, PCBs and herbicides using USEPA methods SW8081, SW8082, and SW8151; and performed instrument calibration and maintenance, prepared analytical standards, participated in method development and prepared analytical reports.
- Researched pesticide-soil dynamics, performed experiments with newly developed pesticides, used radioactive ^{14}C to facilitate experiments, operated laboratory equipment, analyzed experimental data using statistical and graphing computer software, prepared data to submit for publication.
- Assisted scientists with pesticide and environmental research, prepared chemical reagents and standard for experiments, trained personnel on laboratory safety, ordered supplies and equipment, organized stock room and maintained chemical use, performed library research.

PUBLICATIONS & PRESENTATIONS

S.K. Pappiernik, W.C. Koskinen, L. Cox, P.J. Rice, S.A. Clay, R.A. Werdin and K.A. Norberg. Vadose Zone J. Effect of Variability of subsurface Soil Properties on Sorption-Desorption of Imidicloprid and its Metabolites, 2006.

T. Berglof, W.C. Koskinen, M. Duffy, K.A. Norberg, H. Kylin, Metsulfuron Methyl Sorption- Desorption in Field Moist Soils. J. Agric. Food Chem., 51:3598-3603, 2003.

W.C. Koskinen, A.M. Cecchi, R.H. Dowdy and K.A. Norberg, Adsorption of Selected Pesticides on a Rigid PVC Lysimeter. J. Environ. Qual. 28:732-734, 1999.

Appendix C
Community Air Monitoring Plan

Community Air Monitoring Plan

Hunts Point Former MGP - Parcel C

Recipient:	**Con Edison of NY**
Document type:	**CAMP**
Version:	**1**
Date:	**April 2024**

Contents

<u>Appendices</u>

1. Introduction

On behalf of Consolidated Edison Company of NY, Inc. (Con Edison), this Community Air Monitoring Plan (CAMP) has been prepared by Ramboll Americas Engineering Solutions, Inc. (Ramboll) to support off-Site supplemental remedial investigation (RI) activities for the Hunts Point former Manufactured Gas Plant (MGP; the "Site"). The Site is currently identified by the New York State Department of Environmental Conservation (NYSDEC) under a Voluntary Cleanup Agreement (VCA) index number of D2-0003-02-08. This CAMP has been devised in accordance with the New York State Department of Health (NYSDOH) Generic CAMP (**Appendix 1A**).

For investigation purposes, portions of the Site have been divided into parcels (Parcels A through F) and other properties. An Off-Site Supplemental Remedial Investigation Workplan (Off-Site RI Work Plan) was submitted to the NYSDEC in July 2014 to investigate areas located in Parcel C. Parcel Site C is primarily occupied by a warehouse / beverage distributor (Anheuser-Busch) and associated parking areas. Previous investigations have identified potential MGP-related impacts in surface water / sediment in the East River adjacent to the Site. The Off-Site RI Work Plan will evaluate upland areas and will involve utility clearance work, outfall video inspections and drilling soil borings. This CAMP provides the procedures for conducting real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter the Site's designated work area during ground invasive activities such as drilling and utility clearance work involving air knifing or soft-digging. 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., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne releases as a direct result of the drilling 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 potentially MGP-impacted vapors or particulates off-site through the air. Reliance on the CAMP should not preclude simple, common-sense measures to keep VOCs, dust, and odors at a minimum around the work areas.

This NYSDOH CAMP is a stand-alone companion document to the Site-specific health and safety plan (HASP) and is further defined below. The Site-specific HASP provides details related to health and safety for Site activities for Ramboll personnel and the CAMP details air monitoring activities to protect the surrounding community.

2. Air Monitoring

2.1 Particulate Air Monitoring

Particulate monitoring will be conducted during ground intrusive activities at the Site in accordance with the *Fugitive Dust and Particulate Monitoring from DER-10 Technical Guidance for Site Investigation and Remediation* (**Appendix 1B**). Dust and particulate monitoring will be conducted near the approximate upwind and downwind perimeters of the exclusion zone, when possible, or where dust generating operations are apparent. Dust monitoring may be suspended during periods of precipitation or snow cover.

Particulate air monitoring will be conducted with a TSI DUSTTRAK DRX Dust/Aerosol Monitor (or a similar device). This instrument is equipped with an audible alarm (indication of exceedance) and is capable of measuring particulate matter less than 10 micrometers in size (PM-10). It will continually record emissions (calculating 15-minute running average concentrations) generated during field activities. The dust monitoring devices will be checked and recorded periodically throughout the day of intrusive activities to assess emissions and the need for corrective action.

2.2 Volatile Organic Compounds

Air monitoring for VOCs will be conducted in conjunction with the particulate air monitoring. VOC air monitoring will be conducted using a RAE Systems MuliRae (or a similar device) to provide real-time recordable air monitoring data. VOC monitoring will be conducted for ground intrusive (continuous monitoring) and non-intrusive activities (periodic monitoring).

- **Continuous monitoring** for total organic vapors and particulates will be performed during ground intrusive activities, including drilling and utility clearance work that involves air knifing or soft-digging.

- **Periodic monitoring** for total organic vapors will be performed during non-intrusive activities such as soil logging, video inspections of the outfalls, or utility clearance work that does not involve air knifing or soft-digging (i.e., Ground Penetrated Radar surveying).

VOCs will be monitored and recorded at the downwind perimeter of the immediate work area. Upwind concentrations will be measured before field activities commence and periodically throughout the day to establish background conditions. The downwind VOC monitoring device will also be checked periodically throughout the day to assess emissions and the need for corrective action.

2.3 Special Requirements for Work Within 20 Feet of Potentially Exposed Individuals or Structures

When work areas are within 20 feet of potentially exposed populations or occupied structures, the continuous monitoring locations for VOCs and particulates must reflect the nearest potentially exposed individuals and the location of ventilation system intakes for nearby structures. The use of engineering controls will be considered to prevent exposures related to the work activities and to control dust and odors if they are identified. The structures which fall under this are specifically located within the

Anheuser Busch parcel. An additional CAMP station will be placed adjacent to the opposite side of the wall of the occupied structure or next to an intake vent, whichever is closer.

In the event VOC concentrations at this additional CAMP station exceeds 1 part-per-million, monitoring should occur within the occupied structure(s). Contamination within the Site consists of coal tar or purifier bed material.

If MGP impacted material is identified, monitoring would include VOCs utilizing a photoionization detector (PID). If total particulate concentrations at the additional CAMP station exceeds 150 micrograms per cubic meter, work activities should be suspended until controls are implemented and are successful in reducing the total particulate concentration to 150 micrograms per cubic meter or less at the monitoring point.

3. Alert and Action Levels

VOCs will be monitored downwind of daily activities on a continuous basis. The equipment used for monitoring for VOCs will be calibrated daily and will be set up to log 15-minute running average concentrations. Particulates will also be monitored at the upwind and downwind perimeters. Instruments capable of detecting matter less than 10 micrometers in size and to measure the average PM_{10} levels over 15 minutes or less will be used. Visual dust will also be monitored and documented, if encountered. Upwind / background ambient dust levels and VOC concentrations will be established at the start of each workday.

The following Table 1-1 summarizes action levels and responses for VOC and particulate monitoring:

Table 1-1. CAMP – Action Levels and Responses

Action Levels	Responses
Downwind ambient air exceeds 5 ppm above background for 15 minutes but returns to below 5 ppm after pausing work	Work activities can continue.
Downwind Ambient air concentrations exceed 5 ppm but are less than 25 ppm	**Work must be stopped to determine source of emissions**. Corrective actions must be taken to abate the emissions. Work can resume only if the VOC concentrations are less then 5 pp, 200 feet from the nearest residential or commercial structure OR VOC concentrations are 5ppm or less halfway between the work zone and nearest sensitive receptor.
If VOC are detected above 25 ppm at perimeter of work zone	**Work must stop, work approach will be reevaluated.**
Downwind PM_{10} particulate levels are 100 micrograms per cubic meter are greater than the ambient levels for 15 minutes or if airborne dust is observed	Work may continue with the use of particulate suppression techniques (e.g., water spraying or utilize dust suppression systems).
Downwind levels are greater than 150 micrograms per cubic meter even with the use of suppression technologies	**Work must be stopped to re-evaluate the source and the activities being performed.** Work can resume once suppression measures and other controls are successful in reducing PM_{10}.

4. Reporting Requirements

4.1 General

Recorded monitoring data will be logged daily and will be submitted to the NYSDEC and NYSDOH for review with the next remedial phase report, or earlier if requested. These logs will contain:

- Date and day of the week
- General location and description of work performed
- Daily weather conditions (wind direction and speed, high and low temperatures, humidity, precipitation)
- Average concentrations and max 15-minute TWA concentrations of total VOCs and PM_{10}
- If applicable, exceedances of total VOCs and PM_{10}
- A copy of any exceedance report(s)
- Odor complaints if any are received

4.2 Exceedance Reports and Notification

Con Edison will notify the NYSDEC and NYDOH within two hours via email or phone call if VOC or PM_{10} action levels are exceeded during the project. Within 24 hours of the exceedance, an exceedance report will be prepared and submitted to the NYSDEC and NYSDOH. The exceedance report will include the following:

- Date and day of the week, time, and duration of the exceedance
- Air monitoring station where the exceedance occurred
- General location and description of work performed at the site at the time of the exceedance
- Weather conditions at the time of the exceedance
- The 15-minute TWA concentration of VOCs and PM_{10} at all stations at time of exceedance
- Source or cause of exceedance
- Corrective actions taken or will be taken in response to the exceedance
- Record of date and time verbal or written notice was provided to the NYSDEC and NYDOH

5. Meteorological Data

Meteorological data collected from a nearby weather station with publicly available records will be documented at the start of each workday and periodically thereafter to establish background conditions, particularly if wind direction changes. The meteorological data to be documented consists of wind speed, wind direction, temperature, barometric pressure, and relative humidity. Wind direction measurements will be utilized to position the total organic vapor and particulate monitoring equipment in appropriate upwind and downwind locations.

Appendix 1A
New York State Department of Health
Generic Community Air Monitoring Plan

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., off-site receptors including residences and businesses and on-site 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 off-site 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

Volatile organic compounds (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.

December 2009

Appendix 1B
Fugitive Dust and Particulate Monitoring

A program for suppressing fugitive dust and particulate matter monitoring at hazardous waste sites is a responsibility on the remedial party performing the work. These procedures must be incorporated into appropriate intrusive work plans. The following fugitive dust suppression and particulate monitoring program should be employed at sites during construction and other intrusive activities which warrant its use:

1. Reasonable fugitive dust suppression techniques must be employed during all site activities which may generate fugitive dust.

2. Particulate monitoring must be employed during the handling of waste or contaminated soil or when activities on site may generate fugitive dust from exposed waste or contaminated soil. Remedial activities may also include the excavation, grading, or placement of clean fill. These control measures should not be considered necessary for these activities.

3. Particulate monitoring must be performed using real-time particulate monitors and shall monitor particulate matter less than ten microns (PM10) with the following minimum performance standards:

(a) Objects to be measured: Dust, mists or aerosols;
(b) Measurement Ranges: 0.001 to 400 mg/m3 (1 to 400,000 :ug/m3);
(c) Precision (2-sigma) at constant temperature: +/- 10 :g/m3 for one second averaging; and +/- 1.5 g/m3 for sixty second averaging;
(d) Accuracy: +/- 5% of reading +/- precision (Referred to gravimetric calibration with SAE fine test dust (mmd= 2 to 3 :m, g= 2.5, as aerosolized);
(e) Resolution: 0.1% of reading or 1g/m3, whichever is larger;
(f) Particle Size Range of Maximum Response: 0.1-10;
(g) Total Number of Data Points in Memory: 10,000;
(h) Logged Data: Each data point with average concentration, time/date and data point number
(i) Run Summary: overall average, maximum concentrations, time/date of maximum, total number of logged points, start time/date, total elapsed time (run duration), STEL concentration and time/date occurrence, averaging (logging) period, calibration factor, and tag number;
(j) Alarm Averaging Time (user selectable): real-time (1-60 seconds) or STEL (15 minutes), alarms required;
(k) Operating Time: 48 hours (fully charged NiCd battery); continuously with charger;
(l) Operating Temperature: -10 to 50^{o} C (14 to 122^{o} F);
(m) Particulate levels will be monitored upwind and immediately downwind at the working site and integrated over a period not to exceed 15 minutes.

4. In order to ensure the validity of the fugitive dust measurements performed, there must be appropriate Quality Assurance/Quality Control (QA/QC). It is the responsibility of the remedial party to adequately supplement QA/QC Plans to include the following critical features: periodic instrument calibration, operator training, daily instrument performance (span) checks, and a record keeping plan.

5. The action level will be established at 150 ug/m3 (15 minutes average). While conservative,

this short-term interval will provide a real-time assessment of on-site air quality to assure both health and safety. If particulate levels are detected in excess of 150 ug/m3, the upwind background level must be confirmed immediately. If the working site particulate measurement is greater than 100 ug/m3 above the background level, additional dust suppression techniques must be implemented to reduce the generation of fugitive dust and corrective action taken to protect site personnel and reduce the potential for contaminant migration. Corrective measures may include increasing the level of personal protection for on-site personnel and implementing additional dust suppression techniques (see paragraph 7). Should the action level of 150 ug/m3 continue to be exceeded work must stop and DER must be notified as provided in the site design or remedial work plan. The notification shall include a description of the control measures implemented to prevent further exceedances.

6. It must be recognized that the generation of dust from waste or contaminated soil that migrates off-site, has the potential for transporting contaminants off-site. There may be situations when dust is being generated and leaving the site and the monitoring equipment does not measure PM10 at or above the action level. Since this situation has the potential to allow for the migration of contaminants off-site, it is unacceptable. While it is not practical to quantify total suspended particulates on a real-time basis, it is appropriate to rely on visual observation. If dust is observed leaving the working site, additional dust suppression techniques must be employed. Activities that have a high dusting potential--such as solidification and treatment involving materials like kiln dust and lime--will require the need for special measures to be considered.

7. The following techniques have been shown to be effective for the controlling of the generation and migration of dust during construction activities:

(a) Applying water on haul roads;
(b) Wetting equipment and excavation faces;
(c) Spraying water on buckets during excavation and dumping;
(d) Hauling materials in properly tarped or watertight containers;
(e) Restricting vehicle speeds to 10 mph;
(f) Covering excavated areas and material after excavation activity ceases; and
(g) Reducing the excavation size and/or number of excavations.

Experience has shown that the chance of exceeding the 150ug/m3 action level is remote when the above-mentioned techniques are used. When techniques involving water application are used, care must be taken not to use excess water, which can result in unacceptably wet conditions. Using atomizing sprays will prevent overly wet conditions, conserve water, and provide an effective means of suppressing the fugitive dust.

8. The evaluation of weather conditions is necessary for proper fugitive dust control. When extreme wind conditions make dust control ineffective, as a last resort remedial actions may need to be suspended. There may be situations that require fugitive dust suppression and particulate monitoring requirements with action levels more stringent than those provided above. Under some circumstances, the contaminant concentration and/or toxicity may require additional monitoring to protect site personnel and the public. Additional integrated sampling and chemical analysis of the dust may also be in order. This must be evaluated when a health and safety plan is developed and when appropriate suppression and monitoring requirements are established for protection of health and the environment.

Appendix D
Health and Safety Plan

Prepared for:
Con Edison of NY

Prepared By:
Ramboll Americas Engineering Solutions, Inc.
Princeton, New Jersey

Date:
January 2024

HEALTH AND SAFETY PLAN (HASP)

HUNTS POINT FORMER MGP SITE
550 FOOD CENTER DRIVE
HUNTS POINT, THE BRONX, NEW YORK

CONTENTS

ATTACHMENTS

1. INTRODUCTION

Project Name:	Hunts Point Former MGP Site	**Ramboll Project Officer:**	Tim Olean (508)-359-6960
Project Number:	TBD	**Ramboll Project Manager (PM):**	William Moore (732)-638-2939
HASP Title:	Site-Specific Health and Safety Plan	**Ramboll Site Supervisor:**	Matt Miller (856)-515-0721
HASP Revision Date:	**Initial January 2024**	**Ramboll Site Safety Leader:**	TBD
HASP Prepared By:	Andrea Felice / Ramboll	**Client Name:**	Con Edison of NY
Client Contact:	Melissa Abt 718-201-4331 Abtm@coned.com	**Subcontractor Company Name:**	ACS (GPR Survey and Outfall Inspection) Driller – TBD
Project Location:	550 Food Center Drive Hunts Point, The Bronx, NY 10474	**Subcontractor Project Manager:**	ACS: Jo Schimke (203-544-7190)
Project Phone No.:	N/A	**Subcontractor Superintendent:**	TBD
Project Fax No.:	N/A	**Sub Safety Competent Person:**	N/A
Scope of Work covered by this HASP (identify subcontractors covered by this HASP)	The Site was a former MGP that ceased operations in the 1960's. A portion of the former MGP property was subdivided into parcels (A through F) for Site cleanup purposes. This investigation focuses on Parcel C, which is located on the eastern portion of the former MGP Site. Parcel C is primarily occupied by a warehouse / beverage distributor (Anheuser-Busch) and associated parking areas. Previous investigations have identified potential MGP-related impacts in surface water / sediment in the East River adjacent to the Site. This Scope of Work is being performed to evaluate the presence of potential upland MGP-related compounds affecting surface water and sediment quality. The Scope of work includes the following activities (further discussed in the Field Sampling Plan [FSP]): • A geophysical survey of the Site to identify subsurface utilities. • A closed-circuit TV (CCTV) of Outfall No. 4, which located on-Site and discharges to the East River. The outfall pipe will be accessed via an upland, accessible manhole or from the outfall at low tide (when the pipe is not submerged in water). • Installation and soil logging of approximately seven soil borings via Rotosonic drilling technology. At the soil boring location, a vacuum operated soft-dig excavator will be used to excavate small diameter holes (approximately two feet by two feet in diameter) to ten feet bgs. • Installation of groundwater monitoring wells if dense non-aqueous phase liquid (DNAPL) is identified in the soil borings. The monitoring wells will be surveyed by a licensed surveyor after installation. • Investigation Derived Waste (IDW) management: Solid IDW will include used PPE, sample tubing, used gloves and other disposable materials that may have potential come in contact with contaminated soil or groundwater. Liquid IDW will include decontamination and well development water. The IDW will be containerized in separate		

	clean, unused 55-gallon drums. The IDW drums will be transported by a licensed and Con Edison approved waste hauler and disposed of at a Con Edison approved Treatment, Storage and Disposal Facility (TSDF).
References **(existing safety plans, manuals, spec's, etc.)**	**Ramboll HSE Manual; State/Fed regulations/policies.**
Key Hazards **(focus on highly hazardous tasks)**	Possible direct contact with contaminated soil and/or groundwater. Working near water. Manual lifting and physical strain. Pinch points from use of hand tools. General traffic concerns – struck by/caught in between. Heat and/or Cold Stress and inclement weather. Biological hazards – seasonal poisonous plants, ticks, spiders, snakes. Potential security issues associated with unmonitored areas in Urban areas.
No Smoking Policy	Under any circumstances, no smoking is allowed on the project Site. Smoke breaks, if absolutely necessary, must be taken at a safe distance from the project Site at a location that is discussed and agreed to during the pre-work briefing.

2. CLOSE CALLS/NEAR MISS REPORTING PROGRAM

Close Calls/Near Misses	A **near miss** is an unplanned event that did not result in injury or illness but had the potential to do so. This notification could also be used to document **unsafe behaviors**. Preparation of a near miss report that can lead to important improvement in safety policies and procedures, training, equipment, or "Lessons Learned" that can be distributed to others. Ramboll Americas HSS staff will support the review and preparation of Near Miss Notifications but rely on people at the scene to make good observations.
Near Miss Reporting Procedures	The following is the general sequence of events that is expected after observing a Near Miss: • Observe a Near Miss: Consider if the event meets the definition of a near miss. Unsafe conditions (by themselves) do not meet the definition of a near miss but should be corrected by the person who observed the unsafe condition if possible or at least reported to area management so that the unsafe condition may be corrected by others. • Notify Supervisor of a Near Miss: The supervisor responsible for the work area should be verbally notified of a near miss immediately. This will allow the implementation of corrective actions that might be necessary to minimize the risk of injury until applicable long-term corrective actions (if any) are completed. • Submit a Near Miss Report: Submit an Ramboll Near Miss Report immediately following the workday (see Attachment 1). Corporate H&S will investigate near misses to the extent warranted by the type of hazard and complexity. The investigation will be conducted jointly with the witness and others involved. Contributing factors will be identified along with appropriate corrective actions. Lessons learned will be developed for those near misses which have value from an organizational learning perspective. • Complete Corrective Actions: Appropriate corrective actions will be identified to prevent the reoccurrence of similar near misses in the future. Corrective actions may include short-term "interim" preventative measures that can be implemented quickly to prevent re-occurrence such as stopping work, erecting temporary barricades, conducting air monitoring, replacing worn equipment, etc. As the near miss is investigated, long-term corrective actions which result in systemic improvements include procedure changes, training improvements, design changes, permanent safety guards, etc.

3. DRUG AND ALCOHOL PROGRAM

Drug and Alcohol Policy	Ramboll is committed to maintaining a safe and healthy work environment for its employees, its clients, and the community. Consistent with this commitment, the following is prohibited on Ramboll property, including Company vehicles, and at Ramboll project sites: • The manufacture, distribution, dispensing, possession, sale, purchase, or use of a controlled substance. • Being legally intoxicated or under the influence of illegal drugs. • The unauthorized use or possession of prescription or over-the-counter drugs. Employees are required to abstain from alcohol for a minimum period of four hours prior to any work shift in which safety-sensitive activities will be performed or may reasonably be anticipated. Drug and alcohol testing may be performed in accordance with the Ramboll Employee Handbook. Ramboll maintains a confidential employee assistance program (EAP). Employees who test positive for a controlled substance or who are experiencing a problem with alcohol abuse will be given an opportunity to participate in the EAP or another substance abuse program approved by the Human Resources department. See Ramboll ’s H&S Manual for additional information.

4. HEARING CONSERVATION

Hearing Conservation	Ramboll implements a hearing conservation program to manage noise exposures following 29 CFR 1910.95, Occupational Noise Exposure and 29 CFR 1926.52, Occupational Noise Exposure and 29 CFR 1926.101 Hearing Protection. Feasible engineering or administrative controls will be utilized to reduce excessive sound level exposure to acceptable levels. • Engineering controls include properly designed enclosures around equipment, barrier walls, stack silencers, changing fan types, equipment mufflers, etc. • Administrative controls include proper maintenance of equipment and rotating employees through high noise areas for short periods of time to keep their average exposure below 85 dBA. However, the Company does not allow management or employees to solely rely on worker rotation and associated “stay times” at different noise levels to reduce employee exposures. • When engineering and administrative controls are not feasible to reduce noise exposures below 85 dBA, Hearing Protection Devices (HPDs) will be provided and will be required to be worn by employees to reduce exposure to excessive sound levels. Noise monitoring may be conducted for extremely high noise areas to ensure that HPDs are adequate or may be performed to assess the effectiveness of noise controls such as mufflers or barrier walls. Areas where noise levels are consistently above 85 dBA will be posted to require HPDs upon entry into those areas. Ramboll maintains an Audiometric Testing Program for Affected Employees that includes audiometric testing and subsequent review audiograms compared to an employee’s initial (baseline) audiogram. See Ramboll’s H&S Manual for additional information and training. Noise generating activities will comply with applicable New York City noise ordinance regulations.

5. JOB BRIEFINGS/SAFETY MEETINGS

Pre-Task Safety Meeting Procedures	Safety meetings will be held with all project personnel in attendance to review the hazards, controls, and required procedures that apply for each day's activities. Everyone involved in the day's work needs to sign a sign-in form to show they've had a briefing/attended a meeting. A copy of the pre-work briefing acknowledgement template is included in Attachment 2.	
Con Edison's "Rules We Live by"	See Attachment 3 for Con Edison's "Rules We Live By" (RWLB). The RWLB will be reviewed as part of the Job Briefing. A violation of the RWLB will result in significant consequences. Any employee who witnesses a violation of a Rule We Live By and does not stop the work and report the violation will also be considered to have violated the Rule.	
Pre-Work Documentation & Certifications **(NOTE - Insert any additional training requirements identified in the body of the HASP.)**	**Documentation and Certifications**	**To Be Submitted or Provided By…….**
	☐ Drug Testing (☐ alcohol testing is also required)	
	☒ Project Safety Plan or Job Safety Analysis (HASP)	Ramboll
	☐ Client/Facility Contractor Safety Orientation	
	☒ Project Safety Orientation (HASP Review)	Ramboll
	☒ Daily Safety Meetings (Daily Pre-Task Planner)	Ramboll
	☐ Verification of Hazwoper Medical Surveillance	
	☒ OSHA 40-hr Hazwoper w/ current 8-hr Refresher	Ramboll
	☐ Respirator Training, Fit Test, and Resp. Medical	
	☐ Confined Space Entry Certification (necessary for permit-required entry or non-permit designations)	
	☐ Excavation Competent Person designation	
	☐ Heavy Equipment "Acceptance Inspections"	
Permits & Inspections applicable to scope of work	☐ Confined Space Entry Permit ☐ Hot Work Permit	☐ Daily Excavation Inspection Checklist ☐ Daily Heavy Equipment Inspection Checklist
	☐ Energized Electrical Work Permit	☐
Individuals must sign the "Pre-Work Briefing" form on the last page after reviewing this HASP.		

6. CHANGE MANAGEMENT

Change Management Procedures	This document discusses the physical, chemical, and biological hazards associated with scoped activities. However, unanticipated site-specific conditions or situations might occur during the implementation of the work. Also, contractors may elect to perform certain tasks in a manner that is different from what was originally intended due to a change in field conditions. As such, this HASP must be considered a working document that is subject to change as field conditions and planned activities change. Should significant information become available regarding potential on-site hazards, it will be necessary to modify this HASP, via a HASP revision or addenda to the HASP. A revised HASP or addenda shall be distributed during the daily safety meeting so that they can be reviewed, discussed and appropriate signatures will be obtained. The Ramboll Project Manager will notify the Con Edison Authorized Representative of any change in working conditions that could affect compliance with environmental or health and safety requirements as soon as the changed conditions are identified. An example of change in conditions can include, but is not limited to the following: • Weather conditions that could affect worker safety. • Unexpected changes in the scope of the project. • Increasing or decreasing the levels of personal protective equipment. The Ramboll Project Manager will identify the contingencies they have prepared for managing change. Appropriate precautions prior to implementing any contingencies prepared to manage change. Precautions can include the following: • Increasing or decreasing the levels of personal protective equipment. • Taking special safety precautions to deal with unsuspected conditions (for example, unanticipated confined space conditions). • Planning for inclement weather. • Identifying the potential for environmental permits due to changing field conditions. All personnel shall be appropriately trained to perform their job function under the changed conditions prior to being allowed to work under the changed conditions. Ramboll’s subcontractors will be held to the management of change procedures outlined by Ramboll.

7. PERSONAL PROTECTIVE EQUIPMENT (PPE) SUMMARY

Personal Protective Equipment (PPE) Summary	*(additional safety equipment may be required for specific hazards identified in the following sections)* ☒ Hard Hat (If overhead hazards exist) ☒ Safety Glasses ☒ Safety Shoes ☒ Cut-Resistant Glove (Job Task Specific) ☒ Ear Protection (during drilling activities) Other (specify): ☒ High Visibility Vests (required for work on roads and in many construction & remediation sites) ☒ Ear Protection (heavy equipment, loud power tools, etc.) ☐ Fall Protection Harness & Lanyard (falls >6') ☐ Respiratory Protection (☐ N95 dust mask, ☐ half face, ☐ full-face) Specify cartridge in HASP. ☐ Tyvek or other chemical protective coverall: ____ ☒ Face Shield and chemical goggles for chemical handling, line breaks, pressure washing ☒ Nitrile Gloves (☒ Surgical Type and/or ☐ "Dishwashing" Type) Fall protection, respiratory protection and / or elevated PPE are not anticipated for this Scope of Work. Additional PPE protocols will be implemented as part of change management as needed. **See Ramboll's PPE and Safety Equipment Guideline for additional guidance (Attachment 4).**

8. RIGHT TO STOP UNSAFE WORK AND TIME OUT PROGRAM

Right to Stop Unsafe Work	All project personnel have the right, and obligation, to stop tasks which they believe to be unsafe or notify their supervisor of unsafe work tasks for which they believe inadequate safety precautions have been implemented. The Ramboll Site Safety Leader (SSL) will communicate this responsibility to all project personnel.
Calling a Time Out	See Stop Work Authority in Attachment 5 for Ramboll’s guidance on calling a time out. These procedures will be followed during the Scope of Work implementation.

9. VEHICLE MANAGEMENT

Vehicle Safety Program	Ramboll implements a vehicle safety program that applies to all Company Drivers and requires the full cooperation of each Driver to operate their vehicle safely and to adhere to the responsibilities outlined in the Vehicle Safety Program. See Attachment 6 for a copy of the Vehicle Safety Program from Ramboll's H&S Manual.

10. WASTE MANAGEMENT

Waste Management	Solid Investigation Derived Waste (IDW) will include used PPE, sample tubing, gloves, PVC piping and other disposable materials that may have potential come in contact with contaminated soil or water. Liquid IDW will include sampling purge water and decontamination water. The IDW will be containerized in separate clean, unused 55-gallon drums. Drums will be staged in a designated area; and will be labeled appropriately. See Ramboll's Safe Lifting and materials Handling Guidance (Attachment 7).

11. ACTIVITY HAZARDS ANALYSIS

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
ELEVATED WORK		
☒ NA	FALLS > **6'** or within **15'** of a ROOF OR MEZZANINE EDGE where the fall is >6' OR at **any height** when working above dangerous machinery, a drowning hazard, exposed rebar (impalement) or similar hazard.	☐ Existing Guardrails ☐ Hole Covers Marked "HOLE" ☐ Temporary Guardrails ☐ Fall Restraint ☐ Warning Line 15' from Edge ☐ Fall Arrest w/ harness/lanyard (**identify tie-off points**) ☐ Aerial Lifts used for elevated work - Refer to the "*Heavy Equipment*" section of this HASP. ☐ Areas below elevated work will be protected to prevent entry by unauthorized personnel (describe how this will be accomplished in "Comments") ☐ Process machinery or equipment onto which persons may fall are locked out. Refer to the "Lockout-Tagout/Electrical" section of this HASP. **FALL PROTECTION COMMENTS (describe equipment used):**
☐ NA	LADDERS / STAIRS ☐ Extension Ladders ☐ Step Ladders ☐ Fixed Ladders ☒ Stairs	☐ Employees training in safe ladder use at toolbox safety meeting ☐ Extension ladders are properly footed, secured at top, and setup at proper angle ☐ Stepladders are set on level ground or properly shimmed with spreaders locked. ☒ Stairs have proper rise over run and stairs >4 steps or 4' have guardrails. **LADDERS/STAIRS COMMENTS:** Minimal Stairs at project site; handrails in place. **Hold both railings when ascending/descending stairs. Carry items in a bag or backpack to have hands free.**
EXCAVATIONS / TRENCHING		
☐ NA	☐ Max Depth ≥ 20' ☒ Max Depth ≥ 5' ☐ Max Depth <5' with potential cave-in hazard ☐ Potential permit-required confined space at depth ≥ 4' ☒ Underground utilities ☒ Structures/foundations ☐ Falls into excavations ☒ Other: Appx. 2' x 2' diameter soft-dig to 10' bgs	☐ Sloping & shoring for excavations ≥**20'** are approved by a professional engineer ☒ Sloping & shoring for excavations ≥**5'** when persons are exposed to cave-in. (specify below) ☐ Sloping & shoring for shallow **(<5')** excavations with cave-in hazard (specify below) ☐ Excavations ≥ **4'** are classified as a **non-permit confined space** ☐ Excavations ≥ **4'** are classified as **Alternate Entry** or **Permit-Required** – Refer to "Confined spaces" section of HASP. ☒ **Underground utilities** have been identified and marked per Ramboll's Subsurface Utility Clearance Guidance (Attachment 8). ☒ **Local "dig safe"** organization will be notified for utility locations in public areas or rights of way. Number: ______TBD______________________ Date: ________________ ☐ **Hand digging** within **3'** of utility locations. ☒ Excavations are protected by **perimeter fencing** (not barricade tape): (☐ rigid fence - chain link or wood ☒ safety fence 6' from edge.) **EXCAVATION COMMENTS:** A vacuum operated soft-dig excavator will be utilized to perform small diameter (approximately 2 feet by 2 feet) excavations to 10 feet bgs to look for subsurface utilities that my have not been identified during the GRP survey. No personnel will enter the excavations. It is not anticipated that the excavation will

HAZARD		**HAZARD CONTROLS (check all that apply and comment as required)**
		be left open overnight. In the event that excavations do need to be left open, the excavation will be covered by a steel plate and fencing secured.
CONFINED SPACES		
☒ NA	☐ No Serious Hazards ☐ Toxic Atmosphere ☐ carbon monoxide ☐ hydrogen sulfide ☐ ☐ Flammable Atmosphere ☐ Low Oxygen ☐ Combustible dust ☐ Drowning - high water level or potential for sudden changes in flow or level ☐ Other Serious Hazard:	☐ Confined space is altered so that it is no longer a confined space. (describe below) ☐ Confined space is downgraded to a non-permit confined space. (identify which spaces below) ☐ Alternate Entry is used. (Identify which space qualify for confined space entry below) ☐ Full permit-required confined space entry is used due to presence of serious hazards. ☐ Rescue team has been notified (☐ Paid FD ☐ Volunteer FD ☐ Plant Rescue) Rescue Team:_______________________________ Phone Number: _____________________ ☐ All entrants and attendants for Alternate Entry and Permit-Required Entry have confined space entry training. ☐ LOTO is required to make conditions safe for entry (Describe in Lockout-Tagout/Electrical) ☐ Refer to "Manual Lifting" section of this HASP for manhole cover removal safety. **CONFINED SPACE COMMENTS:**
LOCKOUT TAGOUT (LOTO)		
☒ NA	Maintenance, construction, or modification of processes and equipment with POTENTIAL UNEXPECTED RELEASE OF ENERGY. Identify energy types: ☐ Electrical ☐ Pressurized liquid piping ☐ Compressed gas / steam ☐ Moving Parts (conveyors, chains, belts, fans, shafts) ☐ Hydraulic systems ☐ Chemical release ☐ Describe Equipment requiring lockout:____________________	**Designate Persons Responsible for Overseeing Ramboll's LOTO activities:** ☐ Qualified LOTO Coordinator (MANDATORY):____ ☐ Test Supervisor (LOTO Equipment-Under-Test): _____________________________________ ☐ Qualified Electrical Worker (Electrical-Arc Flash): ___________________________________ **Identify or Develop Written Equipment-Specific LOTO Procedure (**☒ at least one)**:** ☐ Equipment owner to lockout equipment using their procedures. ☐ Ramboll operators will de-energize equipment following LOTO procedures integrated into O&M procedures. (Reference procedure in "Comments.") ☐ Ramboll to develop and implement lockout procedures for equipment under Ramboll control using the "Equipment-Specific LOTO Form". (Attach completed LOTO form to HASP.) ☐ LOTO procedures are specified below in "Comments" and are equivalent to LOTO form. **Identify How Locks Will Be Applied (**☒ at least one)**:** ☐ Group lock box will be used with all persons working on equipment attaching their own lock(s) and tag(s). Location of lock box: ____ ☐ Equipment or process components will be individually locked with all persons working on equipment attaching their locks and tags directly on equipment.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
		Specify Other Lock Requirements (☒ at least one):: ☐ Ramboll to apply a "***Company Lock***" to prevent premature startup by owners or subcontractors. Company Locks are NOT intended to replace personal locks for anyone. Specify who is responsible for Company Locks: ______________________________ ☐ Workers will **not** be allowed to work under a supervisor's or another's lock [MANDATORY] **Specify Tags (☒ at least one)::** ☐ "Danger" tags with diagonal red & white stripes (required unless client's specify different) ☐ Client-required tags specific to the site. Describe below in "Comments." ☐ "Company Locks" identified with an "Out of Service" tag and **not** a LOTO tag. [MANDATORY for multi-shift or multi-subcontractor lockouts] **Other LOTO or Electrical Safety Requirements:** ☐ All project team personnel are informed that they may not **remove electrical panels** or otherwise expose energized electrical equipment (unless they are **NFPA 70E** trained and have implemented the required precautions). [MANDATORY] **LOCKOUT COMMENTS:**
OVERHEAD POWERLINES		
☒ NA	OVERHEAD POWER LINES ____________ KV ____________ ft above ground ____________ KV ____________ ft above ground	☐ Request to de-energize lines will be submitted for work within 20' of power lines. Request sent to: ___________________________________ Date: __________________ ☐ No one will be permitted to work <10' to power lines without lines being de-energized. ☐ Project persons are informed of 20' safety zone around energized power lines. ☐ Project persons are informed of additional restrictions when working ≤20' but >10': ☐ Dedicated spotter for all elevated work or operation of equipment that can contact lines ☐ Barricades setup at 20' from base of power lines to establish a "restricted work area." ☐ "Power Line Safety Permit' required to work within 20' of power lines. ☐ Power lines are shielded and/or marked with high visibility material **POWER LINE COMMENTS:**
DRILLING / BORING - All self-propelled rigs including trailer-mounted drilling/boring equipment		
☐ NA	Struck By, Run-Over, Caught In Between (pinch points), Roll Over, Hot Work (open flame) Fluid Leaks ☒ Drilling/Boring Rig: specify type(s) below:	☒ **Qualified persons** operate all drilling/boring equipment. Qualifications were determined by: ☒ Work Experience Summary on company letterhead or email with company email address. ☐ Other (describe): __ ______________________ ☒ Equipment will be **inspected** upon mobilization by: _Subcontracted Driller______________________________.

	HAZARD	HAZARD CONTROLS (check all that apply and comment as required)
	1) Rotosonic Drilling Technology 2) Vacuum operated soft-dig excavator	NOTE - Inspections will include (but not be limited to) the following: leaks, defective safety equipment, and loose/unsecured parts that could fall during operation) ☒ Operators will be reminded of **seatbelt** use by: **Ramboll** ☒ **High visibility vests** are required for: **All site work** ☒ **Cut-resistant gloves** are required when handling cable, rods, and other sharp or "splintery" materials ☒ **Chemical-resistant gloves and clothing** are required while handling grout, cement, chemicals, or contaminated materials including soil or groundwater. (Refer to "Environmental Hazards" section for more information.) ☒ Operators and helpers will maintain a **safe distance** to moving parts. All those working near moving or rotating parts will secure loose hair, clothing, and equipment. All those working near the rods/casings are instructed to not put themselves in a position where they could get hurt if the rods/casings should turn or drop. ☒ Drill rods, casings, and other equipment will be **stored neatly** when not in use and secured to prevent them from falling on, or rolling into, site personnel. ☒ The area will be cleared of **rope, cords, weed-block fabric**, or similar material that could become wrapped around the auger, entangle someone and then pull them into the auger. ☒ **Underground utilities** have been identified and marked. ☒ **Local "dig safe" organization** has been notified for utility locations in public areas or rights of way. Number: ____TBD__________________________ Date: ___________________ ☐ **Hand digging** within 3' of utility locations. ☒ **Soft-dig/vacuum dig** within 3' of utility locations. ☒ Damage to underground utilities will be prevented by **cribbing outriggers** to spread the load or **relocated outriggers** so they are not placed on utilities. ☒ **Fall protection** will be worn whenever (if) the drilling/boring mast must be climbed above 6'. (Tie-off Points are specified: ☐ in "Comments" below ☐ in the "Fall Protection" section) ☒ Masts located within 20' of an **overhead power line** will only be lowered or raised with a dedicated spotter. (Refer to the "Overhead Powerlines" section of this HASP for additional safety precautions) ☒ Drill rigs will only be **moved with masts lowered**. ☒ Masts will be erected with **outriggers fully extended** when equipped with outriggers. ☒ Outriggers will be placed on a **firm, stable surface** or will be cribbed to prevent sinking of outriggers and collapse of the drilling/boring rig. ☐ Drilling on **sloped surfaces** will be conducted such that the drilling/boring equipment remains stable and otherwise in accordance with requirements outlined below in Drilling/Boring comments. ☐ **Tripod-mounted drill rigs** will not be used until **matts** are placed under tripod legs when placed on soil and tripod leg **spacing** is verified to be even to maintain center of gravity.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
		☐ Procedures for responding to **natural gas emissions** (explosive vapors) are: ☐ Outlined in "Comments" below. ☐ Outlined in an attached procedure. ☐ Procedures for drilling/boring from a **barge** or otherwise working over water are: ☐ Outlined in "Comments" below. ☐ in the "Working Over Water" section. ☒ Drilling/boring equipment will be **de-energized and locked-out** prior to maintenance. ☒ Site personnel working in the area surrounding the drilling/boring rig have will be informed where the **emergency shutoff** in the event of an emergency. Specify the location of the shutoff in the "Comments" section below. ☒ **Spill equipment** is available for fuel and hydraulic fluid leaks. Location; __Field vehicle___ **DRILLING/BORING COMMENTS:**
HEAVY EQUIPMENT (other than cranes)		
☒ NA	Struck By, Run-Over, Caught In Between (pinch points), Roll Over, Fluid Leaks ☐ Excavator ☐ Dump Truck ☐ mini Skid Steer (bobcat) ☐ mini Excavator ☐ Gator/Off-Road Vehicle ☐ Forklift–rear counter-weight (indoor & yard) ☐ Forklift–rough terrain/lull ☐ Forklift–powered pallet ☐ Aerial Lift - Scissor Lift ☐ Aerial Lift - Extensible Boom ☐ Aerial Lift - Articulated Boom ☐ Aerial Lift - Vertical Lift ("Genie") ☐ Other: ________________ ☐ Other: ________________	☐ **Qualified persons** operate all **heavy equipment**. Qualifications were determined by: ☐ **Heavy equipment operator** designation on company letterhead or email with company email address. Designation is specific to the types of heavy equipment. ☐ **Forklift certification or license** is specific to the type of lift being operated. ☐ Operators have **aerial Lift certification** specific to the type of lift being operated. ☐ **"Acceptance Inspection"** for heavy equipment upon mobilization documented on an inspection checklist by: ________________________________(Mgmt representative). ☐ **Daily Heavy Equipment Inspections** by Operators documented on an inspection checklist ☐ **Preventative Maintenance** performed on all heavy equipment on site >30 days (required) ☐ Ramboll's "**25' Rule**" to be implemented. Unauthorized persons will be kept at least 25' away from heavy equipment. Persons walking within 25' must get operator's permission. ☐ **Blind spot general precautions** will be implemented as indicated below: • Operators will not operate heavy equipment while persons are in blind spots. • Operators are required to use spotters when obstructions are in blind spots or clearances are otherwise tight. ☐ **Backup precautions** will be implemented. Spotters are required when trucks or other heavy equipment are backing up. Clarify procedure in "Comments" below. ☐ Operators and helpers will maintain a **safe distance to moving parts and potential crush or pinch points** as indicated below: • All those working near moving or rotating parts will secure loose hair, clothing, etc. • All personnel working within 25' of heavy equipment will be instructed to stay clear of pinch or crush points between the load and lift and the lift and fixed objects ☐ **Counterweight swing radius** will be barricaded for excavators, aerial lifts, etc.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
		☐ Operators are required to wear **seatbelts** for all equipment provided with seatbelts. ☐ **High visibility vests** are required for: ____________________________________ ☐ Operators will review manufacturer's safety guidelines for all **equipment operated on slopes** including Gators© and similar ATVs/4x4's. (In the "Comments" section below, specify the maximum slope for each piece of equipment that will be operated on slopes. This may be completed upon mobilization.) ☐ Dump trucks, 4x4's, or other haul vehicles will not be loaded beyond manufacturer **capacities or weight limits** established by state and local authorities for transportation. ☐ **Spotters** are required when trucks or other heavy equipment are backing up. Clarify procedure in "Comments" below. ☐ Operators and helpers will maintain a **safe distance to moving parts**. All those working near moving or rotating parts will secure loose hair, clothing, and equipment. ☐ Fall protection will be worn by all those in **Aerial Lifts** (scissor lifts are excepted: ☐ Yes ☐ NO) ☐ Work area is inspected by operators for **overhead and surface obstructions** prior to use of aerial lifts. ☐ **Areas below aerial lifts** will be protected to prevent entry by unauthorized personnel (describe how this will be accomplished in "Comments") ☒ **Spill equipment** is available for fuel and hydraulic fluid leaks. Location; _Field Vehicle_____ **HEAVY EQUIPMENT COMMENTS:**
POWER TOOLS, HAND TOOLS, EXTENSION CORDS AND OTHER ELECTRICAL SAFETY		
☐ NA	eye injury, hand/arm cuts, electrical shock, strains, foot injuries, dust ☒ Misc Handtools (shovels, hammers, trowels, etc.) ☐ Chainsaws (Clearing & Grubbing) ☒ Sharp hand-tools (knives, cutters, scissors) ☐ Electrofishing (Fish Shocking) Equipment ☐ Hand Augers - Iwan or Spiral type	☒ All tools and electrical cords in-use will be **inspected daily** by: ☒ Users ☐ Site Supervisor/Safety Coordinator ☐ Other: ______________________ ☒ Only the right tools will be used in a manner for which they were designed. ☒ **GFCIs** will be used on all extension cords and 120v power tools. ☒ All **extension cords** are in good condition with no cuts through outer insulation, ground plugs are present, and no "vinyl tape" repairs. (Only 12 gauge extension cords may be repaired.) ☐ **Face shield and chemical goggles** used required for chemical splash hazards ☐ **Face shield and safety glasses** required for all chain saws, weed trimmers, and similar tool ☐ **High Hazard Power Tools** must be used because the use of safer tools is not feasible. High hazard power tools include powder-actuated tools, chainsaws, chop/demo saws, weed trimmers with blade cutter, die/end grinders, abrasive wheel tools, hand-held rebar bender, portable HDPE fusion welder, circular saw, portable band saw:

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
	☐ Hand Sampler - Split Spoon or Thin Wall ☐ Hand Probe (GeoProbe) with _____ lb weight ☐ Manual Cathead Hoist with ______ lb weight ☐ Motorized Cathead Hoist with _____ lb weight ☐ Light-weight Motorized Auger drills (not truck-mounted) ☐ Manhole Lifting Devices **(specify in Comments)** ☐ Other (specify):	• Implement HSE Manual Requirements in the "Power Tools-High Hazard" procedure. • Refer to the high hazard power tools safety meeting topics in the Safety Meeting Topics manual to support field safety training prior to use of high hazard power tools. ☐ **Kevlar chaps and jacket** are required for all chainsaw work. ☐ **Kevlar chaps** are required for chop saws, weed trimmers with blades, and similar tools ☒ **Cut-resistant gloves** are worn whenever cutting tools are used. ☐ **Razer & Fixed Blade Knives are Prohibited –** Use is prohibited ☒ **Razer & Fixed Blade Knives are Restricted** – Use is allowed for only the task(s) listed below in "comments" because safer alternatives are not available. Additional safety precautions to prevent hand & forearm lacerations are also explained in "comments". ☒ **Hearing protection** required for which tools or areas: During Drilling Operations. The "3 foot" rule will also be followed. ☐ All **hand augers and sampling probes** will be inspected and verified to be in good conditions with ALL parts required by the manufacturer. Inspections will be completed by: ☐ Users ☐ Site Supervisor/Safety Coordinator ☐ Other: ______________________________ ☐ Persons using sampling probes equipped with **manual slide hammers** are physically capable of handling the weight without difficulty and keep hands clear of pinch-points. ☐ Persons using **manual and motorized cathead hoists** have been trained on how to operate them in accordance with manufacturer guidelines. **(Identify qualified persons by name in the "Comments" Section below.)** ☐ Electrofishing equipment will be **inspected** and verified to be in good conditions with ALL parts required by the manufacturer and exterior cords have no cuts through outer insulation and no "vinyl tape" repairs. Inspections will be completed by: ☐ Users ☐ Site Supervisor/Safety Coordinator ☐ Other: ______________________________ ☐ Persons using **Electrofishing Equipment** have been **trained** on how to operate it in accordance with manufacturer guidelines. **(Identify qualified persons by name in the "Comments" Section below.)** ☐ Electrofishing will be discontinued if the **public** approaches within **100'** ☐ Electrofishing boats will be marked with "**Danger Electricity**" signs (or equivalent) that can be read at a distance of **150'**. ☐ All electrofishing team members wear **electrically-rated rubber gloves** that are inspected daily by users and replaced every 6 months. Use leather or other cut-resistant gloves to protect the rubber gloves. (Similar to NFPA 70E requirements.) ☐ All electrofishing team members wear **chest or hip waders** to insulate the wearer from electrical shock. ☐ **Net handles** for nets used during electrofishing will be nonconductive and long enough to keep hands out of the water.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
		☐ The positive electrode (anode) on portable electroshockers is equipped with a **manual switch** that stops the current when released and is **not "bypassed'** with a hold-down mechanism (i.e., tape) ☐ At least **two (2) persons** on each Electrofishing boat or location are trained in **CPR**. ☐ All persons involved in electrofishing know the location of the **emergency shutoff switch**. ☐ **Backpack electrofishing equipment** is equipped with a **tilt switch** that stops the current if the operator falls. **POWER TOOLS, HAND TOOLS & AUGERS, EXTENSION CORDS, ELECTROFISHING COMMENTS:** • Users shall inspect each tool before use and only utilize the tool for its manufactured use. Cut-resistant gloves will be worn by ADT when using cutting tools. Keep neat workspace and avoid trip hazards with extension cords/tubing. • Workers must inspect all electrical equipment, including extension cords, for the following hazards: o Missing ground pins on plugs (except double-insulated); o Insulation pulled free from plugs or support connections; o Damaged insulation; o Exposed wires; and o Evidence of arcing, sparking, or smoking. • Workspaces, walkways, and similar locations must be kept free of electric cords and tools. • Three-wire extension cords must be used and must be rated for hard or extra-hard use. • Extension cords must not be fastened with staples, hung on nails, or suspended on wires. • Flexible cords must be suitable for the condition and location of use and must be used as appropriate. • Splices and/or taps are prohibited in extension cords. • ALL electrical equipment used on a project (hand tools, etc.) must be protected with a ground fault circuit interrupter (GFCI). While electrical work is not anticipated for this Scope of Work, the following general electrical safety procedures will be followed: • Before work begins, all electric circuits, exposed or concealed, that may be contacted by workers must be posted with warning signs. • Site personnel will be notified of the location and hazard involved with nearby electrical circuits and protective measures taken. • Site personnel will not work near any part of an electrical circuit unless they are protected against shock by guarding or by de-energizing and grounding the circuit. • Equipment will not be stored around electrical cabinets to prevent access.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
		• When any conditions are identified on equipment that make it unsafe to operate, the equipment will be removed from the site until repaired by a qualified person. • Portable lamps must be covered by a fixed, grounded (if metal) guard and equipped with an insulated handle. • All underground utilities will be marked prior to any groundbreaking activities. • Site personnel will be trained in the safety-related work practices that pertain to their job and cannot work near electrical hazards without training to recognize and avoid the hazard. • Electrical workers must test all equipment to verify if energy is present. • Only qualified, trained workers may test electrical equipment. • Site personnel must properly lockout and tagout any circuit or equipment being worked on and verify the equipment is de-energized (See Lockout / Tagout portion of this Section). • PPE used by electrical workers must be appropriate and in good condition. • Portable metal ladders and ladders with metal reinforcement will not be used near energized electrical equipment. • Materials will not be stored in transformer vaults. • AC and DC wiring systems will be properly grounded. • Proper clearance from overhead power lines will be maintained at all times. (See overhead power lines portion of this Section) • ALL electrical equipment used on a project (hand tools, etc.) must be protected with a GFCI.
WORKING OVER/NEAR WATER OR ON ICE		
☐ NA	**drowning, hypothermia (winter months), spills to surface waterways, fall through ice** ☐ Barge-mounted drilling/ boring rigs ☐ Sampling from a boat ☐ Boat required for site Access ☐ Work on an ice covered body of water ☒ Other: Potential CCTV inspection an outfall at low-tide (while outfall is not submerged). Requires work adjacent to / near water.	☐ 100% Fall Protection while working over water or when otherwise exposed to a drowning hazard. **(Describe how fall protection will be implemented, Tie-off points, and the equipment that will be used.** ☐ in "Comments" below ☐ in the "Fall Protection" section) ☐ A "**safety observer**" will remain on shore with the ability to contact emergency response personnel and communicate with those on boats/barges. ☒ USG-approved **flotation vests** will be used. ☒ **Ring-buoy** with 90' of rope and placed within 100' of site personnel. ☐ **Rescue skiff** will be staged such that one person can immediately launch the skiff. ☐ At least **one person will be available to launch** and operate the rescue skiff. NOTE - "Safety Observer" may launch rescue skiff after making emergency response notification(s). ☐ Ice Safety - **Core samples** will be taken every 100' on lakes or 50' on rivers to evaluate the thickness and quality of ice (i.e., *clear/blue ice* = best quality, *white/opaque ice* = moderate quality/use caution, *gray/slushy ice* = poor quality/unsafe). ☐ Ice Safety - Conservative **load estimates** are established for static and/or moving loads as appropriate for the type of work being conducted. Load estimates are explained: ☐ in "Comments" below ☐ in an attached document

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
	NOTE – See "Walking Surfaces" section of HASP for slipping hazards on icy surfaces.	☐ Spill Control - **Floating booms** will be used around barges, shore-based heavy equipment, or other locations where hydraulic fluid may leak from equipment into surface water. ☐ Spill Control - **Silt curtains** will be suspended below floating booms. ☐ Boats and Barges will not be operated above their **weight capacity**. ☐ Boats and barges operated (or potentially operated) in **bad weather** will be operated below their weight capacity by ______% (suggest at least 25%). ☐ Boat and barge emergency calls - **Weather resistant radios** that broadcast on Coast Guard frequencies (Channel 16 VHF/FM or 2182 MHZ) will be available for emergency calls. ☐ Boat or barge-based operations will be discontinued when NOAA issues a **small craft advisory** or when sustained **wind speeds of 20 mph** are observed and create dangerous wave or boat/barge handling conditions. ☐ **NOAA Weather Radio Receiver** will be used to monitor weather conditions that may affect boat or barge-based activities. **WORKING OVER WATER COMMENTS:** Work will not be performed adjacent to (not over) water. Work is dependent on it being at Low Tide. Tide schedules will be confirmed via NOAA website.
MANUAL MATERIAL HANDLING & STORAGE / HOUSEKEEPING / WALKING SURFACES (includes manhole covers, heavy lifting, slippery surfaces, and steep slopes)		
☐ NA	back or shoulder strain, struck by falling objects, trips and falls, incompatible materials (fire or explosion) ☒ heavy manual lifting (>50 lbs) ☐ chemical storage ☒ compressed gas storage ☐ Tall storage greater than 2 pallets stacked. ☒ Material & equipment laydown areas ☒ Trash & debris removal ☒ Manhole Cover Removal ☒ Tripping Hazard (cords, hoses, uneven surfaces) ☒ Slipping Hazard (icy, muddy, oily, etc.) ☐ Steep sloped surfaces ☐ ☐	MATERIAL HANDLING & HEAVY LIFTING ☐ Mechanical lifting equipment used to reduce manual material handling: (☐ Forklift/Lull ☐ Heavy Equipment ☐ Dolly ☒ _Support Vehicle life-gate__) ☒ Manual lifting more than **75 lbs** will require a 2-person lift or mechanical lifting device ☒ Good manual lifting techniques will be reviewed with the following trades/persons prior to site work. Refer to the "*Lifting-Manual*" topic in the Safety Meeting Topics manual: ____ MATERIAL STORAGE & HOUSEKEEPING ☐ Incompatible chemicals will be separated by 20' or a concrete block wall. ☐ Secondary containment will be provided for the following chemicals: ________________ ____ ________ ☐ Safety equipment will be located near chemical storage. ☐ Spill Kit ☐ Emergency Shower ☐ Eyewash ☐ Drench Hose ☐ Splash PPE ☐ Flammable gases and oxygen will be separated by 20'. ☐ All compressed gas cylinders will be transported vertically and secured upright. ☒ Equipment and materials will be stacked in laydown areas with aisles as necessary for safe access. All un-used equipment & materials will be returned to laydown areas daily. Designated laydown areas:_____To be Determined______________________________ ☒ Materials will not be stacked greater than 2 pallets high without being secured.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
		☒ Trash and debris will be removed daily and placed in designated containers. Flammable materials and rags be removed from the area daily. ☒ All chemical containers will be labeled per Hazard Communication requirements. ☒ **Spill equipment** is available for fuel and hydraulic fluid leaks. Location; _Field Vehicle_____ MANHOLE COVERS ☒ **Manhole covers** will ONLY be removed with tools specifically designed to remove them including J-hooks that are at least **30"** long. No pry bars, shovels, or screw drivers. ☐ **"Stuck" manhole** removal equipment and procedures are described in "comments." ☐ **"Paved-over"** manhole removal equipment and procedures are described in "comments." WALKING SURFACES ☒ **Slippery surface** – work area inspected for icy surfaces which will be salted/sanded. ☒ **Slippery surface** –YakTrax® or similar slip-on traction devices will be used for icy areas. ☒ **Hoses & Cords** will be run out of walkways (e.g., within 6" of walls or 7.5' overhead) whenever possible or will be clearly marked by cones or barricades. ☒ Inspect Work Area for **trip hazards**. Hazards will be corrected if possible. If hazards cannot be corrected, then slip & trip hazards will be clearly marked. ☐ **Steep slopes** will be avoided and alternative walkways established to the extent feasible (describe below) **MATERIAL HANDLING & HOUSEKEEPING COMMENTS:** • Good housekeeping standards must be enforced in the work area, including the requirements that waste, rubbish and flammable materials and rags be removed from the area daily. • All waste, rubbish, and flammable materials must be stored in approved containers. • Proper techniques will be used by Ramboll personnel in lifting / moving marine batteries (>50 lbs), purge water buckets, and other equipment. Purge and decon water will be containerized in 55-gallon drums. Drums will be staged in the designated area; and will be labeled appropriately pending waste characterization and disposal. In winter conditions, snow shoveling and application of salt/sand to icy surfaces may be necessary. Equipment will be staged in a manner to minimize potential tripping hazards. **See Attachment 7 – Ramboll's Safe Lifting and materials Handling** Inspect the work areas prior to commencing such work. Be prepared for weather changes and discuss the hazards/risks/controls before commencing work.

HAZARD		HAZARD CONTROLS (check all that apply and comment as required)
ROADWAY, RAILROAD, & SIDEWALK OBSTRUCTION		
☐ NA	☒ Vehicle accidents ☒ Pedestrians struck by vehicles or heavy equipment ☐ Pedestrians falls ☐ Pedestrian struck-by falling objects ☐ Railroad accidents	☐ DOT signal devices will be used to re-route vehicles around excavations or busy site entrances/exits that affect road traffic. ☐ Roadway Flaggers will be used and have DOT Flagger Training ☐ Procedures for work vehicles to enter/exit traffic work zones are required when work zones are setup in high speed roadways or when potential blind-spots exist. Explain in "Comments." ☐ Pedestrian traffic will be safely routed around or over excavations. ☐ Pedestrian traffic will be safely routed around or under overhead work. ☐ Railroad owner notified for permission to work on the railroad right-of-way. ☐ Railroad flagger is required for work in the right-of-way. ☐ Equipment, materials, and personnel may not be closer than 15' to the nearest railroad rail if the railroad flagger or the flagger's signal is not visible. ☐ Derailer(s)/bumper(s) will be installed on railroad tracks to isolate the work area. **ROADWAY, RAILROAD, & SIDEWALK COMMENTS:** Employees will observe local traffic regulations and will work in a buddy system to watch for oncoming traffic or pedestrians in or close to the work area. Ramboll workers will wear high visibility vests and cone off work areas as needed.
BIOLOGICAL HAZARDS		
☐ NA	Infection, Lyme Disease, West Nile Virus, Eastern Equine Encephalitis (EEE), Severe Rash, Allergic Reaction, Venom effects ☒ Ticks ☒ Mosquitoes (EEE, WNV, etc) ☒ Venomous Snakes ☒ Venomous Spiders ☒ Poison Ivy, Oak, or Sumac ☒ Bees & Wasps ☐ Fire Ants ☒ Other (identify below):	☒ Use **DEET** (25%-98%) repellent on skin for protection against mosquitoes, ticks, and similar insects. Use higher concentrations for heavily infested areas. ☒ Use **Permethrin** repellent on clothing in areas heavily infested with ticks, chiggers, etc. ☒ Persons working in tick-infested overgrown areas instructed to wear **spun-poly or Tyvek coveralls** [required for all persons in ESR and working in the NE region plus NJ, & PA.] ☒ Persons returning from work in tick-infested areas instructed to perform **periodic field checks** for ticks and a thorough **tick inspection** as soon as they get home. ☒ Employees (only) instructed to **call WorkCare** for embedded ticks from fieldwork. ☒ All site personnel will be instructed on how to **identify poison ivy, sumac, and oak**. (Ramboll Field Identification Guide or equiv. has been posted? ☐ YES ☒ NO) ☐ Poison ivy **barrier creams** (e.g., Ivy Block) will be used on exposed skin prior to the workday. ☐ Poison ivy **neutralizing wipes or rubbing alcohol** will be used on hands and exposed skin following work activities or incidents where contact with poison ivy/oak/sumac is suspected. ☐ **Protective coveralls** (such as Tyvek™) will be used to prevent contact with ticks or poison ivy. ☒ All site personnel will be instructed on how to **identify venomous snakes** indigenous to the area. List venomous snakes of concern in the "Comments" section below. (Ramboll Field Identification Guide or equiv. has been posted? ☐ YES ☒ NO) ☒ All field personnel with a potential to **encounter venomous snakes** will wear:

HAZARD		**HAZARD CONTROLS (check all that apply and comment as required)**
		☐ Snake Chaps AND/OR ☐ High Leather Safety Boots (NOT ankle-high boots/shoes) ☒ All site personnel will be instructed on how to identify **venomous spiders** indigenous to the area. List venomous spiders of concern in the "Comments" section below. (Ramboll Field Identification Guide or equiv. has been posted? ☐ YES ☒ NO) ☒ Site personnel with known **allergies** to bee/wasp stings, fire ant bites, or other insect bites carry an "EpiPen" or equivalent medication prescribed for treating allergic reaction. **BIOLOGICAL HAZARDS COMMENTS:** Venomous snakes native to the Hudson Valley are the Copperhead and Eastern Timber Rattlesnake. Venomous spiders native to the area are the Brown Recluse and Black Widow spiders. All employees will be cautious when entering certain work areas, buildings, basements for spiders, snakes, long grassy areas for ticks or poisonous plants. Employees will wear gloves appropriate for the job task. Employees will work together in a buddy system and will check each other and surrounding areas for insects (Bees, wasps, etc.), spiders, snakes, ticks.
ENVIRONMENTAL HAZARDS / HAZARDOUS WASTE SITE WORK		
☐ NA	Exposure to hazardous vapors or dust, contact with contaminated materials, fire, explosion. Contaminants of Concern and hazardous chemicals include: ☒ volatile organic compounds (describe; BTEX; carbon disulfide) ☒ semi-volatile organic compounds (describe: PAHs) ☒ metals ☐ PCBs ☐ Caustic (NaOH) ☒ Acid (HCL) ☐ Gas ☒ Lead ☒ Cyanide (many other hazardous waste site hazards are covered elsewhere in this HASP)	☐ Site workers with a potential for contact with contaminated materials and work in Level C PPE will have OSHA 40-hour training, current 8-hour refresher, and medical exam. ☐ Site workers with minimal contact with contaminated materials and no work in Level C PPE will have OSHA 40-hour OR 24-hour training, current 8-hour refresher, and medical exam. ☒ Foremen or Supervisors overseeing field crews will have 8-hour OSHA Supervisor training. ☐ No intrusive work activities or areas are anticipated with current scope of work. ☒ Intrusive work activities include: Soft-dig excavations for utility clearance, soil borings, monitoring well installation ☒ The perimeter of intrusive work areas are identified by:___Cones / fencing________ ☐ Decontamination of personnel or equipment is not anticipated with the current scope of work. ☒ Decontamination of personnel and small tools will be conducted as follows: Water and alconox ☒ Decontamination of heavy equipment will be conducted as follows: soil core barrel will be decontaminated using water and alconox. ☒ **Spill equipment** is available for fuel and hydraulic fluid leaks. Location; _Field Vehicle______ ☐ Heavy equipment leaving the site will be inspected by: _________________________________ ☐ **Work area air monitoring** is not anticipated with the current scope of work. ☐ **Work area air monitoring** will be conducted per attached air monitoring plan.

HAZARD	HAZARD CONTROLS (check all that apply and comment as required)

☒ **Work Area Air Monitoring** as follows for: ☐ Dust, ☒ VOCs, ☐ Other:_ ________

Description of Air Monitoring Approach:

Action Levels[1]	**Description & Response Actions**
PID: <1 ppm in breathing space	1. Level D PPE (General PPE as required in this HASP)
PID: 1 ppm or greater in breathing space	1. STOP work. Leave the area where the action levels were exceeded. 2. Contact project manager and CHS representative to re-assess working conditions.
1. Sustained 1 minute	

☐ **Community Air Monitoring** is not anticipated with the current scope of work.

☐ **Community Air Monitoring** is required per the attached air monitoring plan.

☒ **Community Air Monitoring** as follows for: ☒ Dust, ☒ VOCs, ☐ Other:__________

Description of Air Monitoring Approach: A separate Community Air Monitoring Plan (CAMP) will be implemented following NYSDEC's *Technical Guidance for Site Investigation and Remediation (Appendix A)*

Action Levels[1]	**Description & Response Actions**
Dust: <0.1 mg/m³ **PID:** <1 ppm	1. Normal Operation
Dust: 0.1-0.15 mg/m³ **PID:** 5-25 ppm	1. Increase demolition dust controls until dust levels at the site perimeter (fence line) are <0.1 mg/m³ 2. Work activities will be halted, the source of vapors identified. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.
Dust: >0.15 mg/m³ **PID:** >25 ppm	1. STOP work and evaluate alternate work methods, dust controls. Allow time for passively vent. 2. Implement revised work methods and dust controls to maintain dust levels at the site perimeter <0.1 mg/m³ / <5 ppm 3. Resume work.
1. 15 minutes time-weighted average	

HAZARD		**HAZARD CONTROLS (check all that apply and comment as required)**
		ENVIRONMENTAL & CHEMICAL HAZARD COMMENTS: • Disposable nitrile gloves and safety glasses will be worn to prevent contact with potentially contaminated groundwater. • Federal and State laws will be followed regarding the handling of chemicals identified in this HASP, particularly Section 11 and Section 12. • Flammable and combustible chemicals will not be stored at the site. • Site personnel shall be thoroughly familiar with operation of equipment and the use of materials or chemicals used at the Site. • Site personnel shall have knowledge of the physical properties, hazards, and PPE required (See Section 7). • Site personnel shall be provided with appropriate PPE for the chemicals or hazards present (See Section 7). A complete inventory of chemicals brought onto the Site will be available to be provided on request. Safety data sheets (SDSs) for the material carried or on-Site shall be available on request (see Section 12). • Spill response equipment will be available on-site (field vehicle) and be available to contain or control a reasonably anticipated release or spill (See Section 12). • Spills will be reported to the project manager and Con Edison Authorized representative immediately upon discovery (See Section 12). • The reportable quantity of each hazardous substance and the amount that exceeds the reportable quantity shall be known regardless of the units used (pounds vs. gallons). • At the end of the day, remove any chemicals that were not used. All containers are to be removed from the work areas on a daily basis. • The site supervisor (SS) will communicate with the Ramboll project manager (William Moore) as needed. The SS will be responsible for obtaining and maintaining SDS sheets and initial training of all employees regardless of date of employment. The SS will also be responsible for periodic refreshers and updates as well as insuring proper labeling of materials. **See Ramboll's Stop Work Authority (Attachment 5), CEHS A32.00 (Rules we Live by – Attachment 3) for additional guidance**.
OTHER HAZARDS & CONTROLS not addressed in other sections of this HASP		
☐ NA	☒ Unsecure/public work site ☒ Heat exposure	Buddy system / daylight working hours will be utilized. **See Attachment 9 Ramboll's Heat and cold Stress Management Guidance.** ☒ Work / rest schedules must be altered to minimize the potential for heat stress. Heat stress is defined as a situation where too much heat is absorbed by a person, a plant or an animal and causes stress, illness or even death. Heat stress is manifested by elevated body temperature, hot, dry skin, lack of sweating and neurological symptoms such as paralysis, headache vertigo and unconsciousness. It can also cause heat cramps, heat exhaustion and heat stroke which may lead to death. If workers experience these symptoms, then stop work and implement the following controls. Workers must don adequate dry insulating clothing; and Adjust the work / rest schedule to increase the amount of rest / recooling time.

HAZARD			HAZARD CONTROLS (check all that apply and comment as required)
	☒	Cold exposure	Toolbox safety meetings discussing symptoms of heat stress, clothing requirements, and work breaks must be held EACH DAY when temperatures are elevated and may result in heat stress. **See Attachment 9 Ramboll's Heat and Cold Stress Management Guidance.** Cold Stress is a cold temperature related disorder called hypothermia that occurs when exposure to cold causes a decrease in the core (heart, lungs, and other organs) temperature to a level that leads to impairment of your normal muscular and brain functions. Generally, hypothermia occurs at a core temperature of about 95 degrees Fahrenheit or below. In extreme cases, hypothermia can lead to loss of consciousness, tissue damage, and even death. This disorder is particularly dangerous because it affects your brain's ability to function properly. You lose your capacity for good judgment, reasoning, and mental clarity. You may not even be able to recognize that you have symptoms! The key factors that can bring about or aggravate cold stress: • Age, body size, physical condition, mental attitude, length of exposure, Exhaustion, hunger, dehydration, certain illnesses, some medications, alcohol Intake, smoking, and improper clothing and equipment. Signs of cold stress must be monitored: • Mild Hypothermia-Uncontrolled, violent shivering, etc. • Severe Hypothermia-Mental confusion and more serious effects leading to cardiac arrest. Responses to illnesses due to cold stress: • Mild Hypothermia-Get employee into a warm area and remove any wet clothing, replacing them with dry layers. • Severe Hypothermia-If the victim is semi-conscious, try to keep him or her awake. Unconscious victims should be taken to the hospital for treatment as soon as possible. Methods of preventing cold stress: • Wearing of layers of clothing, including hat and gloves • Keeping dry • Eating and drinking properly • Frequent breaks in warm areas • Buddy system-Watch each other for signs of cold stress.
	☒	Wet conditions	☒ Extra care must be taken when working in wet conditions. A wet work environmental greatly increases the chances for an accident through: – Increased chances for slips, trips, and falls. – Decreased focus on work – Less attention to detail Wet conditions also contribute to cold stress even in temperatures well above freezing, in some cases as high as 60°.
	☒	No Smoking Policy	Under any circumstances, no smoking is allowed on the project Site. Smoke breaks, if absolutely necessary, must be taken at a safe distance from the project Site at a location that is discussed and agreed to during the pre-work briefing.
	☒	Air Resources	Federal, State and local laws require that the public and the environment be protected from nuisance levels of dust, smoke and odors. Regulations have been adopted that limit the release of materials such as particles, combustion exhaust, volatile solvents, paint fumes and many other chemicals. The construction and operation of many types of equipment or facilities may require a permit, certificate or other

HAZARD			HAZARD CONTROLS (check all that apply and comment as required)
			approval from the appropriate regulatory agency. If required, water misting will be utilized to control dust that may be created from the concrete and asphalt removal**.**
	☒	Fire Prevention	In the event of a fire, first consideration is the safety of all personnel. The Ramboll project manager and Con Edison representative will be informed of all fire or explosion occurrences (See Section 12). Potential fire hazards (e.g., hot work welding, grinding and cutting; the use of flammable liquids and gases) will be identified and discussed during the daily safety briefing. Good housekeeping standards will be implemented in the work area, including the requirements that waste, rubbish and flammable materials and rags be removed from the area daily. Waste, rubbish, and flammable materials will be stored in approved containers. Flammable liquids will be stored in approved 1-gallon maximum safety cans that are painted red with a yellow band around the can and labeled to identify the contents. Combustible liquids will be stored in green safety cans that are labeled to identify the contents. Under any circumstances, gasoline or other highly flammable liquids will not be used for cleaning purposes. If needed, use Con Edison approved pumps, or approved self-closing faucets and drip pans when dispensing flammable and combustible liquids (FCL) from drums or portable tanks. For FCL areas, Class B/C rated fire extinguishers will be on site at all times and located in close proximity. Monthly and annual inspections will be performed and labeled with dates to ensure that the units are ready for use. In the event of a fire involving compressed gases, the gases will be permitted to burn and not extinguished, under any circumstances, unless it is possible to control the gas flow. Smoking is prohibited on-Site, including within buildings, within the construction work area or in the vicinity of flammable or combustible liquids and gases. Fuel storage will be limited to 2.5 gallons of gasoline and 10 gallons of diesel fuel (including storage of fuel at the ECC vehicles) unless appropriate local permit(s) is obtained. There shall be no spare empty fuel cans in exceedance of the volume of fuel allowed to be stored at the site. See **Attachment 10** for additional information regarding the safe transport, use, and storage of flammable materials.

12. EMERGENCY RESPONSE

(911 Service is Available ☒ Yes ☐ No **Cell Phone Required** ☒ Yes ☐ No)

Alternate Emergency Number (if not "911"): N/A

Site Address: 550 Food Center Drive Hunts Point, The Bronx, NY 10474

Muster Point in case of site evacuation: Proceed to work vehicle and leave the area.

Emergency Medical Treatment - Hospital Name: Hospital Address:	Lincoln Medical Center 234 E 149th Street, The Bronx, NY 10451	**Phone Number:**	718-579-5000
Non-Emergency Med. Treatment - Clinic Name:	Call WorkCare Incident Intervention for the location of the closest occupational clinic for all non-emergency medical care	**Phone Number:**	888-449-7787
Minor Injury Support for Ramboll Employees:	WorkCare Incident Intervention	**Phone Number:**	888-449-7787
Fire Department Name:	FDNY Engine 94 / Ladder 48 / Battalion 3	**Number:**	911 or 718-430-0203
Spill Response:	911	**Number:**	911
Con Edison (Client) Representative Name:	Melissa Abt	**Office Number:**	718-201-4331
Ramboll **Project Manager** Name:	William Moore	**Office Number:**	732-638-2939
		Cell Number:	973-820-1044
Ramboll **Site Safety Leader** Name:	TBD	**Cell Number:**	TBD
Ramboll **Corporate H&S** Name:	Thomas Mooney	**Cell Number:**	610-212-2187

EMERGENCY RESPONSE COMMENTS:

1. NOTIFICATIONS - Upon occurrence of any injury, fire, explosion, any spills (even incidental spills), property damage >$1,000, or near-miss that could have resulted in a fatality or disabling injury, **IMMEDIATELY NOTIFY** the Ramboll Project Manager, Ramboll Manager of Corporate H&S, and the Con Edison Authorized Representative.
2. WRITTEN REPORT - Complete an *Incident Report* within **24 hours** and submit to the Ramboll Manager of Corporate H&S for review. Report may be submitted as a “draft” or “preliminary” and updated as additional information is identified.
3. INJURY RESPONSE

- First aid injuries will be handled on site with FA-trained personnel. First aid, blood born pathogen and CPR supplies are located: _Field Vehicle_.
- If a person (Ramboll employee or subcontractor employee) may be **working alone** at times when the job site is unoccupied, then regular "check-ins" will be conducted between the lone site person and their supervisor or other designated person. The method of communication (radio, cell phone), the frequency of check-ins, and the names of individual(s) with whom the lone worker will be checking in must be outlined below under "*Other Emergency Information*." Employees should not be assigned to "High Hazard Work" when working alone.
- **All Ramboll employees will call WorkCare for minor injuries** that include any strains, cuts for which an employee is not confident that a band aid is sufficient, tick/insect bites for which the employee is concerned about infection or Lyme, any any other work-related injury for which the employee would like to talk to a WorkCare medical professional regarding proper treatment or follow-up.
- **WorkCare posters must be posted at each job site with a field office or trailer.**
- Minor (not life threatening) injuries that require medical attention will be treated at the "Non-Emergency Med Treatment" clinic identified above **unless an alternate clinic is recommended by WorkCare**. If no clinic is available or identified, then default to the "Emergency Medical Treatment" facility.
- Life Threatening injuries are an emergency and require implementing emergency response (911 or alternate).

4. FIRE or EXPLOSION
   - Incipient stage (trash can size) fires may be handled by site personnel using fire extinguishers or hoses.

     Larger fires will require that affected personnel are evacuation to the identified muster point and implementing emergency response (911 or alternate).

     The Ramboll project manager and the Con Edison representative will be informed of all fire or explosion occurrences as quickly as possible from a safe area.
5. SPILL RESPONSE
   - Spill response equipment will be maintained by Ramboll and be available to contain or control a reasonably anticipated release or spill.
   - Spills will be reported to the project manager and Con Edison Authorized representative immediately upon discovery
   - Major spills that exceed the available supplies and resources to safely control and cleanup will require contacting an off-site spill responder indicated above for "Spill Response" and in accordance with existing site spill response plans. If a specific spill responder is not identified, a large spill will require implementing emergency response (911 or alternate).
   - Review available spill control and prevention plans that may be applicable to the work area. Ensure project personnel are familiar with plan requirements.
   - Minor or incident spills will be cleaned up by site personnel using supplies that are located: _Field Vehicle _.
   - The site owner will make notifications for reportable spills unless Ramboll is authorized to make those notifications.
6. POSTING - Emergency numbers and Hospital Route Map are posted: _in SSL work clipboard_________________________.
7. OTHER EMERGENCY INFORMATION:

Hospital Route and Map

Lincoln Hospital

19 MIN | 3.7 MI

Est. fuel cost: $0.43

Trip time based on traffic conditions as of 2:20 PM on July 16, 2019. Current Traffic: Heavy

1. Start out going **north** on Food Center Dr toward Hunts Point Co Op Mkt.

Then 0.74 miles 0.74 total miles

2. Turn **right** onto Halleck St.

Halleck St is 0.3 miles past Food Dr.

Fratellis Pizza Cafe is on the corner.

If you are on E Bay Ave and reach Drake St you've gone a little too far.

Then 0.25 miles 0.98 total miles

3. Take the 1st **left** onto Randall Ave.

Randall Ave is 0.1 miles past Oakpoint Ave.

If you reach Spofford Ave you've gone about 0.1 miles too far.

Then 0.65 miles 1.64 total miles

4. Randall Ave becomes Leggett Ave.

Then 0.30 miles 1.94 total miles

5. Turn **left** onto Bruckner Blvd.

If you reach Southern Blvd you've gone a little too far.

Then 0.34 miles 2.28 total miles

6. Turn **right** onto E 149th St.

If you reach E 144th St you've gone about 0.1 miles too far.

Then 1.35 miles 3.63 total miles

7. Make a **U-turn** at Park Ave onto E 149th St.

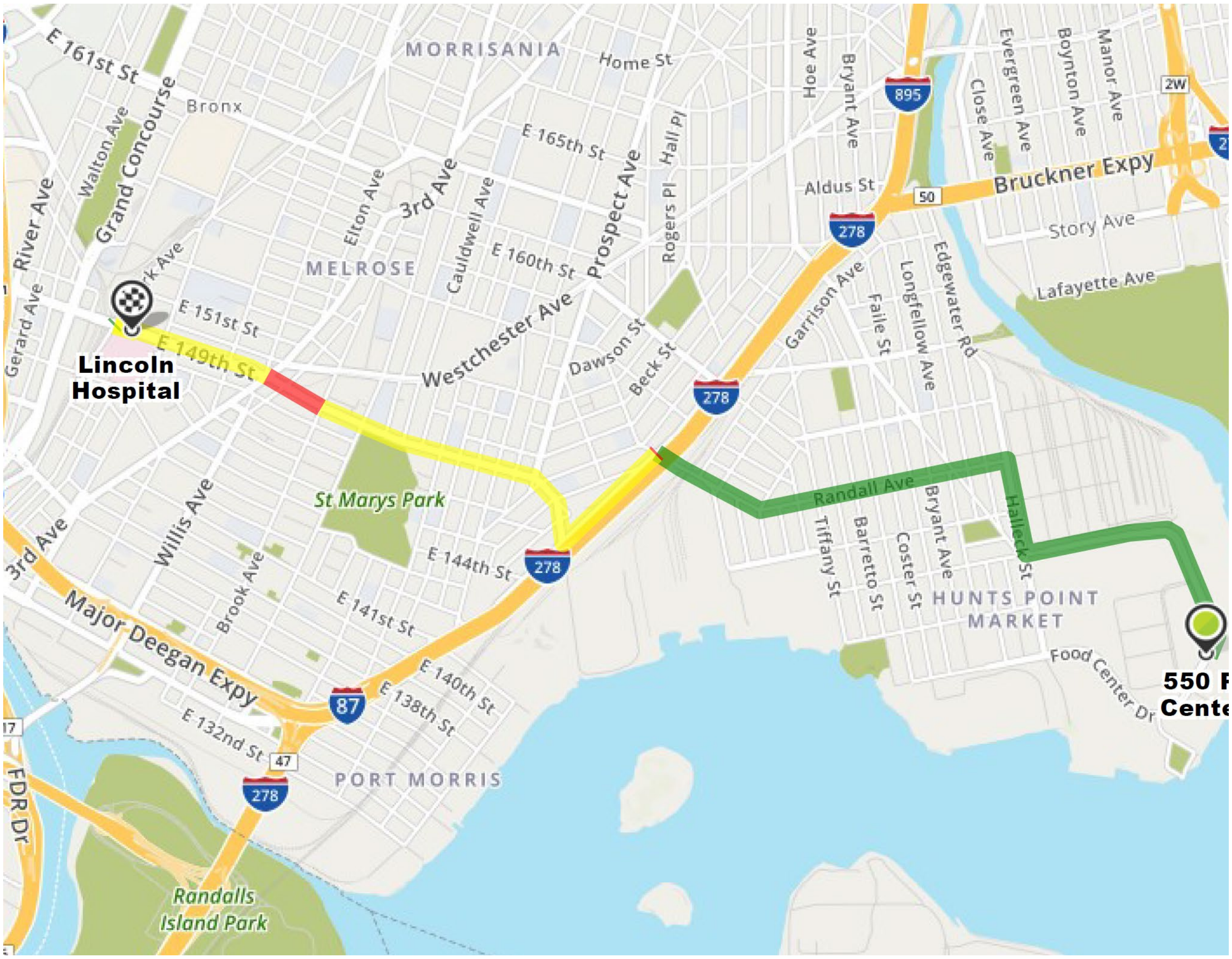
If you reach Anthony J Griffin Pl you've gone a little too far.

Then 0.07 miles 3.70 total miles

8. 234 E 149TH ST is on the **right**.

Your destination is just past E 149th St.

If you reach Morris Ave you've gone a little too far.


Lincoln Hospital
550 F
Cente
MORRISANIA
MELROSE
HUNTS POINT MARKET
PORT MORRIS
St Marys Park
Randalls Island Park
E 149th St
Westchester Ave
Randall Ave
Halleck St
Bruckner Expy
Major Deegan Expy
278
87
895

HASP Review Acknowledgement: Individuals who are performing work covered by this HASP have received a *site-specific Project Safety Orientation (PSO)* that includes a review of the safety requirements outlined in this HASP. The undersigned individuals acknowledge that have read this HASP or reviewed this HASP with a designated project representative and agree to comply with safety requirements, including the **no smoking polic**y. The undersigned individuals understand that these safety requirements are not “all-inclusive” and that they are expected to follow any additional safe work practices applicable or customary to their specific scope of work or trade.

Print Name	Signature	Company	Date

LIST OF ATTACHMENTS

ATTACHMENT 1
NEAR MISS REPORT, INCIDENT REPORT

RAMBOLL

Third-Party Work Observation

Observation Type (pick a predominant type)

☐	**Safe Behavior or Condition** – Record details about a safe behavior or condition
☐	**Unsafe Behavior or Condition** – Record details about an unsafe behavior or condition
☐	**Safety Violation** – Only use if the site owner has issued a formal violation notice
☐	**Great Catch** – Nominate this work observation for safety recognition [one Great Catch is selected each month and presented to the Americas Leadership Team]
☐	**Management Site Visit** – Record details about a management site visit
☐	**Near Miss** – Record details about a potential consequence [Near misses include those observations where an event happened but no one was hurt and there are no other significant consequences]

Observation Details

Business Entity	☐RAES ☐RAIS ☐RUSC ☐HLD ☐Mexico ☐Brazil ☐Canada	**Market**	☐Energy ☐E&H ☐Water ☐ALD ☐MC ☐Buildings
Business Entity (Office)		**Project Number**	
Client Name		**Observation Date**	
Location (site)		**Person(s) Observed**	
Observer			
Observer Company		**Observed Company**	
Did Work Stop	☐Yes ☐No		
Primary Incident Type	☐Asbestos ☐Burns ☐COVID-19 ☐Display Screen/Ergonomics ☐Documentation Issues ☐Electrical ☐Environment ☐Fainting ☐Falling Objects ☐Fire Safety ☐Hygiene & Occ. Disease ☐Manual Handling ☐Moving Objects ☐Pers. Prot. Equipment ☐Road Traffic ☐Security Breach ☐Sharp Objects/Cuts ☐Slips, Trips, Falls ☐Threat from People/Animals ☐Water Safety ☐Working at Height ☐**Other:**		
Description			

Situation Details

Operational Activity	☐Commuting/In Transit ☐Field Based ☐Office Based
Location Within Category	☐Client Office ☐Client/Project Site ☐Public Area ☐Ramboll Office
Primary Equipment	☐Hand Tool ☐Heavy Equipment (e.g., dump truck) ☐Mobile Equipment (e.g., scissor lift) ☐None ☐Power Tool ☐Sampling ☐Other (explain):

Safe Behaviors and Conditions (select those that may be applicable)

Personal Protective Equipment (PPE)
☐Arms & Hands ☐Ears-Hearing Protection ☐Eyes-Safety glasses or goggles ☐Head or face – Hard hat or face shield ☐Legs or feet ☐ Respiratory System ☐Trunk, back, chest, rear ☐Other:
Reason for Behavior
☐Human factors contributed? ☐No procedure in place ☐Permit to work or Job Risk Analysis? ☐Procedures followed? ☐Procedures known ☐Procedures understood
Risk/Injury Causes
☐Awkward, strained, or static positions ☐contact electric current ☐Contact a hazardous substance ☐Contact hot/cold surfaces ☐Noise or vibration ☐Pinched, caught in or between objects ☐Repetitive motions ☐Slips, trips, falls ☐Struck by or between objects
Tools and Equipment
☐Guards/barriers in place ☐Housekeeping ☐Right for the job? ☐Used correctly? ☐Working condition?
Working or Living Conditions
☐Corrosion ☐Lighting ☐Trip Hazards ☐Walkways/stairs ☐Weather ☐Work area

Comments or CAPAs (include at least 1 CAPA for unsafe behaviors or conditions and near misses)

ATTACHMENT 2
PRE-WORK MEETING FORM TEMPLATE

RAMBOLL

DAILY JOB PLANNER (MANAGING CHANGE)

Project Name:		**Date:**	
Company Name:		**Project No.:**	
Authorised Job Tasks (Scope of Work for the Day - Be Specific):			
Identify Risk Assessment(s) Applicable to Work:			

This form (or approved equivalent) is completed daily by each crew leader (foreman, superintendent, supervisor, etc.) who is directly responsible for supervising work. "YES" boxes indicate a change or the need for a permit/inspection that must be addressed.

YES	NO	DAILY SUPERVISOR SAFETY PLANNING (Focus on changes from previous work shift)
		Change in Personnel – Has a new person been added to the work or project? *If YES, then verify the following have been completed prior to work:* ☐ Project Safety Orientation - Safety Plan, JSA/AHA, SDSs, or other safe work documents are reviewed ☐ Pre-Work Documentation – Such as training and medical surveillance documentation is on-site
		Change in Work Scope or Methods – Has the work scope or work methods changed in any way which includes task changes or new tools, new equipment, or different chemicals, or new field-determined fall arrest anchor points? *IF YES, then confirm that the affected risk assessment(s) has been revised and reviewed with crew performing the work by checking the box below.* ☐ RA has been revised and reviewed with field crew. Review is documented (signatures and date).
		Change in Work Area Conditions – Have work area conditions changed or are changes anticipated? *IF YES, identify change below and review changes to safety equipment or procedures under "Key Safety Instructions."* ☐ Heavy Rain ☐ Possible Lightning ☐ High Winds ☐ Heat ☐ Cold or Ice ☐ Hazardous Plants ☐ New Work Area ☐ Other:
		Change in Health or Injury Status – Does anyone have a new work-related injury or illness to report? *IF YES, notify the SSR and investigate for the purpose of identifying corrective and preventative actions.*
		Change in Coordination or Notification (Simultaneous Operations) - Do ANY of the following coordination or notification conditions apply to today's authorised tasks? *IF YES, identify applicable organisations below and take necessary measures (or verify that such measures have already been taken) to coordinate with, or notify, affected organisations including:* ☐ Process owners or operators when working near active process equipment. ☐ Contractors performing work in adjacent work areas or other areas potentially impacted by project activities. ☐ Public officials or agencies for work that may impact public roads, navigable waterways, sewer discharges, etc. ☐ Railroad and Utility Companies for work in rights-of-way OR crossing rights-of-way ☐ Rescue services for permit-required confined space entry. ☐ Other:
		Permits & Inspections – Are any needed for authorised tasks? *IF YES, then check all that apply* ☐ Permit-Required Confined Space Entry ☐ Non-Permit Confined Space Downgrade ☐ Alternate Entry (Confined Space) ☐ Subsurface Clearance Checklist ☐ Hot Work ☐ Energised Electrical Work ☐ Lifting & Rigging Plan ☐ Other: ☐ Daily Excavation Checklist ☐ Daily Scaffolding Inspection ☐ Heavy Equipment Inspections

KEY SAFETY INSTRUCTIONS OR MESSAGE FOR THE DAY (To Be Reviewed with **Field Personnel)**

Prepared By (Name & Company):	
Contractor/Subcontractor Approval (Name & Company): (☐ NA)	
***Ramboll Acknowledgement (SSR or Designee):**	

Crew Signatures (acknowledgement & fit-for-duty):

POST-SHIFT REVIEW OF WORK AREA BY PERSON CONTROLLING THE WORK

(Work area has been inspected and is being left in a safe and clean condition. Any incidents have been reported. Return to Ramboll SSR.)

Name & Company:		**Time:**	

* Ramboll's Acknowledgement is not an assumption of subcontractor's safety responsibilities as an employer, nor does it alleviate contractor or subcontractor's responsibility to comply with health, safety and security regulations and requirements and maintain safe working conditions for their employees.

ATTACHMENT 3
CEHSP A32.00 – RULES WE LIVE BY

CORPORATE ENVIRONMENTAL, HEALTH AND SAFETY PROCEDURE

CEHSP A32.00 – Rules We Live By

Revision Date: 3/30/2022 Effective Date: 5/4/2022

CONTENTS

1.0 PURPOSE

This procedure establishes a consistent approach to communicating and reinforcing the importance of following critical safety work practices designed to protect employees, contractors, and the public.

2.0 APPLICABILITY

This Corporate Environmental, Health and Safety Procedure (CEHSP) applies to all Con Edison employees and contractor employees .

3.0 INTRODUCTION

There are safety and operational procedures specifically designed to protect against the potential for significant injury due to energy sources (e.g., electricity, gas, steam, or falling from an elevation) that must be controlled. Operating groups that work with these energy sources have identified Rules We Live By (RWLB). RWLB are work procedures or safety requirements that, if not followed, could result in a severe injury or fatality or create a significant risk to employees, contractors, or members of the public. When attending classes at -The Learning Center, the RWLB associated with a given activity of an operating department apply.

4.0 COMPLIANCE REQUIREMENTS

4.1 RULES WE LIVE BY IDENTIFICATION, TRAINING, AND REPORTING

4.1.1 IDENTIFICATION

When work tasks require the safe control of energy sources, the operating organization must identify procedures to control or mitigate the effect to the employee, fellow employees, contractor employees, and the public. Operating organizations must consider lessons learned from previous incidents in the identification process.

If an organization changes a RWLB, the organization must notify the EH&S Director, Health and Safety of the change before the change is implemented.

4.1.2 TRAINING AND COMMUNICATION

Each operating organization is responsible for ensuring its employees are trained in the RWLB. This training includes:

- Providing each employee in the organization with OJT training on the RWLB.
- Reinforcing the organization's RWLB and associated procedures in skills training.
- Reinforcing the organization's RWLB in job briefings.
- Incorporating the organization's RWLB into the scope of safety field observations and inspections.

When contractor work practices involve RWLB, contractor employees will be trained on the applicable RWLB, reporting procedure, and consequences. The operating organization must communicate the applicable RWLB to contractor management and ensure the RWLB are incorporated in the eHASP. The contractor supervisor will be required to train their affected employees, including subcontractor employees, before they begin work.

4.1.3 REPORTING AND INVESTIGATION

If a RWLB violation is suspected or observed, all work must stop immediately.

If a non-supervisory employee believes a RWLB may have been violated, that employee must stop the involved work task immediately and report the situation to the supervisor of the employee who committed the alleged violation, If the supervisor of the employee who committed the alleged violation is not available, the employee must notify a supervisor in same department of the employee who committed the alleged violation or a supervisor in their department.

If a supervisor observes a RWLB being violated, that supervisor must stop the involved work task immediately.

Once work is stopped, the supervisor, the person who identified the alleged RWLB violation (if different), the employee who committed the alleged RWLB violation, and any other necessary persons (e.g., crew members or other supervisors who witnessed the alleged RWLB violation) must meet to discuss the alleged RWLB violation.

- If after discussing the alleged RWLB violation, everyone involved agrees that there is no RWLB violation, work can proceed.
- If after discussing the alleged violation, everyone involved agrees that there is a RWLB violation or if there is disagreement whether there is a RWLB violation, the supervisor must contact the EH&S representative to obtain assistance in resolving the alleged RWLB violation.

- If the EH&S representative cannot be reached, the job cannot continue until EH&S has addressed the issue. The operating organization can contact the EH&S Control Desk to assist in contacting another EH&S representative.

Once notified of the potential RWLB violation, the EH&S representative must respond in person to the location of the potential RWLB violation. The EH&S Representative must also notify the EH&S Director, Health and Safety of the potential RWLB violation as soon as possible after being contacted by the supervisor, but in no case later than when the EH&S Representative arrives at the location.

- The EH&S representative will act as the authority (expert) on health and safety rules, regulations, and procedures and will determine whether there has been a RWLB violation.

- If the EH&S representative cannot determine whether there has been a RWLB violation, the EH&S representative must contact a Subject Matter Expert (SME) from other areas of the company, including Engineering, EH&S Safety, or Operations, to assist help make a determination.

- The number of people involved in reviewing the allegations and making the RWLB determination should be kept to the minimum required to resolve the issue. The employee who observed the alleged violation should be included in the discussions to the extent necessary to ensure there is a clear understanding of the facts involved.

- If the EH&S Representative cannot make a determination (e.g., conflicting information or the alleged RWLB is not identified before work has stopped), then the EH&S Representative must notify the operating organization's supervisor that their organization must conduct a fact finding investigation.

- Once the operating organization identifies the facts, they must inform the EH&S Representative of their findings, and the EH&S representative will then make a determination.

- Once the EH&S representative understands all the issues involved in the alleged violation, the EH&S representative will determine whether there is a RWLB violation.

- The EH&S Representative will determine whether there is a RWLB violation as soon as practicable after understanding all the information, but no more than five business days after being notified of the alleged RWLB violation, unless additional fact finding by the organization is necessary. Based on the circumstances and complexity of the incident, the EH&S Director, Health and Safety may grant an extension of time.

- If additional fact finding by the organization is necessary for the EH&S Representative to make a determination,the EH&S Representative will determine whether there is a RWLB violation as soon as practicable after understanding all the information, but no more than five business days after receipt of the information from the organization. Based on the circumstances and complexity of the incident, the EH&S Director, Health and Safety may grant an extension of time.

    - The EH&S representative must lead a close-out discussion with all parties involved, using three-way communication and ensuring that each party involved understands the determination.

- After the close-out discussion, the EH&S Representative must complete the RWLB Determination Report provided in Attachment 1.

- The EH&S Representative must distribute the RWLB Determination Report to the EH&S Director, Health and Safety, the supervisor, the person who identified the RWLB violation (if different), the employee who committed the RWLB violation, and the General Manager or Director of the employee who committed the RWLB violation.

- If the General Manager or Director of the employee who committed the RWLB violation disagrees with the EH&S Representative's determination, the General Manager or Director can appeal the determination to the EH&S Director, Health and Safety within three business days of receiving the Determination Report.

- If the determination is appealed, the EH&S Director, Health and Safety will decide whether there is a RWLB violation. The EH&S Director, Health and Safety's decision is final. (Attachment 2 is a Flowchart of the RWLB process)

- Only EH&S is authorized to make a positive RWLB determination.

- EH&S Operations is responsible to update the KPI reporting system on EH&S Central with the RWLB information.

4.2 VIOLATION OF A RWLB

A violation of a RWLB will result in significant consequences. The operating organization in which the RWLB violation occurred will be responsible for determining the discipline.

Any employee who witnesses a violation of a RWLB and does not stop the work and report the violation will also be considered to have violated the RWLB.

If a company contractor or sub-contractor violates a RWLB, the operating organization with contractor oversight must submit an action line.

The operating organization must notify the EH&S Director, Health and Safety after acting on the violation.

5.0 DEFINITIONS

Con Edison employee: This includes all management and union employees.

Contractor employee: This includes employees working for a contractor company hired by Con Edison, subcontractors, and per-diem contractor employees.

REVISION HISTORY

Revision Date	Revision #	Summary of Change	Author
1/21/14	2013 Annual Review	*CEHSP A32.00.01 RWLB - Table*: Permits, Electric Ops – Added language to clarify that entry for work in structures containing d-faulted feeders is permissible after associated source equipment has been de-energized.	G. Slintak
4/23/14	2013, Revision 1	*CEHSP A32.00.01 RWLB - Table*: Adjusted high hazard PPE rule as applied to Gas Operations in response to 4/22 request. Change clarifies the attachment point for use of PPE (previously associated with "blowing gas," a subjective term).	G. Slintak
5/16/14	2	Combined 'CEHSP A32.00 – Rules We Live By' and 'CEHSP A32.00.01 – Rules We Live By Table' into one document. The table will be an attachment to the procedure.	S. Ng
12/31/14	2014 Annual Review Rev. 3	Edits to reflect organization changes. Minor changes to clarify rules.	W. Capune
12/21/15	2015 Annual Review Rev. 4	Edits to reflect organizational changes in Shared Services. Customer Operations adopted the same language as Electric Operations for High Hazard PPE.	W. Capune
04/06/18	Annual Review Rev. 5	No changes requested. Removed the year (2016) from the RWLB Table. Additional editorial comments added by G.Slintak.	W. Capune
03/18/21	6	Removed reference to the Time Out procedure and outlined the determination process	McFarland
3/08/22	7	Inserted new rule for Customer Operations which requires proper testing of meters.	McFarland
3/30/22	8	Clarified requirements for notifications to EHS Safety and RWLB determination process Added Determination Report template Added "RWLB Process" flow chart Added requirement for reporting through KPI System	E, Dessen M. McFarland T. McGee

Hazard	Electric Operations	Central Operations	Gas Operations	Customer Operations	Utility Shared Services
Verify Dead/Lockout-Tag Out	Properly test or spear to ensure that electric equipment, cable, or wire is "dead" as required regardless of voltage, before beginning dead work activities.	Properly test or verify that equipment is de-energized, isolated and protected prior to initiating dead work activities.		Conduct required testing, following the proper procedure for work on metering equipment	Properly lock out/tag out equipment before beginning work on the equipment. (when not intentionally live and PPE is required)
Permits (Operating, D-faults)	Enter D-Fault tagged structures only when authorized by the operating authority to perform feeder processing, or to perform work after all D-faults have been identified and de-energized.	• Only perform work that is within the authorized scope of work as listed on the work permit. • Do not change the status of a piece of equipment that has a Stop Tag applied to it. • Follow the sequence of an operating order.		Do not enter a structure that has been classified and tagged as a D-fault.	Only perform work that is within the authorized scope of work as listed on the work permit
Atmospheric Testing	• Perform air monitoring and ventilate as required for entry and work in an enclosed space or a permit-required confined space. • For excavations greater than 4 feet in depth the atmosphere shall be tested prior to entry or when the excavation is not already occupied.	• Perform air monitoring and ventilate as required for entry and work in an enclosed space or a permit-required confined space. • For excavations greater than 4 feet in depth the atmosphere shall be tested prior to entry or when the excavation is not already occupied.	• Perform air monitoring and ventilate as required for entry and work in an enclosed space or a permit-required confined space. • For excavations greater than 4 feet in depth the atmosphere shall be tested prior to entry or when the excavation is not already occupied.	Perform air monitoring and ventilate as required for entry and work in an enclosed space or a permit-required confined space.	Perform air monitoring and ventilate as required for entry and work in an enclosed space or a permit-required confined space.
Rescue/Retrieval	Entrant and attendant are required to wear rescue harness when working in enclosed spaces.	Entrant and attendant are required to wear rescue harness when working in enclosed spaces.	Entrant and attendant working in enclosed spaces shall wear rescue harnesses, when required.	Entrant and attendant are required to wear rescue harness when working in enclosed spaces.	Entrant and attendant are required to wear rescue harness when working in enclosed spaces
High Hazard Energy PPE	• Use fall protection equipment as required. • Use appropriate rubber gloves with protective gauntlets, rubber sleeves, fire retardant clothing and eye/protection face shield as required for the electrical hazard.	• Use fall protection equipment as required. • Use appropriate rubber gloves, rubber sleeves, fire retardant clothing, and eye protection/face shield as required for the electrical hazard. • In Steam Distribution, use appropriate water resistant coveralls and face shields before disconnecting any piping from the dead side of the trap valve up to and including the trap inlet valves and trap bypass valve. These coveralls and face shields must be worn until all piping is reconnected.	• Use fall protection equipment as required. • Wear airline respirator, FR coveralls, Fr hood & FR gloves or liners as required by IP-42	• Use fall protection equipment as required. • Use appropriate rubber gloves with protective gauntlets, rubber sleeves, fire retardant clothing, and eye protection/face shield as required for electrical hazard. • Do not come into contact or move a downed or low hanging utility wire while performing Site Safety or Damage Assessment work	• Use fall protection equipment as required • Use the appropriate rubber gloves, rubber sleeves, fire retardant clothing, and eye protection/face shield as required for the electrical hazard
Sheeting/Shoring		Ensure that excavations five feet or deeper are properly sheeted and shored before anyone enters.	Ensure that excavations five feet or deeper are properly sheeted and shored before anyone enters.		
Gas Piping Integrity Test			Perform an integrity test before a customer turn-on.	Perform an integrity test before a customer turn-on.	
Securing Loads					Reels over 5,000lbs (individually or when bundled together) are secured per NYS Metal Coil requirements

ATTACHMENT 1

Rules We Live By Determination Report

EH&S Representative ____
Determination Date ____
RWLB Determination ☐ Yes ☐ No

RWLB Hazard [Check all that apply]
☐ Verify Dead/Lockout-Tag Out
☐ Atmospheric Testing
☐ High Hazard Energy PPE
☐ Gas Piping Integrity Test
☐ Permits (Operating, D-faults)
☐ Rescue/Retrieval
☐ Sheeting/Shoring
☐ Securing Loads

Employee(s) Information
Name ____ ID _______________
Name ____ ID _______________
Name ____ ID _______________

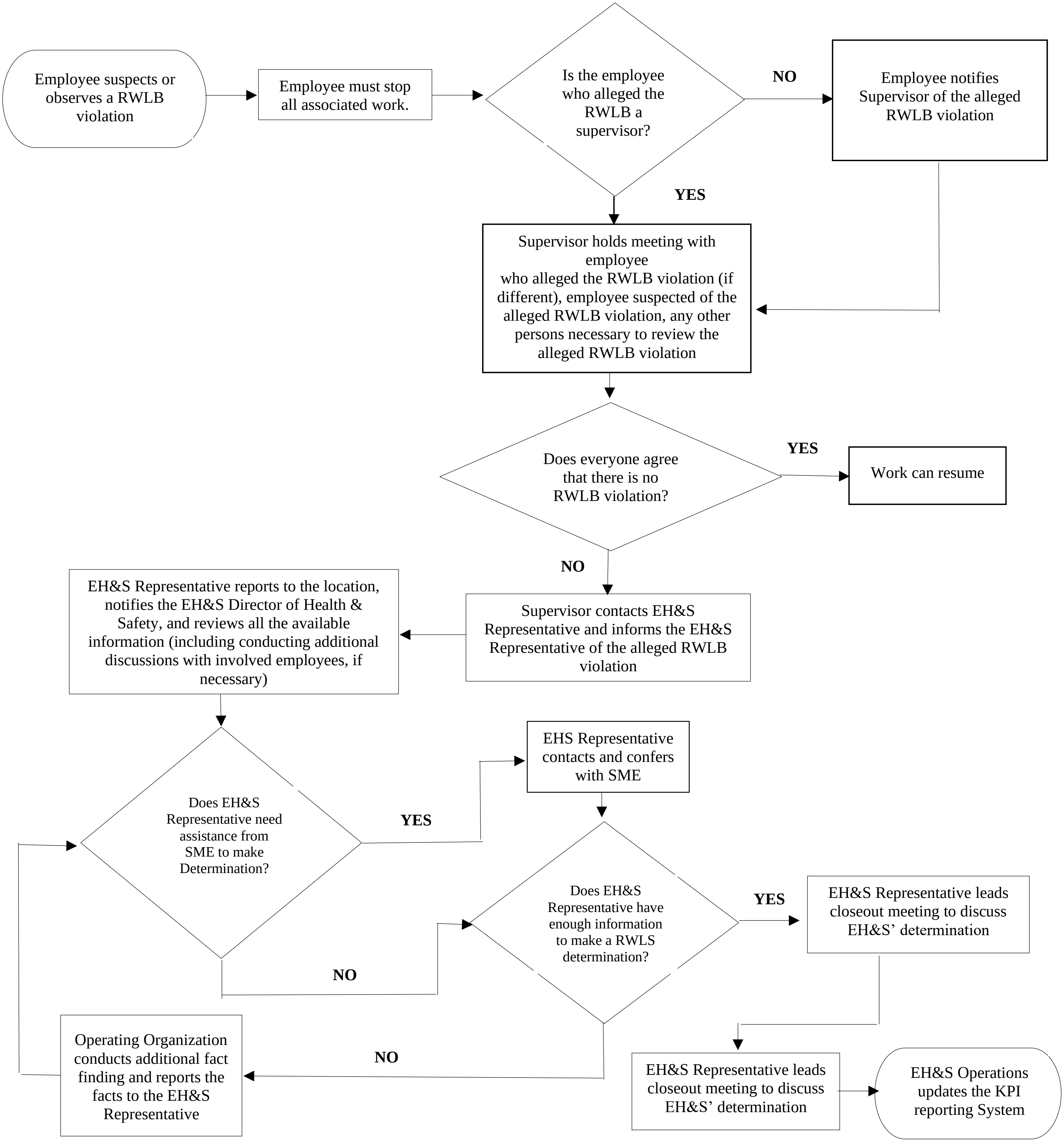
Organization(s) [Check all that apply]
☐ Electric Operations
☐ Customer Operations
☐ Contractor ____
☐ Central Operations
☐ Utility Shared Service
☐ Gas Operations

Incident Information
Date ____________________ **Time** ____________________
Location ____
Work task ____
____

RWLB violation (briefly describe)
____
____
____
____
____

Comments
____
____
____
____

ATTACHMENT 2
RWLB PROCESS FLOWCHART



ATTACHMENT 4
RAMBOLL'S PPE AND SAFETY EQUIPMENT GUIDELINE

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

Maureen Warren | Mark Watka

DATE

November 2021

VERSION

1.0

SAFE WORK PRACTICE

PPE & SAFETY EQUIPMENT

CONTENTS

1. PURPOSE

The purpose of this Safe Work Practice (SWP) is to establish uniform requirements to ensure that proper personal protective equipment (PPE) and safety equipment are provided to protect, shield or isolate workers from hazards.

2. SCOPE

This SWP applies to work at Ramboll offices, client facilities or other sites where PPE or safety equipment is required. Ramboll will ensure that proper PPE is evaluated and provided for projects under its control and supervision with a potential for employee injury. This SWP is intended to comprehensively address the establishment of appropriate procedures for selecting, maintaining and replacing PPE. In the event of a conflict between this SWP and locally applicable regulatory requirements (or project-specific requirements), the more stringent set of requirements will be followed.

3. OVERVIEW

This SWP provides roles and responsibilities, key definitions, work practices, training and documentation requirements for PPE. All PPE must be used and maintained in accordance with the manufacturer requirements and local regulations. The following work practice topics are addressed:

- **Hierarchy of controls –** PPE is the least desirable control and shall only be used if other control methods are not feasible or effective.
- **PPE levels –** Ramboll designates three categories of PPE: low level, medium level and high level. The PPE level should not be confused with the project risk classification. Many countries have different PPE categories (i.e., Level A, B, C and D in the US).
- **Risk assessments** – An assessment of hazards must be completed to determine what PPE will be required for a task/project. However, generally a hard hat, safety glasses and foot protection will be required for construction, demolition, remediation sites and industrial facilities.
- **Chemical protection** – If chemical exposure is anticipated the proper level of hand/skin protection must be selected. The type of chemical protection should be selected based on the chemical(s) of concern, amount of exposure (incidental vs. splash) and manufacturer recommendations.
- **Respirators** – Respiratory protection must be used and maintained in accordance with the Respiratory Protection SWP. Respirator users must be trained and medically clear in accordance with that SWP.
- **Donning and doffing** – PPE must be taken on and off to allow maximum protection and to prevent contact with contaminated items.
- **Heat stress** – When selecting PPE, the risk assessment must include the effects that PPE will have on body temperature. Additional heat stress controls may need to be implemented if heavy or impermeable PPE will be worn.

4. RESPONSIBILITIES

4.1 Project Manager (PM)/Project Owner (PO)

- Request PPE and safety equipment information and requirements from the facility owner and consider the adequacy of the information provided This information should be included in the project safety plan, as appropriate.
- Ensure appropriate resources, including people, budget and schedule to comply with requirements outlined in this SWP.
- Request assistance from the Health, Safety and Security (HSS) department if potential PPE and safety equipment deficiencies are observed or if technical support is needed or if technical support is needed to ensure safe implementation of PPE work practices.
- Support use of stop work authority by employees or subcontractors related to PPE or any other perceived hazard. Work is to be stopped until the identified hazards are evaluated and controlled to the satisfaction of the project team and HSS department and in accordance with safe work practices.
- Discuss stop work situations with the local Health, Safety and Security Coordinator (HSSC), Safety Ambassador or a representative of the HSS department, including reporting of incidents and safety observations in accordance with the HSS Process (HSSP), Event Reporting and Investigation.

4.2 Site Safety Representative (SSR)

- Be present at the site to oversee the project or appoint another on-site Ramboll employee as a backup SSR (with approval from the PM).
- Ensure the project safety plan that contains PPE or safety equipment information is reviewed with site team as part of their project safety orientation and during toolbox safety meetings.
- Communicate project safety requirements to all employees and subcontractors and document all safety meetings, unsafe acts or conditions and corrective actions.
- Inform the PM/PO of important developments or questions regarding project and task safety.
- Assist with reporting of incidents and safety observations in accordance with the HSSP, Event Reporting and Investigation.

4.3 Health, Safety and Security (HSS) department

- Support project safety plan development (when requested by the PM) and include PPE or safety equipment information and appropriate safety controls based on this SWP and site-specific concerns.
- Evaluate site conditions related to PPE through field safety audits and inspections when requested by the client, the PO or other management, or when required by local regulations.
- Provide technical support, consultation and training materials that are consistent with this SWP, when requested or applicable.

- Review and update this SWP on a biennial basis or more frequently if required by local regulation.

4.4 Health, Safety and Security Coordinators (HSSCs) and Safety Ambassadors (SAs)

- Support safety culture and new employee HSS inductions at the local office level, including discussion of this SWP and training resources.
- Provide assistance in PPE ordering, selection and related resources.
- Promote awareness, understanding and use of this SWP among local office employees.
- Facilitate application of this SWP in the context of local regulatory requirements and integration of this SWP into project safety plans.
- Inform the HSS department if the SWP does not adequately address local regulatory requirements.

4.5 Employees, subcontractors and visitors

- Review, understand and comply with project safety plans.
- Do not undertake any activities requiring PPE or safety equipment unless properly trained.
- Follow all PPE safety practices defined in this SWP, as implemented by the site owner or occupant, or as required by local regulations. In the event of a conflict, the more stringent work practices will be used.
- Report safety events, issues or concerns to the PM, SSR or other supervisor and in accordance with the HSSP, Event Reporting and Investigation.
- Exercise stop work authority if any task is perceived to be unsafe or if more information is needed to proceed safely.

5. KEY DEFINITIONS

Personal protective equipment (PPE) - PPE is all equipment or apparel designed to protect, shield or isolate workers from chemical and physical safety hazards. PPE includes head, eye, face, body, hand and foot and, under certain circumstances, respiratory protection. Additional information on PPE used for respiratory protection is provided in the Respiratory Protection SWP.

6. WORK PRACTICES

Employees may work at facilities where PPE or safety equipment is required and could improperly enter a hazardous area without the proper PPE. Employees and subcontractors should be familiar with PPE information in this SWP or as provided by the various client facilities in which we operate. Project teams are expected to be familiar with locally applicable regulatory requirements and project-specific requirements. In the event of conflicting requirements for work practices, the more stringent set of requirements will be followed. These requirements must be outlined in the project safety plan.

Ramboll will establish overall PPE requirements in this document. Project-specific PPE requirements will be determined through project-specific job hazard analysis by the project safety plan preparer and reviewed and approved by the HSS department and PM/PO.

6.1 Written programme

This written programme will be communicated to all team members that are required to wear PPE or use safety equipment. It encompasses projects/areas where Ramboll is actively working, regardless of the number of workers employed or the number of work shifts.

6.2 Regulatory applicability

Specific standards issued by the applicable regulatory agency will be reviewed as part of the overall job hazard analysis and PPE selection. When regulatory standards apply to a specific job, these standards will be incorporated into the hazard analysis and PPE selection to ensure that the requirements of the standard and hazard analysis are combined to create as optimally safe job conditions as is possible. The PPE guidelines presented here are to be followed unless the requirements in the project region/country or at a job site are more protective.

6.3 Identifying and assessing risk

PPE and safety equipment protects, shields or isolates workers from hazards. Because hazards are present at most construction, remediation, industrial and commercial sites where employees operate in a medium or high-risk work environment, employees may need to wear hard hats, safety glasses with side shields and steel-toed safety shoes or boots, as well as any additional PPE required by the client or host facility, such as metatarsal guards, hearing protection or fire-resistant clothing.

The first step in managing hazards at a workplace is to identify them. At some sites, the hazards are:

- Stable
- Well understood
- Have already been appropriately identified and assessed

Standard PPE, such as hard hats, safety glasses, hearing protection and safety shoes will generally be sufficient for project work taking place in a medium-risk environment, like site visits, audits or walk-throughs of commercial or industrial facilities. The project safety plan or risk assessment will outline the PPE needed for the project. It should be noted that the hazards may not be well understood and may change over time depending on site conditions and the scope of work. The PPE for medium and/or high-risk work environments may include items above and beyond those previously mentioned, such as goggles, face shields, respiratory protection, impervious gloves, coveralls or boot covers.

Protective equipment requirements will vary by site; however, the PM/PO, the SSR, local HSSC or other designated person knowledgeable about PPE will ensure that equipment selected will meet the minimum following requirements:

- Appropriate for the identified hazard
- Maintained in good condition
- Properly stored when not in use to prevent damage or loss
- Clean and fully functional

It is Ramboll’s responsibility to make required PPE available to employees and to provide adequate training on how to identify when PPE is necessary, as well as how to use, care for and maintain PPE.

Employees are responsible for the equipment in their possession and must properly use and remove (also known as donning and doffing) and dispose or clean their assigned PPE, as appropriate.

6.3.1 Hierarchy of controls

The hierarchy of controls is the most effective strategy to reduce risks in the workplace. At the top of the hierarchy, elimination or substitution of the hazard is the most effective, while controlling the hazard by implementing the use of PPE is the least effective. Ideally, if a hazard is identified, the project team will be able to eliminate the hazard or substitute with a less hazardous task or location.

Elimination or substitution are not always possible, in which case engineering controls are the next preferred method for protecting workers. These include physical means to mitigate risk such as guardrails to prevent accidental falls, industrial fans to increase ventilation or dust control methods like misting cuttings with water during drilling or digging. After engineering controls, administrative controls are next in order of preference and effectiveness. Administrative controls typically involve changes in workplace procedures, routines and employee training and are used in combination with engineering controls and PPE.

As the final level in the hierarchy of controls, PPE is to be used only when other methods are not feasible or effective in controlling the hazard. PPE may be the final and least effective control in the hierarchy but is one of the most important ways to reduce risk when hazardous work activities or environments are unavoidable. It is imperative that the use of PPE be evaluated for the specific hazards identified at the site and combined with administrative controls, such as training. In addition to selecting the appropriate PPE for the hazard(s) as part of safety planning, PPE users must consistently and competently don and doff their assigned PPE to be adequately protected and to minimise the potential for accidental exposure or injury.

6.3.2 PPE levels

Project safety planning and risk assessments will include consideration of the information gathered about the site hazards and risks to establish the level of PPE required. This evaluation will likely require a coordinated effort between the PM/PO, SSR, the project team and information provided from the client or previous reports. Once the hazard evaluation is complete, PPE is typically assigned to workers as a level or category. The PPE level represents the risk anticipated for workers and includes standard protective items to be worn to protect workers. Any employee who is asked to access or inspect an area that presents new or unexpected hazards, for which the assigned PPE does not mitigate, must stop work to address the health and safety concerns before proceeding.

Employees, with assistance from the SSR and HSS department, should reassess the PPE appropriate to the newly identified hazards. Employees can also choose, at any time during project work, to wear PPE more protective than the assigned items at their discretion, provided they are medically cleared to do so (as in the case of air-purifying respirators). Any changes in PPE, including voluntary upgrades, should be discussed with the project SSR to ensure that this change does not present additional hazards.

The categories of PPE shown here represent the minimum protection required at each of the three PPE levels. PPE levels are defined differently in different regions (see table below). Levels of PPE (low-, medium- or high-level protection) should not be confused with the work environment risk level (low-, medium- or high-risk environment), noting that low-risk environments such as offices do not require PPE, while PPE is typically required for medium- and high-risk work environments. Additional items of PPE can be added to the standard protective items defined within a level of PPE, depending on site-specific factors.

- **Low-level PPE** – Hard hat (if needed), protective footwear, long pants, work shirt, safety glasses with side shields (if needed), hi-vis vest (if needed), hearing protection (if needed)
- **Medium-level PPE** – Low level PPE (with potential upgrade of eye protection) plus protective gloves and/or protective coveralls (for chemical or physical hazards).
- **High-level PPE** – Low level PPE (with potential upgrade of eye protection) plus inner and outer chemically protective gloves, chemically protective coveralls and respiratory protection.

Levels of PPE (low, medium and high level) are typically assigned under a regulation or government department focussed on worker safety, and these regulations use different terms to refer to levels of PPE. The table below provides a comparison of levels of PPE in a few areas of the world with the Ramboll standard PPE levels reference for. Contact the local HSSC or the HSS department for additional information.

Table 1. Ramboll dtandard global PPE levels with comparisons

Ramboll PPE levels	US PPE levels (OSHA[1])	Italy PPE levels	Netherlands PPE levels
Low	D	Category I – Category II	PPE-Light
Medium	Modified D	Category II	PPE-Light to PPE-Intermediate
High	C, B, A	Category III	PPE-Heavy

1 - OSHA – Occupational Safety and Health Administration

Low-level PPE items are covered in detail in Section 6.5. Low-level PPE should only be selected when there are nuisance levels of contamination, limited anticipated exposure to chemicals, and the work environment is stable and well understood (e.g., Phase I ESA, Project site with an engineered barrier, etc.). For medium and high-level PPE, the PPE will build from the low-risk standard PPE items by adding chemical and, under certain circumstances, respiratory protection. Medium- and high-level PPE items are covered in Section 6.6.

6.4 Low-level PPE

This section describes PPE in the low-level category, including skin, head, eye, hearing, foot and general hand protection, including selection, fit and maintenance. This information applies to project work taking place in medium-risk work environments and high-risk environments, and in some cases may also apply to low-risk work environments such as offices, such as the use of work gloves to lift a heavy item.

6.4.1 Skin protection

Skin protection at a low PPE level means taking sensible precautions when exposed to heat, cold, potential injury or chemicals.

Always wear:

- Long pants
- Work shirt with sleeves
- Sturdy closed toe footwear (safety boots with a composite or steel toe may be required if vehicles, equipment, heavy lifts, or other foot hazards are expected)

Never wear:

- Shorts
- Tank tops
- Open-toed shoes

Skin is also at risk for exposure to biological hazards – like plants, animals and bloodborne pathogens – and environmental hazards like the sun and thermal exposures. The following are general guidelines for skin protection:

- Research poisonous plants, insects and animals potentially found at the site and dress appropriately. Refer to the SWP, Dangerous Plants and Animals for additional information on poisonous plants, insects and animals.
- Work in open areas free of vegetation as much as possible.
- Wear sunscreen and sun protective clothing.
- Dress appropriately in layers during cold weather.
- Wear light coloured, loose and breathable clothing during warm weather.
- Refer to the SWP, Heat and Cold Stress, for additional information on thermal stresses.

Some sites may require that long-sleeved shirts, high-visibility vests and steel-toed shoes be worn by all workers on site. High-visibility clothing or vests are required whenever work will be conducted in and around forklifts, other heavy equipment or vehicular traffic. Employees that visit refineries may also need to don fire-resistant or fire-retardant clothing or coveralls.

6.4.2 Head protection

To protect workers where there is a possible danger of head injury from impact by falling or flying objects, or electrical shocks and burns, head protection must be worn. Typical areas with falling object exposure include construction, demolition and remediation work at field sites and industrial facilities. Generally, hard hats can protect against three types of hazards:

1. Falling or flying objects
2. Head bumps (on structures overhead)
3. Electricity

It is important to make sure the hard hat is appropriate for the potential hazards at the site. Hard hats must protect against impact on the crown and sides of the head and, if there is a potential for electrical exposure, the hard hat must be certified to the appropriate electrical class. Information about the certification can be found inside the hat on a label. If information is not provided on the hard hat, employees may not use the hard hat for project work. Additional country-specific guidance is included in Section 10.

Requirements for hard hats include:

- Markings on the product shall include the name or identification of the manufacturer, date of manufacturing, standard designation and head size range.
- User information shall include the manufacturer’s instructions, application and expected useful life, care and adjustment instructions.
- Users shall visually inspect their hard hats prior to each use per the manufacturer’s recommendation. If a hard hat becomes brittle, cracked or damaged, it shall be replaced immediately. Painting on hard hats is prohibited. Suspensions and shells shall be replaced per the manufacturer’s recommendation.
- Metal hard hats and cowboy-style hard hats shall not be worn by employees. If used by a subcontractor, they are subject to additional review to ensure they meet client and regulatory requirements.

6.4.2.1 Proper fit and maintenance

The hard hat must be worn properly, and it must be in good condition:

- Inspect the hard hat prior to and after each use.
- Wear the hard hat square on the head, not tipped forward or to either side.
- Hard hats may be worn backwards when the hard hat is designed to be turned backwards and when required by the risk assessment. When hard hats are worn backwards, the inner hard hat band shall be installed correctly, which requires removing, turning and reinstalling the band per the manufacturer directions.
- Never alter or modify the shell or suspension system.
- Do not use paints, solvents, chemicals, adhesives, gasoline or similar substances on the hard hat.
- Do not store the hard hat in direct sunlight.
- The hard hat shell should not touch the head - the suspension system should hold the shell about 1 in/2.5 cm away from the head.
- The suspension system should provide adjustability for a secure fit. Users must be able to bend over and move freely without the hard hat shifting.
- Do not wear a hard hat over another hat like a baseball cap or skull cap. Use an appropriate hard-hat liner for cold weather (thermal liner) and hot weather (absorptive liner). Refer to the manufacturer’s instructions to determine what is acceptable under the hard hat.
- Avoid dropping or throwing the hard hat. Impact weakens the protective material.
- Inspect the suspension system for signs of deterioration (e.g., cracking, tearing, fraying, no longer holds the shell away from the head, etc.).

- Inspect the brim or shell for signs of exposure to heat, cold or chemicals (e.g., loss of surface gloss, chalking, flaking, cracks or deformities, etc.).

If any signs of damage or deterioration are identified during inspections, the employee must dispose of the hard and obtain a new one. If the hard hat has taken a heavy blow, it should also be replaced, even if no damage is visible. Employees are prohibited from putting stickers on their hard hats unless required by the client. Stickers can obscure signs of damage and wear. Adhesives for the sticker may also damage the hard hat shell.

At a minimum, follow the manufacturer's recommendations for replacing the hard hat. Review regulatory or client requirements in the region for guidelines. In general, the following replacement schedule is recommended:

- Replace the hard hat every five years.
- Replace the suspension every three years.

The replacement schedule applies even if there is no visible evidence of damage or wear. If the employee is working under conditions of intense light or heat, the hard hat should be replaced more frequently.

6.4.3 Eye protection

Work scenarios where eye protection should be worn include, but are not limited to, working with chemicals, around flying objects, in industrial environments, on construction sites, in windy environments or whenever there is a chance of an eye injury. Eye protection is also required when workers may be exposed to extreme heat or intense light. The protective eyewear provided must meet regional- or country-specific safety standards. Additional country-specific guidance is included in Section 10.

The most common types of eye and face protection used by employees include:

- Safety glasses with side shields (clear or shaded lenses)
- Goggles
- Face shields

Specialty eye protection may be required to protect against welding arcs or non-ionizing radiation.

6.4.3.1 Safety glasses

Safety glasses with side shields provide minimum protection and are the most common eye protection used for general working conditions where there may be minor dust, chips or flying particles. The side shields provide angular protection from impact hazards in addition to frontal protection. Glasses may have side shields that fold flat, also known as semi-side shields, or may have full or cup-style side shields. Safety glasses with side shields do not provide the same level of splash or droplet protection as goggles. Some safety glasses have foam or rubber liners to reduce the potential for dust or particles to reach the eye. While useful for dusty or windy environments, these lined safety glasses are also not a substitute for goggles when there is a potential for splashes or droplets.

Safety glasses may also be used to protect against heat and optical radiation that includes visible and near visible light or radiation. Ensure that the safety glasses will provide protection against the hazards identified at the site.

The frames of safety glasses must fit comfortably and correctly to offer the necessary protection. There are different styles available that may be either fixed or adjustable, including:

- Spatula temples, which fit over the ear
- Cable temples, which fit around the back of the ear
- Headband temples, which consist of an elastic strap and are useful for tasks requiring movement

6.4.3.2 Safety goggles

The frames of safety goggles must be properly fitted to the worker's face to form a protective seal around the eyes and are most effective when they fit snugly, particularly from the corners of the eye across the brow. There are different styles available, including:

- Eyecup safety goggles cover the eye sockets completely and are available with direct or indirect ventilation
- Cover safety goggles may be worn over corrective glasses and are available in direct, indirect or non-ventilated types

Ensure that the type of ventilation, direct, indirect or non-ventilated, for the selected goggles is suitable to the potential hazards at the job site. Ventilation helps reduce fogging and improves visibility through the goggle. Ventilated goggles may not be appropriate for use in high-risk or chemical exposure scenarios since the ventilation may allow chemical splash to reach the eyes.

6.4.3.3 Face shield

As opposed to safety glasses or goggles, a face shield can also provide protection to other facial areas and should be used for high-impact, full-face protection. Face shields may be needed when there is exposure to splashing, spraying, chipping and grinding.

Face shields are categorised within the low PPE level. While there may be some appropriate uses of a face shield at medium-risk work environments, medium-risk projects may warrant a re-examination of the project safety plan and assignment of the high-risk category and safety planning documents. Face shields are more commonly used in high-risk work environments.

Face shields should be used in addition to safety glasses or goggles, not as a substitute for them. Face shields provide secondary protection, while safety glasses or goggles provide primary eye protection. Always wear safety glasses or goggles under face shields to provide protection when the shield is lifted. Primary protection helps prevent particles that get under the shield from lodging into the eyes. To provide better face and eye protection from splashes and sprays, a face shield should have crown and chin protection and wrap around the face to the point of the ear, which reduces the likelihood that during higher-risk activities a splash could go around the edge of the shield and reach the eyes.

6.4.3.4 Safety sunglasses

The sun releases energy, or radiation, in many forms. Ultraviolet (UV) rays are invisible to the eye and can damage the eyes. When wearing safety sunglasses or tinted safety glasses, the lenses should:

- Reduce glare
- Filter out 99-100% of UV rays
- Physically protect the eyes from impact
- Not distort colours

Tinted safety glasses may not be appropriate for use indoors or in darker environments, where they may impair visibility. Clear lenses should be worn when lighting is dim or poor or when documenting colour observations is part of the scope of work.

6.4.3.5 Proper eyewear fit and maintenance

Manufacturers make several different sizes of eye and face protection. To ensure a proper and comfortable fit of protective eyewear, follow these guidelines:

- Safety glasses and other safety eyewear should be comfortable when worn, which will increase the chances that they will be used.
- Safety glasses have a three-point fit, meaning the frame should touch the face in three places: at the nose bridge and behind each ear.
- The nose piece should not slide down the face due to sweat or moisture. If the glasses slide down even a small amount, adequate protection may be reduced.
- Goggles and respirators should fit the face snugly to create a proper seal against dust and chemicals.

The eye protection that we have described in this SWP is generally not disposable and should be cleaned before reuse. Eye protection should be cleaned with a disinfectant, rinsed and allowed to air dry in between uses or whenever it becomes soiled. After disinfecting eyewear, place the dry parts or items in a clean, dust-proof container, such as a box or bag, to protect them until reuse. If there is evidence of damage (or if eye protection cannot be cleaned), obtain a replacement pair.

6.4.3.6 Prescription eyewear

Prescription eyeglasses designed for ordinary wear do not protect against workplace hazards, even when equipped with removable side shields. Many non-prescription safety glasses or safety goggles fit comfortably over prescription eyewear and can provide satisfactory protection without impairing the fit of the eyewear.

Contact lenses may be worn with any of the recommended protective eyewear; however, contact lenses may present a significant corneal abrasion risk when working in dusty areas unless tight fitting goggles or a full-face respirator is worn. Contact lens wearers must comply with the site-specific project safety plan as well as rules at job sites where contact lenses may be restricted.

Prescription safety glasses and goggles are also available, as are prescription inserts for full-face respirators. Resources for obtaining prescription safety eyewear vary by country, region and business unit. Employees may be provided with access to an authorised vendor or may participate in a reimbursement programme. More information on these programmes is provided by visiting the Health & Safety page of Rambla and accessing the local H&S information page for the country or region.

6.4.4 Hearing protection

Hearing protection should be worn by all employees working within an area where noise is sufficient to interfere with general conversation at a normal speaking volume, when noise levels exceed 85 decibels (dBA) and/or when client requirements indicate that its usage is mandatory. When hearing protection is required, multiple forms of hearing protection (e.g., ear plugs, earmuffs) can be used. Hearing protection provided must meet regional- or country-specific safety standards. Additional country-specific guidance is included in Section 10.

A variety of hearing protectors will be available (plugs and muffs) to employees exposed to an 8-hour time weighted average (TWA) of 85 decibels, A-weighted or greater. Hearing protection does not have fitting requirements except that employees are encouraged to wear the type or hearing protector they find most comfortable unless a task-specific work instruction requires use of specific hearing protectors.

- Formable plugs should be rolled and compressed into a very thin cylinder. While compressed, insert the plug well into the ear canal. Reach around the head to pull the ear outward and upward during insertion.
- Pre-moulded or pre-formed plugs should be inserted by reaching around the back of the head to pull the ear outward and upward while inserting the plug until it feels like it is sealed.
- Earmuffs must fully enclose the ears to seal against the head. Adjust the headband so the cushions exert even pressure around the ears. Pull hair back and out from beneath the cushions.
- The fit of ear plugs can be checked by pressing firmly cupped hands over the ears while listening to a steady noise. With properly fitted plugs the noise levels should be about the same when the ears are covered or not covered.

Keep formable plugs and earmuff cushions clean and free from material that can irritate the ear canal. Formable plugs and earmuff cushions may be washed in a mild detergent and warm water. Squeeze excess water from the plugs and air dry. Discard plugs if they harden, do not return to their original size and shape or are dirty. Earmuff cushions should be replaced whenever they become stiff, cracked or do not create an effective seal.

6.4.5 Foot protection

There is a basic minimum standard for shoes appropriate for wear in non-office settings – a sturdy shoe with low heels and non-skid soles. Consider shoes with ankle support if walking over uneven ground or in an area where slips, trips and falls may occur. Sandals and gym shoes are not allowed.

Protective footwear, with steel or composite safety toes, will be required for employees visiting hazardous work sites, industrial facilities and construction sites. In some cases, metatarsal guards may also be required. Refer to site- or client-specific requirements regarding composite toe boots.

Protective footwear should be worn to mitigate the potential hazards listed below and whenever required by a client at the job site.

- Impact from heavy objects falling
- Slips on slick surfaces
- Trip hazards
- Compression from heavy rolling objects (e.g., wheels, drums or barrels)
- Puncture from sharp objects (e.g., nails, wire, tacks, screws or staples)
- Chemicals or environmental contaminants
- Electricity

The certification or rating of the safety shoe must be attached to one of the shoes, normally on the "tongue" and will tell the wearer the type and level of protection provided. Foot protection provided must meet regional- or country-specific safety standards. Additional country-specific guidance is included in Section 10.

6.4.5.1 Footwear maintenance

Safety shoes should be cleaned after every use. Remove dust and dirt from the shoes with a soft cloth and stiff brush while still on the project site. Do not wear safety shoes off the project site if there is a potential to track contaminants into a vehicle, a residence or onto another client's site. Use a mild soap and water to clean the uppers and soles, if necessary. If the contamination is potentially hazardous, the water used for decontamination should be collected and properly disposed. If a difficult decontamination is anticipated, disposable boot covers should be used.

Inspect the footwear for:

- Cracks, tears, wearing or holes
- Loss of tread
- Separation between soles and uppers

In general, damaged footwear should be replaced. However, for worn treads some brands of footwear can be re-soled. Safety shoes should only be re-soled by the manufacturer or manufacturer's designated representative to ensure that the safety properties of the shoe will remain intact.

Regular maintenance will help the boots break in and last longer. If wearing leather boots, it is recommended that the leather is periodically conditioned with oil or other manufacturer recommended solution to reduce cracking.

6.4.6 General hand protection

Hand protection may need to be used in any work environment. Even when working in low-risk work environments (offices) and medium-risk work environments (facility sites visits or audits), employees may encounter hazards that could cause hand injuries, such as those shown here:

- Abrasions resulting from lifting heavy objects

- Abrasions resulting from a slip, trip, or fall on uneven or sharp surfaces
- Laceration from using a cutting tool to open packaging
- Exposure to biohazards such as blood
- Heat and cold injuries

In high-risk work environments, hazards may include the following, requiring additional or alternative hand protection that will be discussed further in the next section (Section 6.5).

- Chemical exposure
- Vibration, such as from using power tools or equipment
- Lacerations, such as from using powered or hand tools
- Electric shock

The HSS department or local HSSC can provide guidance on the proper gloves to wear to mitigate identified hazards and risks at job sites. Employees working in low-risk work environments should wear gloves primarily to protect against physical hazards such as abrasions during lifting or related to cold temperatures. In medium-risk work environments and high-risk work environments, glove requirements may include cut-resistant, puncture-resistant or chemical-resistant gloves.

6.4.7 High-visibility clothing

High-visibility clothing including vests are required for all work areas in or near roadways. Vests are also frequently required for construction, demolition and remediation work areas depending on site-specific requirements. The type, colour, level of reflection and configuration of materials on a high visibility vest is dependent on the type of activity, the site conditions and the local regulatory authority. High-visibility clothing should be inspected for damage and evaluated for required visibility. Items should be replaced or repaired when they are torn, noticeably faded, soiled, cracked, burned, heavily abraded or otherwise damaged. Additional country-specific guidance is included in Section 10, where available.

6.5 Medium- and high-level PPE

This section discusses PPE in the medium-level and high-level categories. The information in this section applies to high-risk work environments and activities, including work at hazardous waste and heavy industrial sites, as well as project sites requiring sampling and potential exposure to chemicals. This section will cover the following:

- Skin and body protection
- Respiratory protection
- Hand protection
- Specialised eye and face protection
- Electrical protection
- Personal flotation devices

- Fall protection
- PPE matrix

Depending on the job site and potential hazards, employees may be required to wear outer coveralls, chemical-resistant or protective suits, or fire-resistant or -retardant clothing. To have a better understanding of the hazards at a site, information must be obtained about the site during pre-project planning. Methods include:

- Discuss potential hazards with the site contact.
- Conduct a preliminary site walk-through.
- Review previous reports.
- Discuss with employees who have previously visited the site.

The selection of the appropriate protective coveralls, hand protection and respiratory protection will depend on the potential chemicals of concern identified at the project site. Employees should base PPE selection on safety data sheets (SDS) for identified chemicals and local regulatory guidance. Contact the local HSSC or the HSS department for assistance. SDSs for potential chemicals of concern must be included in a project-specific safety plan.

6.5.1 Protective coveralls

Dust coveralls are to be used when there is a risk of airborne contamination, such as when drilling soil or rock or cutting concrete, or when working on an asbestos abatement project. These coveralls may be reusable or disposable. The project safety plan should identify whether reusable, that is washable, coveralls should be used, or if the coveralls should be dedicated to the site and disposed after use. The SSR should consider the type of contaminants anticipated at the site when making this determination. Dust coveralls should not be used if there is a risk of exposure to chemicals via splashing. Review the manufacturer’s label for protection information to ensure the coveralls are appropriate for the potential hazards anticipated at the site.

Chemically resistant coveralls should be used when there is a splash risk based on the scope of work and the chemicals of concern are present at unknown concentrations or at known concentrations that present a risk when exposed to skin directly or via damp work clothing. Chemically protective coveralls may also be warranted when there is a risk of skin exposure to chemical vapours. Types of coveralls below are listed at increasingly protective levels:

- Splash resistant
- Chemically protective
- Chemically protective with hood
- Chemically protective with hood and boot covers

The factors shown here will help determine what material is appropriate for the chemically protective coveralls. This material compatibility information also applies to glove selection discussed in Section 6.6.4. An evaluation of the PPE material should be available from the manufacturer and should be considered when selecting PPE during project safety plan preparation.

- Permeation

- Amount of chemical that passes through the material over a specified duration
- May not be noticeable without a microscope
- Breakthrough time
- Amount of time it takes a chemical to break through
- Degradation
- Changing the physical property due to chemical interaction
- Penetration
- Large flow of any chemical through protective barrier

As the required PPE level rises from medium to high risk, due to potential exposure to increasingly hazardous chemicals, respiratory protection may also be required to protect against inhalation hazards. The PM/PO should consider engineering controls and administrative controls, such as training and work schedule management, first before considering appropriate PPE. Work and rest schedules should be outlined in the project safety plan, discussed at least daily at the site and documented in the field notebook.

6.5.2 Flame-resistant clothing

Many employees work at client sites, like oil and gas facilities, where flame resistant or retardant clothing (FRC) may be required. Determine the client and site requirements before purchasing flame-resistant clothing. If 100% cotton coveralls are not required, the HSS department recommends Nomex® coveralls. Cotton coveralls are less costly but are very heavy and potentially present a heat stress hazard. When using Nomex® in cold environments, purchase a larger size and layer appropriately underneath.

The use of FRC shall be on a site-by-site basis and shall be determined by risk assessment and shall be included in the project safety plan for the site. An employee or site supervisor may identify a site-specific job and/or area requiring FRC such as when there is potential exposure to flash or arc burn injuries (i.e., electrical circuit). FRC may be required when working at a production facility with hydrocarbon-containing equipment.

FRC garments shall comply with the requirements below:

- Fabric Weight: FRC material shall not weigh less than 4 oz./yd2 (150 g/m2)
- FRC materials shall comply with National Fire Protection Association (NFPA) 2112, Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire and tested to ASTM F1930, Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin, or equivalent standard

Reflective stripes shall conform to the International Safety Equipment Association (ISEA) 107, Level 2, American National Standard for High Visibility Safety Products and Headwear, as applicable.

FRC shall be worn and maintained accordingly:

- Team members shall wear FRC as the outer-most garments except when other protective clothing is required (e.g., chemical-resistant suits, welder’s leather and PFDs).

- External protective garments shall be made of flame-retardant material.
- Team members shall not wear synthetic blends such as nylon, polyester, rayon or polyethylene under FRC - only natural fibres such as cottons and wools shall be worn under FRCs.
- Only long-sleeved FRCs shall be worn in designated FRC areas or jobs - FRC shall cover the torso, arms and legs (sleeves rolled down and body fully zipped or buttoned up).
- FRC shall be laundered, repaired and taken out of service per the manufacturer's recommendations.

6.5.3 Respiratory protection

The respiratory protection programme is covered under the Respiratory Protection SWP and includes the following programme elements:

- Procedures for selecting respirators for use in the workplace
- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators
- Procedures for proper use of respirators in foreseeable emergency situations
- Procedures and schedules for donning, cleaning, disinfecting, storing, inspecting, repairing, discarding and otherwise maintaining respirators
- Procedures to ensure adequate air quality, quantity and flow of breathing air for atmosphere-supplying respirators
- Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations

6.5.4 Hand protection

6.5.4.1 Chemical protection

Proper glove selection for chemical protection should consider the glove's resistance to:

- Chemical degradation
- A chemical penetrating the glove through pinholes, seams or other imperfections
- A chemical flowing through the glove on a molecular level through absorption or diffusion

After the potential chemicals of concern are identified for the project site, review the chemical SDS and use this information to determine the compatibility of the glove with the chemicals of concern. Glove manufacturers may offer guidance glove selection based on the chemical of concern.

Always change gloves if degradation is visible, or if the glove is punctured or torn. Even if the gloves are not visibly deteriorated, they may need to be changed between each sample to avoid cross-contamination.

In addition to chemically protective gloves, employees may need physically protective gloves to protect from vibration, abrasions, lacerations, or other site-specific hazards identified. Physically protective gloves may be made of leather, heavy canvas, various synthetics, or cut-resistant material. The SSR, local HSSC, or HSS department can provide guidance on the proper protective gloves when preparing the site-specific project safety plan.

6.5.4.2 Cut-resistant gloves

Ramboll prefers that safety knives (e.g., self-retracting blade), scissors, shears or safety cutters be used instead of fixed blade knives, razor knives or box cutters. If the use of a cutting device is required for a certain task, the safest device available that meets the needs of the job should be used.

In the event a fixed blade knife is the only tool that will perform a specified task, the worker shall justify its use in an approved job safety analysis (JSA) or other safe work procedure that provides justification that a razor or fixed blade knife is the only tool suitable for a given task and specifies the use of cut resistant gloves and sleeves (ANSI cut level A5 or greater or equivalent) as well as forearm sleeves (e.g., Kevlar®).

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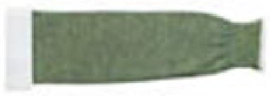


ASTM ANSI CUT LEVEL A5

2200 - 2999 grams to cut

Medium/heavy cut hazards: appliance manufacturing, bottle and light glass handling, canning, dry walling, electrical, carpet installation, HVAC, pulp and paper, automotive assembly, metal fabrication, metal handling, packaging, warehouse, aerospace industry, food prep/processing

6.5.5 Specialised eye and face protection

The following sections describe eye and face protection for specific activities.

6.5.5.1 Welding goggles and face shields

Electromagnetic energy given off by an arc or flame can injure workers' eyes and is commonly referred to as radiant energy or light radiation. For protection from radiant energy, workers must use PPE, such as safety glasses, goggles, welding helmets, or welding face shields. This equipment must have filter lenses with a certain shade that provides the appropriate level of protection.

- Safety glasses with side shields worn under a welding helmet with a proper lens tint for the type of welding conducted. Refer to the Lens Shade Table in Section 10, Additional Information of the Hot Work – Welding and Cutting SWP.
- Other workers who are not welding but in the immediate area to support welding must wear tinted safety glasses (face shield not required).

6.5.5.2 Laser work

Employees may encounter lasers during fieldwork. Refer to the Radiation SWP for information on laser work PPE.

6.5.6 Electrical protection

Refer to the Electrical Safety – Arc Flash SWP for information on electrical safety PPE.

6.5.7 Personal flotation devices

Personal floatation devices (PFDs) provide an individual buoyancy to stay afloat in water. There are several different types and ratings of PFDs depending on the application and water conditions. In general, PFDs must be a high visibility colour; properly sized and fitted to the individual (as applicable); applicable to the type of work and water conditions; and be approved by the local regulatory authority.

PFDs should be fitted with a Safety of Life at Sea (SOLAS) Convention-compliant whistle or noise making device. Prior to each use, the user shall examine PFDs for deterioration or damage that might affect their strength and buoyancy. Defective PFDs shall be removed from service and either repaired or replaced. Additional information on PFDs is provided in the Water Work - Inland, Near Shore and Facility SWP.

6.5.8 Fall protection

Fall arrest equipment shall be suitable for the planned tasks, used only by medically suitable and competent persons and subject to documented regular inspection. Fall arrest equipment shall be used only as a last resort due to the difficulty of a timely rescue. In addition to regularly planned inspections, all fall arrest equipment shall be checked by the user immediately before use. If it is damaged, the equipment should immediately be labelled as faulty and taken out of use. New fall arrest equipment shall be provided before the work task commences. Refer to the SWP, Work from Heights – Fall Prevention and Protection for additional information on fall protection including harnesses, lanyards, fall arrestors and anchoring devices.

6.6 PPE and safety equipment matrix

PPE and safety equipment requirements will vary by project site. Each project is risk-assessed in a site-specific project safety plan. PPE and safety equipment selection for each task is based on that risk assessment. The project safety plan should outline the necessary PPE needed for a particular task and should include items such as, hard hats, face shields, safety goggles, glasses, hearing protection, foot guards and gloves. Minimum requirements for typical job tasks are provided in the example PPE and safety equipment matrix (Attachment A). Tasks and requirements shown in the matrix should be customised for the site-specific project safety plan to ensure that they are adequately protective. The PPE and safety equipment matrix allows for the addition of specialised equipment (including communication equipment) and/or clothing for use in particular hazard situations, which are risk assessed and chosen prior to work commencing.

6.7 Donning and doffing

Employees must become familiar with how to properly don and doff PPE, which means to put on and take off the PPE. This is particularly important when wearing multiple items of PPE. For PPE to function properly, the following steps must be completed:

- Ensure that the proper PPE is selected and obtained for the job.
- Inspect PPE for damage, tears or other deterioration before use.
- Start with the base layer and inner gloves, adding additional items of PPE as specified in the project safety plan.

- If coveralls are required to protect skin from atmospheric hazards or splashes, use appropriate tape and cut lengths suitable for wrapping around the waist, ankles and wrists before getting dressed. Use care not to restrict circulation in the hands or feet. Form a tab of tape and leave the tab exposed to simplify removing the tape while doffing.

When doffing PPE, reverse the steps taken when donning PPE. For proper glove doffing, refer to Section 10.2. Depending on the hazards at the site, a decontamination process may also be required. Dispose of all disposable PPE as indicated in the project safety plan and clean all reusable PPE (e.g., safety glasses; boots) after each workday or shift.

6.8 PPE-related hazards

PPE mitigates a hazard, but also presents a potential risk. PPE can change an individual's movement and body temperature. Employees need to be fit for duty and aware of the surroundings, especially when wearing PPE. Any changes in PPE, even voluntary upgrades, should be discussed with the SSR or PM/PO to ensure that this change does not present additional hazards (e.g., heat stress). Additional information is provided in the HSSP, Medical Surveillance and Fitness for Duty and the SWPs, Respiratory Protection and Heat and Cold Stress.

6.9 Provision and maintenance of PPE

Ramboll will provide project-specific and general overhead PPE to employees. Employees issued PPE are responsible for the equipment in their possession and for properly donning, doffing, maintaining and cleaning PPE. Each office or project should maintain enough PPE supplies to accommodate the level of field activity for the office or project. All expense associated with PPE must be approved in advance by the PM/PO, local HSSC or designee. Defective or damaged PPE must not be used and the maintenance of defective or damaged PPE will only be conducted by authorised manufacturer's representatives.

Resources for purchase and distribution of PPE and other safety equipment vary by country, region and business unit. For example, in the Americas, a PPE and Safety Equipment resource page is established as part of the Americas HSS Rambla page. This resource includes a vendor-supported PPE Portal, including available branded items and commonly used or requested items, and is enabled to allow ordering and shipping of approved items by US employees and project teams. Additional instructions for Americas employees to access the PPE Portal are posted on Rambla. To inquire about PPE ordering in your region, contact the local HSSC, Safety Ambassador or a representative of the HSS department.

7. TRAINING & COMPETENCY

The HSS training programme includes new employee induction training, supervised on-the-job training and annual completion of online modules or classroom instruction related to safety requirements and work practices. Training assignments vary based on employee roles and training classification. Completion of assigned training will be documented by a training completion certificate, which will be stored in the employee's electronic training record.

7.1 Training requirements specific to PPE and safety equipment

Employees shall be adequately trained in the PPE programme and proper use of PPE and other equipment through online HSS training modules, in-person training, or virtual instructor-led training. Employees must be trained in and demonstrate knowledge of the following:

- When and where the PPE or equipment is required
- The type of PPE or equipment required
- How to properly wear the PPE or equipment, including donning and doffing
- Limitations of the PPE or equipment
- Care, maintenance, useful life and disposal of PPE and equipment
- Retraining will be administered when the following situations occur (at a minimum):
    - Changes in the workplace or the type of PPE render previous training obsolete
    - Inadequacies in the employee’s knowledge or use of the PPE indicate that the employees have not retained the requisite understanding or skill; or any other situation arises in which retraining appears necessary to ensure safe respirator use

8. DOCUMENTATION

The following documentation is required, specific to PPE and Safety Equipment. These requirements may vary by country, region or business unit.

8.1 Medical surveillance questionnaire

The medical surveillance questionnaire is completed annually as part of Ramboll’s medical surveillance programme. Any previous known or suspected chemical exposures above action levels (after accounting for respirator use) should be documented on the employee’s medical surveillance questionnaire. Refer to the HSSP, Medical Surveillance and Fitness for Duty.

8.2 Medical and respirator clearance certificate (“fit for duty”)

This record is maintained by Human Resources and the HSS department, or in some regions may be maintained by the local HSSC or Safety Ambassador. Medical clearance documentation must also be obtained from any subcontractors who will be wearing respirators on projects and will be maintained in project records. Refer to the HSSP, Medical Surveillance and Fitness for Duty and the SWP, Respiratory Protection.

8.3 Annual respirator training certificate

Annual respirator training may be required for persons who wear a respirator in work areas that are potentially above local regulatory occupational exposure limits (OEL). Training records are maintained and documented through an online training platform (e.g., Ramboll Academy or equivalent). Refer to the HSSP, Training Programme and the SWP, Respiratory Protection

8.4 Annual fit test

This test is required for all persons who wear a respirator in work areas that are potentially above local regulatory OELs. Record is maintained by Human Resources. Qualitative and quantitative fit tests must be documented on a Respirator Assignment and Fit Testing Form (see HSS Forms Library) unless the fit test was administered during the medical exam or by another outside contractor or vendor. Fit test documentation from Ramboll’s Medical Consultant or a third party must meet requirements under local or regional occupational safety and health regulations. Refer to the SWPs, Respiratory Protection and Hazardous Waste Operations and Response.

8.5 Voluntary usage of respirator acknowledgement

All persons who elect to wear a respirator when not otherwise required, for example to control nuisance odour, and/or as a precaution when airborne contaminant levels are below occupational exposure limits established under local or regional regulations, must read and understand important information presented in the Voluntary Usage of Respirator Acknowledgement (available in the HSS document library) and must be medically fit to wear the respirator. Documentation signifying completion of this review will be stored as part of the employee's training record in Ramboll Academy or equivalent training management system.

9. INTERNATIONAL TILTS

9.1 Asia/Pacific

9.2 Brazil

9.3 Canada

CAN/CSA – Z195-02 Protective Footwear. A national standard of Canada approved in March 2003. The CSA Standard Z195, Protective Footwear, covers the design and performance requirements for protective footwear.

https://www.ccohs.ca/oshanswers/prevention/ppe/footwear.html

9.4 European Union (EU)

In accordance with **Regulation (EU) 2016/425**, all PPEs must be tested and marked to prove that it can meet the relevant protective standards.

All **eyewear** intended for use in the workplace must meet a core European standard EN ISO 66:2001.

The standard EN352 covers the basic requirements of hearing protection and defines the passive performance requirements. This includes the requirements for size, materials and construction. The EN 13819 includes the testing methods common to all types of hearing protectors covered by EN 352 and the EN 458 covers selection, use, care and maintenance of hearing protectors.

High-visibility protective clothing must comply with EN ISO 20471, the European standard for high-visibility clothing.

The standard EN ISO 20345:2011 specifies basic and additional requirements for **safety footwear**. Footwear meeting this standard must bear the CE mark as **protective gloves.**

Many EN ISO standards exist for many different protective gloves. Gloves manufactured outside the EU may not be designed to comply with the EU PPE Directive. It's therefore important to verify the gloves are compliance with applicable and PPE Directive track record and related EN standards before placing the product on the EU market.

According to the definition of the European Commission, the **CE marking** is a "certification mark that indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area (EEA)". There are 25 CE Directives which affect a wide variety of products, which includes the Personal Protective Equipment (PPE). **The CE mark must be permanently affixed to the PPE** (it is not appropriate to put a sticker with the CE mark on the products).

9.5 Mexico

9.6 United Kingdom (UK)

9.7 United States (US)

American National Standards Institute (ANSI) Z89.1-2014, American National Standard for Industrial Head Protection

ANSI Z87.1-2020, American National Standard for Occupational and Educational Personal Eye and Face Protection Devices

ANSI 105-2016, American National Standard for Hand Protection Classification

ANSI/ISEA 107-2020, American National Standard for High-Visibility Safety Apparel

ASTM F2412, Standard Test Methods for Foot Protection

ASTM F2413-18, Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear

Occupational Safety and Health Administration (OSHA), 29 CFR 1910.133: Eye and face protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.133

OSHA, 29 CFR 1910.135: Head protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.135

OSHA, 29 CFR 1910.138: Hand protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.138

OSHA, 29 CFR 1910.136: Foot protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.136

OSHA (Construction), 29 CFR 1926.95: Criteria for personal protective equipment. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.95

OSHA (Construction), 29 CFR 1926.100: Head protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.100

OSHA (Construction), 29 CFR 1926.101: Hearing protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.101

OSHA (Construction), 29 CFR 1926.102: Eye and face protection. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.102

OSHA Personal Protective Equipment. Publication 3151-12R 2003. https://www.osha.gov/sites/default/files/publications/osha3151.pdf

U.S. Department of Transportation (USDOT) Federal Highway Administration. Manual on Uniform Traffic Control Devices (MUTCD). 2009 with Revisions 1 and 2 dated May 2012. https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm

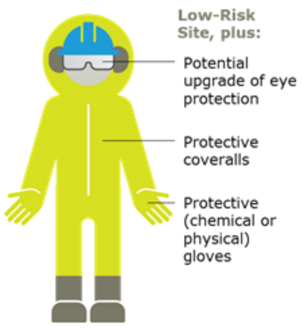
9.8 Other regions

SS513:2005 (ISO 20345:2004). The Singapore Standard was prepared by the Technical Committee on Personal Safety and Ergonomics under the supervision of the General Engineering and Safety Standards Committee. www.standards.org.sg

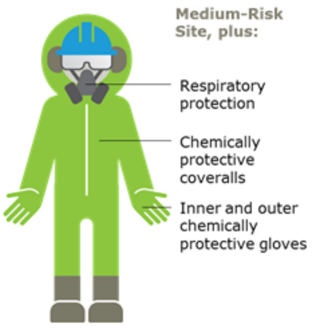
10. ADDITIONAL INFORMATION

10.1 Standard global PPE levels

Low-level PPE



Medium-level PPE



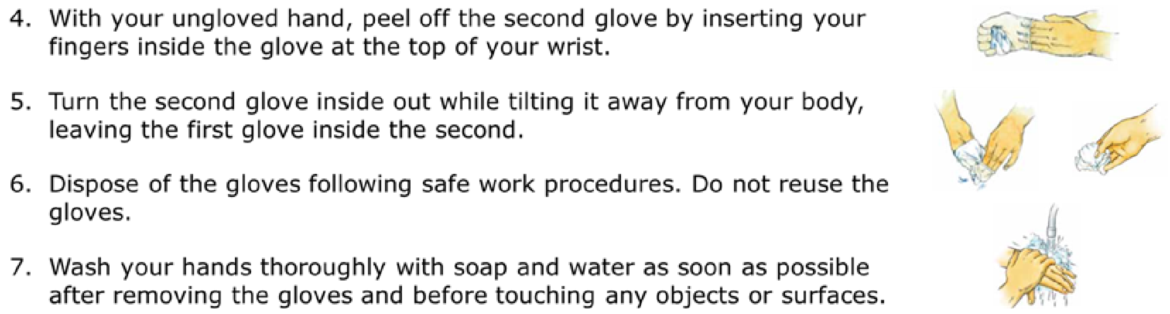
High-level PPE

10.2 Proper glove doffing

1. With both hands gloved, grasp the outside of one glove at the top of your wrist.

2. Peel off this first glove, peeling away from your body and from wrist to fingertip, turning the glove inside out.

3. Hold the glove you just removed in your gloved hand.



4. With your ungloved hand, peel off the second glove by inserting your fingers inside the glove at the top of your wrist.
5. Turn the second glove inside out while tilting it away from your body, leaving the first glove inside the second.
6. Dispose of the gloves following safe work procedures. Do not reuse the gloves.
7. Wash your hands thoroughly with soap and water as soon as possible after removing the gloves and before touching any objects or surfaces.

10.3 PPE guidance specific to the United States

In the US, OSHA defines the PPE levels as follows: low-level PPE is defined as Level D, medium-level PPE is defined as Level D Modified, and high-level PPE is defined as Levels C, B and A, becoming more protective in reverse alphabetical order.

Levels of PPE

The four levels of PPE are Levels A, B, C and D, with Level A providing the highest available level of respiratory, skin and eye protection. A summary of the basic PPE ensemble for Levels A, B, C and D is provided below. PPE selection will be tailored to address specific task conditions.

Level A

Level A PPE provides the maximum degree of respiratory, skin and eye protection. A Level A PPE ensemble should include:

- Full-face piece self-contained breathing apparatus (SCBA) or full-face piece supplied air respirator with escape SCBA
- Fully encapsulating, chemical-resistant suit, safety boots and inner gloves
- Hard hat (if overhead or bump hazards exist)

Level B

Level B PPE provides the maximum level of respiratory protection. Since chemical-resistant clothing is not considered gas, vapour, or particulate tight, Level B PPE does not provide the maximum skin protection. However, a good quality, hooded, chemical-resistant one-piece garment with taped wrists and ankles provides a reasonable degree of protection against splashes of liquids and lower concentrations of chemicals in ambient air. It is the minimum level recommended for confined space entries and initial Site entries until the hazards have been further identified. Level B PPE should be used when **any** one of the following criteria is met:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection but less skin protection—this includes atmospheres with immediately dangerous to life or health (IDLH) concentrations of specific substances that do not represent a severe skin hazard or atmospheres that do not meet the criteria for use of air-purifying respirators.
- Atmosphere contains less than 19.5% oxygen.

- Presence of incompletely identified vapours or gases is indicated by air monitoring instruments but vapours and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.

Level C

Level C PPE provides the same level of skin protection as Level B PPE, but a lower level of respiratory protection. Air-purifying respirators can be used only if the substance has adequate warning properties; the individual passes a qualitative fit-test for the mask; an appropriate cartridge/canister is used and its service limit concentration is not exceeded; and site operations are not likely to generate unknown compounds or excessive concentrations of already identified substances. Level C PPE can be used when all the following conditions are met:

- Oxygen concentrations are not less than 19.5%.
- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any exposed skin.
- Types of air contaminants have been identified, concentrations measured and a cartridge or canister is available that can remove the contaminant.
- Atmospheric contaminant concentrations do not exceed IDLH levels.
- Job functions do not require self-contained breathing apparatus (SCBAs).

Modified Level D

Modified Level D PPE provides minimal skin protection (i.e., hand/glove protection along with standard work clothes with optional coveralls) and no respiratory protection. Modified Level D PPE can be used when the following conditions are met:

- Atmosphere contains no known hazard.
- Oxygen concentrations are not less than 19.5%.
- Work functions include minimal contact with contaminated soil, water, groundwater and precludes splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Level D

Level D PPE provides no skin protection other than standard work clothes and no respiratory protection. Work functions are limited non-hazardous environments and preclude contact with media that may be potentially contaminated at hazardous levels for any type of chemical.

10.3.1 Head protection

Hard hats shall meet the requirements as outlined below from American National Standards Institute (ANSI) Z89.1-2003, Standard for Industrial Protective Helmets. ANSI Z89.1 provides minimum performance requirements to reduce the forces of impact and penetration from falling objects and, where applicable, to provide protection from electrical shock hazards. Additional country-specific guidance may be used to supplement this guidance.

Headwear classification is categorised in terms of impact type and electrical class. All helmets shall meet requirements for impact Type I or Type II.

- Type I is for risk of impact to the crown of the head only. The standard kind of hard hat is called a Type I helmet, which provides protection for the top of the head.
- Type II is for impacts to the crown and sides of the head. Helmets that provide some degree of top and off-centre protection are called Type II helmets.

If there is the potential to be exposed to electrical current, the hard hat must meet the appropriate Electrical Class. Electrical Classes, G, E or C further categorise each Type (1 or 2).

- Class E to reduce danger from higher voltages and proof tested at 20,000 V
- Class G to reduce danger with lower voltages and be proof tested at 2,200 V
- Class C provides no protection against electrical current

10.3.2 Eye protection

All safety glasses will meet the ANSI Z87.1, "Practice for Occupational and Educational Eye and Face Protection." Additional standards apply to safety eyewear for specialised hazards like welding and lasers. Eye and face protection will meet the following requirements:

- Provide adequate protection against the particular hazards for which they were designed
- Reasonably comfortable when worn under the designated conditions
- Fit snugly and not unduly interfere with the movements of the wearer
- Durable
- Capable of being disinfected and easily cleanable
- Kept clean and in good repair

Face shields will also meet ANSI Z87.1 and must be worn for all tasks where there is a risk of chemical splash to the face and tasks that generate extensive flying debris such as grinding, welding, cutting, weed trimming and chainsaw use. Face shields must be worn in combination with safety glasses or goggles.

10.3.3 Hearing protection

The hearing protection will be evaluated for attenuation by the HSS department per 29 CFR 1910.95 Appendix B. The hearing protection must attenuate employee exposure at least to an eight-hour Time-Weighted Average (TWA) of 90 decibels, A-weighted.

10.3.4 Foot protection

Safety shoes or shoe coverings must meet the ASTM F2412/2413 standard. These standards use a safety rating label/code to identify the type and level of protection. For example:

ASTM F 2413-05

F/ I/75 C/75

The first line indicates which performance standard the shoe manufacturer used for its safety tests. This shoe was tested under the American Society of Testing and Materials (ASTM) standard, a standard widely accepted internationally, ASTM F 2413-05, Standard Specification for Performance Requirements for Protective Footwear. Newer steel toed shoes may have the certification ASTM F 2412-11 Test Methods for Foot Protection.

The second line indicates whether the shoe is Male or Female. In this case, it is a female shoe, marked “F” and also indicates its Impact (I) and Compression (C) resistance/rating. These letters are followed by a number 75, which is the amount of force the shoe was tested to resist.

The third line identifies what other specific types of protection the footwear offers. In this case, Electrical Shock (EH) is noted. EH shoes are intended to provide protection for the wearer against hazards that may result from incidental contact with live electrical circuits, energised conductors, parts, or apparatus.

If the safety shoes are marked with ZN41, this references ANSI Z41, specific to the 1999 Protective Toe section (PT99). This protocol was replaced by the ASTM standards presented here. Contact the manufacturer of the shoe to ensure it meets the current protective standards for the region.

Other protection identifiers used for safety shoes are shown here.

- **Conductive (Cd):** protect the wearer against hazards that may result from static electricity build-up (transfers build up from body to ground).
- **Static Dissipative (SD):** protect the wearer against hazards that may result from very low and very high static electricity build-up.
- **Puncture resistant (PR):** has a puncture resistant plate between inner and outer soles capable of withstanding a minimum puncture resistance of 270 pounds.
- **Chain saw cut resistant (CS):** protect against chain saw cuts.
- **Dielectric insulation (DI):** provide additional insulation if accidental contact is made with energised conductors.

Although not technically part of the coding label, safety shoes can also have thermal insulation and be waterproof. Safety shoes can also come in different forms – rubber boots or waders – depending on the work condition requirements.

10.3.5 High-visibility clothing

The American National Standards Institute (ANSI) / International Safety Equipment Association (ISEA) 107 standard is an industry voluntary consensus standard for design and performance requirements for high-visibility safety apparel. This includes colour, reflection, physical properties, type and configuration of materials. This standard is codified into the Department of Transportation Federal Highway Administration (FHWA).

The standard establishes three primary types:

- Type O (“off-road”)
- Type R (“roadway”)
- Type P (“public safety”)

Type O is defined as apparel that “provides daytime and nighttime visual complicity enhancement for workers in occupational environments which pose struck-by hazards from moving vehicles, equipment and machinery, but which will not include exposure to traffic on public access highway rights-of-way or roadway temporary traffic control (TTC) zones.” Typical examples include workers in warehouses and refineries.

Type R “provides daytime and night-time visual conspicuity enhancement for workers in occupational environments which include exposure to traffic (vehicles using the highway for purposes of travel) from public access highway rights-of-way, or roadway TTC zones or from work vehicles and construction equipment within a roadway TTC zone.” Typical examples include roadway construction workers, airport operations and other activity exposed to vehicles and moving equipment.

Type P apparel “provides daytime and night-time visual conspicuity enhancement for emergency and incident responders and law enforcement in occupational environments which include exposure to traffic (vehicles using the highway for purposes of travel) from public access highway rights-of-way, or roadway TTC zones, or from work vehicles and construction equipment within a roadway TTC zone or from equipment and vehicles within the activity area.”

ANSI/ISEA 107 contains four performance classes:

- Performance Class 1
- Performance Class 2
- Performance Class 3
- Supplemental Class E

Each performance class has specific minimum design requirements regarding the background materials, retroreflective/combined performance materials and width of reflective materials used in the garments.

Performance Class 1 is the minimum amount of high-visibility materials to differentiate the wearer from non-complex work environments and is only appropriate for off-road (Type O) environments.

Performance Class 2 have higher amounts of high-visibility materials that allow for better definition of an individual. This class is considered the minimum level of protection for workers exposed to roadway rights-of-way and TTC zones, as required in the FHWA Manual on Uniform Traffic Control Devices (MUTCD).

Performance Class 3 has an even a greater minimum level of high-visibility material the apparel must contain. This class provides more visibility to the wearer in both complex backgrounds and through a full range of movement by the required placement of background, retroreflective and combined performance materials on the sleeves and pant legs (if present). A garment or vest without sleeves worn alone is not considered Class 3 protection.

Supplemental Class E is comprised of high-visibility garments such as pants, bib overalls, shorts and gaiters. These items do not qualify as meeting the requirements of the standard when worn alone, but when a Class E item is worn with a Performance Class 2 or Class 3 garment, the overall classification of the ensemble is Performance Class 3.

11. REVISION SUMMARY

ATTACHMENT A
EXAMPLE PPE & SAFETY EQUIPMENT MATRIX

PPE requirements		**Drilling operation**	**Sample collection**	**Working at heights**	**Working on/near water**	**Oil/gas facility**
Low-risk level PPE	Hard hat	●	○	●	○	●
	Steel toe shoes	●	●	●	●	●
	Long sleeve / long pants	●	●	●	●	●
	Safety glasses w/ side shields	●	●	●	●	●
	Highly visible clothing	●	○	○	●	●
	Hearing protection	●	○	○	○	●
Medium-risk PPE levels (low risk + items shown)	Flame resistant clothing (FRC)	-	-	-	-	●
	Goggles	-	○	-	-	-
	Face shield	-	○	-	-	-
	Personal flotation device	-	-	-	●	-
	Fall protection	-	-	●	-	-
	Leather gloves	○	○	○	○	○
	Inner chemical gloves	-	●	-	○	○
High-risk PPE levels (medium-risk + items shown)	Outer disposable boots	-	○	-	-	○
	Tyvek suit	○	○	-	-	-
	Outer chemical gloves –	-	○	-	-	○
	Poly-coated Tyvek / Saranex suit					
	Full encapsulated chemical suit					
	Scba					
	Full-face airline Respirator					

PPE requirements		**Drilling operation**	**Sample collection**	**Working at heights**	**Working on/near water**	**Oil/gas facility**
🟩	Full-face negative pressure Respirator	▨	▨	▨	▨	▨
	Half-face negative pressure Respirator	▨	▨	▨	▨	▨
	Powered air purifying respirator	▨	▨	▨	▨	▨
H&S supplies	First aid kit	●	●	●	●	●
	Fire extinguisher	○	-	-	○	○
	Mobile phones	○	○	○	●	○
	Walkie talkies	▨	▨	▨	○	▨
	Water / fluid replenishment	●	●	●	●	●
	Eye wash	-	○	-	-	-
	Sunscreen	○	○	-	○	-
	Insect repellent	-	○	-	○	-
KEY						
-	Not required. If site conditions require, discuss with local HSC and/or H&S department					
○	Recommended					
●	Required					
▨	To be considered if site conditions require					

ATTACHMENT 5
STOP WORK AUTHORITY

RAMBOLL

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

Maureen Warren | Mark Watka

DATE

February 2023

VERSION

2.0

HEALTH, SAFETY & SECURITY PROCESS

STOP WORK AUTHORITY

RAMBOLL

CONTENTS

1. PURPOSE

The purpose of this HSS Process (HSSP) is to define the Ramboll process for stop work authority. Stop work authority means that all Ramboll employees, contingent workers and subcontractors are authorised and required to stop unsafe work if there is a safety concern relative to the performance of a task, and take the follow-up actions necessary to continue work safely. This HSSP is consistent with Ramboll Group health and safety requirements.

2. SCOPE

This program applies to all work environments and includes employees, contingent workers and subcontractors. All individuals are granted the authority and the responsibility to stop unsafe work in their own work area, or to intervene in unsafe work performed by others, if an unsafe condition or behavior is perceived to exist.

3. OVERVIEW

Additional information pertinent to stop work authority is provided in the HSSPs, Event Reporting and Investigation, Safety Planning and Risk Assessment, and Project Safety Responsibilities.

Key HSSP inputs

- Observation of an unsafe (or potentially unsafe) behaviour or condition
- Execution of stop work
- Discussion of concerns
- Reporting and notifications

Key HSSP outputs or results

- Time and opportunity to resolve unsafe behaviours or conditions
- Reduced risk of incidents
- Improved safety culture
- Safe continuation of work

Stop work authority is an important strategy for controlling unexpected hazards that may be encountered on the job. Issuing a stop work at the right time or place can prevent injuries and other incidents. Ramboll will support any employee or subcontractor who, in good faith, stops work due to something perceived to be unsafe or not quite right. Safety is our number one priority every day. At the very least, a stop work action gives everyone involved the time to develop a better understanding of the job hazards and ensure that safety controls are in place.

Stop work authority is also about recognising both safe and unsafe situations. Raising our awareness of the activities and conditions around us is an everyday work habit that must be individually motivated to have a positive impact on safety. When team members are ‘seeing safety’, the stop work authority process can be most effectively used to assess the safety of a situation, apply additional controls and proceed with the job in a safer manner. We empower and encourage others around us, including colleagues, subcontractors and clients, to do the same.

4. RESPONSIBILITIES

4.1 Country/Market Managing Director

- Support implementation of stop work actions that are initiated in good faith.

4.2 People Manager/Project Manager (PM)/Project Owner (PO)

Managers are responsible for taking the following actions. Project Owners (or Officers) are accountable for implementation of the stop work authority process as outlined in this HSSP.

- Understand, within the manager's area of responsibility, the resources needed to comply with requirements outlined in this HSSP. Communicate resource needs to the appropriate leadership authority and/or HSS department.
- Promote a safety culture that is supportive of stop work authority.
- Demonstrate support for stop work authority HSSP without the potential for retribution.
- Resolve conflicts when they arise and consult with the HSS department as necessary.
- Consider recognising individuals for identifying unsafe work conditions and exercising stop work authority that results in safer working conditions, work methods or demonstrates safety leadership (see the Recognise section).

4.3 Health, Safety and Security (HSS) department

- Monitor compliance with this HSSP including reviewing, communicating and recognising work observations pertaining to stop work situations, and other responsibilities related to event reporting, as described in the HSSP, Event Reporting and Investigation.
- Provide technical assistance (when requested or required) to resolve stop work situations, including performing safety inspections or audits, or assisting with preparation or review of project safety plans and other documents related to stop work authority.
- Develop and support HSSPs, SWPs, tools, templates, training materials and other resources as related to stop work authority.
- Provide Ramboll leadership and employees with periodic updates regarding the implementation of stop work authority.

4.4 Health, Safety and Security Coordinator (HSSC)

- Promote awareness, understanding and use of this HSSP by employees at the office and project level.
- Facilitate the communication between local employees and the HSS department in relation to questions or concerns pertaining to stop work authority.

4.5 Site Safety Representative (SSR)

- Promote and support the use of stop work authority if unsafe work or conditions are observed.
- Review and understand this HSSP and other guidelines for stop work authority, and encourage others to do the same.

- Consider recognising individuals for identifying unsafe work conditions and exercising stop work authority that results in safer working conditions, work methods or demonstrates safety leadership.

4.6 Employees, subcontractors and visitors

- Review, understand and comply with all project safety plans.
- Exercise stop work authority in good faith. Work is to be stopped if any task is perceived to be unsafe or if more information is needed to proceed safely.
- Report all safety events, issues or concerns to the SSR, PM, PO, HSSC and the HSS department in accordance with the HSSP, Event Reporting and Investigation.

5. KEY DEFINITIONS

Contingent worker – Worker who is hired through an agency, but Ramboll management provides day-to-day direction of the worker's activities. From an HSS perspective, contingent workers are managed in a manner equivalent to Ramboll employees.

Good faith – An honest or sincere motive without any intent to defraud, act maliciously, or take unfair advantage. With respect to a stop work action, the individual has a sincere belief that an unsafe condition may exist.

Health and safety plan (HASP) – This term refers to a systematic review of major tasks and associated job steps included in a particular scope of work where hazards and corresponding controls (i.e., preventative measures) are identified. Additional information regarding HASPs and safety planning in general is available in the HSSP, Safety Planning and Risk Assessment or by contacting the HSS department.

Risk assessment – A broad reference to a systematic evaluation of potential hazards associated with the work environment, including work performed by subcontractors. Risk assessment tools are available for low-risk work environments (offices and similar), medium-risk work environments (onsite, non-office work) and high-risk work environments (onsite work with exposure, involvement, or creation of hazards). Risk assessment tools for high-risk work environments may be incorporated in a HASP and/or presented in one of several different formats (e.g., high-risk assessment [HRA], job safety analysis [JSA] or activity hazard analysis [AHA]). Additional information is available in the HSSP, Safety Planning and Risk Assessment or by contacting the HSS department.

Stop work action – The act of stopping work for safety concerns to address the unsafe condition or behaviour before resuming work safely.

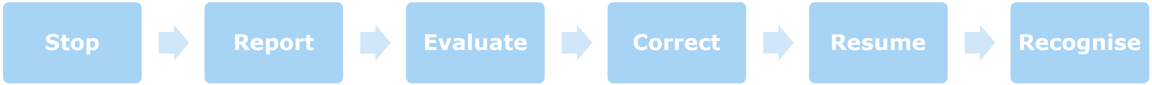
6. PROCESS

Stop work authority is intended to be initiated for conditions that threaten or endanger people, property or the environment. Situations which may create unsafe conditions and thus warrant a stop work action may include, but are not limited to the following:

- Unanticipated change in conditions
- Unplanned changes to scope of work or work plan

- Unplanned changes in work methods
- Unaddressed unsafe behaviours or conditions
- Lack of knowledge, understanding or information
- Incidents or near misses
- Alarms and emergency situations

Stop work authority provides all individuals working on a task the authority and responsibility to address safety concerns in a timely and consistent manner, as outlined below.



NOTE – The ultimate goal of a stop work action is to continue work in a safer manner.

6.1 Stop

When an employee, contingent worker or subcontractor perceives a condition or behaviour that poses a danger to people, property or environment, that person has the authority and responsibility to immediately initiate a stop work action. The stop work action may apply only to one's self, or may be an intervention for others who are performing work that is related to the potential risk or uncontrolled hazard.

If the supervisor for the task or the SSR is readily available and the affected person(s) or environment is not in imminent danger, coordinate with the supervisor or SSR, who will take the lead to initiate or assign the following steps. If the supervisor or SSR is not readily available, the following three steps (report, evaluate and correct) must still be completed before work resumes, and will be completed in coordination with the manager, supervisor, SSR or other designated and authorised person.

6.2 Report

Report the stop work action to the affected individuals, the SSR and the task supervisor. Make the area(s) as safe as possible by removing individuals or deactivating equipment to stabilise the situation, if applicable and if possible to accomplish without endangering oneself or others. Apply barriers, barricades or signage to prevent others from being exposed to the hazard. Once the situation is stable, make a report of the stop work action on EHS Insight, Ramboll's safety event reporting system (see the Work observation reporting section).

6.3 Evaluate

Affected individuals, the SSR, and other site or task supervisor(s) will discuss the reason(s) for the stop work action and come to an agreement on the safe resolution of the issue.

If the affected persons come to an agreement that the issue is safe to proceed without modifications, (e.g., the initiator was unaware of certain information or circumstances), the notified persons should show appreciation to the individual who stopped work for their concern and then resume work. The stop work action is complete at this point and no further steps are needed to proceed with work safely.

If it is determined and agreed the unsafe condition warrants additional assessment or actions to achieve a safe resolution, the condition must be further evaluated and corrected before restarting work.

6.4 Correct

Affected individuals, the SSR, and other site or task supervisor(s) will assist, as needed, to identify the correct modifications to the affected area(s) or work tasks and should agree that the modifications sufficiently resolve the stop work action. They will confer with the PM/PO, HSSC, a representative of the HSS department or another qualified subject matter expert as necessary.

A possible outcome is that modifications may require a revision to the project safety plan or individual risk assessment documents. Work will stop during the period of revisions and approval, which should involve management review followed by review with affected individuals. Procedures or protocols specific to the location or task may be revised as applicable to the type of work.

All resulting modifications must be communicated to affected individuals including discussion during project safety orientation and toolbox safety meetings.

6.5 Resume

The supervisor, SSR or person who initiated the stop work action will notify affected individuals to resume their work after confirming that the agreed upon modifications have been implemented. Affected individuals must review and acknowledge in writing (e.g., by signing a management of change log or equivalent document) any changes to safety plans, JSAs or other safety planning documents that may have resulted from the stop work action.

6.6 Recognise

Supervisors and SSRs should consider recognising individuals who initiate a stop work action that results in safer working conditions or work methods and communicating their recognition of the individuals to others on the project team or more broadly within Ramboll. Stop work actions are considered a proactive and exemplary safety behaviour and should be recognised as such. Additional information is provided in the Work observation reporting section.

6.7 Other considerations

Employees may work on project sites where they are not the only contractor, or are not the supervising contractor. This program does allow stop work actions to be made as an intervention to contractors who work directly for the owner, except when the owner may require similar stop work responsibilities and authorises Ramboll to act in this manner, or if the work practice or condition observed has the potential to adversely impact the safety and wellbeing of Ramboll employees or our subcontractors.

If an employee or subcontractor observes a situation that may warrant a stop work action but Ramboll does not have the authority over the person or entity conducting the work, the observing employee should ensure that Ramboll employees and our subcontractors are out of danger, and then the project manager should contact the client for discussion to resolve the issue.

Stop work actions should be scaled appropriately to the identified concern and the scope of the project. On large projects where multiple tasks are being performed concurrently, a stop work action that occurs on one task does not necessarily create a stop work action for concurrent tasks, the shutdown of a project or the closure of an office or facility.

7. TRAINING AND COMPETENCY

Stop work authority is included in new employee HSS induction training and annual risk-based HSS training for existing employees. No further training is required as related to this HSSP.

8. DOCUMENTATION

The following information relates to documentation associated with this HSSP.

8.1 Work observation reporting

Situations resulting in stop work moments should be entered into EHS Insight or equivalent event reporting system as a work observation. Assuming no incident or injury occurred, these situations are typically categorised as an “Unsafe Act or Condition” and the report should include information about how the issue was recognised, how the stop work was communicated, and how the issue was corrected or addressed. Corrective and preventative actions (CAPAs) should be attached to the obsedrvation report.

Consider designating these work observations as a “Great Catch,” which elevates the submission for additional recognition or safety award. Additional information is provided in the HSSP, Event Reporting and Investigation.

9. INTERNATIONAL TILTS

9.1 Asia-Pacific

9.2 Brazil

9.3 Canada

9.4 Europe

- Council Directive 1989/391/EEC - The "Framework" Directive

9.5 Mexico

9.6 Middle East

9.7 Nordics

9.8 United Kingdom (UK)

9.9 United States (US)

Contractual considerations – Ramboll’s standard terms and conditions and standard subcontract agreements in the US accommodate stopping work in response to unsafe conditions. Subcontractor safety requirements are recommended to be included in subcontract agreements, including specific accommodations for stopping unsafe work. It is also recommended that in the event there is an actual unforeseeable site safety condition that causes a project schedule delay, the PM/PO should seek protection from delay damages and an appropriate schedule extension under the force majeure or other applicable provisions of a client contract.

9.10 Other Regions

10. ADDITIONAL INFORMATION

11. REVISION SUMMARY

Date of Release	Summary of Key Changes
December 2021	Initial Release
February 2023	Document review – Minor changes only

ATTACHMENT 6
VECHICAL SAFETY

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

Maureen Warren | Mark Watka

DATE

February 2023

VERSION

2.0

SAFE WORK PRACTICE

DRIVING, TRANSPORTATION & JOURNEY MANAGEMENT

CONTENTS

1. PURPOSE

The purpose of this Safe Work Practice (SWP) is to define Ramboll practices for driver safety, safe use of other modes of transportation and journey management for work-related trips. The SWP is intended to mitigate the risk of vehicle accidents, security incidents or other problems that may result from unsafe equipment, external risk factors or unsafe actions.

2. SCOPE

The SWP applies to all Ramboll employees who drive or use other forms of transportation to access project sites, client facilities or other locations as part of their work. Journey management includes administrative practices, communication planning, trip/route plans and related documentation, usually involving actions taken by the traveler as well as other non-traveling employees who support the traveler.

The SWP does not apply to commuting from an employee’s home to their primary workplace (typically an office or facility), which is considered non-work-related travel. However, Ramboll recommends that employees consider these practices during personal commutes and any other personal time away from work.

In the event of a conflict between the Ramboll SWP and locally applicable regulatory requirements (or project-specific requirements), the more stringent set of requirements will be followed.

3. OVERVIEW

This SWP outlines the requirements for driving and the use of other ground transportation when conducting Ramboll business. This SWP does not apply to international travel or commuting. When traveling on behalf of Ramboll, drivers are expected to know and adhere to all local regulations. Ramboll employees may not check email, text or otherwise operate mobile devices while driving. Ramboll allows limited use of devices in hands-free mode, if permitted by local regulations.

- This SWP applies to Ramboll-owned vehicles (fleet or leased), rental vehicles and personal vehicles (when being used to conduct Ramboll business).
- Prior to operating a vehicle, the driver is responsible for ensuring the vehicle is in acceptable condition and meets all local regulatory requirements.
- While operating vehicles, all Ramboll employees are expected to drive defensively and never drive under the influence of illegal drugs, alcohol or other substances or medications that may impair driver attention or ability.
- All loads must be properly secured using tie-downs that are in good condition. Trailers may only be used if the vehicle operator is trained in the use of the equipment, loading requirements and methods to control hazards associated with trailers.
- A journey management plan is a formal plan for driving or other travel on company business, including route selection, communication and action planning. It is recommended for extended

solo roadway travel (less than one day). It is required for multi-day solo roadway travel and when projects involve extensive travel or transit connections in areas with identified security risks.

- The use of rideshare and taxi services are generally permitted, but are not permitted for site visits to unsecured sites or sites with potential personal safety or security risks. Having a vehicle available onsite can help to control these risks.
- All accidents must be reported through Ramboll's event reporting system, and those involving more than minor damage also require a police report.

4. RESPONSIBILITIES

4.1 Project Manager (PM)/Project Owner (PO)

- Request information related to onsite driving or transportation from the facility owner (for example, onsite driving rules or vehicle-related requirements) and consider the adequacy of the information provided. This information should be included in the project safety plan.
- Ensure adequate resources, including people, budget and schedule to comply with requirements outlined in this SWP.
- Support use of stop work authority by employees or subcontractors related to driving, transportation and journey management or any other perceived hazard. Work is to be stopped until the identified hazards are evaluated and controlled to the satisfaction of the project team and Health, Safety and Security (HSS) department and in accordance with Ramboll safe work practices.
- Discuss stop work situations with the local Health, Safety and Security Coordinator (HSSC), regional representative of the HSS department, or other designated HSS representative, including reporting of incidents and safety observations in accordance with HSSP, Event Reporting and Investigation.

4.2 Site Safety Representative (SSR)

- Ensure the project safety plan containing driving, transportation and journey management information is reviewed with site employees as part of their project safety orientation.
- Act as an onsite contact person for employees and managers if support is needed in relation to employees who are in transit to or from the site.
- Communicate applicable vehicle, transportation and journey management work requirements to employees and subcontractors working at the project site.
- Inform PM/PO of important developments or questions regarding driving, transportation and journey management where applicable to the project.
- Assist with reporting of incidents and safety observations in accordance with the HSSP, Event Reporting and Investigation.

4.3 Health, Safety and Security (HSS) department

- Support project safety plan development (when requested by the PM) and include driving or transportation hazard information, journey management and appropriate safety controls based on this SWP and site- or journey-specific concerns.
- Review and update this SWP on a biennial basis or more frequently if required.

4.4 Legal department

- Periodically update and review driver Motor Vehicle Records (MVR).
- Following a motor vehicle incident involving a Ramboll owned, leased, or rented vehicle, make a determination regarding whether the incident was preventable or non-preventable.
- Recommend disciplinary action as defined in this programme for drivers with poor or unsatisfactory driving performance or vehicle accident resulting in vehicle damage or other property damage.
- Maintain documentation for all company vehicle accidents.
- Coordinate maintenance of driver files and records as required under Commercial Driver License (CDL) regulations.

4.5 Human Resources (HR) department

- Notify Ramboll’s Occupational Medical Provider when an employee requires medical exams, drug or alcohol testing, or other medical evaluation related to CDL regulations.
- Notify Ramboll’s Fleet Manager or appropriate person when an employee will be assigned driving responsibilities for CDL Regulated Vehicles, based on information from the hiring manager.
- Coordinate maintenance of driver files and records as required under CDL regulations.

4.6 Health, Safety and Security Coordinators (HSSCs)

- Promote awareness, understanding and use of this SWP, including supporting journey management plans when requested by project team members.
- Facilitate application of this SWP in the context of local regulatory requirements and integration of this SWP into project safety plans.
- Inform the HSS department if the SWP does not adequately address local regulatory requirements.

4.7 Employees, subcontractors and visitors

- Review, understand and comply with all project safety plans regarding driving, transportation and journey management.
- Do not undertake any driving activities unless properly trained and licensed.

- Follow all driving and transportation safety practices defined in this SWP, other practices as defined by the site owner or occupant, and as required by local regulations. In the event of a conflict, the more stringent requirements will be used.
- Report safety events, issues or concerns to the SSR and complete Ramboll's event reporting process as required. See the HSSP, Event Reporting and Investigation.
- Event Reporting, Investigation and Corrective Action.
- Exercise Stop Work Authority if any task is perceived to be unsafe or if more information is needed to proceed safely.
- Maintain minimum insurance requirements, state mandated vehicle inspections and state mandated registration on personal vehicles used for company business.
- Immediately notify HR and Legal departments of any serious driving offenses as described in the Motor Vehicle Record section.
- Maintain valid driver's license to operate the specific class or type of vehicles driven.
- Only Ramboll employees are permitted to operate vehicles rented under a Ramboll contract. Contractors, subcontractors, or family members are not permitted to operate these vehicles at any time.
- Interns must be approved before driving for Ramboll business purposes. Supervisors must ensure that the Intern completes an MVR form to verify that their driving record is satisfactory.

5. KEY DEFINITIONS

At-risk behavior – Employee actions that create a potential risk for harm to themselves, harm to others or property damage.

Authorised driver - An employee with all required qualifications, including proper/current driver's license, adequate insurance coverage and limits, who Ramboll has given permission or authority to use a company vehicle, rental vehicle, or personal vehicle for business purposes.

Commute – An employee's regularly-scheduled trip (typically daily) from their home to their primary place of work such as an office or facility where the employee is employed. Commutes are considered personal time, as opposed to work-related travel.

Company vehicle – Company owned or leased ("fleet") vehicle, including passenger or light-duty vehicles [cars, sport utility vehicles (SUVs), pickup trucks and vans] used by Ramboll employees for business purposes.

DUI – Driving a motor vehicle while under the influence of alcohol or drugs.

DWI – Driving a motor vehicle while intoxicated (i.e., blood alcohol content above legal limit).

Motor Vehicle Record (MVR) review – The Legal and/or HSS department(s) will conduct a review of an employee's MVR upon hire, as needed for administration of this SWP, including as related to incident investigations or disciplinary actions.

Rental vehicle - Rented passenger or light-duty vehicle (cars, SUVs, pickup trucks and vans) used by Ramboll employees for business purposes.

Personal vehicle – An employee-owned vehicle.

Preventable accident – Defined as a collision in which the driver failed to do everything reasonable to prevent it. "At-fault" accidents are typically preventable accidents. Accidents commonly occur under the following driving situations: following too closely, backing, intersections, driving too fast for conditions, and failure to yield the right-of-way. Drivers should be alert to each of these situations and avoid causing or contributing to an accident.

Rideshare service – a third-party vehicle transportation service (e.g., Uber; Lyft).

6. WORK PRACTICES

Ramboll employees may work at facilities where driving or other means of transportation are required, both to travel to and from the site, while moving within or between sites or during other travel related to site work. Driving and other modes of transportation involve hazards that require control measures to be in place. Improper operation or use of vehicles or other transportation may result in property damage, injury or death. Ramboll project teams are expected to be familiar with the content of this SWP, locally applicable regulatory requirements and any project-specific requirements related to driving, transportation and journey management. In the event of conflicting requirements for work practices, the more stringent set of requirements will be followed. All project-specific driving, transportation and journey management requirements must be outlined in the project safety plan.

6.1 General safe-driving practices

All employees who are authorised to operate company vehicles, rental vehicles or personal vehicles for work purposes will maintain a current and valid driver's license for the class of vehicle they are operating, in accordance with applicable regulations in the country or region. Company vehicles and rental vehicles will only be operated by authorised employees, and employees who drive on company business shall be appropriately assessed, licensed, trained and fit to operate the vehicle. The driver of the vehicle is responsible for the safe operation of the vehicle and the conduct of any passengers in the vehicle.

- All Ramboll employees are expected to drive defensively using caution and good judgment, and avoid driving under conditions that increase the risk of an accident such as:
    - Fatigued driving
    - Aggressive driving, speeding or tailgating (following too closely)
    - Distracted driving

- Driving under the influence of alcohol, illegal drugs or prescription or over-the-counter substances or medications that might impair driving skills.
- Weather conditions, work locations and site conditions must be considered when designating and selecting a vehicle for use.
- Driving in low light conditions (before sunrise, after sunset, or during normal sleep hours) may increase the risk of accidents. Drivers shall ensure they are adequately rested and taking appropriate breaks to avoid fatigue. See the SWP, Fatigue Management.
- Prior to operating a vehicle, the driver shall conduct a 360-degree walk around the vehicle. Refer to the Vehicle inspections section for additional information.
- Adjustment of all mirrors, seats, seat belts; and verifying that all gauges are functioning properly must be conducted prior to placing the vehicle in motion.
- Driving directions should be obtained before traveling to an unfamiliar destination, including entering the destination address into a mobile phone, global positioning system (GPS) or navigation system prior to placing the vehicle in motion.

6.1.1 Operation of a vehicle

While operating a vehicle, all regulations of the country or region that apply to the vehicle and to the driver will be followed at all times. Regulations may differ depending on the country or region. Ramboll safe driving practices align with these regulations, which typically include:

- Avoid mobile phone (or similar device) usage when driving including text messaging. Ramboll prohibits using mobile devices when driving, except for hands-free devices. However, some countries or regions may have more stringent regulations that prohibit the use of any mobile device, even a hands-free device.
- Observe all posted traffic signs, roadway markings, traffic lights, signals and speed limits.
- Maintain a safe distance between other vehicles.
- When encountering emergency and/or construction vehicles parked on the shoulder, slow down and change lanes (if safe to do so) to provide adequate space for the parked vehicle(s).
- Transport people, equipment and supplies in a safe manner that is legal and minimises risk.
- Under no circumstances will employees or subcontractors be permitted to ride in the back of an open truck bed, on running boards or exterior of a vehicle, in a cargo area, or in any area of a vehicle that is not designed for passenger use.
- Drivers shall not operate a motor vehicle while under the influence of alcohol, illegal drugs or prescription or over-the-counter substances or medications that might impair driving skills. It is the driver’s responsibility to notify their supervisor if they have a medical condition or use medication that would impair their ability to operate a vehicle.

- Seatbelts shall always be worn by all occupants whenever a vehicle is in motion. All employees of Ramboll must wear seatbelts when operating or as a passenger of any company-owned vehicle, rental vehicle, personal vehicle or any other vehicle while on company business, with exception of public transit buses/trains or private shuttle buses that do not have seat belts.
- Dim headlights from the bright setting to the standard setting when other vehicles are approaching. Spotlights or fog lights could create a hazard to other drivers and must also be turned off or minimised when other vehicles are approaching or when visibility improves.

6.1.2 Using communication devices

Employees will adhere to the applicable local, state, federal, country and/or client-specific regulations governing the use of communication devices while operating a vehicle.

- Use of any communication device increases the risk of experiencing a motor vehicle accident. Even the use of a hands-free device to communicate while driving has been proven to cause distraction. Ramboll strongly cautions the use of mobile devices when driving on company business, unless in the event of an emergency.
- Unless usage of a communication device while driving is prohibited in the country or region or per client-specific regulations, employees using mobile phones while driving will use a hands-free mobile phone device, or cease driving and park in a safe location while using mobile phones.
- Texting or e-mailing while driving is always prohibited.

6.1.3 Hours of service

Three basic hours of service (HOS) limits generally apply to Ramboll drivers, as listed below. HOS regulations may differ by country or region. Drivers of commercial vehicles (see the Commercial driver license section) are **required** to meet applicable HOS restrictions. Drivers of all other (i.e., non-commercial) vehicles are **recommended** to follow the same restrictions that apply to commercial drivers in their region as part of a journey management strategy to mitigate fatigue. When HOS limits cannot be met, employees should stay in a hotel and continue travel on the following day.

- 14-hour “driving window” – Drivers have 14 hours to complete up to 11 hours of driving
- 11-hour driving limit per day (excludes rest breaks)
- Duty limits of 60 hours per seven-day period and 70 hours per eight-day period

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HOS limits are a potential issue for drivers when returning from a long work week. Employees and their managers must adjust fieldwork schedules to accommodate driving times and/or allow an extra night layover.

6.1.4 Adverse weather conditions

Special consideration should be taken when weather conditions reduce roadway traction and/or visibility while driving.

- Adverse weather conditions may include:
    - Snow, ice or wet weather
    - High winds, hail or heavy rains
    - Fog, smoke or wind-blown debris
    - Any other weather condition that impairs the ability to safely operate a vehicle.
- Driving during adverse weather conditions should be avoided when practicable.
- When driving in these conditions cannot be avoided, appropriate measures should be taken including selection of an appropriate vehicle and being prepared with emergency supplies.
- Use Stop Work Authority when it is unsafe to continue to drive, and return to the origin or closest place of refuge when safe to do so.
- Extended road travel will be preferentially conducted during daylight hours if practicable.

6.1.5 Offroad vehicles

Riders and passengers of off-highway vehicles (OHVs) including utility terrain vehicles (UTVs), all-terrain vehicles (ATVs), snowmobiles or similar offroad vehicles shall operate the equipment in accordance with manufacturer recommendations, including safety helmets when required (e.g., when the vehicle does not have seat belts). Use of offroad vehicles will be addressed in an approved safety planning document. In addition:

- Approval from the HSS department is **required** when OHVs will be used by employees. Notification is required when equipment is used only by subcontractors.
- OHVs are not permitted for use on Ramboll projects without installed rollover protection. Contact the Ramboll HSS department for further information on acceptable aftermarket products.
- In addition to rollover protection, UTVs (i.e., those with side-by-side seating configuration) must have seatbelts, horn, lights and signals.
- All-terrain vehicles (i.e., ATVs or “quads”) and snowmobiles (i.e., those with “saddle” seating configuration) are prohibited (see the Prohibited vehicles and equipment section) unless rollover protection and other safety features are installed, operators are trained and appropriate PPE (including helmet) is used, with approval from the HSS department.
- Operators will have the appropriate training for the type of vehicle being used. Refer to the Offroad vehicle training section.

- The project safety plan shall identify vehicle inspection requirements and route inspection requirements, offroad hazards, speed limits and fueling requirements. These practices will be reviewed prior to use of offroad vehicles and will be followed at all times.
- Installed windscreens may need to be lowered or removed (if so equipped) in low-light, dusty, wet or muddy conditions to avoid unintentional contact with other vehicles, personnel, or stationary objects.
- Headlights must be installed and utilised during low-light conditions.
- Rental pickup trucks or other rental vehicles are not to be used in an offroad capacity unless permitted by the rental company and covered under an appropriate insurance plan as part of the rental agreement.

WARNING: Insurance coverage under Ramboll's standard rental agreements with Hertz and Enterprise is void when an accident occurs and the rental vehicle is being used for off-road driving

6.1.6 Low-speed Vehicles

Golf carts and similar vehicles (Cushman carts) must be operated in accordance with manufacturer recommendations. In addition:

- Operators will have the appropriate training for the type of vehicle being used.
- The project safety plan shall identify vehicle inspection requirements and route inspection requirements, offroad hazards, speed limits and charging requirements. These practices will be reviewed prior to use and will be followed at all times.
- Installed windscreens must be lowered or removed in low-light conditions to avoid unintentional contact with other vehicles, personnel, or stationary objects.
- Headlights must be installed and utilised during low-light conditions.

6.1.7 Parking

- Park vehicles in designated areas and avoid parking in areas where parking is against the law, against site-specific rules or in areas where the vehicle may obstruct critical infrastructure (e.g., under pipe racks or pipe bridges).
  - Parking or idling over dry vegetation is prohibited due to the risk of starting a fire beneath the vehicle.
  - Vehicles shall not be left unattended while idling, except where necessary to maintain vehicle temperature, operating capability, equipment or samples – and in these cases proper planning and controls must be enacted.

  - When an automatic transmission vehicle is deemed to be safe to leave idling, the parking brake shall be engaged and the automatic transmission placed in park.
  - Vehicles to be parked and left unattended in a designated parking area should be placed in gear, with the parking brake engaged (even on a flat surface), with all doors and windows closed and locked.
  - Drivers should preferentially park vehicles in areas that allow for maintaining personal safety and security, such as secure parking facilities, well-lit areas and outside of areas with elevated crime rates. Additional personal security practices are described in the SWP, Working Alone and Personal Security.
  - Ensure that any valuables (company owned or rented equipment, company owned computers or personal items) are not left visible in the vehicle while unattended. If items need to be left in the vehicle, they must be left out of sight in a locked trunk. Otherwise, items must be taken out of the vehicle and carried with the driver into a secure building, hotel or site.

6.1.8 Fueling

- Safe fueling guidelines must be followed, regardless of the type of vehicle:
  - Turn the engine off while fueling.
  - No smoking or other open flames in or near the fueling area.
  - If refueling vehicles in the field, designate an appropriate refueling area and have appropriate spill clean-up supplies and fire extinguisher available.
  - Use appropriate fuel containers labeled with the type of fuel, when necessary.

6.1.9 Load securement and trailers

- Load securement guidelines must be followed, regardless of the type of vehicle or trailer:
  - Loads shall only consist of necessary equipment and shall be secured with straps, ropes or chains appropriate for the load. All straps, ropes or chains must be inspected prior to use and in acceptable condition.
  - Tools or equipment should be secured while being transported to prevent unsafe movement of materials.
  - Objects that could become a hazard should be secured or stored outside the passenger compartment.
  - Loads shall not exceed the manufacturers’ specifications and legal limits for the vehicle or trailer.
- Trailers shall not be used unless the driver and employees who load the trailer are properly trained in the use of the equipment, loading requirements, and methods to control hazards associated with trailers:

  - Trailers will be equipped with appropriate supplemental restraints/chains, braking systems and lights.
  - Trailers will display license plate or license number in accordance with applicable regulations of the country or region.

6.1.10 Prohibited vehicles and equipment

- Motorcycles and bicycles are prohibited from being used on work sites or for work-related travel.
- All-terrain vehicles (i.e., ATVs or "quads") and snowmobiles (i.e., those with "saddle" seating configuration) are prohibited unless rollover protection and other safety features are installed, operators are trained and appropriate PPE is used. Use of offroad vehicles is subject to HSS department approval as described in the Offroad vehicles section.
- Legacy ATVs that are currently in-service must be replaced with a UTV that meets current safety standards when the ATV is replaced or otherwise requires maintenance greater than its current market value.
- Ramboll prohibits the use of radar detectors in company vehicles, rental vehicles or personal vehicles if the vehicle is being used for work purposes.

6.1.11 Vehicle safety features

This section outlines vehicle safety features and recommendations for owned, leased, and rental vehicles.

6.1.11.1 Owned and leased

Owned and leased vehicles are equipped with internal (driver) backup sensors to alert the Driver of objects behind the vehicle when backing up. Owned or leased vehicles will be equipped with backup alarms when required for use on project sites.

6.1.11.2 Rental

Drivers are encouraged to rent vehicles equipped with side air bags and Electronic Stability Control (ESC). ESC reduces the risk of fatality by 50% in single car accidents. Fortunately, ESC is now a required feature and is on all rental vehicles after 2012. Additional rental vehicle guidance is presented below.

- Side air bags are not required but are installed in the majority (>90%) of passenger vehicles.
- Backup cameras: These cameras increase safety by helping drivers determine if anything is in the vehicle's path when driving in reverse – including both objects or people. Backup cameras became mandatory equipment for all new manufactured vehicles in 2018.
- Automatic braking systems: Automatic braking systems monitor and automatically slow or stop a car upon detection of a potential collision. According to a Geico contributor, this feature is likely to become more and more common.

- Forward collision warning: Forward collision warning systems identify objects in front of a vehicle and warn the driver of a potential collision. The system can use lasers, cameras, radar, or a combination of those technologies. The system may include automatic braking, discussed above.
- Lane keeping systems: These systems monitor the location of the automobile in the lane and are designed to help the driver keep the car in the lane appropriately. Depending on the system, it may only give a warning, or may actually assist in moving the car.

Drivers can also evaluate available crash test ratings for specific rental vehicles by referring to the National Highway Traffic Administration Internet site.

The Company's preferred vehicle rental services, Enterprise and Hertz do not rent cars which are under a safety recall. If another rental agency must be used, drivers are encouraged to ask if they follow the same policy.

6.1.12 Project safety planning

The inherent risks of traveling to and from project sites via vehicle are to be considered as part of the safety planning process for any project or task that requires driving or other means of transportation.

- For high-risk projects that utilise a comprehensive or customised project safety plan, all identified hazards that are related to driving, transportation or journey management must be addressed in the project safety plan.
- For medium-risk projects that utilise a basic or generic safety plan, and for low-risk work (i.e., Ramboll or client office settings or business support activities) where transportation is involved, applicable safe work practices described in this SWP are to be followed.
- Regardless of the overall project risk level, some types of travel may be considered a high-risk activity (e.g., extended roadway journeys, lone or solo work, areas with personal security concerns, or remote locations) and may require journey management activities and documentation to control risks related to travel and personal safety or security (see the Journey management section).

6.2 Vehicle inspections

- Vehicles shall be maintained in safe working order as required by the manufacturer. This would include a routine preventive maintenance schedule as recommended by the manufacturer for servicing and checking of safety-related equipment. Appropriate service documentation shall be maintained, including service records, lubrication receipts and/or maintenance checklists.
- When renting vehicles through Ramboll corporate rental agreements, the maintenance activities and documentation are the responsibility of the rental car agency.
- Regardless of the vehicle ownership (owned, rented, or leased), vehicles shall be visually inspected prior to each use by walking all the way around the vehicle, looking for signs of damage. Note any scratches, dings, dents or scuffs, no matter how small, and check the interior of the vehicle as well, including the spare wheel and interior accessories. Any defects should be

reported immediately to a supervisor and/or rental company, and vehicles with broken and/or defective equipment should not be used.

- A vehicle inspection checklist shall be documented yearly for all company owned vehicles, and the records shall be maintained for a minimum of three years. If annual inspection is already required per local ordinance, the mechanic's inspection documentation can satisfy this requirement. If an annual inspection is not required per local ordinance, Ramboll must conduct (or subcontract) an inspection and retain documentation.
- Vehicle inspections may be required more frequently at the request of specific clients or at certain Ramboll work locations.
- A Vehicle Inspection Checklist is available in the HSS document library. Return the completed form to the designated individual responsible for maintaining fleet (owned, leased) vehicles and inspection records.

6.3 Client-specific requirements

Ramboll employees should be aware of client- or site-specific driving, vehicle or transportation requirements that may exceed applicable regulations and/or the practices defined in this SWP. Additional training and information may be provided on projects requiring client-specific safe driving or transportation requirements and should be documented in the project safety plan. Client-specific requirements may include, but not be limited to:

- Prohibition of all cell phone usage (including hands-free devices) while driving.
- Defined work hours that include commuting to and from the project site.
- Incident review procedures that may require drug and/or alcohol screening.
- Additional safety requirements when vehicles are left idling, including chocking at least one drive wheel of the vehicle in front and back.
- A 'first move forward' driving practice when feasible, meaning that vehicles should be parked in a way that avoids the need for reversing to exit a parking space.
- Use of headlights to increase visibility on the road, even in daylight and good weather.

6.4 Rental vehicles

6.4.1 Rental vehicle providers

Employees should use providers with which Ramboll has a corporate agreement or master service contract whenever possible, and should book reservations through Ramboll's travel agency, which is connected to the applicable corporate rental agreements. See the Business Travel page on Rambla for details.

- When renting an automobile on company business, the employee's name should appear on the rental car agreement. Employees should ensure that the applicable master services ID number appears on the contract.

- **If renting outside of a Ramboll corporate agreement**, you must add all available supplemental insurance and liability coverages.
- When renting a vehicle, the following best practices should be followed:
- Inform the rental agency of all anticipated drivers. It should be noted that under most master service contracts, including those in the US, other Ramboll employees are permitted to drive the vehicle. To the extent these details are known in advance, notify the rental agency at the time of rental.
- Inform the rental agency if the vehicle will be taken outside the state, region or country where it was rented.
- Perform a cursory inspection of the vehicle for damages and defects (e.g., cracked windows, dents, and/or scratches). Vehicles with broken and/or defective equipment should not be rented or should be returned to the rental agency upon their discovery. Make sure that any damage is noted in full on the rental agreement and that you are fully satisfied with the condition of the vehicle before you sign it.

6.4.2 Rentable vehicle types

Ramboll employees should avoid renting sub-compacts, luxury cars and other types of "specialty" cars (e.g., Hummers, convertibles, sports cars, and sub-compact cars) unless approved by the employee's line manager. In some cases, rental vendors may request to provide a specialty vehicle as a free upgrade based on inventory. Ramboll employees are advised to consider carefully the class/model of vehicle that is being offered, ensure that it is safe, reasonable and appropriate for the task. Ramboll's Group Policy – Business Travel requires the use of plug-in hybrid or electric vehicles where availability and circumstances allow. Plug-in hybrid and electric vehicles may be utilised only after the operator has identified suitable charging station locations for the duration of the rental period with the charging station information documented on a travel risk assessment.

6.4.3 Rental vehicle insurance

- Ramboll currently maintains corporate agreements with Enterprise/National and Hertz. Renting vehicles from other rental car vendors which do not have corporate agreements with Ramboll is strongly discouraged. However, if unavoidable, you MUST accept the liability insurance and damage waiver options. When renting vehicles under a Ramboll corporate agreement in the US, a liability and damage waiver is typically included in the base rate.
- However, this may depend on the type of vehicle, the rental agency and the location. Be sure to understand requirements specific to your country or region and ensure the appropriate coverages are included or selected.
- Rental vehicles may be utilised for personal use (i.e. trips to restaurants, grocery stores, etc.) on a limited, as needed basis during the business rental period. Non-Ramboll employees and family members, although discouraged, may occupy the vehicle during these trips, however, under no circumstances may any such passengers operate the rental vehicle. Operation of a rental vehicle by any non-authorised persons (persons not authorised by the rental company) will void

coverage of the vehicle under Ramboll’s corporate agreement and insurance, leaving the employee who signed the rental agreement vulnerable to personal liability for damages or injury caused.

6.4.4 “Prohibited” and/or “limited use” roadways

These definitions vary by rental company but in general, the vehicle should remain on a designated roadway.

- Drivers should use prudent judgment and proceed cautiously when driving on non-paved roads. If the project will include driving on unpaved surfaces such as parking lots, temporary roads or roadway shoulders, a pickup truck should be selected instead of a car or SUV.
- Rental vehicles are not to be taken off-road unless such use is covered under the insurance and liability agreement.
- Damages caused by the improper use of the rental vehicle may not be covered by the rental agency coverage and would revert to Ramboll’s automobile insurance coverage, assuming the damage was sustained during authorised use of the rental vehicle on company business.

6.5 Personal vehicles

If personal vehicles are used while conducting business on behalf of the company, the owner assumes the responsibility that proper maintenance has been performed in a manner that provides the employee with maximum safety and reflects positively on the company. The owner also must provide adequate damage and liability insurance.

- When an accident occurs involving the use of a personal vehicle while traveling on company business (excluding daily commutes), depending on the circumstances, Ramboll may offer partial reimbursement of the employee’s personal insurance deductible.

6.6 Ridesharing and taxi services

Ridesharing services (e.g., Uber or Lyft) and taxis may be an appropriate and cost-effective means of transportation when travelling to or from Ramboll offices, client or agency offices, or secure facilities (i.e., those that include fencing, security guards, and/or controlled entry). However, as a security and personal safety measure, it is important that employees have access to their own vehicle (company owned, rental, or personal) in the following situations, or similar:

- When conducting field work or site visits in outdoor areas that are unsecured or accessible to the public.
- When visiting unsecured facilities, vacant buildings, private residences, or areas with identified security risks.
- When transporting samples, equipment, or supplies (other than personal luggage or equivalent size parcels related to our work).

- Refer to the SWP, Working Alone and Personal Security for more information about security concerns associated with the use of ridesharing and taxi services.

6.7 Journey management

Journey management includes trip/route planning and documentation, communication planning (e.g., check-in schedule), and action planning for situations where a scheduled check-in event is missed. Journey management work practices are recommended for long roadway travel (less than one day), or when driving extensively in areas without mobile telephone coverage. Journey management is **required** for multi-day solo roadway travel, travel to remote locations (see the Remote driving section) and when traveling extensively through areas with identified security risks.

Ramboll provides resources that inform employees and enable them to make educated decisions for travel planning and journey management, and to prepare for and respond safely to changing or unexpected conditions that may occur while away from home on business travel.

Effective travel planning, communication and location tracking can allow the HSS department and country or market leaders to respond quickly and appropriately to travel-related emergencies. Elements of Ramboll's safe travel work practices pertaining to journey management include:

- A customisable Journey Management Plan template is available in the HSS document library.
- Resources to maintain personal security, communication ability and regular contact with colleagues and managers while traveling (see the SWP, Working Alone and Personal Security).
- International travelers are directed to the Business Travel page on Rambla, prior to planning international journeys. Information resources are available to prepare employees prior to travel, and to inform and advise employees of changing/unexpected conditions while traveling. See International SOS, an online resource for travel safety to which Ramboll carries a subscription (membership code: 11BYCA000248).

6.8 Remote driving

Remote driving is defined as driving a vehicle to, from or through locations that are remote from civilisation due to terrain, access, or availability of facilities.

- Locations may be considered remote if other drivers may be infrequently encountered and/or if the route is unlikely to be regularly patrolled by law enforcement, or when there is uncertain communication ability with standard means, such as mobile phones.
- Remote driving should only be undertaken when necessary, for the achievement of a business objective and after safer journey options have been evaluated and found to be infeasible (i.e., air, rail, or virtual meeting).
- All road journeys deemed to be remote should be risk assessed and have appropriate safety controls implemented before travel, including but not limited to the following:
- Journey management actions including trip/route planning, reliable communication device, and communication planning (see the Journey management section).

- Vehicle selection and inspection to ensure operability and dependability.
- Emergency preparedness equipment and roadside emergency kit.
- A Remote Driving Checklist is provided in the HSS document library.

6.9 Emergency procedures

Conditions that may result in an accident, illness or injury while driving, or during travel using other means of transportation, are unique depending on the situation. Ramboll employees, whether a driver or a passenger, shall use their best judgment in the event of an emergency.

If an accident, incident, collision or unsafe contact occurs, all precautions will be taken to ensure the safety of those involved.

- In general, if the vehicle is mobile, or if vehicle failure occurs while in motion, use designated emergency flashing lights and pull over to the side of the road to move out of the lane of traffic.
- If the vehicle is not mobile and is within the lane of traffic, remain inside the vehicle until help arrives and you can safely exit.
- Stay with the vehicle and call for assistance. If the vehicle is in or near the lane of traffic and you have exited the vehicle, move to a safe location nearby, if possible (e.g., on the other side of a traffic barrier on the highway shoulder).

6.9.1 Documenting an accident

- If safe to do so, collect identification, driver’s license number, vehicle plate number, and insurance information from other driver(s) or witnesses, if involved.
- Do not admit fault.
- Document the circumstances by taking photographs.
- Contact local police and obtain a police report.

6.9.2 Emergency supplies

Be aware of your surroundings and take action to protect your personal safety. Consider your travel route, weather conditions, and the availability of services or roadside assistance and plan accordingly by bringing appropriate emergency supplies. Depending on the situation, appropriate emergency supplies may include:

- Jumper cables to charge battery and restart engine
- Cat litter or sand for tire traction
- Snow shovel
- Ice scraper to clear window shield
- Warm clothes, gloves, a hat, sturdy boots, warm jacket, change of clothes, blankets

- Flashlights and extra batteries
- First aid kit
- Fire extinguisher
- Food and water
- Cell phone, CB radio or other reliable method of communication
- A list of emergency contacts and telephone numbers
- Flares, traffic cones, or other reflective objects to place around a disabled vehicle.

6.10 Incident reporting

Regardless of severity, travelers will verbally report any incident, accident, collision, traffic violation, unsafe condition or security incident while traveling on company business, to their PM, PO, line manager, local HSSC, or regional HSS representative as soon as feasible after the incident but no later than 24 hours after the incident. Verbal reporting will be followed up by making an entry in Ramboll's incident reporting system within 72 hours. The Legal department will request a Vehicle Accident Report providing additional details for any accident likely to result in an insurance claim, including accidents involving other parties or property damage. See the HSSP, Event Reporting and Investigation. This requirement applies to all Ramboll owned, leased, or rented vehicles as well as personal vehicles operated for Ramboll business purposes.

Minor incidents or damage events also require reporting, except within the definitions provided in the Reporting instructions for minor damage section. Examples of minor damages that do require reporting (unless specifically exempted) include, but are not limited to the following:

- A scratch or dent to the vehicle body
- Damage to the windshield or glass
- Repair or replacement of tires; use of spare tire
- Damage to ancillary component
- Damage to the vehicle interior.

6.10.1 Reporting exceptions for minor damage

For minor damages, employees should follow these definitions of damage to determine when an incident report must be filed:

- **Paint:** Scratches over 0.98 inches/25 mm length, or any length when a scratch penetrates the base coat of paint.
- **Dents:** Dents over 0.98 inches/25 mm diameter, or any panel with more than two dents of any size.

- **Glass:** Stone chips over 0.08 inches/2 mm diameter, cracks greater than 0.88 inches/22.5 mm, or any cracks to the front and rear windshields.
- **Tires:** When a repair is possible (i.e., the tire has not been run on flat), use of spare tire and subsequent repair of damaged tire may be reported as a Safety Observation. When a repair is not possible (e.g., punctures where the tire has been run flat) and a replacement tire is needed, or when side wall damage exists (including bulges) over 0.79 inches/20mm including the kerbing band or where tire cords are exposed, use of spare tire and subsequent replacement of tire will be reported as an incident in the "asset" category.
- **Ancillary Components:** Damage to mirrors, damage to light clusters including chips, holes, scratches and cracks, structural damage to the wheel trim, or scratches or scuff over 25mm long to alloy wheels.
- **Vehicle Interior:** Any missing original equipment, damage or missing parts of the interior trim, or burns, cuts, stains or tears to the seats, carpets, roof lining and material in the glove box, trunk or boot.

6.10.2 Damage to rental vehicles

- Rental companies generally require drivers to report any damage immediately.
- The rental company will provide guidance on what types of damage require the driver to return the vehicle to the rental agency and exchange for another vehicle.
- Whenever a rental company determines a vehicle has been damaged, an incident report should be filed.

6.11 Motor Vehicle Record (MVR) review and disciplinary action

MVR reviews will be conducted upon hire, as part of incident investigation, or as determined by Ramboll legal department. Offenses indicative of a poor or unsatisfactory MVR include:

- DUI, DWI or similar conviction within the past 5 years
- Other serious offenses or convictions within the past three years: reckless driving, speeding, leaving scene of an accident, driving under a suspended license, school bus violations, or three moving violations within 18 months
- Two preventable accidents within a one year period

Disciplinary action to be recommended by the Legal and/or HSS department(s) for violation of the practices as defined in this SWP or based on requirements of the country or region may include one or more of the following actions:

- Warning
- Mandatory defensive driving or vehicle safety course

- Restriction of authorised driver status (e.g., for specific types of vehicles) (for a specified or unspecified period of time)
- Suspension of authorised driver status (for a specified or unspecified period of time)
- Revocation of authorised driver status (for a specified or unspecified period of time)
- Termination of employment
- Rejection of prospective employment (in new hire situations).

The minimum disciplinary action to be taken as a result of a DUI, DWI or similar conviction, or a revoked or suspended license, will be immediate suspension of employee's authorised driver status. Disciplinary action for other infractions and performance issues will be assigned on a case-by-case basis. Drivers and their supervisors will be notified of specific disciplinary actions in writing. The HR department will also be notified if disciplinary action includes restriction, suspension, or revocation of authorised driver status.

7. TRAINING AND COMPETENCY

Ramboll's HSS training programme includes new employee induction training, supervised on-the-job training, and annual completion of online modules or classroom instruction related to safety requirements and work practices. Training assignments vary based on employee roles and training classification. Completion of assigned training will be documented by a training completion certificate, which will be stored in the employee's electronic training record.

7.1 Training requirements

7.1.1 External driver safety training

In addition to the Ramboll HSS training programme units pertaining to driving, employees who drive or operate vehicles may receive external training to address regulatory compliance, Ramboll practices or policies, or project-specific requirements.

- Drivers of commercial vehicle classes are subject to external training requirements specific to the country or region. The United States section contains US-specific commercial driver requirements.
- Per client requirements, additional training may be required on a project basis.
- If an employee is involved in a vehicle incident, remedial driver safety training may be assigned based on determination by the Legal, HR, and/or HSS department. Remedial training may include, but will not be limited to:
- General driving safety courses (e.g., distracted driving; defensive driving)
- In-person, classroom, or behind-the-wheel driver safety course
- Other in-person or online driving courses specific to the employee or task.

7.1.2 Offroad vehicle training

When use of OHVs (UTVs; ATVs or snowmobiles with rollover protection) is approved by the HSS department (see the Off-road vehicles section), employees who are designated as operators of off-road vehicles on project sites must complete a training programme specific to the type of equipment before using the offroad vehicle and upload the training certificate to Ramboll Academy.

- **External operator (driver) training:** Employees who complete an approved safety training course applicable to the type of offroad vehicle (e.g., UTV, snowmobile, etc.) and combined with previous driving experience and/or passing a "road test" as part of external training are consider qualified to operate vehicles of that type. Training certificates must be uploaded into Ramboll Academy. This qualification is "transportable" to other projects where operation of the same type of offroad vehicle is required. A driver's authorisation to operate off-road vehicles may be revoked if unsafe driving is observed and reported.
- **Site-specific operator (driver) orientation:** Project team members may have sufficient training and experience to provide documented off-road vehicle orientation to colleagues, either onsite or at an offsite location where the activity is permitted. Project Managers with this intent must first obtain approval from the Project Owner and HSS department. Unlike external operator training, site-specific off-road vehicle orientations delivered by Ramboll are not transferrable to other project sites.
- **Passenger safety:** Employees who will ride in (but not operate) an approved UTV (i.e., side-by-side configuration) must have previously reviewed a risk assessment that is applicable to the work being performed and includes UTV/offroad vehicle hazards and controls.

8. DOCUMENTATION

The following documentation is required as applicable to driving, transportation and journey management.

8.1 Vehicle inspection checklist

A vehicle inspection checklist shall be documented yearly for all company owned vehicles, and the records shall be maintained for a minimum of three years. Vehicle inspections may be required more frequently at the request of specific clients. An example Annual Vehicle Inspection Checklist is provided in the HSS Documents Library.

8.2 Remote driving checklist

The Remote Driving Checklist (available in the HSS Documents Library) may be used by a driver or their managers to plan for remote travel. The form also includes a section to create a communication plan as required in the SWP, Working Alone and Personal Security.

8.3 Vehicle accident report

The Vehicle Accident Report (available in the HSS Documents Library) may be requested by the Legal department following any vehicle accident or damage that may require an insurance claim or involves other parties or property damage. The Vehicle Accident Report provides additional details to supplement the general event reporting requirements as described in the HSSP, Event Reporting and Investigation, and after completion should be attached to the event report or file as supporting documentation. Employees will be notified by the Legal and/or HSS department(s) if corrective or disciplinary actions are assigned because of a vehicle accident.

8.4 Authorisation to Obtain Motor Vehicle Records (MVR)

The MVR Authorisation Form is a US-specific form that is completed by employees when initially hired. The form allows Ramboll (HR and Legal departments) to evaluate a driver's performance including accidents and citations. Employees will be notified by the Legal department if MVR review indicates unsatisfactory driver safety performance. While this form is US-specific, other countries or regions may use an equivalent form for review of driver records upon hire.

8.5 Commercial Driver License (CDL) regulated driver and vehicle documentation

Be aware of the applicable documentation requirements for regulated commercial vehicle classes and licensure for the country or region before starting work. Commercial driver licensing and related documentation requirements specific to different countries or regions are summarised in the International tilts section where applicable.

8.6 Vehicle-specific training and other driver training documentation

Any other driver safety training or vehicle-specific training (e.g., off-road vehicle training) will be documented in Ramboll Academy or an equivalent training certificate management system. For off-road vehicle certification provided internally (where approved), the HSS department will provide a template and will approve the form before first use.

9. INTERNATIONAL TILTS

9.1 Asia-Pacific

9.2 Brazil

9.3 Canada

- Employees renting in Canada may rent with Enterprise/National and with Hertz with direct booking and by using the Ramboll Counter Discount Program (CDP) number for the corporate contract. Ramboll's CDP for Enterprise/National is XZ16GM0, and for Hertz is 207384.
- There are rare circumstances that a 'best rate/pay now' would be available that may not include coverages on a vendor booking tool. Employees should not utilise this option.
- Selection of a different rental vehicle provider is allowed only if there is no rental option with Enterprise/National or Hertz. In this case, you must actively select all available insurances, as they are not automatically included.
- Rentals shall not be driven across the U.S.-Canada border without the applicable Renting Entity's prior written consent.

9.4 Europe

- Road safety and traffic rules differ within the EU. Find out what the various country-specific rules are at the following link: http://ec.europa.eu/transport/road_safety/going_abroad/index_en.htm
- Directive (EU) 2015/413 of the European Parliament and of the Council of 11 March 2015 facilitating cross-border exchange of information on road-safety-related traffic offences. Sets up a procedure for the exchange of information between EU Member States in relation to eight road traffic offences.

9.5 Mexico

- Employees renting in Mexico may rent with Enterprise/National and with Hertz with direct booking and by using the Ramboll Counter Discount Program (CDP) number for the corporate contract. Ramboll's CDP for Enterprise/National is XZ16GM0, and for Hertz is 207384.
- There are rare circumstances that a 'best rate/pay now' would be available that may not include coverages on a vendor booking tool. Employees should not utilise this option.
- Selection of a different rental vehicle provider is allowed only if there is no rental option with Enterprise/National or Hertz. In this case, you must actively select all available insurances, as they are not automatically included.
- Rentals shall not be driven across the U.S.-Mexico border without the applicable Renting Entity's prior written consent.

9.6 Middle East

9.7 Nordics

9.8 United Kingdom (UK)

9.9 United States (US)

9.9.1 Rental cars

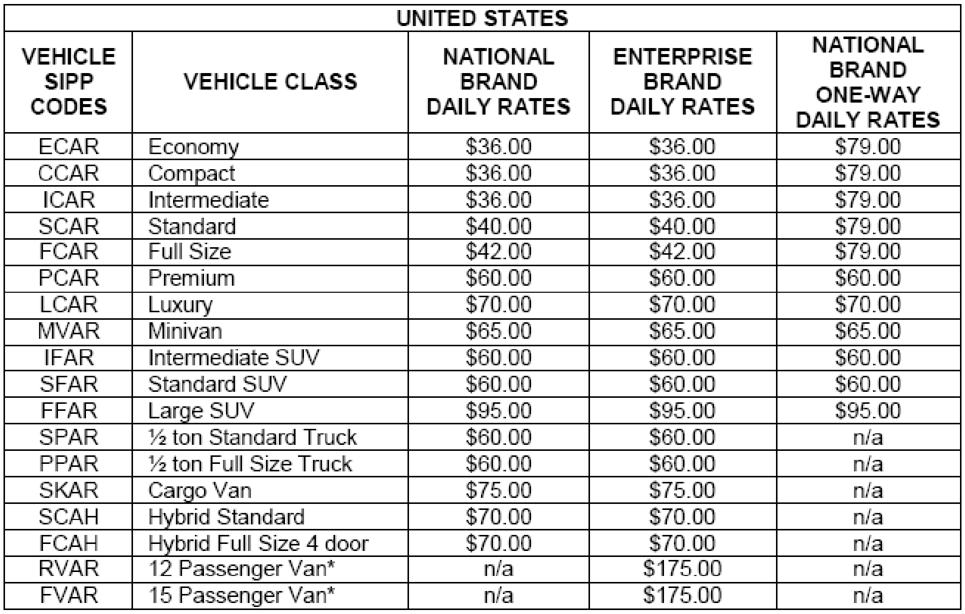
All rental vehicles are to be booked on NEO, the AMEX online booking tool. This is to ensure that employees who rent vehicles for company business secure Ramboll rates and related insurance coverage, and can be located and supported in case of an emergency.

All Rental cars are to be booked on NEO using Ramboll's Enterprise/National or Hertz company contracts, where Ramboll rates and relevant insurance are automatically applied. Selection of a different rental vehicle provider is allowed only if there is no rental option with Enterprise/National or Hertz. In this case, you must actively select all available insurances, as they are not automatically included.

Enterprise/National

- The Liability damage waiver (LDW) is included on all rental vehicles.

- When picking up vehicle, it should list Ramboll and/or XZ16GM0 on the rental agreement. This is the Ramboll Counter Discount Program (CDP) code for business rentals for Enterprise and National.
- Employees may use their points with Enterprise/National for a personal rental. However, the Ramboll (LDW) will not apply, and personal insurance must be utilised. The CDP for personal (leisure) rentals is XZ16G91.
- The LDW applies to all rental vehicles provided they are listed on the rate schedule listed in the tables below.



UNITED STATES				
VEHICLE SIPP CODES	**VEHICLE CLASS**	**NATIONAL BRAND DAILY RATES**	**ENTERPRISE BRAND DAILY RATES**	**NATIONAL BRAND ONE-WAY DAILY RATES**
ECAR	Economy	$36.00	$36.00	$79.00
CCAR	Compact	$36.00	$36.00	$79.00
ICAR	Intermediate	$36.00	$36.00	$79.00
SCAR	Standard	$40.00	$40.00	$79.00
FCAR	Full Size	$42.00	$42.00	$79.00
PCAR	Premium	$60.00	$60.00	$60.00
LCAR	Luxury	$70.00	$70.00	$70.00
MVAR	Minivan	$65.00	$65.00	$65.00
IFAR	Intermediate SUV	$60.00	$60.00	$60.00
SFAR	Standard SUV	$60.00	$60.00	$60.00
FFAR	Large SUV	$95.00	$95.00	$95.00
SPAR	½ ton Standard Truck	$60.00	$60.00	n/a
PPAR	½ ton Full Size Truck	$60.00	$60.00	n/a
SKAR	Cargo Van	$75.00	$75.00	n/a
SCAH	Hybrid Standard	$70.00	$70.00	n/a
FCAH	Hybrid Full Size 4 door	$70.00	$70.00	n/a
RVAR	12 Passenger Van*	n/a	$175.00	n/a
FVAR	15 Passenger Van*	n/a	$175.00	n/a

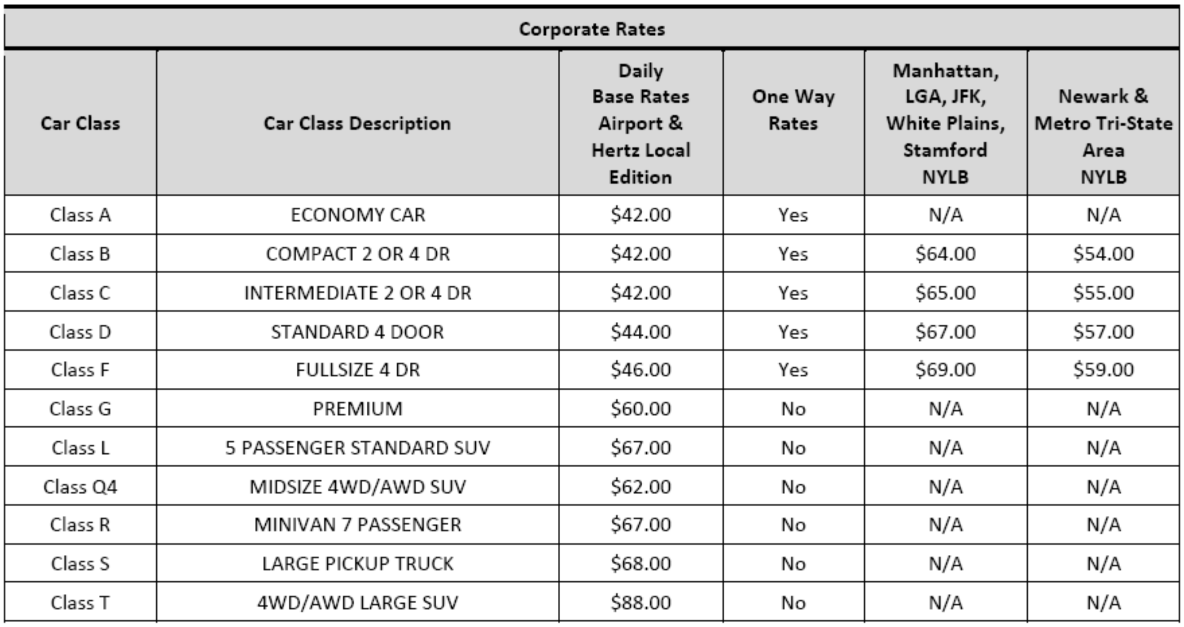
- Because the use of commercial vehicles pertains to a very small Ramboll subset, these vehicles may be rented directly from the vendor with discussions taking place with the local branch.

Commercial Truck Programme

SIPP CODE	**VEHICLE CLASS**	**DAILY RATES**	**WEEKLY RATES**	**MONTHLY RATES**	**MILEAGE CHARGES**	**DAILY MILEAGE INCLUDED**	**WEEKLY MILEAGE INCLUDED**	**MONTHLY MILEAGE INCLUDED**
DBOX	16' Box	$80.25	$426.50	$1,844.00	$0.16	0	0	0
FBOX	24' Box	$89.75	$473.50	$2,048.00	$0.18	0	0	0
OPAR	¾ ton P/up 2wd	$84.50	$445.50	$1,927.00	$0.25	150	750	3,000
OQAR	¾ ton P/up 4wd	$84.50	$445.50	$1,927.00	$0.25	150	750	3,000
FSTK	24' Stakebed	$66.25	$356.50	$1,541.00	$0.25	100	500	2,200
RKAR	HD Cargo Van	$59.25	$367.50	$1,491.00	$0.25	100	500	2,200

Hertz

- The Liability damage waiver (LDW) is included on all rental vehicles with Ramboll and/or 207384 listed on the rental agreement. This is the Ramboll CDP for business rentals for Hertz.
- Employees may use Hertz points for personal rentals, but the rental agreement should not have the Ramboll CDP listed on the agreement. Hertz locations may not have a leisure CDP. Employees must check this with their local branch when picking up a vehicle to ensure the Ramboll (LDW) will not apply. Personal insurance must be utilised.
- The LDW applies to all rental vehicles provided they are listed on the rate schedule below.



Corporate Rates					
Car Class	**Car Class Description**	**Daily Base Rates Airport & Hertz Local Edition**	**One Way Rates**	**Manhattan, LGA, JFK, White Plains, Stamford NYLB**	**Newark & Metro Tri-State Area NYLB**
Class A	ECONOMY CAR	$42.00	Yes	N/A	N/A
Class B	COMPACT 2 OR 4 DR	$42.00	Yes	$64.00	$54.00
Class C	INTERMEDIATE 2 OR 4 DR	$42.00	Yes	$65.00	$55.00
Class D	STANDARD 4 DOOR	$44.00	Yes	$67.00	$57.00
Class F	FULLSIZE 4 DR	$46.00	Yes	$69.00	$59.00
Class G	PREMIUM	$60.00	No	N/A	N/A
Class L	5 PASSENGER STANDARD SUV	$67.00	No	N/A	N/A
Class Q4	MIDSIZE 4WD/AWD SUV	$62.00	No	N/A	N/A
Class R	MINIVAN 7 PASSENGER	$67.00	No	N/A	N/A
Class S	LARGE PICKUP TRUCK	$68.00	No	N/A	N/A
Class T	4WD/AWD LARGE SUV	$88.00	No	N/A	N/A

All other rental vehicle vendors – use only if Enterprise/National or Hertz are unavailable

- Rent on AMEX NEO.
- Select all optional insurance provided.

9.9.2 Commercial drivers

- Drivers of CDL Regulated Vehicles must comply with all requirements of this SWP, except as modified below:
    - **Commercial Driver License (CDL)** – Drivers of these vehicles must maintain a valid CDL of the appropriate type (A, B, or C).
    - **Hazardous materials** – Obtain a Hazmat endorsement to your CDL if transporting any quantities of hazardous materials that require placarding as outlined in the “Hazardous Materials (DOT)” section in the SWP, Hazardous Materials Shipping and Transportation.

  - **Drug and alcohol testing** – CDL Drivers will be subject to random drug and alcohol testing.
  - **Driver files** – Commercial driver files are maintained by Ramboll in FleetWorthy or an equivalent database. A driver file must be maintained for each driver who may be assigned to drive regulated vehicles or vehicle-trailer combinations greater than or equal to 10,001 pounds. Within the driver file, copies of the following are maintained: license, medical clearance, drug test results, Motor Vehicle Record (MVR) checks, post-trip Documented Vehicle Inspection Reports (DVIRs), completed driver's log entries for past trips, and driving citations.
- Vehicle Classes
  - **Class A -** Any combination of vehicles which has a gross combination weight rating or gross combination weight of 11,794 kilograms or more (26,001 pounds or more) whichever is greater, inclusive of a towed unit(s) with a gross vehicle weight rating or gross vehicle weight of more than 4,536 kilograms (10,000 pounds) whichever is greater.
  - **Class B -** Any single vehicle which has a gross vehicle weight rating or gross vehicle weight of 11,794 or more kilograms (26,001 pounds or more), or any such vehicle towing a vehicle with a gross vehicle weight rating or gross vehicle weight that does not exceed 4,536 kilograms (10,000 pounds).
  - **Class C -** Any single vehicle, or combination of vehicles, that does not meet the definition of Class A or Class B, but is either designed to transport 16 or more passengers, including the driver, or is transporting material that has been designated as hazardous under 49 U.S.C. 5103 and is required to be placarded under subpart F of 49 CFR Part 172 or is transporting any quantity of a material listed as a select agent or toxin in 42 CFR Part 73.

Class A vehicle combinations may include a towing unit that is not recognised as requiring a CDL to operate, such as heavy-duty pickup trucks with trailers that carry heavy loads. In these cases, the combined weight of both towing unit and trailer must be equal to or greater than 26,001 lbs.

Most states allow for the towing of a trailer up to 45 feet in length without a CDL. Check state laws before towing a trailer to ensure a CDL is not required.

9.9.3 International driving

- Guidance on International Driving Safety U.S. Department of State – Road Safety Overseas

9.10 Other regions

10. ADDITIONAL INFORMATION

11. REVISION SUMMARY

Date of Release	Summary of Key Changes
March 2021	Initial Release
February 2023	Added information requiring the use of Barricade Information Signs. Added warning for insurance coverage under rental agreements becoming voided if vehicles are used off-road. Added information regarding classes of Commercial Motor Vehicles. Added warning regarding Heavy Duty Pickup Trucks and CDL requirements for vehicle/trailer combinations over 26,001 lbs. Added warning to verify state laws regarding maximum trailer length use without a CDL. Added recommended/required vehicle safety features for Ramboll-owned, leased, and rented vehicles. Added Rental Vehicle information and the use of the AMEX NEO portal for US employees to the International Tilts section. Added Rental Vehicle information for Canada and Mexico to the International Tilts section. Added requirement for Interns to complete an MVR form and be approved to drive for Ramboll business purposes. Added prohibition to contractors and subcontractors operating Ramboll-rented vehicles. Added allowance for use of rental vehicle for personal use and allowance for Non-Ramboll employees to occupy vehicles. Added requirement for rollover protection, horn, lights, signals on offroad vehicles; expanded offroad vehicle guidance and training requirements; added prohibition of non-rollover-protected ATVs and snowmobiles; added guidance for legacy ATVs. Added requirements for low-speed vehicles.

ATTACHMENT 7
SAFE LIFTING / MANUAL MATERIALS HANDLING

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

Maureen Warren | Mark Watka

DATE

May 2021

VERSION

1.0

SAFE WORK PRACTICE

SAFE LIFTING AND MANUAL MATERIAL HANDLING

CONTENTS

1. PURPOSE

The purpose of this Safe Work Practice (SWP) is to evaluate ergonomic risk factors associated with lifting and material handling tasks and provide guidelines on how to mitigate these risks.

Ergonomics work practices involve adapting the work environment to the individual, as well as reinforcing worker behaviours and posture, with a goal to reduce the amount of physical stress on the body. Physical stresses can result from improper body mechanics, unsafe lifting procedures or weights, repetitive motions, static positions, contact with objects resulting in pressure points and other risk factors. These physical stressors can lead to musculoskeletal disorders (MSDs) or cumulative trauma disorders (CTDs).

2. SCOPE

This SWP applies to all employees and all work environments. Lifting and manual material handling occur in a wide range of locations and task, including in the field and in office settings. While these safe work practices apply to many different tasks, the general risk factors and mitigation methods are relatively constant throughout all Ramboll work environments where lifting or moving of heavy objects may be performed. Workstation ergonomics, pertaining to safe work practices for the use of computers, office desks and other workstations, is addressed separately from this SWP. Please refer to Ramboll's SWP, Workstation Ergonomics.

In the event of a conflict between the Ramboll SWP and locally applicable regulatory requirements (or project-specific requirements), the more stringent set of requirements will be followed.

3. OVERVIEW

This SWP defines work practices for safe lifting and other manual material handling activities. This SWP contains descriptions of work practices, training requirements, equipment safety and documentation.

- **Risk factors** – object weight and other physical forces, awkward or static postures, ambient temperature, personal risk factors (stress level, physical condition)
- **Lifting/lowering** – assessing the load, safe body positioning, recommended weight limitations
- **Carrying** – route planning, bulky objects, stability of load
- **Pushing/pulling** – comparative techniques, preference for pushing rather than pulling
- **Mechanical equipment** – non-powered (hand carts), powered or mechanical (pallet jacks)
- **Drum handling** – drum types, selection, labelling and physical handling methods
- **Gas cylinders** – positioning, handling, transport and storage
- **Material handling controls** – how to use the hierarchy of controls as part of safety planning to mitigate risk of incidents

4. RESPONSIBILITIES

4.1 Project Manager (PM)/Project Owner (PO)/Office Responsible Person

- Recognise potential ergonomic risk factors that will be associated with a project task, office task or work area, or employee workstation.

- Recognise and evaluate manual lifting and material handling tasks and risk factors associated with a project task, office work area/workstation or office task.
- Utilise administrative procedures and engineering controls to minimize exposure to potential injuries related to manual lifting and material handling.
- For project sites, develop a project safety plan that provides guidance and controls for any anticipated lifting and manual material handling hazards.
- For Ramboll offices, promote employee understanding and use of safe work practices described herein.
- Ensure that employees who conduct manual lifting and material handling have completed relevant safe lifting training lessons and are familiar with supplemental training materials and other resources.
- Support employee use of stop work authority related to safe lifting, manual material handling or any other perceived hazard until such hazards are evaluated and controlled to the satisfaction of the project team and HSS department.

4.2 Site Safety Representative (SSR)

- Ensure implementation of project-specific safety controls or preventative measures as outlined in this SWP and the associated site-specific safety plan
- Participate in Ramboll training programs, as required
- Ensure that material laydown and storage areas are maintained as outlined in this procedure
- Periodically inspect storage areas and correct deficiencies
- Support employees' use of stop work authority and report all HSS questions or concerns to the PM

4.3 Ramboll Health, Safety and Security (HSS) department

- Overseeall issues related to health and safety and will have final approval authority for any revisions or changes made to this SWP
- Provide technical support related to training, assess ergonomic hazards and determine preventative measures
- Review and evaluate this SWP on a biennial basis or more frequently as needed

4.4 Health, Safety and Security Coordinator (HSSC) and Safety Ambassador

- Promote awareness, understanding and use of this SWP by project team members and employees in the office
- Facilitate application of this SWP in the context of local regulatory requirements and integration of this SWP into project safety plans
- Inform the HSS department if this SWP does not adequately address local regulatory requirements

4.5 Employees, subcontractors and visitors

- Review, understand and comply with all project safety plans
- Be aware of ergonomic hazards associated with material handling
- Takeinto account any personal risks or sensitivities that may increase the chance of injury

- Avoid lifts that may cause a risk of injury, ask for help and utilize appropriate safety control methods
- Implement safe lifting and manual material handling preventative measures defined in this SWP and as instructed by the PM or SSR
- Store materials only in designated areas and in a safe manner
- Report safety events, issues, or concerns to the SSR
- Exercise stop work authority if any task is perceived to be unsafe or if more information is needed to proceed safely

5. KEY DEFINITIONS

Cumulative Trauma Disorders (CTDs) - Conditions in which a part of the body is injured by repeatedly overusing or causing trauma to the nerves or tendons of that body part

Ergonomics - an applied science concerned with the relationship between people and their working environment, including any objects or equipment that a person may handle or use

Musculoskeletal Disorders (MSDs) - Refers to injuries of the muscles, joints, tendons, ligaments and nerves

6. WORK PRACTICES

Ramboll employees’ work activities may require manual material handling and lifting that involve risk factors that could result in ergonomic injury. Ramboll project teams are expected to be familiar with the content of this SWP, as well as locally applicable regulatory requirements. In the event of conflicting requirements for work practices, the more stringent set of requirements will be followed. These requirements must be outlined in the project safety plan.

The early identification of potential hazards during material handling and lifting is important to determine before they result in an injury. Ramboll employees and subcontractors may encounter ergonomic injuries that develop over a long period of time when singular traumas are repeated and build up to an MSD or CTD. Signs and symptoms of these potential injuries often appear early and on occasion, as time goes on, persist into a constant pain or soreness before they develop into an injury. Employees are trained to identify these early signs and symptoms and are encouraged to seek assistance from the HSSC, SSR, Ramboll HSS department, Human Resources (HR) representative or office manager.

When an ergonomic concern is raised, all issues will be taken seriously and followed up with by the SSR or local HSSC or Safety Ambassador, with support from Ramboll’s HSS department as needed. Employee confidentiality will be preserved in every situation. An initial evaluation will be performed to discuss the concerns and the signs or symptoms.

6.1 Risk factors

Ergonomic risk factors shall be determined, controlled and documented in the project safety plan or risk assessment. Ergonomic risk factors are the aspects of a job or task that impose a biomechanical stress on the worker. These risk factors can be present during any type of job: dynamic (i.e., standing), static (i.e., seated) or a mix of both. In general, the applicable risk factors can include:

- Force - carrying or lifting heavy loads; typing or forcefully resting on hard edges
- Repetition - frequent reaching, lifting or carrying

- Awkward postures - bending, twisting or crouching or abduction of the extremities
- Static postures - maintaining fixed positions for long periods of time
- Quick motions – fast-paced movements with little rest or recovery time
- Compression/contact stress – leaning against edges or surfaces, tightly grasping
- Vibration – exposure to pulsation, shaking, or tremors from tools or equipment. Two classifications: whole-body vibration and arm-hand vibration
- Cold temperatures – may reduce sensory feedback, dexterity, blood flow, muscle strength and balance. Can impact performance of complex mental and physical tasks

Exposure to one or more of the risk factors listed above may increase the likelihood of injury or the speed and/or severity with which an injury occurs. Recognized risk factors should be designed out of the work process whenever possible.

Outside risk factors also affect the likelihood of an ergonomic injury or illness. For example, psychological stressors like an intensified workload, time-sensitive pressures, low job control or monotonous work may decrease a worker’s tolerance. Further, the physical fitness or age of the worker and the presence of existing injuries or habits (e.g., smoking) may affect an employee’s ability to safely perform work tasks.

6.2 Lifting or lowering

Lifting and lowering of containers, equipment or supplies is a task many Ramboll employees perform as part of their regular job duties. It is every employee’s responsibility to realistically evaluate the object to be moved to determine if the weight and size and the physical motions involved, may exceed their own ability to lift, lower or carry the object. It is important to practice safe lifting techniques to reduce bending and reaching, decrease the amount of stress on the back and shoulders, and avoid overexertion.

These techniques depend on the size and shape of the load, the duration and frequency of lifting that is required and the person performing the lift. Assessing and planning the lift is always the first step. Before lifting an object:

- Always assess the load, first. What is being lifted? If it is an unmarked box, package or drum, carefully confirm the contents before moving it. Evaluate the load for the presence of any physical hazards, such as pinch points, sharp or jagged edges, burrs, or rough or slippery surfaces.
- Evaluate the integrity of the load. Is it securely packaged, and will it stay intact during transport? Does it need to be supported or redesigned in some way to make the lift safer? Can it be broken down into several smaller lifts instead of one large lift? Do any cords or accessories need to be secured prior to transport?
- Evaluate the weight of the load, as well as the frequency, duration and distance of the lift. These factors, as well as any personal factors that may affect an employee’s ability to lift (for example, a recently sprained ankle or a previous back injury), should be considered on a lift by lift basis. If you ever feel you cannot perform a lift safely, STOP work and seek assistance.

Several scientific models can be used to help assess the hazards associated with a particular lift. However, in most cases, knowing your capabilities and following the practices described in this SWP are most important to avoid situations that could cause an injury. Contact the Ramboll HSS department for assistance in the use of scientific models, if such models may be useful or are otherwise required.

Regardless of mathematical calculation, not everyone can lift the same amount of weight. Employees are NOT expected (or permitted) to lift a load they believe could cause them harm or injury from lifting, regardless of its weight. As a general rule, Ramboll employees should not attempt to lift objects heavier than 35 lbs/15.8 kg without assistance, unless they are physically conditioned to do so and a risk assessment has been performed, and assistance or other controls are not readily available.

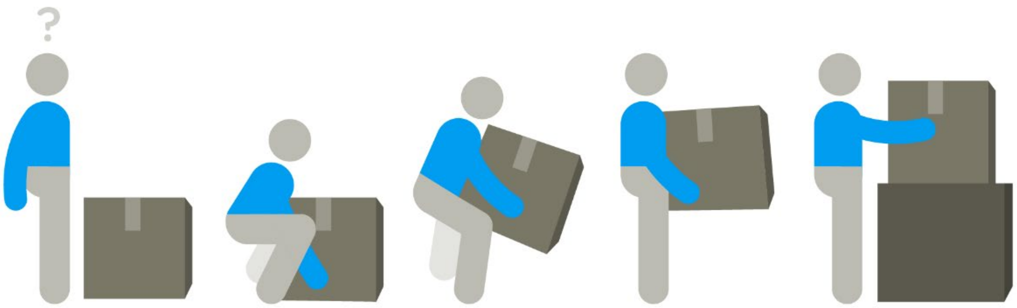
NOTE: In general, HSS recommends that even persons who are physically conditioned to regularly perform heavy lifting as part of their job duties, should not repeatedly lift more than a maximum of 75 lbs/34 kg under ideal lifting conditions. Ideal conditions include appropriate gloves, good handholds, keeping the load close to the body, and a level walking surface that is free of obstructions. Under less than ideal lifting conditions, the recommended maximum for repetitive lifts is 50 lbs/22.7 kg.

Specific weights discussed in this SWP should be considered as guidelines only, and individuals should consider the actual lifting conditions and their personal lifting capacity. Those with a history of back injuries or other physical limitations should reduce these lifting guidelines and work with their supervisor to implement appropriate safety controls.

NOTE – the use of back belts, braces or similar devices to artificially increase lifting capabilities, or as a means to complete an unsafe lift(s), is prohibited. If a support device is needed, the lift(s) should be re-evaluated to find a safer approach.

Proper lifting and lowering techniques should be followed even if the load to be lifted is of lighter weight. Keep the load as close to the body as possible and:

- Establish firm footing with feet at approximately shoulder width and one foot slightly ahead of the other. This posture will aid in keeping good balance and provide a stable lifting base.
- Always bend at the knees, not at the waist when lifting or lowering an object.
- Obtain a good secure grip on the load. Grip object firmly at opposite corners.
- When beginning to lift, tighten your stomach muscles and use your legs to lift the object, as leg muscles are generally stronger than back muscles.
- Keep your elbows and arms close to your body.
- Lift slowly and smoothly, keeping the load close and centred while looking up and forward.
- Keep shoulders and hips aligned (i.e., no twisting) –If you need to turn as you lift, **do not twist** at the waist, instead turn the whole body and keep the load in front.
- When possible, conduct lifting activities over a period with adequate rest breaks. If material handling must take place over a short time period, use mechanical means and/or the buddy system to rotate or assist with the lifting of objects.



6.3 Carrying

To safely carry loads, follow the general rules of lifting and lowering and plan to carry only what you can safely handle by yourself. Before lifting or carrying, plan the work using the following steps:

- Plan the route that will be taken to eliminate unnecessary carrying. "Front-end loading" of the lift (i.e., pre-planning) will enable appropriate staging and storage areas to be designated or reduce the number of trips or distance of carries involved. If a long trip is required, use assistive equipment and/or the buddy system. Slide, push or roll instead of carrying, when appropriate. When there is a choice between pushing and pulling, pushing an object is generally safer than attempting to pull an object.
- Evaluate the route which the object will be carried. The route should be free from obstructions/obstacles, which could cause difficulty in moving the object. Make sure to have a clear line of sight. Try to avoid slopes, stairs, or other obstacles that make carrying materials more difficult. Beware of and try to avoid slippery surfaces. (e.g., liquids, ice, oil and fine powders). Evaluate route for trip hazards and other risks (e.g., uneven surfaces or low lighting).
- Assess whether interactions with other employees may occur during the lift. If the object needs to be lifted through an active work zone, determine what controls need to be implemented to perform the lift safely.
- Organize the work so that the physical demands and work pace increase gradually. This gives the body a chance to warm up and the muscles a chance to loosen and build up strength. Further, performing some light stretching can assist in warming up the body and loosening muscles to get ready for physical activity.
- If an object is stored at a level higher than five feet or on the floor, an appropriate mechanical device may be necessary to move the object.
- Always test the load for stability and weight before carrying the load. For loads that are unstable and/or heavy, tag the load to alert other workers. Use mechanical devices or equipment to carry or move the loads that pose a hazard or are unknown. Use extra caution when moving loads that may be unstable.
- Try reducing the weight of the load by putting fewer things in the container; using smaller and/or lighter weight containers; or dividing the load between two containers and carrying one in each hand. Repack the containers so contents will not shift, and the weight is balanced. Avoid carrying large, bulky objects that may impair vision.

- Seek help when handling loads that are too bulky to grasp or lift, when employees cannot see around or over a load, or when they cannot safely handle a load for any other reason. Ask for assistance from others as a temporary measure for heavy or bulky objects, but not as a permanent lifting solution. Reduce the frequency and amount of time workers carry materials by rotating workers in carrying tasks with other workers in non-carrying tasks.
- Consider the use of additional PPE, such as forearm protection, when appropriate.

6.4 Pushing/pulling

When a task requires pulling and/or pushing a load as opposed to carrying it, consider the following guidelines:

- When there is a choice, push instead of pull. If pulling a load while facing the direction of travel, the arm is stretched behind the body, placing the shoulder and back in an awkward position that increases the likelihood of injury. If pulling a load while walking backwards, the view is obstructed, or the cart may accidentally roll over a foot or bump into the body. Pushing usually is the safer option.
- Push equipment with the entire body instead of with just the arms and shoulders. Using body weight can achieve higher push forces and reduce strain on limbs and joints.
- When pushing (and in cases where pulling is used) use both hands when feasible. This will ensure better balance and control over the load.

6.5 Use of mechanical equipment for material handling

When it is necessary to move heavy and/or bulky objects that are unsafe to move even with a two-person approach, assistive or mechanical equipment must be used.

6.5.1 Non-powered hand carts

- Keep the centre of gravity of the load as low as possible and place heavy objects below lighter ones
- Place loads where the weight of the load will be carried by the axle, not the handles and where it will not slip, shift or fall during movement
- Load only to height to allow a clear view ahead. Only walk backwards with a hand truck in specific instances, such as when going up an incline
- When going down an incline, the hand truck should be in front of the operator. When going up an incline, the hand truck should be downhill from the operator
- Move the hand truck at a safe speed

6.5.2 Powered or mechanical handling equipment

- Ensure sufficient safe clearances are present, including for aisles, at loading docks, through doorways and wherever turns or passages must be made.
- Aisles and passageways will be kept clear and in good repair, with no obstruction across or in aisles that could create a hazard.
- Permanent aisles and passageways will be appropriately marked.
- Clearance signs to warn of clearance limits will be provided.
- Powered mechanical equipment must be operated in accordance with Ramboll’s SWP, Heavy Equipment and Forklifts.

6.6 Drum handling

This section applies to drums containing chemicals stored and handled in work areas to support Ramboll operations. Examples include drums that contain:

- Toluene used as a solvent to support spray painting operations
- Drums of paint or coatings
- Lubricants and hydraulic fluid
- Water treatment chemical including polymers and corrosives

6.6.1 Drum type and selection

Drums come in two basic styles. An open-head drum, used for storing solid materials or liquids/sludges where additional access is needed, has a lid held in place by a bolt ring and gasket, and the bolt ring is loosened with a standard wrench or socket wrench to open and seal the lid. A closed-head drum, used for storing liquids, has one or more small bungs (openings) on the top, which are opened and sealed using a special drum wrench. Most drums are made of steel, but fibre drums may be used for storing solids, and certain corrosive liquids must be stored in plastic drums. Other drum types and materials are available for specific chemicals. Drums used for transporting chemicals or wastes must comply with applicable regulations.

6.6.2 Labelling

All drums that are not new or thoroughly cleaned and decontaminated must be labelled in accordance with applicable hazard communication requirements. Refer to the Ramboll’s SWP, Communication of Chemical Hazards for more information. Drums that have been emptied of their contents but have not been cleaned and decontaminated must be labelled, handled and stored as if they were full.

6.6.3 Handling drums

Before moving a drum, inspect it for dents, cracks or rust, especially around seams. It may have been damaged during previous transit and handling. Check that lid gaskets (open top) and bungs (closed top) are secure.

NOTE: Inspecting drums of highly hazardous materials like corrosives prior to handling and transportation is critical. Even small leaks can be dangerous.

Use an appropriate mechanical aid, such as a forklift or drum dolly, to move drums. Drum dollies must have large primary tires with a secondary set of tires for use when moving drums around the facility. Dollies used to move drums must be designed for that purpose, and two-wheel drum dollies are not permitted. Attempting to move drums by hand is difficult and dangerous because the weight of the materials inside may shift and throw you off balance, resulting in injured fingers or a severe back strain.

NOTE: Ramboll does not allow drums to be rolled on their side. Drums may be manually moved on their bottom edge only a very short distance from the mechanical aid to its final position. Watch for crush points between other drums or between the drum and adjacent equipment.

Before attempting to handle or transport drums or containers containing corrosives or similar chemical hazards, refer to Ramboll's SWPs, PPE and Safety Equipment and Corrosives Handling to understand hazards and control measures. Document PPE and other control measures in the project safety plan.

6.7 Cylinder handling

- Cylinders must be transported in an upright position after being delivered to work location.

NOTE: Cylinders are not permitted to be transported or stored horizontally in the workplace, except if cylinders are specifically designed for use in the horizontal position or the cylinders are <5 litres in water volume (such as calibration cylinders). However, some cylinders (e.g., acetylene) must be kept upright at all times. Understand the country-specific regulations that apply to all types of cylinders being handled at a Ramboll facility or project site.

- Once cylinders arrive to the job site, they must immediately be secured in an upright position if they were previously in a horizontal position for transportation. Refer to Ramboll's SWP, Hazardous Material Transportation and Shipping for requirements when transporting compressed gas cylinders in the horizontal position.
- Make sure protective valve cover is tightened prior to moving.
- Use hand trucks to transport cylinders with a chain or strap to secure the cylinder in place.
- Secure cylinders to hand trucks prior to moving cylinders (i.e., chain or rope cylinders in).
- Cylinders should only be rolled on their bottom edge for short distances associated with positioning the cylinder in its final position after being removed from a cart or dolly.

6.8 Material handling controls

Lifting, carrying and lowering objects represent a potential physical hazard to Ramboll employees. To eliminate or minimise the risk of lifting hazards, utilize proper techniques, such as keeping the back straight and legs bent. Objects should always be lifted, lowered and carried as close to the body as possible. If the equipment cannot be lifted in this manner, it is too heavy to lift alone. Call other employees or use a mechanical device for aid in lifting. Mechanical aids, like hand trucks and carts, or the buddy system should be used to move heavy objects, objects with poor handgrips or large bulky objects. Ergonomic improvements between the tasks and the worker should be made according to the hierarchy of controls:

1. Elimination or substitution – The most effective ergonomic control is to eliminate a potentially hazardous task or substitute items to be handled with those that present less of a risk.
    - Field example: Eliminate the need for carrying a 40 lb/18.1 kg bag of topsoil by purchasing smaller bags or dividing the soil into smaller containers that are easier to handle.
2. Engineering controls - Rearrange, modify, redesign, provide or replace tools, equipment, workstations, packaging, parts, processes, products or materials
    - Example: If heavy materials are delivered to the site, arrange for them to be dropped off at their final location instead of introducing an additional lifting task.
3. Administrative controls – Best work practices that may reduce but do not eliminate material handling hazards include:
    - Examples: Alternating heavy tasks with light tasks; providing variety in tasks to reduce repetition; adjusting work schedules, work pace, or work practices; providing recovery time; modification of tasks so work occurs within the power zone (i.e., above the knees, below the shoulders and close to the body); and rotating workers through jobs that use different muscles, body parts, or postures. Many stretching and gentle exercises can help relieve muscle fatigue. Every 1-2 hours stretch any limbs or muscles that may feel tense or fatigued. Remember to listen to your body and do not do any exercises or stretches that cause discomfort or pain (consult with your doctor before starting any exercise regimen).
    - Best practices also help to minimize potential for injury and are task-specific. Examples include the use of proper lifting techniques and keeping the work area clean. Some additional work practice controls include minimizing the distance between the load and the body; lifting loads from knuckle height; keeping the travel distance to less than 10 feet (3 metres); minimizing twisting; and providing appropriate handles on objects to be lifted where feasible.
4. PPE –PPE is the final protective control method and should be relied upon only when other controls do not sufficiently eliminate or reduce the risk. PPE should be task-specific:
    - Field example: knee pads to protect from contact stress or insulating gloves to protect from vibration/cold. Wear appropriate shoes to avoid slips, trips, falls and protect the top of the foot. Wear appropriate protective gloves of the right size to provide better grip on material.

PPE should only be relied upon once appropriate training has been received on the use, advantages and limitations of specific items. Ramboll's HSS department is available to support selection of PPE and appropriate training related to safe lifting and manual material handling.

7. TRAINING AND COMPETENCY

Ramboll's HSS training program includes new employee induction training, supervised on-the-job training and annual completion of online modules or classroom instruction related to safety requirements and work practices. Training assignments vary based on employee roles and training classification. Completion of assigned training will be documented by a training completion certificate, which will be stored in the employee's electronic training record.

7.1 Applicable training requirements

The purpose of training and education is to ensure that our employees are sufficiently informed about the ergonomic hazards to which they may be exposed during material handling and lifting. Training will consist of initial training and follow-up training every 3 years. Additionally, training will be conducted in a language understandable to the employee.

Safe lifting training is conducted through an online training module. The safe lifting training reviews the ergonomic hazards and risks associated with all types of material handling, with a focus on safe lifting techniques and assisted lifting and moving devices.

Safety Ambassadors, HSS Coordinators, and key office management employees (office managers, IT and HR) are provided training to assist in hazard identification and how to provide assistance for ergonomic issues, which may include ergonomic concerns related to safe lifting and manual material handling. When an ergonomic-related issue is identified, the local office Ramboll HSS Coordinator or Safety Ambassador will work with Ramboll's HSS department to resolve the case using ergonomic assessments and safe work planning, and where necessary, may assist with equipment adjustments or other ergonomic improvement strategies.

8. DOCUMENTATION

No additional documentation is required for Safe Lifting and Material Handling. Project teams will document on-site work activities as required by the Client and as instructed by the PM.

9. INTERNATIONAL TILTS

9.1 Asia/Pacific

9.2 Brazil

9.3 Canada

9.4 European Union (EU)

9.5 Mexico

9.6 United Kingdom (UK)

9.7 United States (US)

See Occupational Safety and Health Administration (OSHA) publication 2236:

https://www.osha.gov/Publications/OSHA2236/osha2236.html

See Centers for Disease Control and Prevention (CDC)/National Institute for Occupational Safety and Health (NIOSH) guidance for ergonomics and musculoskeletal disorders:

https://www.cdc.gov/niosh/topics/ergonomics/nlecalc.html

9.8 Other Regions

10. ADDITIONAL INFORMATION

11. REVISION SUMMARY

ATTACHMENT 8
SUBSURFACE UTILITY CLEARANCE GUIDANCE

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

Maureen Warren | Mark Watka

DATE

February 2023

VERSION

2.0

SAFE WORK PRACTICE

SUBSURFACE UTILITY CLEARANCE

CONTENTS

1. PURPOSE

The purpose of this Safe Work Practice (SWP) is to reduce the likelihood of Ramboll project teams (or our subcontractors) unintentionally contacting or damaging subsurface utilities. The SWP provides guidance and safe work practices for subsurface utility clearance. These practices are collectively and historically referred to within Ramboll using the acronym SSC, which stands for subsurface clearance.

Unintentionally contacting or damaging a subsurface utility may present an immediate danger to the life, health and safety of our employees, our contractors and the surrounding community. Subsurface utility incidents can also cause property damage, trigger financial and legal repercussions, and damage our professional reputation. When utility hazards are identified and controlled prior to starting work, the risks associated with such hazards can be minimised.

2. SCOPE

This SWP applies to client facilities or other sites where Ramboll employees and/or subcontractors are performing intrusive work. Intrusive work is defined as any penetration of the soil, sediment or any other ground surfacing material (asphalt, concrete, etc.), whether using hand tools or mechanised equipment. Examples include digging test pits or exploratory trenches, excavations or grading for property development or soil remediation, boreholes advanced with hand tools or mechanised drilling equipment, gas spiking, remedial injections, installation of monitoring wells or soil vapour probes, horizontal or directional drilling, work on water that disturbs the sediment or substrate, and any other on-site activity where penetration of the ground surface is required.

This SWP does not apply to clearance of overhead utility lines. Overhead line clearance safe work practices are discussed separately in the SWP, Overhead Utility Clearance.

3. OVERVIEW

This SWP outlines requirements for identifying and locating subsurface utilities before intrusive work to avoid unintentional contact or damage.

- **Public utility notification** is always required, using a utility notification and marking service where available.
- **Private utility clearance** is always required unless specific conditions are met.
- **Critical Zone** (5 feet [ft]/1.5 metres[m]) is the required radius for utility clearance, representing a distance from the intrusive location within which no buried utilities, surface indicators of buried utilities, or recognised uncertainty areas are allowed to be present unless Critical Clearance is completed, as defined below.
- **Critical Clearance** activities are specialised locating and clearance techniquest that are required if a utility or recognised uncertainty area intersects the Critical Zone and the intrusive work cannot be moved further from the utility.
- **Clearance site supervisor** is the employee who is responsible to oversee and document utility clearance activities, including identifying historical resources (maps, plans or interviews) and conducting a visual search for surface utility indicators and markings.

- **SSC Planning Worksheet** details responsibilities of the clearance site supervisor during safety planning for an intrusive project.
- **SSC Field Checklist** details responsibilities of the clearance site supervisor at the field site before intrusive work begins.
- **Variances** must be obtained from the HSS department if the subsurface work is deviating from SWP requirements.
- **Technical experts group** will be engaged to review variance applications.
- **Utilities strikes are reportable** and subject to investigation and corrective actions.

4. RESPONSIBILITIES

4.1 Project Manager (PM)/Project Owner (PO)

- Define contractual and legal responsibilities associated with intrusive activities and underground utilities as early as possible (e.g., at the proposal stage) and before intrusive work begins.
- Request subsurface utility information or plans from the facility owner and assign qualified and experienced employees to review the information provided.
- Ensure adequate resources including project team members, budget and schedule to comply with requirements of this SWP.
- Assign responsibility for subsurface utility activities and intrusive work to trained and experienced employees.
- Direct the collaborative effort between the clearance site supervisor and Site Safety Representative (SSR) to ensure the field team understands all subsurface utility hazards.
- Confirm that all documentation has been completed for each intrusive event (i.e., pre-project and field SSC checklists, public utility notification, utility plot plan, etc.).
- Assess whether the area where intrusive activities are to take place is suspected or known to contain Unexploded Ordnance (UXO) including explosive residues. If UXO is known or suspected, ensure project is compliant with the SWP, Unexploded Ordnance (UXO) Anomaly Avoidance.
- Support employee use of Stop Work Authority related to subsurface utility clearance or any other perceived hazard. Work is to be stopped until the identified hazards are evaluated and controlled to the satisfaction of the project team and Health Safety and Security (HSS) department and in accordance with Ramboll safe work practices and regulatory requirements, as applicable.
- Discuss stop work situations with the local HSS Coordinator (HSSC), regional representative of the HSS department, or other designated HSS representative, including reporting of incidents and safety observations in accordance with HSSP, Event Reporting and Investigation.

4.2 Site Safety Representative (SSR)

- Be present at the site to oversee the project or appoint another on-site employee as a backup SSR (with approval from the PM).

- Ensure the project safety plan containing subsurface utility clearance information is reviewed with site team as part of their project safety orientation.
- Communicate project safety requirements to all employees and subcontractors and document safety meetings, unsafe acts or conditions, and corrective actions.
- Report any utility clearance difficulties, uncertainties or variance requests to the local or regional HSS representative.
- Inform PM/PO of important developments or questions regarding project and task safety.
- Assist with reporting of incidents and safety observations in accordance with HSSP, Event Reporting and Investigation.

4.3 Clearance site supervisor

- Be present at the site during utility clearance and marking, and/or provide supervision if utility clearance activities are conducted by several different individuals.
- Engage a private utility locating contractor and discuss the project scope to identify the appropriate utility locating methods and technologies.
- Complete the SSC Planning Worksheet including notification of public utility owners either individually or through the local utility marking service (e.g., "One-Call"; "Dig Safe") and document responses from all notified utility owners.
- Complete the SSC Field Checklist prior to beginning intrusive work.
- Support the SSR in reporting any utility clearance difficulties, uncertainties, or variance requests to the local or regional HSS representative.
- Authorise intrusive work ONLY when all utilities have been cleared within the Critical Zone or have been confirmed and cleared using soft-dig techniques.
- Recognise situations where overhead power lines may intrude into work areas and evaluate in accordance with the SWP, Overhead Utility Clearance.
- Stop work if there is a suspicion that utilities have not been properly identified or if an unsafe condition is identified or perceived.
- If utilities are discovered, contacted or damaged, coordinate emergency response and other response activities as defined in this SWP.

4.4 Health, Safety and Security (HSS) department

- Support project safety plan development (when requested by the PM) including subsurface utility clearance and appropriate safety controls based on this SWP and site-specific concerns.
- Review and update this SWP on a biennial basis or more frequently if required.
- Review applications for variances and coordinate review by a technical experts group.
- Respond to variance applications in a timely manner, particularly if the need for a variance arises during intrusive work activities.

- Assist in variance-related dialogue between the project team and the technical experts group.
- Grant variance approval after the technical experts group has reached consensus between three or more members. The process for technical review may differ by country or region.
- Host quarterly meetings, or facilitate discussions on an as-needed basis, with technical experts group(s).

4.5 Health, Safety and Security Coordinator (HSSC)

- Promote awareness, understanding and use of this SWP by project team members.
- Facilitate application of this SWP in the context of local regulatory requirements and integration of this SWP into project safety plans.
- Inform the HSS department if this SWP does not adequately address local regulatory requirements.

4.6 Technical experts group(s)

- Support project teams with peer review of complex utility scenarios by reviewing requests for variances from approved safe work practices, whether related to Critical Clearance (i.e., clearance of utilities within the Critical Zone) or to recognised utility uncertainty, as defined in this SWP.
- Recommend additional utility clearance steps, technologies and controls for hazards and related liabilities.
- Consult with the HSS department as needed and participate in quarterly meetings with HSS leaders.
- In the US, this group is referred to as the SSC Area Experts Group. Technical experts groups and peer review processes may be named and/or defined differently by country or region.

4.7 Employees, subcontractors and visitors

- Comply with all requirements described in this SWP.
- Do not perform intrusive work without authorisation from the PM, SSR and/or clearance site supervisor.
- Review subsurface utility locations in relation to the planned intrusive work location.
- Use Stop Work Authority if there is a suspicion that utilities have not been properly identified or if an unsafe condition is identified or perceived.
- Stop work if unknown utilities are discovered or damaged. Follow the response actions described in the Responding to contact with a utility section of this SWP.

5. KEY DEFINITIONS

5.1 Critical Zone (CZ)

The CZ is the required radius for utility clearance, representing a distance from the intrusive location within which no buried utilities, surface indicators of buried utilities, or recognised uncertainty areas are allowed to be present unless Critical Clearance is completed, as defined below.

5.1.1 Critical Clearance

A term that refers to utility clearance methods and activities to safely perform manual clearance and/or establish the precise horizontal and vertical position of utilities within the Critical Zone (see Critical Clearance section).

5.1.2 Reduced Critical Zone (RCZ)

An area surrounding an intrusive work area that has been reduced (replacing the CZ) after completion of appropriate Critical Clearance activities. The size of the RCZ depends on utility type and the utility hazard level.

5.2 Electromagnetic (EM) utility locating

This technology is used in many different types of pipe locating tools and is one of the most common methods to locate underground utilities. Tools include a signal generator (Genny) that generates an electromagnetic energy wave in the radio frequency. The signal generator can be directly connected or indirectly applied (inducted) to utilities containing conductive materials (“active mode”). The generated frequency is detected using a signal receiver, or cable avoidance tool (CAT), which can also detect electromagnetic signals that are generated by most electrical utilities and some communications utilities without use of the Genny (“passive mode”). Note that in passive mode, the utility needs to be active (powered on) to be detected. Active mode with direct connection is the preferred method. Active mode with indirect induction is not as effective.

This technology cannot locate plastic, asbestos, concrete, terracotta or non-ductile pipes unless conductive materials are embedded or introduced within the pipe, or a tracer wire is present. This technology is normally limited to depths of 10 ft/3 m to 15 ft/4.5 m, and may be subject to interference from aboveground or belowground objects, which may “push” or “pull” the signal. Lithology can also be a source of interference. A highly trained and experienced operator is needed to select appropriate methods and interpret results.

- **Sondes and Traceable Push Rods** – Sondes and traceable push rods can be inserted into an accessible utility and generate a signal that allows an experienced operator to trace utilities that may be otherwise non-locatable.

NOTE - If EM equipment is used to trace a pipe that is large enough to enter, or if entry into a vault or manhole is needed to make a connection to a utility, it must be done without breaking the plane of the confined space unless confined space protocols are applied (see the SWP, Confined Space Awareness and Entry).

5.3 Ground Penetrating Radar (GPR) and related devices

GPR transmits waves of electromagnetic energy into the ground or other surface, which are deflected back up to the surface where a receiver generates and displays a subsurface profile for interpretation by the operator. This type of locating equipment is generally used for buried pipes, tanks, manholes, cables and other objects that cannot be located with other methods such as electromagnetic locating. GPR is significantly affected by site geology and has limited depth of penetration depending on the radio wave frequency that is used. GPR systems designed to locate underground pipes are typically mounted on a cart. A highly trained and experienced operator is needed to properly select the type of antenna and frequencies to apply.

- **GPR concrete scanner** - GPR systems designed to locate utilities and structural elements within a concrete slab are smaller and typically hand-held. Required for commercial or industrial slabs if there is potential for in-slab or sub-slab utilities or critical structural elements (i.e., utilities within or immediately beneath a concrete slab).
- **Acoustic Pipe Locator (APL)** - Acoustic location methods have historically been used to locate mostly water lines. With the recent introduction of new APL technologies, now even unmarked plastic pipe (or where tracer wire has broken), water and sewer laterals, or other types of utilities may be located. This instrument sends a series of acoustic waves (“pings”) down into the earth and monitors the acoustic wave pattern to produce a subsurface image or profile. APL equipment may be used in soil, grass, concrete, gravel and asphalt. Similar to GPR, the detection depth is proportional to utility size and also depends on acoustic frequency.

5.4 Non-scientific methods

Non-scientific methods are those which are not based on a known geophysical principle, are heavily dependent on user technique, and are subject to various forms of bias. These methods are not a satisfactory method of adding lines of evidence. Examples include “witching sticks” consisting of a copper or other metal bar that is held in the hand and appears to “gravitate” in the direction of pipes or void spaces.

5.5 Intrusive work

Any indentation, intrusion, excavation, grading, boring or other activity that penetrates into a surface (soil, sediment, asphalt, concrete, etc.), regardless of the depth, area or type of tool or equipment being used.

5.6 Soft dig methods

Methods to positively identify or provide clearance of subsurface utilities with minimal risk of damage to the utility. Typically, “soft dig” methods involves air knifving or hydro excavating in combination with vacuum excavation. In some situations, hand digging may qualify as a soft dig method depending on the utility type and control measures, such that the individuals who perform hand digging are protected from hazards related to the target utility, and the utility is protected from damage that may be caused by the hand digging equipment.

5.7 Private utility locator

A subcontractor who employs non-intrusive surface geophysical methods to locate and mark underground utilities and clear intrusive work locations.

5.8 Public utility notification ticket

The record of the intrusive work notification made to public utility companies and/or line locating contractors who are responsible for public utility marking. Organisations that process these public utility notifications may be referred to as a "One Call", "Dig Safe" or "Dig Alert" service. In locations where these services are available (and typically mandatory), they are a required component of utility clearance work practices.

5.9 Recognised utility uncertainty

Uncertainties related to expected or known underground utilities that cannot be effectively located due to obstructions, lithologic conditions, equipment limitations, or the construction of the utility. Recognised utility uncertainties that are within or potentially within the Critical Zone will require appropriate Critical Clearance activities and/or a variance from the HSS department, which typically involves review by a technical experts group.

5.10 Utility quality level

A professional opinion of the quality and reliability of utility information associated with a specific utility or group of utilities. Such reliability is determined by a professional engineer or other qualified professional with responsibility for Subsurface Utility Engineering (SUE) and plan design. In the US, four different quality levels exist (A through D), in order of decreasing quality (Level A is the highest quality and Level D is the lowest). Utility quality levels are assigned only by qualified and appropriately licensed professional engineers. Additional information is provided in the Utility quality levels section.

5.11 Vacuum excavation

Vacuum excavation is a soft-dig method, typically used in combination with an air knife or water knife (also called hydro excavation) to break up and loosen soil for removal. A vacuum truck with tank and hose assembly are used to apply a strong vacuum for excavation of limited areas, with the intent to safely clear intrusive locations and expose underground utilities for repair or locating. It may also be referred to as potholing, hydro-digging, hydro-trenching or soft digging.

- **Air or water knife** - A soft-dig device that directs compressed air or water to advance a pothole or other excavation. Usually used in conjunction with vacuum excavation equipment.

6. WORK PRACTICES

Ramboll employees may work at sites or facilities where intrusive work is being performed and may directly perform and/or oversee work involving subsurface utility hazards. Unintentional contact with utilities, or contact that is intended (e.g., excavating to expose utilities for repair or removal) but improperly executed, can result in risks to life and health of workers as well as severe property damage. Ramboll project teams are expected to be familiar with the content of this SWP, as well as locally applicable regulatory requirements and any project-specific requirements. In the event of conflicting requirements, the more stringent set of requirements will be followed. Project-specific requirements must be outlined in the project safety plan.

6.1 Pre-field requirements before intrusive work

All intrusive work areas must be evaluated for the presence of subsurface utilities and structures prior to implementing the intrusive work. Planning for intrusive activities begins at the proposal stage when the project owner must request the necessary budget and resources to implement the work safely, and continues with document review, pre-field planning, and on-site utility clearance activities. This section describes requirements and documentation for these activities.

6.1.1 Pre-field planning activities

Planning activities involve several steps that must be completed and documented, including but not limited to the steps identified below. Project teams are required to document these activities using the SSC Planning Worksheet, or equivalent, and add this information to the project safety plan.

- Identify the clearance site supervisor.
- Identify a site contact who is knowledgeable about utilities, if available.
- Request and review existing or historical utility information, if available.
- Develop a utility plot plan base map, to which all known utility information pertaining to the work areas and the overall site (with detail as relevant to current and potential work areas) will be added.
- Coordinate public utility notification and marking.
- Retain a private utility locator, including discussion of the scope of work and appropriate locating methods to be used.
- Schedule site reconnaissance and private utility locating (attended by clearance site supervisor or designee).

6.1.2 Review existing documents and information

When locating subsurface utilities and structures, all available sources of information should be considered, including but not limited to the following:

- Historical site information (maps, photos, plans, or other files)
- As-built drawings (or design plans, if as-builts not available)
- Easement maps and related public records
- Documentation from previous utility clearance, repair, or installation activities
- Utility elevations and location coordinates, if available
- Interviews with knowledgeable site/facility personnel, if available

Project teams should document their efforts to seek out existing documents and information while planning intrusive work activities and evaluating utility locating methods. Because the availability or non-availability of site-specific records can affect costs, it is recommended to evaluate availability of utility records and anticipated level of effort for review at the proposal stage.

Note that as-built plans, historic maps, or knowledgeable personnel may or may not be available, and in cases where this information is available, these resources may not accurately represent existing conditions. Hence, additional lines of evidence are necessary to confirm utility information.

6.1.3 Public utility location services

Most localities require the use of a public utility notification and locating service prior to beginning any intrusive work activities. These services are commonly referred to as "One Call", "Dig Safe" or "Dig Alert" services, and providers typically partner with local utility companies to identify public utilities. **If available, public utility location services must be utilised**, even if the work is to occur on private property or inside a building. If not available, public utilities serving the area of the site must be contacted individually to notify and request utility marking service. The following requirements apply unless there are more stringent local regulations:

- Submit a notification and marking request meeting applicable advanced notice regulations. If local requirements are not established, allow at least two full days' advance notice but not more than 10 business days prior to the starting date of the intrusive work.
- Mark anticipated intrusive work areas with white spray paint or white flags
- Ensure that the notice ("ticket") received from the location service is valid for the anticipated duration of the intrusive activity.
- Submit change requests, updates or renewals in accordance with local requirements.

Most localities have standardised colours to indicate the various types of utilities. The following table summarises standard marking colours in the United States. Other standard marking colours may apply in other countries or regions.

Utility	Colour
Electric	Red
Gas/Oil/Steam	Yellow
Communications	Orange
Water	Blue
Sewer	Green
Survey markings	Pink
Proposed Excavation	White

If a utility marking is not present and no response has been received by the person who initiated the public utility notice, the utility owner(s) who do not mark or respond to the notice must be contacted to confirm that their utilities are not present in the intrusive work area. Some public locating services will signify that their respective utilities are not present ("all-clear" notice) via a call, email, or online portal.

6.1.4 Utility plot plan

All intrusive projects must include development of a utility plot plan that shows the planned intrusive work areas and all known utility information pertaining to the work area and the overall site (with detail as relevant to current and potential work areas), including information obtained from public utility notification and private utility clearance. Plot plan requirements are further discussed below:

- Computer-generated plot plans utilising CAD/GIS are always preferred. Plot plans may also be added by hand to an existing drawing, aerial photograph or site map, but depictions of utilities must be to scale and as accurate as feasible. Plot plans must be legible and use a scale that is appropriate to show important utility details in and around the intrusive work location.
- If the scale of the available site map or aerial photo prevents adequate recording of utility details in and around the work area, alternate methods will be used to create a plot plan at an appropriate scale (e.g., field sketches and measurements, photographs, or GPS coordinates).
- Prior to intrusive activity, the plot plan must be reviewed by the SSR, clearance site supervisor, and the equipment operator (e.g., driller or excavation contractor).
- The review shall be documented in a pre-field checklist, field logbook or appropriate project record.

6.1.5 Private utility location services

Private utility locators use a variety of non-intrusive surface geophysical methods to identify the presence of subsurface utilities and structures. **Ramboll requires the use of these services if available**, regardless of whether the work is taking place on privately owned or public land.

> *Private utility locating is **REQUIRED** prior to intrusive tasks unless specific conditions are met, or a variance is granted by the HSS department. If private locating services are not available or if this step is proposed to be bypassed, consultation with the HSS department is required and the project team would typically be instructed to apply for a variance.*

The SSC Field Checklist is intended to be completed during private utility locating. This checklist, or the equivalent information, must be completed and saved in the project file. In addition, the following procedures shall be followed when using private utility location services:

- Provide a site map to the private utility locator outlining planned intrusive work areas.
- At a minimum, private utility location must occur within the Critical Zone of each intrusive work area. In most cases, private utility location should also extend outside the Critical Zone(s) and typically include locating efforts and observations elsewhere on the property to adequately understand expected utilities and locations.
- The private utility locator will need to review public utility markings and responses in order to assess expected utilities in the work area and in other parts of the site when relevant to current or future phases of intrusive work. Include any aboveground visual indicators of underground utilities nearby in the private locator’s scope of work and field discussions.
- Positive identification of all major utilities listed in the SSC Field Checklist should also be expected from the private utility locator.

- Inform the private locating service of any expected or suspected utilities or any existing information obtained through historical records and plan review.
- Ensure that the private utility locator is using the proper utility location technologies for the site and the work being done. The private utility locator may be best suited to determine which and how many different utility locating technologies should be applied to obtain the highest feasible level of confidence for a project. The HSS department and/or technical experts groups can assist when necessary.
- The clearance site supervisor or SSR must meet with the private utility locator on-site to oversee activities and walk over the planned intrusive work areas.
- The clearance site supervisor or SSR will document utility clearance activities and results in a field logbook or equivalent, take photographs and measurements as needed, complete the SSC Field Checklist, and update the utility plot plan.
- The private locator should provide a record of on-site activities, including at minimum the identifiers of specific intrusive work locations that have been cleared, a description of locations cleared, and the locating tools that were used. Some private locating companies can also provide a report with photographs, maps, diagrams and detailed descriptions of clearance activities and results.

6.2 On-site requirements during intrusive work

The following requirements apply to all intrusive activities and must be completed before work begins:

- Confirm that underground utilities have been located and marked, including intrusive work locations. Surrounding or adjacent areas should also be cleared and marked as needed, such that cleared areas and markings extend 5 feet/1.5 m beyond the intrusive activity in all directions to identify the Critical Zone.
- Complete the required documentation (e.g., SSC Field Checklist or equivalent) and keep on site.
- Communicate all potential utility concerns, protocols and safe work distances to Ramboll employees and subcontractors, including equipment operators.
- De-energise electrical utilities and isolate piping where possible, particularly if present in or near Critical Zones.
- Identify emergency shutoffs and add locations to the plot plan.

6.2.1 Maintaining utility markings

A duration of time may pass between public and private utility marking and the time of intrusive work. If this is the case, Ramboll or our subcontractor will be responsible for maintaining utility markings or requesting re-marking. Markings must be consistent in shape, size, and colour with the original marking.

6.2.2 Finalising intrusive locations and Critical Zones

Finalising the exact locations of intrusive work will take place after completion of subsurface utility locating using public and private utility locating services.

- If a utility or recognised utility uncertainty is identified within the Critical Zone, intrusive work locations **must be moved** and the Critical Zone re-cleared, or a pre-cleared alternate location must be substituted such that no utilities are present in the Critical Zone.

- If intrusive work locations cannot be moved or substituted, Critical Clearance efforts are required (See Critical Clearance section). Boreholes or other intrusive activity **must be manually cleared using soft digging techniques** (or other appropriate methods depending on the utility type) beyond the maximum depth of known or suspected site utilities. For excavations, this process may require a soft-dig trench to an appropriate depth along the perimeter of the intrusive area.

- ***Exception:*** if one or more known utilities are in conflict with the Critical Zone but there are no other uncertainties, **daylighting** the utilities of concern using soft dig methods (to verify depth, location and direction) may be an acceptable Critical Clearance alternative to clearing the borehole or intrusive location with soft dig methods if doing so is infeasible.

- Without the use of soft dig manual clearance or daylighting to clear Critical Zone utilities as described in this SWP, or if a recognised utility uncertainty is not resolved with these methods, **a variance from the HSS department is required.**

6.3 Critical Clearance

In general, a variance from the HSS department is required when a utility (or recognised utility uncertainty) is identified within the Critical Zone and the location cannot be moved. However, certain steps may be approved at the project level to allow work to proceed without a variance.

- Use of soft dig methods within the Critical Zone can reduce or eliminate the need for a variance (see Finalising intrusive locations and critical zones section).

- Other methods may also be acceptable to minimise risk (e.g., manual clearance if appropriate; daylighting of utilities; previous direct experience with utility installation; availability of highly accurate utility plans/elevations; or documented disconnection and abandonment of all utilities serving the site).

These actions are collectively referred to as **Critical Clearance**. The following sections describe Critical Clearance requirements and provide examples of appropriate responses and safety controls for different Critical Clearance scenarios.

6.3.1 Utility hazard level

Regardless of whether a variance is obtained, Critical Clearance activities require an assessment of utility hazard level, which depends on the risk that damaging a utility would pose to employees, the environment, or the community, in order to establish a Reduced Critical Zone (RCZ).

High hazard utilities, if damaged, have a potential to result in one or more of the following:

- Injury or death of workers

- Secondary property damage

- Release of toxic or flammable substances

- Uncontrolled releases from a pressurised line

- Unexpected loss of fire protection systems that are required by local ordinance

- Impact to active facility operations (including low-voltage security, communication or process control utilities)
- Public or community impacts and/or temporary loss of utility service

Low hazard utilities do not result in the above factors if damaged.

- They may be repaired at a cost that is acceptable to project liability tolerances and budget, OR
- The client has accepted liability in writing for any damage to the utility that may result from our work and the Legal department is involved.

No hazard utilities or objects are confirmed abandoned, inert or without any hazard, permanently inactive, approved for demolition or removal, and would not require any type of repair or replacement.

High Hazard	Low Hazard	Abandoned/No Hazard
Energised electrical Gas/flammable Toxic/biohazard Pressurised Fire protection Security, communication or process control impact Public/Community Impact Damage/Repair Unacceptable	LOTO/inactive electrical Non-flammable/inert Non-pressurised Non-toxic No impacts to active facility Damage/repair acceptable	Abandoned/inactive Owner-verified status Subsurface debris No repair required (see Verified disconnection)

Critical Clearance requirements are most stringent for high hazard utilities, and whenever possible project teams should use Lockout/Tagout (LOTO) or similar measures to render the utility safe and inert during the intrusive work. This practice can change the utility hazard level from high hazard to low hazard. See the SWP, Lockout/Tagout.

Another means of reducing the utility hazard level is by the client accepting liability (in writing, with Legal department involvement) for damage to specific utilities that will not or cannot be shut off, or those for which damage/repair would represent an unacceptable liability for Ramboll. An example would be **directional drilling** above or below fire protection water lines that would be inside the RCZ of the borehole. This practice cannot apply to electrical lines or any utility that poses an injury or illness risk to workers or the public.

If soft-dig methods are infeasible and our work will be in close proximity to a non-locatable utility, specific steps are required to limit Ramboll liability. A variance from HSS will be required, including technical review and/or consultation with the Legal department.

6.3.2 Reduced Critical Zone (RCZ)

The RCZ is a safety radius around an intrusive activity, within which no mechanical digging may be done, and only applies as a substitute for the CZ once the precise horizontal/vertical locations and hazard levels of all CZ utilities are known and appropriate controls are in place. This is typically accomplished by application of soft dig measures (see the Using hand-digging as a soft-dig method section).

- Utility owners and operators (for both public and private utilities) also usually define a minimum approach distance and may have specific requirements to work within this distance, such as using soft dig methods and having a representative on-site during excavation. Always confirm safe work practices with the utility owner when reduced critical zones are to be applied.
- The table below illustrates types of high risk and low risk utilities and the corresponding RCZ around the intrusive activity.

Utility Hazard Level	**RCZ (apply once hazard levels, locations, and depths are known)**	**Dig Method within RCZ**
High hazard	1.5 feet/46 centimetres	Soft dig required
Low hazard	0.5 feet/16 centimetres	Soft dig recommended (*hand dig ok for utilities that are resistant to damage, or damage/repair liability is deemed acceptable*)

- Unless other more stringent requirements apply, excavation within the RCZ may only be performed using soft dig methods, or alternatively by hand digging, which is only acceptable if certain conditions are met.
- Hand digging may only be used for utilities that do not represent a risk to those using the hand tools, either because the utility is in the low hazard level or because the utility is encased in a material able to withstand impacts from hand tools (see the Using hand-digging as a soft dig method section).
- For situations where soft digging or hand digging are not possible and a utility is expected to be encountered within the RCZ (for example, during **directional drilling**), exceptions to the above RCZ distances can only be authorised by obtaining a variance from the HSS department including technical expert review and/or consultation with the Legal department.

6.3.3 Using hand-digging as a soft dig method

Hand digging may be used only to clear for (or expose) utilities that are in the low hazard category and/or one or more of the following is true:

- It is isolated/inert or otherwise not presenting a risk to those using the hand tools
- It is encased in a material that is protective against damage by hand tools.

- It may be damaged by hand tools but does not pose an unacceptable liability for repair

The following table provides examples of the types of utilities that may permit use of hand digging within the RCZ (if permitted by the utility owner), and those that would require soft dig.

Hand Digging Acceptable	**Soft Dig Required**
De-energised or protected electrical lines	Energised electrical lines
Utilities that are confirmed protected within an engineered duct bank	Unprotected high hazard utilities or when duct bank or other protection is not confirmed
Isolated, inert gas or fuel lines or pipelines	Active gas or fuel lines or high-pressure gas pipelines
Reinforced concrete sewer main	Unreinforced clay or brick sewer main
Isolated, inert public water lines	Pressurised public water supply lines
Low pressure, private PVC water lines if shutoff is feasible	Low pressure, private clay/unknown water lines, or PVC if shutoff is infeasible
Non-pressurised sewer force main	Pressurised sewer force main
Shallow (<5ft/1.5m) and small diameter PVC sewer laterals	Deep (>5ft/1.5m) or large diameter PVC sewer laterals
Isolated/inert fire protection water lines	Pressurised fire protection water lines
Corrugated steel storm drains	Utilities of unknown type or condition; older utilities; clay pipes
Private telecommunications or fibre optic lines (within protective conduit)	Public telecommunications or fibre optic lines

6.3.4 Critical clearance scenarios

The following subsections describe Critical Clearance and related activities as applied in three different scenarios. These scenarios represent categories of subsurface utility-related work that Ramboll may perform.

6.3.4.1 Avoiding Critical Zone utilities using hand dig, soft dig or daylighting

For most intrusive investigation or sampling tasks, utility clearance activities are designed to avoid unintentionally contacting or damaging any utilities. When utilities are within the Critical Zone, a variance is required unless using soft dig methods to clear intrusive areas to a depth beyond that of the utility in question, or through an area or depth interval that represents a recognised utility uncertainty.

- **Hand digging** can be used in lieu of soft dig methods only if identified or potential utilities are in the low hazard category (see Utility hazard level section) and do not pose a risk to employees, the environment or the community. In addition, the utility is resistant to damage by hand tools (see Using hand-digging as a soft dig method section); or does not pose an unacceptable liability for repair.

Solely using manual digging or "hand clearance" tools (shovel, hand auger, soil probe), regardless of depth, is not a substitute for, nor does it satisfy, any aspects of this SWP.

- **Intrusive work that is shallow or only requires hand tools** still requires an assessment of subsurface utilities, including plan review, public utility notification, inspection for visual indicators, and use of a private utility locator. The level of controls applied should match the relative risk of encountering a utility.
    - ***Exception:*** If Ramboll already has direct project experience (e.g., previous installations or excavations **encompassing the entire intrusive area**), and has detailed as-built plans that describe all utilities in the area, including locations and elevations with verified accuracy, or if the property has never been developed with underground utilities, hand digging or mechanical digging projects may proceed without the use of a private locator (but all other steps are still required).
    - **In any other situation**, a variance is required if project teams propose to not conduct private utility locating.
- **Daylighting:** If soft dig or hand dig clearance is not feasible for the location or task, Critical Zone utilities (or utilities that represent a recognised utility uncertainty) may be daylighted using soft dig methods in order to accurately locate and trace the utility and clear the intrusive area.
    - This assumes that there are no other known utilities or recognised utility uncertainties in conflict with the Critical Zone
    - Daylighting always requires advance notification and approval of the utility owner

6.3.4.2 Utility direct interaction (inspect, repair, construct, tie-in, decon/demo)

If the project will involve **direct interaction with a utility** (e.g., tie-in, repair, inspection, construction, decontamination or demolition), follow the steps below to satisfy Critical Clearance requirements and HSS notification/review requirements:

- Complete standard SSC process (plan review, public notification, visual inspection, private locating) (see On-site requirements during intrusive work section).
- Assess the hazard level of the target utility; define the RCZ (see Reduced Critical Zone section).
- LOTO, isolate and render inert the target utility. For most high hazard utilities, this reduces the utility hazard level to low hazard, allowing a smaller RCZ and potential to use hand dig methods within the RCZ (as opposed to soft dig methods).
- Confirm location/depth of utility. If unknown, daylight with soft dig or hand dig methods as appropriate (daylighting not required for utility demolition if all utilities are confirmed to be disconnected/abandoned/inert).
- Confirm no other utilities are present within CZ of target utility. If other utilities exist, reapply the same process.

- Mechanical dig to RCZ. Within RCZ, soft dig (or hand dig if appropriate) to expose the utility (Critical Clearance and RCZ are not applicable for utility demolition if all utilities are confirmed to be disconnected/abandoned/inert).
- HSS review is **required** for direct interactions with **high hazard** utilities.
- HSS review is **recommended** for direct interactions with **low hazard** utilities.
- HSS may designate review responsibility to the technical experts group or other subject matter expert(s).

6.3.4.3 Verified site-wide utility disconnection/abandonment

When we work at demolition sites or redevelopment sites, clients or general contractors may provide documentation of all utility services having been shut off at the property line by the utility owner. If all utilities on site are **confirmed deactivated AND inert** (i.e., not representing a potential for injury or environmental release), some (but not all) utility clearance safe work practices do not apply, including use of a private utility locator. Appropriate documentation (described below) must be obtained before proceeding with intrusive work, or the area will be subject to Ramboll utility clearance requirements. In addition, project teams must obtain a public utility notification ticket and confirm responses and markings, and perform a visual inspection of intrusive areas and critical zones for surface indicators, including surface markings or temporary utilities.

Documentation requirements are described below:

- Map or drawing, to scale and showing locations of prior utility connections (shut-off points).
- Written communication from all previous utility providers describing date of shutoff, name of operator or technician, and activities performed.
- Project plans or written communication from client or general contractor demonstrating that after public utility disconnections, all utilities potentially remaining are abandoned, inert, and scheduled for in-place abandonment or demolition, and no other temporary or permanent underground utilities are present within/nearby the work area.
- Public utility notification ticket issued to Ramboll after notification, and responses.
- Written log entry or SSC Field Checklist describing visual check for surface indicators.

If any of these documents are not applicable, not obtained and/or not readily available in the project file, full subsurface utility locating requirements will apply, or a variance from the HSS department must be issued before proceeding with the work.

6.4 Variance process and requirements

This section describes the process and requirements to apply for a variance to subsurface utility clearance requirements as detailed in this SWP.

6.4.1 Situations requiring a variance

The following situations would require a variance from the HSS department, and may also require approval by the designated technical experts group:

- A utility (or a recognised utility uncertainty) is present within the CZ and will not (or cannot) be resolved using soft dig (or hand dig if appropriate).
- Project team proposes to not utilise public utility notification services.
- Project team proposes to not utilise private utility location services and does not have direct experience or detailed as-built drawings with verified utility information (see Avoiding critical zone utilities while using hand dig, soft dig or daylighting).
- Project team proposes to use hand digging where soft digging would be required under this SWP.
- Project team proposes direct interaction with a utility that meets the definition of a high utility hazard level (see Utility hazard level).
- Project team proposes to exclude aspects of this SWP because all utilities are disconnected/inactive, but we do not have full documentation (see Verified site-wide utility disconnection/abandonment).
- Project team proposes to deviate from any of the practices defined in this SWP.

6.4.2 Variance process description

The sections below describe the expectations and established workflow for variance applications and review by the HSS department and technical experts group.

- Because every situation is different, there is not an established form or worksheet for this process.
- HSS department representatives and technical experts group members are committed to responding to variance applications in a timely manner and will provide additional instruction or submittal requirements as needed.

6.4.2.1 Completion of subsurface utility clearance requirements

These are the expectations for any intrusive project not involving Critical Clearance, consistent with this SWP. Documentation should be available and provided for review upon request.

- Historical site information has been reviewed where available.
- Expected utility types are understood (based on type of site).
- Utility information or maps have been requested from the facility and available documents have been reviewed.
- Public utility notification has been completed and clearance site supervisor has reviewed responses from utility companies.
- Private utility locating has been completed under clearance site supervisor oversight; utility contractor’s daily log or report is available.
- Field SSC Checklist, daily log and photos from clearance activities are completed and available.
- Project team has prepared a site utility plot plan showing known public and private utilities in the work area and elsewhere at the site as related to current and potential work areas.

- Project team has assessed whether any expected utilities have not been accounted for and has identified any areas of recognised utility uncertainty.

6.4.2.2 Initial notification to HSS

Advanced notice to HSS (i.e., telephone or email) is always preferred, if possible. HSS will provide advanced notice to the technical experts group as needed, to facilitate scheduling of the review. For short-notice or same-day issues, this information should be combined with the submittal of the variance application and sent to HSS with cc to one or more representatives of the designated technical experts group.

- Contact the HSS department representative first and cc the project team members involved (e.g., the PO, PM and SSR)
- Identify site location and type of facility
- Summarise scope of work
- Summarise why a variance is needed
- Identify utilities within CZ
- Identify any recognised utility uncertainties
- Justify why the location cannot be moved such that all utilities are outside the CZ
- Describe the requested variance approval timeline and the desired work date/time

6.4.2.3 Submit variance request materials to HSS

Compile the following information and email to a representative of the HSS department. HSS will review and forward to the technical experts group.

Describe the site and utility scenario, including:

- Type of intrusive activity (including diameter of drill rig tools)
- Type, size, and depth of utilities within CZ
- Recognised utility uncertainties or other data gaps
- Photos of intrusive area and surroundings (preferably annotated with utility information and dimensions)
- Utility plot plan, drawn to scale and including intrusive areas and utilities identified within or nearby the CZ, at a scale appropriate to understand dimensions and scope of work
- Project team’s proposed best practice plan to minimise safety hazards and risk of utility damage

6.4.2.4 Best practice planning expectations

Project teams should use the Critical Clearance guidance in this SWP to propose best practices or other methods to minimise safety hazards and risk of damage to utilities in the CZ or in areas that represent a recognised utility uncertainty. Examples of best practices to minimise risk include:

- Identify the type, size, and depth of the utility (confirm with additional utility locating methods; additional discussion with utility owner; additional plan review).
- Understand local requirements for utility notification within a certain safety distance and coordinate with utility companies for their permission when required.
- Take additional steps to render the utility safe, if possible (e.g., isolate, de-energise, de-pressurise, LOTO, aboveground physical barrier).
- Maximise the distance between the borehole path or other intrusive activity and the utility.
- Manually clear the borehole with soft dig methods (or hand dig if appropriate) to beyond the expected utility depth, if feasible.
- Daylight the utility of concern using soft dig methods to identify the location, depth and direction of the utility.
- For private, non-locatable utilities that do not present an injury or illness risk, have the client provide a written letter accepting liability for potential damage to the utility (must be signed by an authorised client representative and reviewed by the Legal department).

6.4.2.5 Variance workflow and interactions

Variance review workflow and interactions are described below.

- Project team member responds directly to questions posed by reviewers regarding site subsurface utilities or historical site information.
- Consider and discuss the alternative approaches suggested by the reviewers and by the project team and ensure project objectives are clearly communicated and understood.
- HSS will notify project team when consensus between three or more members of the review group has been reached.
- Project team commits to implementing the best practice utility clearance procedures as agreed upon by the technical experts group.
- Project team notifies HSS and technical experts group after successful implementation (and/or describe any utility-related problems or issues encountered)

7. TRAINING AND COMPETENCY

Ramboll’s HSS training programme includes new employee induction training, supervised on-the-job training, and annual completion of online modules or classroom instruction related to safety requirements and work practices. Training assignments vary based on employee roles and training classification. Completion of assigned training will be documented by a training completion certificate, which will be stored in the employee’s electronic training record.

7.1 Clearance site supervisor

The clearance site supervisor must be in the high-risk training category and must have completed all assigned subsurface utility clearance training modules, internal training certificates, or external training certificates that apply within the country or region. The individual will have relevant field experience that is sufficient to understand clearance requirements and methods for the type of site or project. Project managers are responsible to assign this role to an individual with relevant experience that is commensurate to the type of site, type of intrusive field activities, and potential utility-related hazards.

7.2 Technical expert group

The technical expert group members must be in the high-risk training category and current on all assigned subsurface utility clearance training modules, internal training certificates, or external training certificates that may apply within the country or region. The individuals will have relevant field experience at commercial and industrial sites, including management experience, over a period of at least five years. Participation in a technical expert group is intended as a rotating position and is subject to approval of the individual's PDP manager, service line leader or department head, and HSS Director or HSEQ Lead (or designee).

8. DOCUMENTATION

The following documentation is required, specific to subsurface utility clearance.

8.1 SSC Planning Worksheet

The SSC Planning Worksheet or equivalent must be completed by the clearance site supervisor prior to mobilising for intrusive work. The purpose of the checklist is to document these efforts and avoid complications or delays in the field as related to access or locating techniques.

8.2 SSC Field Checklist and utility plot plan

Prior to beginning intrusive work, the SSC Field Checklist or equivalent must be completed, and the associated utility plot plan developed or updated for each intrusive work location. The clearance site supervisor must complete the SSC Field Checklist, and utility information, maps and markings must be reviewed with the equipment operators.

- For intrusive locations that are separated by (or elongated along) significant distances, or for intrusive activities in multiple areas with widely varying utility types or concentration, professional judgment must be used to determine whether separate SSC checklists should be completed for intrusive work in separate areas.
- Completed documentation (SSC Field Checklist, plot plan, public utility notification ticket and responses) must be kept on site and available for review and will be archived in the project files.

8.3 Documentation of utility disconnection and inert status

- Refer to the Verified site-wide utility disconnection/abandonment section.

8.4 Variance application and issuance

- Written response from three or more members of the technical experts group approving proposed safety controls.
- Written response from a representative of the HSS department, granting the variance.

9. INTERNATIONAL TILTS

9.1 Asia-Pacific

9.2 Brazil

9.3 Canada

CSA S250-2020 – Mapping of Underground Utility Infrastructure (https://webstore.ansi.org/standards/csa/csas2502020)

9.4 Europe

9.5 Mexico

9.6 Middle East

9.7 Nordics

9.8 United Kingdom (UK)

9.9 United States (US)

OSHA 1926.651 - Specific Excavation Requirements

https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.651

Utility Quality Levels: American Society of Civil Engineering CI/ASCE 38-02 – Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data

9.10 Other Regions

10. ADDITIONAL INFORMATION

10.1 Responding to contact with a utility

Regardless of the type of utility, the unintentional striking, damaging or dislocating of an underground utility are all considered to be incidents and therefore require incident reporting in EHS Insight, in accordance with the HSSP, Event Reporting and Investigation.

- Uncovering or encountering a previously unknown underground utility, even if the utility is not damaged, also must be reported as an incident.
    - ***Exception***: If a previously unknown utility is uncovered while using an approved soft dig method and the utility is not damaged, this situation may be reported as a work observation.
- The sections below describe response actions in the event of striking or damaging high-risk utilities including electrical, gas and high-pressure water mains. If a utility is damaged and is in a category other than those outlined below, stop work and contact the utility owner and HSS department representative.

10.1.1 Uncovering an underground utility intact

If an unknown or unexpected underground utility is uncovered intact while not using an approved soft dig method, the following actions should be completed by the field team:

- Stop work in the area of the facility/pipeline or utility.

- Clear everyone from the area.
- Notify the affected utility owner and the public utility notification service, if applicable. The public utility notification service may be able to assist with contact numbers for notifying member companies in the event of any damage.
- Notify the PM, PO and the local or regional representative of the HSS department.
- The PM, PO, or designee will notify the Client, property owner or tenant.
- Once the HSS department representative has approved continuation of work, mark the underground structure(s) on the plot plan, backfill as appropriate, and move to an alternate cleared location if available.

ALWAYS ASSUME THAT AN UNDERGROUND PIPE IS ACTIVE AND MAY BE DANGEROUS TO LIFE AND HEALTH!

10.1.2 Damaging/contacting underground electric lines

Damaging underground electrical lines can result in electric shock to those in the area around the equipment. The following steps must be implemented immediately:

- Stop work.
- If you are NOT in danger from fire or otherwise exposed to danger:
  - Stay where you are.
  - Move the equipment away from line if possible.
  - Warn others not to approach the area.
- If you are in danger:
  - Equipment operator should jump as far as possible from the equipment and land with both feet on the ground. Do NOT touch the equipment and the ground simultaneously.
  - Hop or shuffle away from the equipment keeping both feet on the ground at the same time.
  - Do not touch the equipment until the utility owner says it is safe to do so.
- Call the designated emergency response telephone number or use the designated emergency response radio channel.
- Provide first aid and call for emergency medical assistance as needed.
- Notify the PM, PO and the local or regional representative of the HSS department.
- The PM, PO or designee will notify the client, property owner or tenant, and Managing Principal.
- Do not allow anyone to enter the area until the utility owner declares it is safe to do so.
- Take photographs from a safe distance and take statements from witnesses at the scene.

10.1.3 Damaging a pressurised gas pipeline

Damaging a gas pipeline could result in an explosive atmosphere in the immediate area. If a gas pipeline is damaged, the following steps must be implemented immediately:

- Stop work.
- Leave tools in place, but shut off any running/energised equipment. Eliminate potential sources of ignition in the area.
- Evacuate the immediate area to a safe distance as site conditions warrant.
- Call the designated emergency response telephone number or use the designated emergency response radio channel.
- Contact the pipeline owner.
- Notify the PM, PO and the local or regional representative of the HSS department.
- The PM, PO or designee will notify the client, property owner or tenant, and Managing Principal.
- Do not allow anyone to enter the area until the utility owner declares it is safe to do so.

10.1.4 Damaging a pressurised water main

Although usually less hazardous than damaging an electric line or gas line, damaging a pressurised water main can cause large amounts of property damage, may render fire suppression water utilities inoperable, and can be hazardous to the life and health of those nearby. The following steps should be implemented if a pressurised water main is damaged:

- Stop work.
- Remove tools and confine jetting water if safe and necessary to do so.
- Evacuate the immediate area.
- Call the designated emergency response telephone number or use the designated emergency response radio channel.
- Contact the water utility owner.
- Ensure that water is not creating additional potential hazards (e.g., electrical shorting, flooding, contaminant migration, etc.). Where possible, warn those likely to be affected.
- Notify the PM, PO and the local or regional representative of the HSS department.
- The PM, PO or designee will notify the client, property owner or tenant, and Managing Principal.
- Do not allow anyone to enter the area until the utility owner declares it is safe to do so.

10.2 Utility quality levels

Utility quality levels are used to describe the level of accuracy and confidence in utility location data on plan drawings for larger or utility-intensive engineering projects. The quality level will determine SSC requirements prior to beginning intrusive work and will be considered during variance requests. Information gathered at lower quality levels is incorporated into higher quality levels; however, information from a higher quality level may be obtained before lower quality level information. Quality levels may be used on engineering plans generated or reviewed by Ramboll.

10.2.1 Quality level D

Information derived from existing records or oral recollections.

- As applied to this SWP, this is information that is typically gathered through records review, plan review, and interviews with a knowledgeable site representative.

10.2.2 Quality level C

Information obtained by surveying and plotting visible above-ground utility features and by using professional judgment in correlating this information to quality level D information.

- As applied to this SWP, this quality level represents visual observations and information that may be gathered during site reconnaissance visits, while marking intrusive locations, and during private utility locating.

10.2.3 Quality level B

Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of subsurface utilities. Private utility locators may provide estimated vertical positions, but they should not be considered highly accurate. Quality level B data should be reproducible by surface geophysics at any point of their depiction. This information is typically surveyed to applicable tolerances defined by the project and reduced onto plan documents.

- This quality level roughly equates to the private locating step of this SWP. However, depending on the scope, methods and documentation, a private locating effort may not be sufficient to meet project-specific requirements for quality level B.

10.2.4 Quality level A

Precise horizontal and vertical location of utilities obtained by the actual exposure (or verification of previously exposed and surveyed utilities) and subsequent measurement of subsurface utilities, usually at a specific point. Minimally intrusive excavation equipment is typically used to minimise the potential for utility damage. A precise horizontal and vertical location and other utility attributes are included in plan documents. Accuracy is typically set to 15-mm vertical and to applicable horizontal survey and mapping accuracy as defined or expected by the project owner.

- This quality level roughly equates to soft-dig “daylighting” and Critical Clearance concepts in this SWP, but these activities are not necessarily sufficient to meet project-specific requirements for quality level A.

10.3 Utility construction using safety warning tape

Utilities installed as part of construction projects are required to meet the engineering standards of the country or region and project-specific engineering specifications. Engineering standards typically require the installation of detectable warning tape within backfill material above utilities. Warning tape is used to prevent utility damage or injuries resulting from unintentional contact during future construction or excavation. Warning tape is used for gas and high voltage utilities and may also be used for communications and other utility types.

10.4 Utility clearance for water work areas

When intrusive activity is planned in areas that are in or adjacent to a water body (e.g., boreholes, sediment cores, excavation, dredging, etc.), in addition to water safety requirements (refer to the SWP, Water Work – Inland, Near Shore and Facility) the project safety plan must include utility clearance methods for undeveloped property as described in this SWP including public utility notification, document review and interview with a knowledgeable person (if available). Private utility clearance may not be feasible for the intrusive location (although specialised contractors and equipment are available for water-based utility clearance, and should be used for water areas that are developed with utilities).

If public utility notification or document review indicates that utilities are present within or immediately adjacent to the water body, at a minimum a private utility clearance will be conducted along the shoreline or river banks in order to confirm public utility markings and understand whether utilities may approach the intrusive work location. Water-based private utility locating will be required if the utility position is within 50 ft/15 m of the intrusive location, unless the utility location data are available and confirmed accurate, and the vessel position is determined and stabilised using GPS and multiple anchorages (or equivalent stabilisation system) such that the location can be advanced at a safe distance from the utility (and in accordance with utility owner requirements).

11. REVISION SUMMARY

Date of Release	Summary of Key Changes
March 2021	Initial Release
February 2023	Added reference to UXO SWP in Responsibilities section under "Project Manager/Project Owner". Added references to sediment to Scope and Key Definitions sections (included in definition of "intrusive work"). Added section in Key Definitions discussing non-scientific methods (e.g., "witching"). Minor text edits to Critical Clearance section. Added reference to use of warning tape for utility construction to Additional Information section. Added guidance for utility clearance in and adjacent to water bodies to Additional Information section.

ATTACHMENT 9
HEAT / COLD STRESS MANAGEMENT

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

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DATE

April 2021

VERSION

1.0

SAFE WORK PRACTICE

HEAT AND COLD STRESS

CONTENTS

FIGURES

APPENDICES

1. PURPOSE

The purpose of this Safe Work Practice (SWP) is to provide instructions for identifying and evaluating specific heat and cold stress hazards, communicating information concerning these hazards and establishing appropriate protective measures.

2. SCOPE

This SWP applies to all Ramboll work areas where work is performed in hot or cold conditions and areas where such conditions may exist related to our work (for example, cold stress may be an unexpected hazard if a person’s clothing became wet as a result of splashes or immersion).

In the event of a conflict between this Ramboll SWP and locally applicable regulatory requirements (or project-specific requirements), the more stringent set of requirements will be followed.

3. OVERVIEW

This SWP outlines the requirements to prevent and treat heat or cold stress. Heat and cold stress occur when Ramboll employees work in hot or cold environments for extended periods of time. The task being conducted in these environments can also contribute to heat and cold stress.

- Heat-related illness may result from a combination of factors, including the environment (temperature and humidity), physical exertion and personal risk factors. Individuals who are not acclimated to hot environments are more likely to develop a heat-related illness.
- PPE, such as chemical protective clothing and respirators, can contribute to the onset of a heat-related illness, and this must be considered when developing controls.
- Heat-related illness can be prevented by adequate work/rest breaks, hydration and acclimation periods.
- If an individual develops a heat-related illness, first aid must be rendered, and in extreme cases (heat stroke) immediate medical treatment is required.
- Cold stress also results from a combination of factors, including the environment (temperature and wind speed), clothing and an individual’s personal risk factors.
- Wet clothing or skin will result in a more rapid onset of cold stress, such as frostbite or hyperthermia.
- Dressing adequately and layering clothing will aid in preventing cold-related illnesses and injuries. In cold environments, wet clothing should be removed immediately and replaced with dry clothing.
- If an employee begins to become hypothermic, they must be moved to a warm environment and given warm fluids. Moderate to severe hypothermia will require immediate medical treatment.

4. RESPONSIBILITIES

4.1 Project Manager (PM)/Project Owner (PO)

- Request information about relevant hazards from the facility owner and consider the adequacy of the information provided. This information should be included in the project safety plan
- Ensure adequate budget and schedule to comply with requirements outlined in this SWP
- Recognize the potential for heat and cold stress when assigning persons to work under ambient conditions that may be excessively hot or cold
- Develop a project safety plan to identify project-specific hazards and control measures
- Verify that project employees have completed the applicable training requirements
- Support employee use of Stop Work Authority related to heat and cold stress or any other perceived hazard until such hazards are evaluated and controlled to the satisfaction of the project team and HSS department

4.2 Site Safety Representative (SSR)

- Be present at the site to oversee the project or appoint another on-site Ramboll employee as a backup SSR (with approval from the PM)
- Confirm the project safety plan containing relevant heat and cold stress information is provided to site employees as part of their project safety orientation
- Communicate work requirements to Ramboll employees and subcontractors on the project site
- Implement heat and cold stress preventative measures as outlined in this SWP and referenced in the project safety plan
- Inform PM/PO of important developments or questions regarding heat and cold stress or any other project or task safety concerns

4.3 Ramboll Health, Safety and Security (HSS) department

- Support project safety plan development (when requested by the PM) and review proposed heat and cold stress hazard information and safety controls based on this SWP and site-specific concerns
- Provide technical support related to training, assessing heat and cold stress conditions and identifying preventative measures
- Review and update this SWP on a biennial basis or more frequently if required

4.4 Health, Safety and Security Coordinator (HSSC)

- Promote awareness, understanding and use of this SWP by project team members
- Facilitate application of this SWP in the context of local regulatory requirements and integration of requirements into project safety plans
- Inform Ramboll's HSS department if the HSSP does not adequately address local regulatory requirements

4.5 Employees, subcontractors and visitors

- Review, understand and comply with project safety plans
- Do not undertake any activities with heat or cold stress hazards unless properly trained and equipped for site conditions
- Follow heat and cold stress safety practices defined in this SWP, as implemented by the site owner or occupant or as required by local regulations. In the event of a conflict, the more stringent requirements will be followed
- Report safety events, issues or concerns to the Site Supervisor or SSR
- Exercise Stop Work Authority if any task is perceived to be unsafe or if more information is needed to proceed safely

5. KEY DEFINITIONS

Acclimation - Refers to a physiologic adjustment process occurring when a healthy employee accustomed to a temperate environment begins to work in a hotter or colder environment. These adjustments may occur over a period of days to several weeks.

Cold Stress - What constitutes extreme cold and its effects can vary across different areas of the country. In regions that are not used to winter weather, near freezing temperatures are considered "extreme cold." In certain conditions, like if a person’s clothing is wet, cold stress may occur in environments that are not typically considered to present cold stress risks.

Heat Index - Refers to a specialized temperature/humidity index (also called the apparent temperature) that is a measure of how hot weather is perceived by the average person at varying temperatures and relative humidity.

Heat Stress - Heat stress refers to the effects of working in hot environments, which can lead to heat-related illnesses.

Heat Wave - Refers to a temperature condition when the apparent temperature exceeds 108ºF/42.2ºC or is 15 to 20ºF /8 to 11ºC higher than the noon, midsummer average temperature.

Wet Bulb Globe Temperature (WBGT) – A type of apparent temperature used to estimate the effect of temperature, humidity, wind speed and visible and infrared radiation, which are affected by sun angle and cloud cover. A WBGT device, also referred to as a Wet Bulb Globe Thermometer, is designed to measure these parameters. WBGT is used as a basis for selecting or designing heat stress control measures.

Wind Chill - Refers to the apparent experienced temperature when taking air temperature and wind speed into consideration. It can also refer to the lowering of body temperature due to the passing flow of lower temperature air.

Winter Weather Advisory - Refers to a weather event where a low-pressure system produces a hazard but does not meet warning criteria. Meteorological authorities of the country or region will typically issue advisories (or similar term) for one or more of the following: 3 to 5 inches/8 to 12 centimetres of snow in 12 hours, up to one-half inch or 1.3 centimetres of sleet, freezing rain with sleet/snow, blowing snow or freezing rain with an ice accumulation of less than one-quarter inch.

Winter Weather Warning - Meteorological authorities of the country or region will typically issue warnings (or similar term) for one or more of the following: 6 inches/15 cm of snow in 12 hours or 8 inches/20 cm in 24 hours, or one-half inch/1.3 cm or more of sleet; ice accumulation of one-quarter inch/0.6 cm or more; or blizzard conditions for 3 hours or more.

Winter Weather Watch - Meteorological authorities of the country or region will typically issue weather watches (or similar term) when conditions are favourable for a winter storm event that might threaten life or property but may not yet meet criteria for an advisory or warning.

6. WORK PRACTICES

Ramboll employees may work in a variety of environmental conditions capable of causing heat and cold stress. Environmental conditions include outdoor work during the winter or summer, work in or nearby bodies of water (such as ecological or sediment investigations) and work within industrial facilities with heat or cold sources, such as furnaces, smelters, ovens, freezers or cold rooms. When properly implemented, the guidelines presented in this SWP will help to mitigate the risk of heat and cold stress.

6.1 Heat stress

At times, workers may be required to work in hot environments for long periods. When the human body is unable to maintain a normal temperature, heat related illnesses can occur and may result in serious injury or death. This section outlines the risk factors, symptoms, treatments, assessments and preventative measures necessary to manage heat stress risks in the workplace.

6.1.1 Risk factors

- Risk factors for heat stress include high temperature and humidity, direct sun exposure, radiant heat sources, limited air movement and insufficient fluid intake for hydration.
- These risk factors can be exacerbated by PPE, clothing and strenuous physical activity.
- In addition to environmental and workload risk factors, personal risk factors must also be considered when evaluating and controlling heat stress risks. Individual susceptibility to heat stress varies widely due to physiological differences.
- Human responses to hot environments are extremely varied and depend on the individual’s personal susceptibility and the unique environmental conditions to which the person is exposed.
- Figure 1 presents some of the factors that influence an individual’s ability to adapt to heat stress conditions.

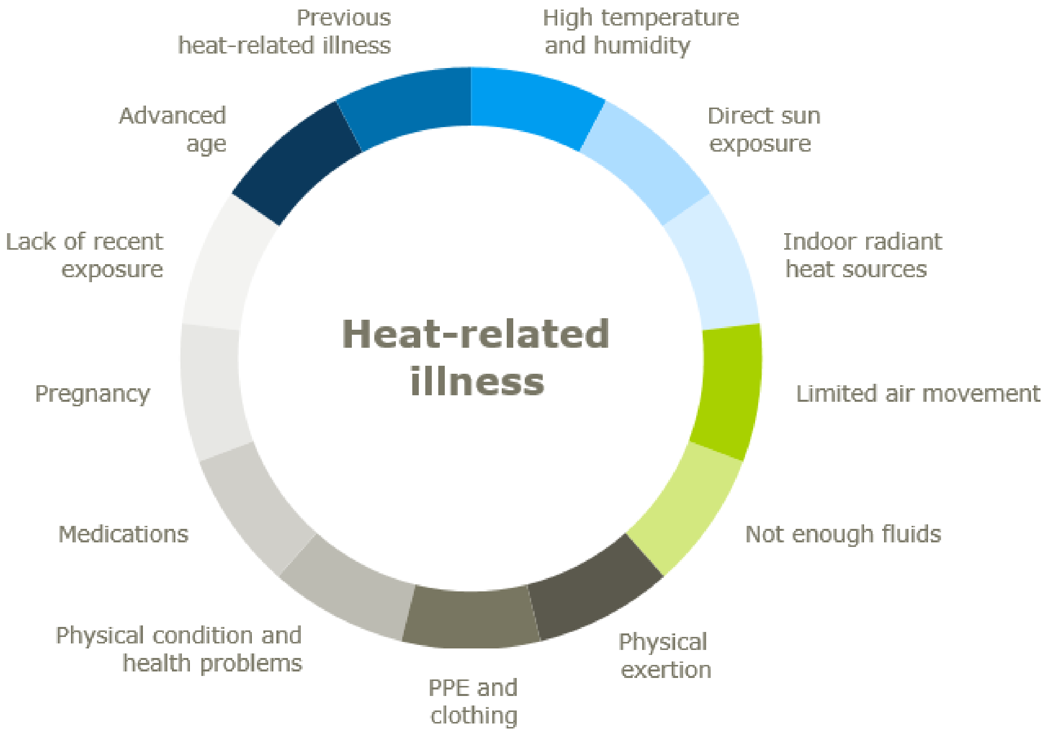


Figure 1. Factors affecting heat stress risk

6.2 Heat-related illness and treatments

In the event of a heat related illness, employees will be administered first aid and will have access to Ramboll's occupational medical provider to facilitate medical evaluation, treatment, medical follow up and ongoing surveillance activities, and documentation as outlined in Ramboll's HSSP, Medical Surveillance and Fitness for Duty. If at any point employees feel symptoms or exhibit signs of heat stress, a Stop Work must be called, first aid will be administered, and additional controls will be selected and implemented before re-starting work if safe to do so. As discussed above, susceptibility to heat stress varies by individual and must be assessed and monitored on a case-by-case basis. Below are the common heat-related syndromes and treatments.

6.2.1 Heat rash

Heat rash is skin irritation caused by sweat that does not evaporate from the skin. Signs and symptoms of heat rash include red clusters of pimples or small blisters. It is more likely to occur on the neck, upper chest, groin, under the breasts and in elbow creases. Treatments may include:

- Provide a cooler, less humid environment
- Keep the affected area dry
- Apply a drying body powder, but do not use ointments and creams

6.2.2 Heat cramps and hyponatremia

Heat cramps and hyponatremia are caused by the loss of body salts and fluids during sweating.

Signs and symptoms of heat cramps and hyponatremia include muscle cramps, pain or spasms in the abdomen, arms or legs. Hyponatremia signs and symptoms may be minimal or severe (e.g., encephalopathy, cerebral and pulmonary edema, respiratory distress or death). Treatments may include:

- Stop Work and move the affected person to a cool, shaded area
- Drink water, have a snack or drink carbohydrate-electrolyte replacement liquids (e.g., sports drinks). When working in environments where heat stress is a hazard, workers should be doing this every 15 to 20 minutes
- Avoid salt tablets unless instructed to do so by a physician or medical professional
- Seek medical evaluation and treatment if the worker has heart problems, is on a low-sodium diet or if cramps do not subside within one hour

6.2.3 Heat exhaustion

Heat exhaustion is the body's response to loss of water and salt from heavy sweating. The signs and symptoms of heat exhaustion are headache, nausea, dizziness, weakness, irritability, confusion, thirst, heavy sweating, decreased urine output and a body temperature greater than 100.4°F/38°C. Heat exhaustion is a medical emergency. Treatments may include:

- Stop Work and move to a cool, shaded area and remove outer clothing. Encourage the worker to take frequent sips of cool water
- Call the local emergency number or take the affected person to a clinic or hospital for emergency medical assistance. If calling for emergency responders, someone should stay with the affected person
- Douse the affected person with cool (not cold) water and circulate air to improve evaporative cooling
- Place cold, wet cloth or ice on head, neck, armpits and groin of worker

6.2.4 Heat stroke

Heat stroke occurs when the body's temperature regulating system fails and body temperature rises to critical levels (greater than 104°F/38°C). Heat stroke is a medical emergency that can result in death. The primary signs and symptoms of heat stroke are confusion; irrational behavior; loss of consciousness; convulsions; a lack of sweating; hot, dry skin; and an abnormally high body temperature. Treatments may include:

- Stop Work and move to a cool, shaded area and remove outer clothing
- Call the local emergency number or take the affected person to a clinic or hospital for emergency medical assistance. If calling for emergency responders, someone should stay with the affected person.
- Douse the worker with cool (not cold) water and circulate air to improve evaporative cooling
- Place cold, wet cloth or ice on head, neck, armpits and groin of worker
- It is important to note that heat stroke can occur as either "classical" or "exertional" types:
    - Classical heat stroke is a major disruption of the central nervous system, a lack of sweating and high internal body temperature

- Exertional heat stress occurs in physically active individuals who will often continue sweating – this is much more common in occupational settings

6.2.5 Rhabdomyolysis

Rhabdomyolysis is associated with heat stress and prolonged physical exertion, resulting in the rapid breakdown of muscle. Signs and symptoms include muscle cramps, abnormally dark urine (e.g., tea or cola colored), weakness and exercise intolerance. The person may also be asymptomatic. Treatments may include:

- Stop Work, move to a cool, shaded area and drink water
- Arrange for medical evaluation at an occupational medical clinic or hospital and ask to be checked for rhabdomyolysis (i.e., blood sample analyzed for creatine kinase)

6.2.6 Heat syncope

Heat syncope (fainting/light headedness) usually occurs with prolonged standing or sudden rising from a sitting or stooped position. Signs and symptoms include fainting, dizziness and/or light-headedness during prolong standing or suddenly rising from a sitting or lying position. Treatments may include:

- Stop work, move to a cool, shaded place and sit or lie down
- Slowly drink water, clear juice or sports drink

6.3 Assessing heat stress

The Ramboll PM or designee shall evaluate potential heat stress risks prior to project work, as part of the project safety plan. A Heat Stress Planning Worksheet is included as Appendix A to assist with evaluating heat stress risk factors and selecting control mechanisms. This worksheet is recommended to be used in combination with a project safety plan. If necessary, a project heat stress control plan should be developed. Heat stress controls must be planned well in advance of field work to allow for acclimation to the heat and integration of the selected control measures into the project scope of work.

- Heat stress regulations are generally consistent around the globe, though some country-specific nuances may apply (see Section 9, International Tilts). Employees must be familiar with applicable requirements in the country or region where they are working.
- The following sections will review the methods to measure heat stress risk factors and the tools used to predict and prevent heat-related illnesses. Factors that must be considered when assessing potential heat stress risks include the following:

6.3.1 Environmental factors

- Radiant heat, humidity, air temperature and wind speed may be monitored using a WBGT device, also referred to as a Wet Bulb Globe Thermometer. Obtaining real-time data on environmental conditions using a WBGT is the preferred method when monitoring field conditions and assessing heat stress controls.
- Environmental heat measurements should be taken at least hourly during the hottest portion of the workday, during the hottest portion of the year and when a heat wave occurs or is predicted.
- Consider collecting heat measurements before commencing a project, as a conservative measure to understand environmental conditions that may not be well understood or may be difficult to predict.

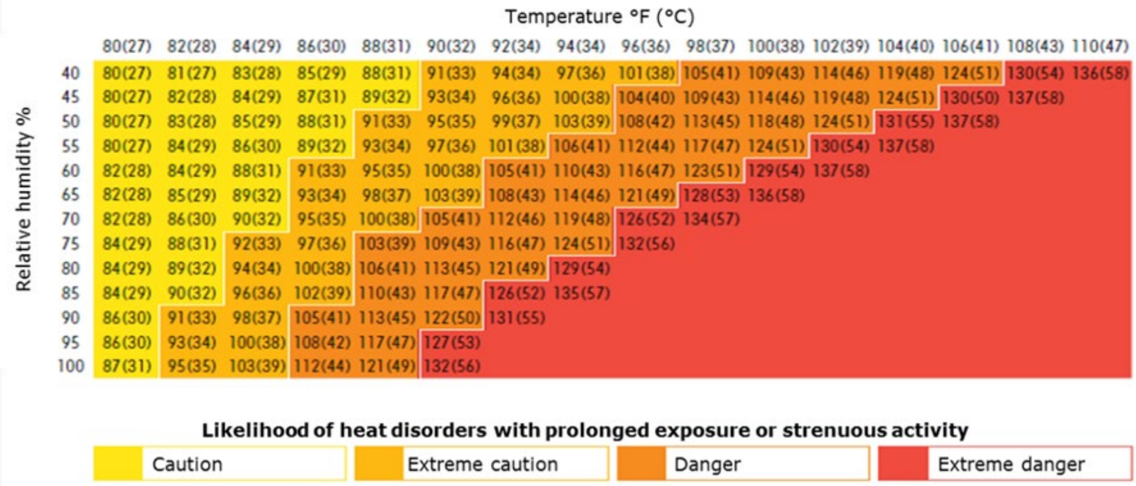
- This can be especially important when working in indoor spaces that are not well ventilated and may be warmed and/or are subject to increased humidity due to operating equipment rather than weather conditions.
- Tools to assess and plan for future heat stress conditions include:

6.3.1.1 Argonne national laboratory tool

- This US-specific tool uses an algorithmic equation to determine WBGT from user-entered weather data. Similar resources may be available specific to other countries or regions.
- The individual can input local weather centre data from a location near the work area.
- Most data can be obtained from Weather.com other weather forecasting services local to the country or region.
- Irradiance based on cloud cover can be estimated from a chart within the tool or similar local resource.
- Regardless of the tool used and source of the weather information, data used must be reliable and accurate to form a reliable estimate for heat stress.
- The tool may be accessed here (see Section IV).

6.3.1.2 Heat index

- The heat index is based on published information from the National Oceanic and Atmospheric Administration (NOAA), a US agency, and is a measure of how hot it feels when relative humidity is factored with actual air temperature. Similar resources are available specific to other countries or regions.
- Humidity is an essential gauge for heat stress as it dictates how quickly sweat will evaporate, which is a process that helps our bodies to cool off. However, the heat index is not as complete a measurement as WBGT.
- The heat index was designed for shady, light wind conditions, and this simple analysis does not consider several of the environmental factors that the WBGT takes into account, such as working in full sun.



Temperature °F (°C)

Relative humidity %	80(27)	82(28)	84(29)	86(30)	88(31)	90(32)	92(34)	94(34)	96(36)	98(37)	100(38)	102(39)	104(40)	106(41)	108(43)	110(47)
40	80(27)	81(27)	83(28)	85(29)	88(31)	91(33)	94(34)	97(36)	101(38)	105(41)	109(43)	114(46)	119(48)	124(51)	130(54)	136(58)
45	80(27)	82(28)	84(29)	87(31)	89(32)	93(34)	96(36)	100(38)	104(40)	109(43)	114(46)	119(48)	124(51)	130(50)	137(58)	
50	80(27)	83(28)	85(29)	88(31)	91(33)	95(35)	99(37)	103(39)	108(42)	113(45)	118(48)	124(51)	131(55)	137(58)		
55	80(27)	84(29)	86(30)	89(32)	93(34)	97(36)	101(38)	106(41)	112(44)	117(47)	124(51)	130(54)	137(58)			
60	82(28)	84(29)	88(31)	91(33)	95(35)	100(38)	105(41)	110(43)	116(47)	123(51)	129(54)	137(58)				
65	82(28)	85(29)	89(32)	93(34)	98(37)	103(39)	108(43)	114(46)	121(49)	128(53)	136(58)					
70	82(28)	86(30)	90(32)	95(35)	100(38)	105(41)	112(46)	119(48)	126(52)	134(57)						
75	84(29)	88(31)	92(33)	97(36)	103(39)	109(43)	116(47)	124(51)	132(56)							
80	84(29)	89(32)	94(34)	100(38)	106(41)	113(45)	121(49)	129(54)								
85	84(29)	90(32)	96(36)	102(39)	110(43)	117(47)	126(52)	135(57)								
90	86(30)	91(33)	98(37)	105(41)	113(45)	122(50)	131(55)									
95	86(30)	93(34)	100(38)	108(42)	117(47)	127(53)										
100	87(31)	95(35)	103(39)	112(44)	121(49)	132(56)										

Likelihood of heat disorders with prolonged exposure or strenuous activity

Caution

Extreme caution

Danger

Extreme danger

Figure 2. Heat Index

Note: The predictive information in the Heat Index table or similar resource should be used as a guide, rather than as an absolute value.

6.3.2 Physical workload

- The metabolic heat load that an individual produces - from light work to high intensity physical activity

Work category	**Metabolic rates (watts)**	**Examples**
Rest	115	Sitting
Light	180	Sitting, standing, light arm/hand work and occasional walking
Moderate	300	Normal walking, moderate lifting
Heavy	415	Heavy material handling, walking at a fast pace
Very heavy	520	Pick and shovel work

Figure 3. Metabolic Rates

6.3.3 Personal protective equipment

- Most heat indices assume a single layer of long sleeves and pants. Any more substantial clothing or PPE, and particularly impermeable PPE, needs to be factored into the heat stress analysis.
- A clothing adjustment factor (CAF) specific to the heat index used should be implemented, as needed (Figure 4).

Clothing worn	**Examples**	**CAF - WGBT °F (°C)**
Work clothes (long sleeves and pants)	Standard cotton shirt/pants	0° F/C
Coveralls (with only underwear underneath)	Cotton or light polyester material	0° F/C
Double-layer woven clothing		5.4° F (3° C)
SMS Polypropylene Coveralls		0.9° F (0.5° C)
Polyolefin coveralls	Micro-porous fabric (eg, Tyvek™)	1.8° F (1° C)
Limited-use vapor-barrier coveralls	Encapsulation suits, whole-body chemical protective suits, firefighter turn-out gear	19.8° F (11° C)

Figure 4.Clothing Adjustment Factor

6.3.4 Acclimation

- Worker acclimation is another important consideration when evaluating heat stress. If workers are traveling from their home environment to an area with different environmental conditions or are commencing work with a higher level of heat stress risk factors than their normal activities, they will need time to adjust.
- An adequate amount of time (typically 1 to 2 days with minimal exposure to heat and only light or moderate work rates) should be incorporated into the project schedule for this purpose.
- Heat acclimation can greatly reduce an individual's susceptibility to heat stress.

6.3.5 Carry-over effect

- There is evidence that the previous day's exposure can carry-over creating a cumulative effect. Workers should be aware that they may not develop a heat stress syndrome on the same day as the exposure.
- Individuals may be more susceptible to cumulative effects of heat stress (potentially leading to a heat stress syndrome) over multiple days of exposure to elevated heat conditions.

6.3.6 Heat stress indices and related tools

- Many organizations have established heat stress indices to evaluate heat stress via the factors previously discussed, including environmental conditions, physical workload, clothing and acclimation.
- A heat index tool developed by the American Conference of Governmental Industrial Hygienists (ACGIH), a US organization, may be used to evaluate potential heat stress (Figure 5). Similar tools, including region-specific mobile applications, may be available in different countries or regions.
- Heat index tools typically combine WBGT environmental readings and the metabolic rate of the workload being performed to estimate heat stress and provide limits for safe work.
- Based on the WBGT and metabolic rate, the heat index tool establishes recommended Threshold Limit Value (TLV) for acclimated workers and an Action Limit (AL) (i.e., half the TLV) for unacclimated workers.

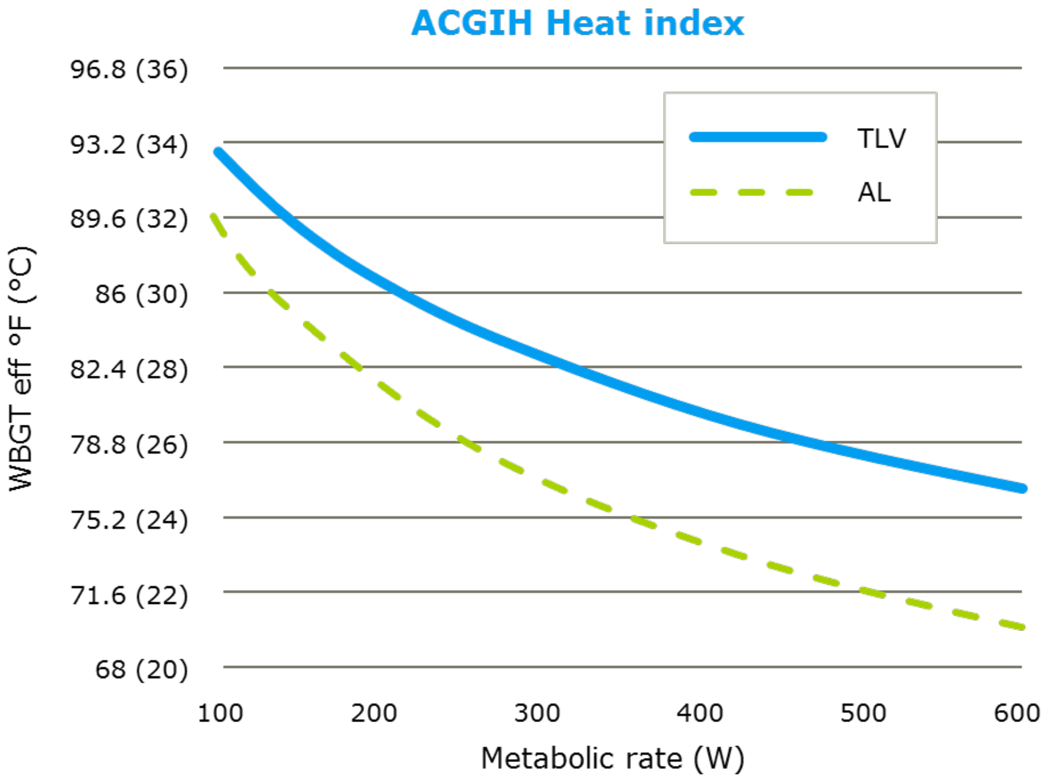
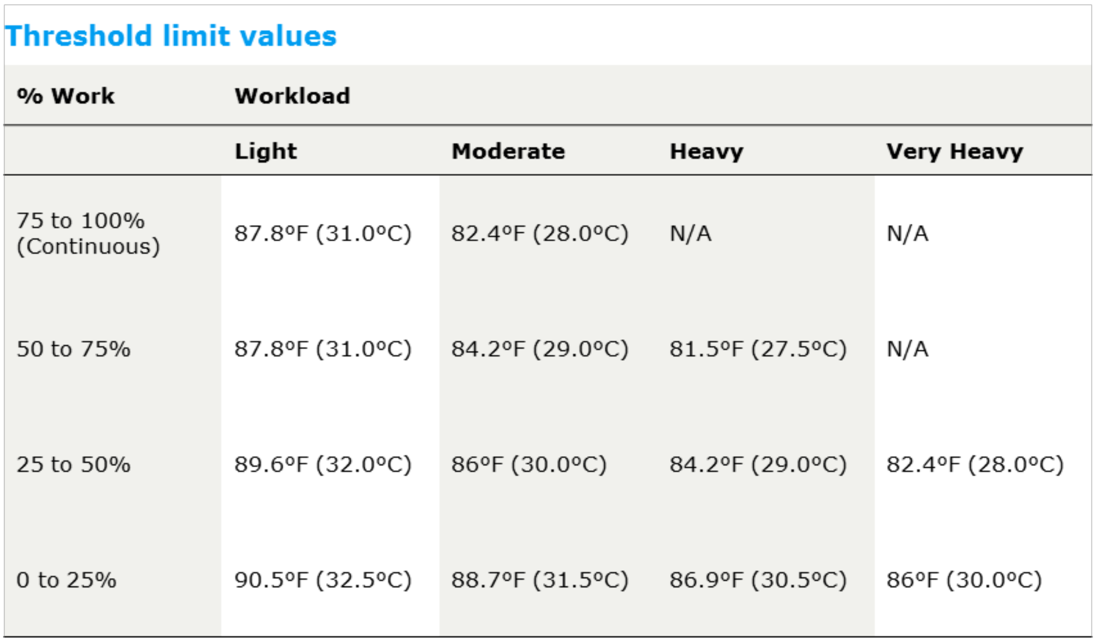


Figure 5. ACGIH Heat Index Tool

- ACGIH has also developed a screening tool to recommend TLVs for heat stress exposure based on WBGT, workload and percentage of time spent performing each job task (Figure 6).



Threshold limit values

% Work	Workload			
	Light	Moderate	Heavy	Very Heavy
75 to 100% (Continuous)	87.8°F (31.0°C)	82.4°F (28.0°C)	N/A	N/A
50 to 75%	87.8°F (31.0°C)	84.2°F (29.0°C)	81.5°F (27.5°C)	N/A
25 to 50%	89.6°F (32.0°C)	86°F (30.0°C)	84.2°F (29.0°C)	82.4°F (28.0°C)
0 to 25%	90.5°F (32.5°C)	88.7°F (31.5°C)	86.9°F (30.5°C)	86°F (30.0°C)

Figure 6. Threshold Limit Values (TLVs) for Workoad Type and Percentage

6.4 Heat stress prevention

6.4.1 Elimination and substitution

The most effective way to prevent heat stress is to eliminate the risk or substitute a task with lower risk.

- Examples would include working indoors or rescheduling work for a cooler season.
- If tasks with heat stress risks cannot be eliminated or substituted with lower-risk tasks, then project teams should rely on other controls as described below and document these controls in the project safety plan.

6.4.2 Engineering controls

Engineering controls can be used to improve heat exchange by modifying air temperature and movement. Outdoor work environments may present challenges for successful application of engineering controls. Please contact the local HSSC or regional HSS department representative for assistance when evaluating the practicality or feasibility of implementing an engineering control to mitigate heat stress risks. Examples of heat stress engineering controls are as follows:

- Spot coolers, fans or blowers to increase heat exchange and improve evaporative heat loss
- Air-conditioned vehicles or trailers worker breaks
- Physical shields if radiant heat from equipment or adjunct processes are an issue
- Equipment or tools to reduce metabolic workload (e.g., rent a properly equipped golf cart to carry sampling equipment for tasks that require walking long distances)
- When shaded areas are not present on the site, establish a shaded area using a tent, umbrella or other sun shade to use for rest breaks or when work tasks are stationary

- Drinking water dispensers, bottled water and/or sports drinks in adequate quantities for workers

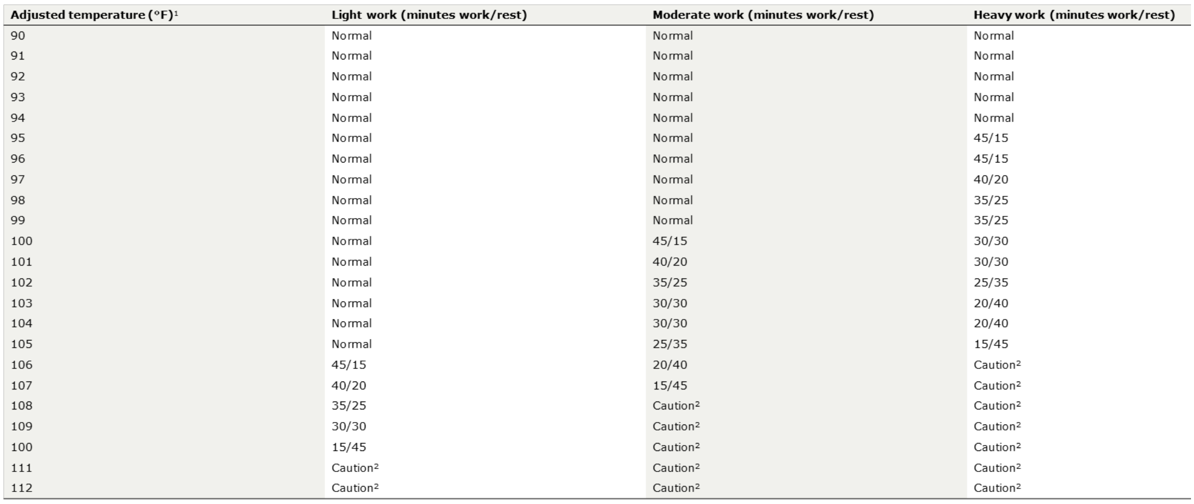
6.4.3 Administrative controls

Administrative controls should be heavily relied upon to control heat stress. One of the most effective methods to control heat stress is controlling the exposure to hot environments. Examples of administrative controls are:

- Schedule hot jobs for the cooler part of the day and/or schedule hot jobs on alternate rather than successive days to reduce carry-over effect
- Schedule routine maintenance and repair for cooler seasons
- Postpone tasks that are not urgent
- Alter the work/rest schedule to permit more rest time
- Assess work area and select, if available, an area to work that is shaded from sun (e.g., under a tree)
- Add extra employees to reduce exposure time for all members of the team. Encourage use of Stop Work Authority when a worker feels heat discomfort or any signs or symptoms of heat-related illnesses
- Increase water and other hydrating fluid intake on the job
- Provide breaks in a shaded/cool place, with variable duration in relation to the climate and activity. The SSR must supervise and remind workers to respect break periods and participate in breaks
- Utilize Occupational Exposure Limits to heat exposure based on acclimation and workload
- Create an acclimation plan and schedule
- Minimize work in isolated locations and follow Ramboll's SWP, Working Alone and Personal Security
- A buddy system should be initiated when heat stress is a job hazard and exposures are above the occupational exposure level
- Buddies should be responsible for observing their co-worker for signs and symptoms of heat stress and be trained to provide first aid and preventative measures if onset of overheating is observed
- Since heat strain stays with the body 1-2 hours following final exposure, buddies should check in with one another after the last exposure to ensure employees are feeling healthy and well
- During pre-work safety briefings, the SSR should instruct supervisors, field employees and subcontractors to recognize early signs and symptoms of heat intolerance, such as weakness, unsteady gait, irritability, disorientation, changes in skin colour or general malaise
- Restrict overtime work in heat stress conditions

6.4.3.1 Work/rest schedule

Another heat stress control is a work/rest schedule. Below are tables developed by NIOSH and the Center for Disease Control (CDC), both US agencies, that are based only on ambient temperature with adjustment factors for sun and humidity. Similar resources may be available specific to other countries or regions.



Adjusted temperature (°F)[1]	Light work (minutes work/rest)	Moderate work (minutes work/rest)	Heavy work (minutes work/rest)
90	Normal	Normal	Normal
91	Normal	Normal	Normal
92	Normal	Normal	Normal
93	Normal	Normal	Normal
94	Normal	Normal	Normal
95	Normal	Normal	45/15
96	Normal	Normal	45/15
97	Normal	Normal	40/20
98	Normal	Normal	35/25
99	Normal	Normal	35/25
100	Normal	45/15	30/30
101	Normal	40/20	30/30
102	Normal	35/25	25/35
103	Normal	30/30	20/40
104	Normal	30/30	20/40
105	Normal	25/35	15/45
106	45/15	20/40	Caution[2]
107	40/20	15/45	Caution[2]
108	35/25	Caution[2]	Caution[2]
109	30/30	Caution[2]	Caution[2]
100	15/45	Caution[2]	Caution[2]
111	Caution[2]	Caution[2]	Caution[2]
112	Caution[2]	Caution[2]	Caution[2]

Figure 7. Work Rest Schedule

6.4.3.2 Hydration

- The normal thirst mechanism is not sensitive enough to ensure sufficient water intake; thus, individuals must be encouraged to consistently drink small quantities of potable water that is at temperatures less than 59°F/15°C.

- A good rule of thumb is to drink about 8 ounces/0.2 litre of cool water every 15-20 minutes. Salt, mineral and electrolyte loss should not be an issue for those with a modern diet, as fruits and vegetables are good source for electrolytes – though un-acclimated workers may experience greater salt loss during the first 2 days of hot work. Sports drinks can be consumed in combination with cool water to supplement salt and electrolyte loss, as needed.

- One way to monitor sweat loss and hydration is by monitoring the color of urine output throughout the work period. The Dehydration Color Chart is one analysis of body hydration based on urine color (see Appendix A). This chart can be printed and posted at the job site when heat stress is a hazard.

6.4.3.3 Heat acclimation plan

- A properly designed and implemented heat acclimation plan can increase the ability of workers to work at a hot job and decrease the risk for heat-related illness. The acclimation plan should be included in the project safety plan, and the PM must consider this plan when scheduling activities for the project.

- Begin with 50% of the normal workload and time spent in the hot environment and then gradually build up to 100% by the 5th day. Implementing acclimation activities is essential for new employees, those traveling to work in a new climate, workers who have been sickor on vacation and all workers during a heat wave. PMs must consider worker acclimation in the project schedule for activities where heat stress is a potential hazard.

- Job reassignments will be coordinated with the PM and must be chosen with knowledge of whether the new task will aid in acclimating the worker to the new job. Inappropriate job reassignment can prolong the acclimation period. The worker may be placed in a low heat stress job. Assigning the worker to a restricted or low heat stress risk job is a helpful method for acclimating workers.

6.4.4 Personal monitoring

Personal monitoring can be done by checking heart rate and recovery heart rate, oral temperature or body water loss. While this type of monitoring will not be required for every project with elevated temperatures, some Ramboll projects may benefit from, or may require such activities to monitor those at risk of developing a heat stress syndrome. If during project planning there are uncertainties relative to the level of controls and monitoring that must be put in place to protect employees, contact the HSSC or HSS department representative for support. Below are examples of personal monitoring protocols:

- To check heart rate, count the pulse for 30 seconds at the beginning of the rest period. If the heart rate exceeds 110 beats per minute (BPM), shorten the next work period by one third and maintain the same rest period. Check the recovery heart rate by comparing the first reading to subsequent readings taken at 2.5 minutes. If the recovery heart rate is greater than 90 BPM or the difference between them is less than 10 BPM, work periods should be reduced.
- Oral temperature must be checked with a clinical thermometer after the work period but before water is consumed. If the oral temperature under the tongue exceeds 99.5°F /37.6°C, the next work cycle should be shortened by one-third.
- Extended work in heat stress conditions may be monitored by weighing each worker at the beginning and end of the work shift. Weight loss should not exceed 1.5% of total body weight; if it does, then fluid intake should be increased.

6.4.5 Personal protective equipment

The final control for heat stress is PPE. PPE, such as reflective clothing and wetted or water-cooled garments, can be effective in reducing heat stress. Below are examples of PPE that can be worn to mitigate the effects of heat stress. If you have questions regarding the selection of PPE, please contact the HSSC or regional HSS department representative.

- Auxiliary cooling systems come in a range of approaches and varying complexity – some research and planning will be required to determine which method is best suited for each site-specific application. Keep in mind that these types of systems add weight, which in turn adds to an individual’s workload, and some systems can limit mobility.
  - Cooling vests: Contain ice packs or other cooling materials secured to or integrated within the garment. They must be frozen prior to use, and effective cooling time varies by vest and with environmental factors and metabolic workload. Cooling vests do not provide continuous and regulated cooling and will require re-freezing or replacement of ice packs periodically. The vests do provide increased mobility as they are not tethered to a pump or other energy source.
  - Cooling scarves/pads: Uses crystal polymer or gel cooling technology. These fabric cooling devices can be applied to various areas on the body to reduce body temperature. Most are activated by soaking the fabric in water; they will likely need to be recharged throughout a shift.
- Adjustable and add-on visor and neck shades, which can be used with or without hard hats.
- Long-sleeve shirts: Help to keep the body cooler by clocking skin from the sun.
- Sunscreen on exposed body parts is also recommended. Sunscreens with active mineral ingredients act as physical blockers to the sun and have less impact on aquatic habitats.

Note: Wearing PPE, such as impermeable clothing to protect against other hazards (e.g., chemical and environmental), can significantly increase heat stress risks because it reduces heat loss from the body and can also increase metabolic load.

- When the air temperature exceeds the skin temperature, convective heat gain will be reduced by decreasing air temperature and/or decreasing the air velocity if it exceeds 1.5 metres per second (300 ft/min).
- When air temperature is lower than skin temperature, convective heat loss will be increased by increasing air velocity. The type, amount and characteristics of clothing will influence heat exchange between the body and the environment.
- When the temperature of surrounding solid objects exceeds skin temperature, radiative heat gain will be reduced by:
  - Placing shielding or barriers that are radiant-reflecting or heat-absorbing between the heat source and the employee
  - Isolating the source of the radiant heat
  - Modifying the hot process or operation
- When necessary, evaporative heat loss will be increased by increasing air movement over the employee by reducing the influx of moisture from steam leaks or from water on the workplace floors, or by reducing the vapor content of the clothing worn by the employee will influence the rate of heat exchange by evaporation.

6.5 Cold stress

For some Ramboll projects, employees may be asked to work in cold environments for long periods. When the human body is unable to maintain a normal temperature, cold-related illnesses can occur and may result in serious injury or death. This section outlines the risk factors, symptoms, treatments, assessments and preventative measures that are necessary to manage cold stress in the workplace.

6.5.1 Risk factors

- Situations that present cold stress risks include working outdoors during winter months or working near waterways that may result in splashes or immersion in water <70°F/21°C.
  - Immersion or splashing with cold water can result in cold stress even if the local climate would not normally present a cold stress risk
- Environmental conditions that contribute to cold-related stress include:
  - Low temperatures
  - Wind
  - Dampness
  - Cold water
  - Wind chill (a combination of temperature and wind velocity)

- Individual susceptibility to cold stress varies widely due to physiological and other differences.
- Physiological and other individual risk factors for cold-related stresses may include:
    - Wearing inadequate or wet clothing increases the effects of cold on the body.
    - Taking certain drugs or medications, such as alcohol, nicotine, caffeine and other medications that inhibit the body's response to the cold or impairs judgment.
    - Having a cold, other illness or certain conditions, such as diabetes, heart, vascular and thyroid problems may increase cold stress risks.
    - Becoming exhausted or immobilized, especially due to injury or entrapment, may speed up the effects of cold stress.
    - Individuals of advanced age may be more vulnerable to the effects of cold stress.
    - Lack of personal protective equipment or clothing appropriate for the conditions will quickly increase cold stress risks.

6.6 Cold-related syndromes and treatments

In the event of a cold stress related illness, employees will be administered first aid and will have access to Ramboll’s Medical Consultant to facilitate medical evaluation, treatment, follow up and ongoing surveillance activities and documentation as outlined in Ramboll’s HSSP, Medical Surveillance and Fitness for Duty (see Document Library). If at any point employees feel symptoms or exhibit signs of cold stress, a Stop Work must be called, first aid will be administered, and additional controls will be selected and implemented before re-starting work. As discussed above, susceptibility to cold stress varies by individual and must be assessed and monitored on a case-by-case basis. Below are the common cold stress related syndromes and treatments.

6.6.1 Hypothermia

Hypothermia occurs when body temperature falls to a level where normal muscular and cerebral functions are impaired. The first symptoms of hypothermia include shivering, difficulty with complex motor functions, lethargy and mild confusion. These symptoms occur as the core body temperature decreases to around 95°F/35°C. As body temperature continues to fall, hypothermia becomes more severe. The individual falls into a state of dazed consciousness, failing to complete even simple motor functions. The victim's speech becomes slurred, and their behavior may become irrational. The most severe state of hypothermia occurs when body temperature falls below 90°F/32°C. As a result, the body moves into a state of hibernation, slowing the heart rate, blood flow and breathing. Unconsciousness and full heart failure can occur in the severely hypothermic state.

6.6.1.1 Hypothermia treatment

- Seek medical assistance for persons suspected of being moderately or severely hypothermic. If the person is unresponsive and not shivering, assume they are suffering from severe hypothermia.
- Conserve the victim's remaining body heat and provide additional heat sources. Reduction of heat loss can be accomplished by various means: obtaining shelter, removing wet clothing, adding layers of dry clothing or blankets or using a pre-warmed sleeping bag.
- For mildly hypothermic cases or those more severe cases where medical treatment will be significantly delayed, external rewarming techniques may be applied. This includes body-to-

body contact (e.g., placing the person in a prewarmed sleeping bag with a person of normal body temperature), chemical heat packs or insulated hot water bottles. Good areas to place these packs are the armpits, neck, chest and groin. It is best to have the person lying down when applying external rewarming.

- You also may give mildly hypothermic people warm fluids orally but avoid beverages containing alcohol or caffeine.

6.6.1.2 Cold water immersion (accelerated hypothermia)

Cold water immersion creates a specific condition known as immersion hypothermia.It develops much more quickly than standard hypothermia because water conducts heat away from the body 25 times faster than air.

- Typically, people in temperate climates don’t consider themselves at risk from hypothermia in the water, but hypothermia can occur in any water temperature below 70°F/21°C.
- Survival times can be lengthened by wearing proper clothing (wool and synthetics and not cotton), using a personal flotation device (PFD, including life vest, immersion suit, or dry suit), having a means of signalling rescuers (strobe lights, personal locator beacon, whistles, flares, waterproof radio).

6.6.2 Frostbite

Frostbite occurs when the skin tissue freezes, causing ice crystals to form between cells and draw water from them, which leads to cellular dehydration. Symptoms include a reddening and extreme numbness of the skin. Frostbite treatment includes:

- Move the affected person to a warm dry area
- Seek medical assistance immediately. Any existing hypothermia should be treated first. Frostbitten parts should be covered with dry, sterile gauze or clean cloth bandages. Do not massage frostbitten tissue because this can cause greater injury
- Severe cases may require hospitalization and even amputation of affected tissue

6.6.3 Trench foot

Trench foot is caused by long, continuous exposure to a wet, cold environment or actual immersion in water. Symptoms include a tingling and/or itching sensation, burning, pain and swelling, sometimes forming blisters in more extreme cases. Trench foot treatment includes:

- Move the affected person to a warm dry area
- Carefully wash and dry, re-warm and slightly elevate affected tissue
- Seek medical assistance as soon as possible

6.7 Assessing cold stress

- POs and PMs shall develop project safety plans that include use of equipment and work practices to prevent injuries resulting from cold stress.
- Cold stress controls must be developed well in advance of field work to allow workers to integrate controls into their regular field practices.
- Cold stress regulations are generally consistent around the globe, although some country-specific nuances may apply. Employees must be familiar with applicable requirements in the

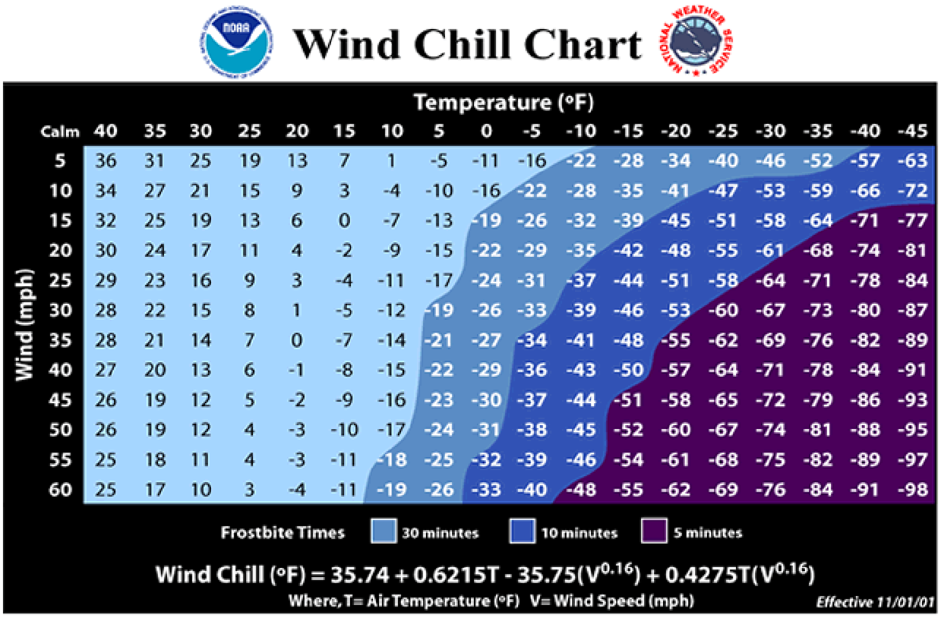
country or region. The project HSSC or a representative of the HSS department can assist in the interpretation and application of local requirements.

- This section will review the means used to measure cold stress and the tools used to predict and prevent cold-related illnesses. Items that must be considered when assessing potential heat stress include the following:

6.7.1 Environmental factors

As discussed above, low temperatures, winds, dampness and cold water can all contribute to cold-related illnesses and these risk factors should be evaluated prior to project work.

- The local weather forecast information should be monitored for winter weather advisories, warnings or watches or similar terms applicable to the country or region
- Temperature readings shall be documented in the project field book to maintain an accurate record of cold stress exposure
- Figures 8a and 8b show the effect of wind chill on exposed skin



Wind Chill Chart

Temperature (°F)

Wind (mph)	Calm 40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

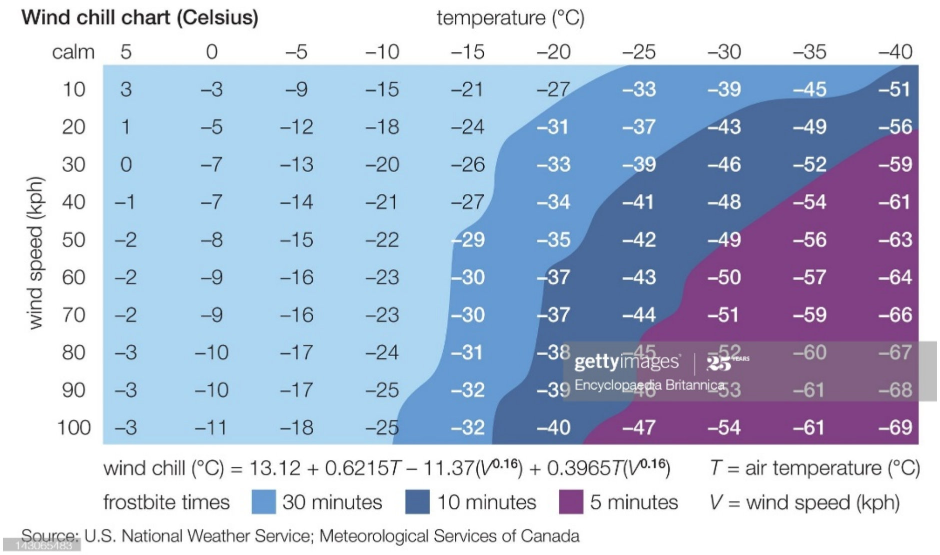
Frostbite Times 🟦 30 minutes 🟦 10 minutes 🟪 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Figure 8a. Wind Chill Chart (Farenheit)



Wind chill chart (Celsius)

wind speed (kph) \ temperature (°C)	5	0	−5	−10	−15	−20	−25	−30	−35	−40
calm	5	0	−5	−10	−15	−20	−25	−30	−35	−40
10	3	−3	−9	−15	−21	−27	−33	−39	−45	−51
20	1	−5	−12	−18	−24	−31	−37	−43	−49	−56
30	0	−7	−13	−20	−26	−33	−39	−46	−52	−59
40	−1	−7	−14	−21	−27	−34	−41	−48	−54	−61
50	−2	−8	−15	−22	−29	−35	−42	−49	−56	−63
60	−2	−9	−16	−23	−30	−37	−43	−50	−57	−64
70	−2	−9	−16	−23	−30	−37	−44	−51	−59	−66
80	−3	−10	−17	−24	−31	−38	−45	−52	−60	−67
90	−3	−10	−17	−25	−32	−39	−46	−53	−61	−68
100	−3	−11	−18	−25	−32	−40	−47	−54	−61	−69

wind chill (°C) = $13.12 + 0.6215T - 11.37(V^{0.16}) + 0.3965T(V^{0.16})$

T = air temperature (°C)

V = wind speed (kph)

frostbite times 🟦 30 minutes ■ 10 minutes 🟪 5 minutes

Source: U.S. National Weather Service; Meteorological Services of Canada

Figure 9b. Wind Chill Chart (Celsius)

6.7.2 Acclimation

Worker acclimation is another main consideration when evaluating cold stress. If workers are traveling from their home environment to an area with different environmental conditions, they will need time to adjust. An adequate amount of time should be incorporated into the project schedule for this purpose. Similar to heat acclimation, cold acclimation can greatly reduce an individual's susceptibility to cold stress.

6.8 Cold stress prevention

6.8.1 Elimination or substitution

The most effective way to prevent cold stress is to eliminate the risk or substitute a task with lower risk.

- Examples would include working indoors or rescheduling work for a warmer season
- If tasks with cold stress risks cannot be eliminated or substituted with lower-risk tasks, then project teams should rely on other controls as described below and document these controls in the project safety plan

6.8.2 Engineering controls

When possible, engineering controls should be used to bring the work environment up to safe temperatures. Below are examples of engineering controls. Outdoor work environments may present challenges for the application of engineering controls. Please contact the local HSSC or regional HSS department representative for assistance when determining the practicality or feasibility of implementing an engineering control to mitigate cold stress risks. Examples of cold stress engineering controls are as follows:

- Placing insulation, shielding or barriers between the cold source and the employee
- Using radiant heaters
- Isolating the source of the cold
- Modifying the cold process or operation

6.8.3 Administrative controls

Administrative controls will be introduced when engineering controls are not adequate or are not feasible. One of the most effective methods to controlling cold stress is controlling the exposure to cold environments. Examples of administrative controls are presented below:

- Schedule jobs for the warmest part of the day
- Schedule maintenance and repair jobs in cold areas for warmer months
- Postpone outdoor tasks that are not urgent
- Increase the number of workers in each team to reduce each worker's individual cold exposure
- Encourage Stop Work Authority when a worker exhibits signs or symptoms of cold stress
- Reduce the physical demands of workers
- Provide warm sweetened liquids to employees and remind employees to drink water in small amounts frequently to prevent dehydration
- Increase cold tolerance by implementing a cold acclimation plan
- Exercise additional caution on the first day of a shift change or after a weekend, even for acclimated employees, because some level of acclimation may be lost during several days outside of work
- Provide warm areas for use during break periods and increase rest allowances
- Restrict overtime work in cold stress conditions
- Minimize the presence of workers in isolated locations
- Initiate a buddy system when cold stress is identified to be a job hazard. Buddies should be responsible for observing their co-worker for signs and symptoms of cold stress and be trained to provide first aid and preventative measures
- Train supervisors and their employees to recognize early signs and symptoms of cold stress

6.8.3.1 Acclimation and rest breaks

- Acclimation and planning for rest breaks are important parts of preparing for work in cold environments. Appendix C includes a Work/Warm-up Schedule developed by ACGIH, a US organization. Similar guidance for cold stress acclimation and rest breaks may be available in other countries or regions.

6.8.4 Personal protective equipment

Dressing properly is extremely important to preventing cold stress. The type of fabric worn also makes a difference. Cotton loses its insulation value when it becomes wet. Wool, silk and most synthetics, on the other hand, retain their insulation properties even when wet. The following are recommendations for working in cold environments:

- Wear at least three layers of loose-fitting clothing. Layering provides better insulation. Do not wear tight fitting clothing.
    - An inner layer of wool, silk or synthetic to keep moisture away from the body
    - A middle layer of wool or synthetic to provide insulation even when wet

  - An outer shell for wind and rain protection, made of a material that allows some breathability or ventilation to prevent accumulation of moisture from perspiration

- Wear a hat or hood or use an insulated hard hat liner. Do not wear a hard hat over a standard hat or insulated hood unless permitted by the manufacturer, as this can interfere with the fit and protection provided by the hard hat.

- Use a knit mask or balaclava to cover the face and mouth (if needed)

- Use insulated gloves to protect the hands (water resistant if necessary). Make sure that gloves used will offer an appropriate level of chemical protection, as required for chemical hazards

- Wear insulated and waterproof boots. Boots should have a safety toe where required. A composite safety toe may be preferred to steel, as steel may conduct heat away from a wearer's foot

7. TRAINING AND COMPETENCY

Ramboll's HSS training program includes new employee induction training, supervised on-the-job training and annual completion of online modules or classroom instruction related to safety requirements and work practices. Training assignments vary based on employee roles and training classification. Completion of assigned training will be documented by a training completion certificate, which will be stored in the employee's electronic training record.

7.1 Heat/cold stress training

Prior to job assignment, Ramboll shall provide training to educate employees who may be exposed to heat/cold stress risks about the hazards and verify that employees have the knowledge and skills required for the application and usage of safe work practices that may be required for specific projects or tasks.

- The degree of training provided shall be defined by the complexity of the job assignment and the associated heat or cold stress hazards

7.2 Refresher training

Scheduled refresher training will be conducted on an annual basis. Retraining shall be provided for authorized and affected employees whenever there is a change in their job assignments, a change in equipment or processes that present a new heat/cold stress hazard, or when their work takes them into other areas where cold/heat injuries could occur.

- Additional retraining shall also be conducted whenever a periodic inspection reveals or whenever Ramboll has reason to believe that there are deviations from or inadequacies in the employee's knowledge of known hazards or in use of equipment or work practices.

- The retraining shall re-establish employee proficiency with equipment, control methods and safe work practices, as necessary.

8. DOCUMENTATION

The following documentation is required, specific to heat and cold stress.

8.1 Monitoring data

Temperature readings and other relevant meteorological, environmental or personal health monitoring data, and descriptions of work cycles and breaks shall be documented in the project field logbook to maintain an accurate record of project conditions and exposure to heat and cold stresses.

9. INTERNATIONAL TILTS

9.1 Asia/Pacific

9.2 Brazil

9.3 Canada

9.4 European Union (EU)

The European Union and its EU-OSHA do not outline specific heat safety laws. However, several countries in the EU have their own rules and guidelines.

For example, in Germany, a workplace is normally 26°C maximum, but if the outside temperature is higher, it may be allowed to be higher, although an upper limit isn't clearly defined. France doesn't have a maximum temperature limit either, but employers must ensure their employees are safe and provide fresh drinking water. In Spain, the temperature should be between 17 and 27°C where sedentary work is taking place and between 14 and 25°C for light physical work. In Italy, the legislation states that the microclimate is a physical risk agent and that consequently a risk assessment must be carried out.

The main ISO standards that intervene in the thermal stress assessment process are:

- **ISO 16595** Working practices in hot environments
- **ISO 15743** Cold workplaces - Risk assessment and management
- **ISO 13732-1** Methods for the assessment of human responses to contact with surfaces, Part 1: Hot surfaces
- **ISO 7243** Assessment of heat stress using the WBGT (wet bulb globe temperature) index
- **ISO 7933** Analytical determination and interpretation of heat stress using calculation of the predicted heat strain
- **ISO 11079** Determination and interpretation of cold stress when using required clothing insulation (IREQ) and local cooling effects
- **ISO 9886** Evaluation of thermal strain by physiological measurements
- **ISO 9920** Estimation of thermal insulation and water vapour resistance of a clothing ensemble
- **ISO 8996** Determination of metabolic rate

9.5 Mexico

9.6 United Kingdom (UK)

9.7 United States

9.7.1 Employer responsibilities (OSHA Standard: General Duty Clause)

Under the General Duty Clause, Section 5(a)(1) of the Occupational Safety and Health Act of 1970, employers are required to provide employees with a place of employment that "is free from recognized hazards that are causing or likely to cause death or serious harm to employees."

The courts have interpreted OSHA's general duty clause to mean that an employer has a legal obligation to provide a workplace free of conditions or activities that either the employer or industry recognizes as hazardous and that cause, or are likely to cause, death or serious physical harm to employees when there is a feasible method to abate the hazard. This includes heat/cold-related hazards that are likely to cause death or serious bodily harm.

9.7.2 NIOSH recommended standards

The National Institute for Occupational Safety and Health (NIOSH) has published criteria for a recommended standard for occupational heat and cold stress (links: NIOSH Heat Stress; NIOSH Cold Stress). The NIOSH documents include recommendations for employers about how to prevent heat- and cold-related illnesses.

9.7.3 Criteria for a recommended standard – occupational exposure to heat and hot environments

U.S. Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH) Publication No. 2016-106, (February 2016).

9.7.4 Heat standards in specific states

Many U.S. states run their own OSHA-approved State Plans. Some states have adopted standards that cover hazards not addressed by federal OSHA standards. The following states have standards for heat exposure:

- California: California’s Heat Illness Prevention Standard requires employers to provide training, water, shade and planning. A temperature of 80°F triggers the requirements. See CalOSHA's website
- Minnesota: The standard applies to indoor places of employment
- Washington: See Washington State’s Outdoor Heat Exposure Rule

10. ADDITIONAL INFORMATION

11. REVISION SUMMARY

APPENDIX A

HEAT STRESS PLANNING WORKSHEET

HEAT STRESS PLANNING WORKSHEET

Brief Project Description	**Location**
Date(s) of work	**Working Hours**

1. Investigate weather conditions

Use local weather center data from Weather.com or other reputable source to estimate Wet Bulb Globe Thermometer (WBGT) temperature range for the project.

See calculator developed by the Argonne National Laboratory: http://www.osha.gov/dts/osta/otm/otm_iii/wbgtutil.zip	***Estimated WBGT Range***

2. Calculate Effective Wet Bulb Globe Temperature ($WGBT_{eff}$)

Find the applicable Clothing Adjustment Factor (CAF) from the Reference Information provided. Add that number to the Estimated WBGT Range.

Is Personal Protective Equipment (PPE) beyond a single layer of breathable clothing required to protect against Chemical or Physical hazards? **Yes No**	***WGBT + CAF = $WGBT_{eff}$***

3. Estimate Metabolic Rate by Work Task

Group work tasks together considering the physical effort required to perform and assign an estimated metabolic rate in Watts based on the reference information provided.

Work Tasks: 1. 2. 3.	Metabolic Rate: 1. 2. 3.

4. Acclimation

Full heat acclimation occurs with relatively brief daily exposure to working in the heat over the course of a few days provides reduced risk to heat stress.

Are workers travelling from to an area that presents different environmental heat factors than their home location, such as temperature and humidity? **Yes No**

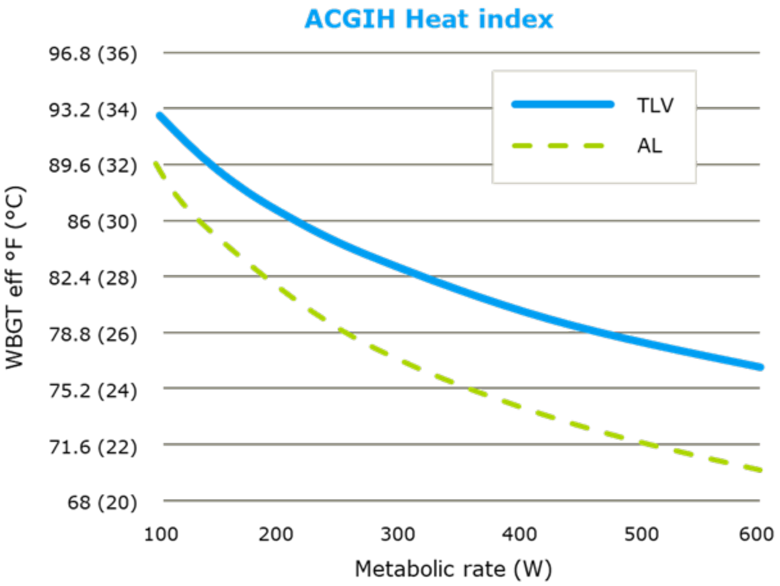
If Yes, Non-acclimated workers must be considered separately from those acclimated to the local environment.

5. Assess Heat Stress Levels by Work Task

Compare the calculated Metabolic Rate for each Work Task to the $WBGT_{eff}$ using a Heat Index such as the ACGIH Heat Index below.

Drag a representative 'dot' to the graph to represent each work task.

● ● ●



The TLV is the temperature at which there is a heat hazard present for an acclimated worker, and the AL is the temperature at which there is a heat hazard present for a non-acclimated worker.

Do any work tasks exceed applicable AL or TLV limitations for Heat Stress?

Yes No

If limits are reached, controls are necessary to prevent heat-related illness.

HEAT STRESS Planning

Hierarchy of Controls *Consider the baseline AL and TLVs calculated and determine additional controls required to mitigate risk for heat stress.*

Elimination/Substitution (eliminate the need to work during high risk heat stress season, or substitute a task with lower risk level)

Yes	☐	Description:
No	☐	

Engineering Controls (increase air movement e.g., fans, air conditioning, swamp coolers; reflective shields; insulating hot surfaces; providing shade)

Yes	☐	Description:
No	☐	

Administrative Controls (acclimate workers; reacclimate workers after absence; schedule work early or late; use work/rest schedule; limit strenuous work)

Yes	☐	Description:
No	☐	

Heat-Related Personal Protective Equipment *(water- or air-cooled garments; cooling vests; sun hats; light colored clothing; sunscreen)*

Yes	☐	Describe:
No	☐	

Acclimation Plan *Describe the plan to mitigate physical hazards from heat and humidity by gradually introducing employees to the hazard. Depending on the project location and the location of staffing, the acclimation plan may need to be customized on an employee-specific basis.*

NOTE: See the end of this worksheet for additional reference information.

Work/Rest Cycle Plan *Describe the Work/Rest Cycle Plan. The work/rest cycle should take into account, at a minimum, the chemical/physical-required PPE, the heat hazard-required PPE, the task-specific workloads, hydration and the acclimation plan. The plan may need to be customized on an employee-specific basis.*

NOTE: See the end of this worksheet for additional reference information.

Checklist for Operations in High Heat Stress Risk Projects	Yes	No
People		
Have the hazards involved in this task been adequately addressed in a health and safety plan or other document with documented approval by project leadership and HSS?	☐	☐
Are you (and others) appropriately trained, medically fit and competent to carry out this task?	☐	☐
Are you (and others) aware of the signs and symptoms of heat-stress related illnesses?	☐	☐
Do I know what to do in an emergency?	☐	☐
System		
Are there any other steps that are needed to further minimize the risk?	☐	☐
Do you know the scope of work and how to do it?	☐	☐
Do you have the right tools, equipment and PPE?	☐	☐
Is there a reliable means of communication to emergency responders?	☐	☐
Are other required control measures in place?	☐	☐
If any "No" answers, or if answers are unknown or more information is needed, use your STOP WORK AUTHORITY		

HEAT STRESS PLANNING REFERENCE INFORMATION

Workload Metabolic Rates

(OSHA, undated, https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html#illness_prevention)

Work Category	Workload Metabolic Rate (Watts)	Representative Activities
Rest	115	Sitting, limited arm movement
Light	180	Sitting or standing to control machines; perform light hand or arm work; occasional walking; driving
Moderate	300	Walking about with moderate lifting and pushing or pulling; walking at moderate pace
Heavy	415	Heavy material handling; walking at a fast pace
Very Heavy	520	Very intense activity at a fast to maximum pace

Clothing Adjustment Factors (CAF)

(OSHA, undated, https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html#illness_prevention)

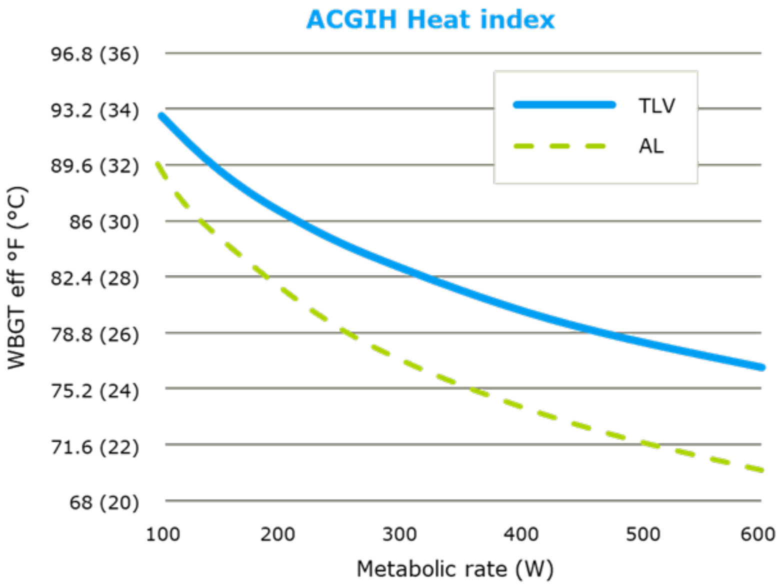
Clothing Worn	CAF
Cotton or Light Polyester Work clothes (e.g., long sleeves and pants)	0
Cotton or Light Polyester Coveralls (e.g., w/only undergarments underneath	0
Double-layer woven clothing	3
SMS Polypropylene Coveralls	0.5
Polyolefin coveralls (e.g., microporous fabric such as Tyvek™)	1
Limited-use vapor-barrier coveralls (e.g., encapsulating suits, whole body chemical protective suits, firefighter gear)	11

ACGIH Action Limit and Threshold Limit Curve

(OSHA, undated, https://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html#illness_prevention)

The TLV is the temperature at which there is a heat hazard present for an acclimated worker, and the AL is the temperature at which there is a heat hazard present for a non-acclimated worker. Once these limits are reached, either through environmental factors or workload, controls are necessary to prevent heat-related illness. Controls include work/rest regimens, shade and hydration.

See also **Work /Rest Cycle and Acclimation Information**.



Acclimation Guidance

(NIOSH, 6-June-2018, https://www.cdc.gov/niosh/topics/heatstress/acclima.html)

Acclimation is the beneficial physiological adaptations that occur during repeated exposure to a hot environment. These physiological adaptations include:

- Increased sweating efficiency (earlier onset of sweating, greater sweat production and reduced electrolyte loss in sweat).
- Stabilization of the circulation.
- The ability to perform work with lower core temperature and heart rate.
- Increased skin blood flow at a given core temperature.

To acclimate workers, gradually increase their exposure time in hot environmental conditions over a 7-14-day period. New workers will need more time to acclimate than workers who have already had some exposure.

Acclimation schedule

For new workers, the schedule should be no more than a 20% exposure on day 1 and an increase of no more than 20% on each additional day.

For workers who have had previous experience with the job, the acclimation regimen should be no more than a 50% exposure on day 1, 60% on day 2, 80% on day 3 and 100% on day 4.

In addition, the level of acclimation each worker reaches is relative to the initial level of physical fitness and the total heat stress experienced by the individual.

Maintaining acclimation

Workers can maintain their acclimation even if they are away from the job for a few days, such as when they go home for the weekend. However, if they are absent for a week or more, then there may be a significant loss in the beneficial adaptations leading to an increased likelihood of heat-related illness and a need to gradually reacclimate to the hot environment.

Some additional information on maintaining acclimation:

- It can often be regained in 2 to 3 days upon returning to a hot job.
- It appears to be better maintained by those who are physically fit.
- Seasonal shifts in temperatures may result in difficulties.
- Working in hot, humid environments provides adaptive benefits, which also apply in hot, desert environments, and vice versa.
- Air conditioning does not typically affect acclimation to outdoor conditions.

Work / Rest Cycle and Acclimation Information

ACGIH screening criteria for heat stress exposure in degrees Celsius for an 8-hour workday 5 days per week with conventional breaks will be used in determining safe exposure for acclimated and unacclimated employees.

Allocation of Work in a Work/Rest Cycle	**Acclimated**				**Action Limit (Unacclimated)**			
	Light	**Moderate**	**Heavy**	**Very Heavy**	**Light**	**Moderate**	**Heavy**	**Very Heavy**
75-100%	31.0 (87.8F)	28.0 (82.4F)	--	--	28.0 (82.4F)	25.0 (77F)	--	--
50-75%	31.0 (87.8F)	29.0 (84.2F)	27.5 (81.5)	--	28.5 (83.3F)	26.0 (78.8F)	24.0 (75.2F)	--
25-50%	32.0 (89.6F)	30.0 (86F)	29.0 (84.2F)	28.0 (82.4F)	29.5 (85.1F)	27.0 (80.6F)	25.5 (77.9)	24.5 (76.1F)
0-25%	32.5 (90.5F)	31.5 (88.7F)	30.5 (86.9F)	30.0 (86F)	30.0 (86F)	29.0 (84.2F)	28.0 (82.4F)	27.0 (80.6F)

APPENDIX B

URINE COLOR CHART

Dehydration Color Chart

(color represents urine appearance)

●	Doing ok. You’re probably well hydrated. Continue to drink water periodically.
●	You’re just fine. You could stand to drink a little water now, maybe a small glass of water.
●	Drink about 1/2 bottle of water (1/4 liter) within the hour or drink a whole bottle (1/2 liter) of water if you’re outside and/or perspiring.
●	Drink about 1/2 bottle of water (1/4 liter) right now or drink a whole bottle (1/2 liter) of water if you’re outside and/or perspiring.
●	Drink 2 bottles of water right now (1 liter). If your urine is darker than this or appears red or brown, then you need medical attention.

APPENDIX C

ADDITIONAL COLD STRESS GUIDEANCE

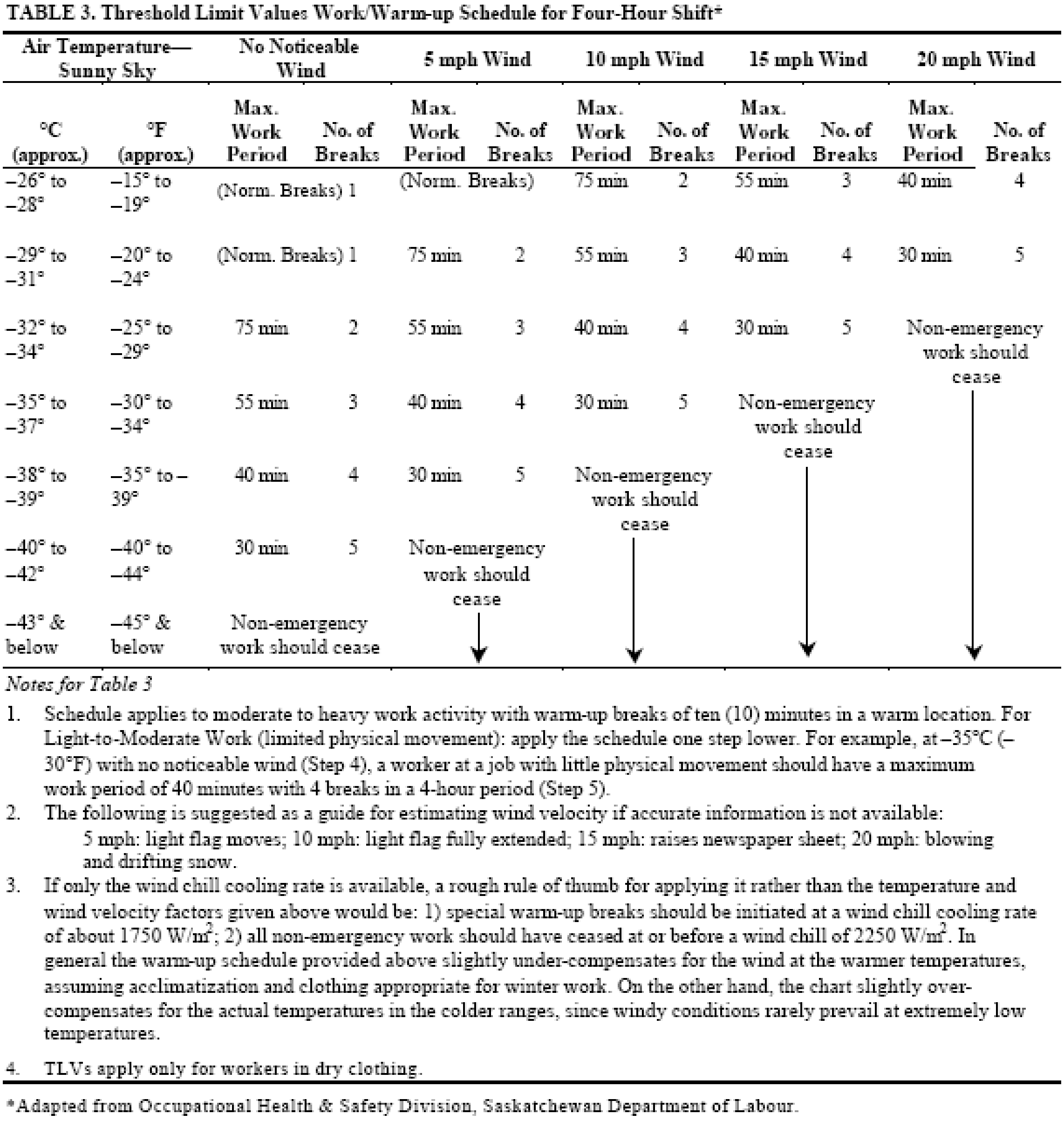


TABLE 3. Threshold Limit Values Work/Warm-up Schedule for Four-Hour Shift*

Air Temperature—Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (approx.)	°F (approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
–26° to –28°	–15° to –19°	(Norm. Breaks)	1	(Norm. Breaks)		75 min	2	55 min	3	40 min	4
–29° to –31°	–20° to –24°	(Norm. Breaks)	1	75 min	2	55 min	3	40 min	4	30 min	5
–32° to –34°	–25° to –29°	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
–35° to –37°	–30° to –34°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease		↓	
–38° to –39°	–35° to –39°	40 min	4	30 min	5	Non-emergency work should cease		↓		↓	
–40° to –42°	–40° to –44°	30 min	5	Non-emergency work should cease		↓		↓		↓	
–43° & below	–45° & below	Non-emergency work should cease		↓		↓		↓		↓	

Notes for Table 3

1. Schedule applies to moderate to heavy work activity with warm-up breaks of ten (10) minutes in a warm location. For Light-to-Moderate Work (limited physical movement): apply the schedule one step lower. For example, at –35°C (–30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5).
2. The following is suggested as a guide for estimating wind velocity if accurate information is not available:
   5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind chill cooling rate of about 1750 W/m^2; 2) all non-emergency work should have ceased at or before a wind chill of 2250 W/m^2. In general the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.
4. TLVs apply only for workers in dry clothing.

*Adapted from Occupational Health & Safety Division, Saskatchewan Department of Labour.

ATTACHMENT 10
FLAMMABLE COMBUSTIBLE MATERIALS GUIDANCE

PREPARED BY

Americas Health, Safety and Security | E&H Health, Safety and Security

APPROVED BY

Maureen Warren | Mark Watka

DATE

February 2022

VERSION

1.0

SAFE WORK PRACTICE

FLAMMABLE & COMBUSTIBLE LIQUIDS

RAMBOLL

CONTENTS

1. PURPOSE

The purpose of this Safe Work Practice (SWP) is to define Ramboll practices for safe storage and handling of flammable and combustible liquids to mitigate the risk of fire, explosions and injury. Improper storage and handling of flammable chemicals and failure to recognise and control ignition sources, have accounted for many accidents involving flammable liquid use and storage.

This SWP also facilitates compliance with applicable governmental health and safety standards and requirements, which may vary depending on the country or region.

2. SCOPE

This SWP applies to work at offices, Ramboll-owned industrial facilities, client facilities and project sites where flammable and combustible liquids are stored and used. This SWP includes discussion of flammable and combustible liquids as related to fire extinguishers and other fire prevention protection topics but does not completely address all related work practices and associated requirements. For additional information, please refer to the SWP, Fire Prevention and Protection. For requirements specific to spray coating activities, please refer to the SWP, Spray Coating and Paint Booths.

Ramboll has generally adopted the National Fire Protection Association (NFPA) codes and standards (which are based on US requirements) for this SWP. Refer to Section 9 for additional information on country- or region-specific regulations, where available. In the event of a conflict between this SWP and locally applicable regulatory requirements (or project-specific requirements), the more stringent set of requirements will be followed.

3. OVERVIEW

This SWP provides roles and responsibilities, key definitions, work practices, training and documentation requirements for work involving flammable and combustible liquids. Includes the following work practice topic areas:

- **Storage requirements** – Containers and portable tanks, indoor general requirements, flammable liquid storage cabinets, indoor storage rooms and outdoor storage.
- **Dispensing of flammable and combustible liquids** – Container requirements; separation from other operations; ignition sources; containment measures; ventilation; bonding and grounding; electrical equipment; pump, valve and nozzle requirements; protection from collision; fire extinguishers; and signage.
- **Fuel dispensing from temporary storage tanks** – Addresses tank size, positioning, markings and dispensing equipment requirements.
- **Mobile re-fuelling services** – Use of mobile refuelling tankers, trucks and trailers, dispensing of Class I or Class II liquids, spill prevention and clean-up practices and equipment.
- **Transporting fuel in vehicles** – Allowable quantities, securing of containers, fire extinguisher availability and related considerations.
- **Liquified petroleum gas (LPG) storage** – Refer to the SWPs, Material Storage and Handling and Process Safety.

4. RESPONSIBILITIES

4.1 Project Manager (PM)/Project Owner (PO)

- Request flammable and combustible liquids information from the facility owner and consider the adequacy of the information provided. This information should be included in the project safety plan, as applicable.
- Identify work activities with a potential for storage or handling of flammable or combustible liquids.
- Provide appropriate resources, including people, budget and schedule to comply with requirements outlined in this SWP.
- Support employee use of stop work authority related to flammable and combustible liquids or any other perceived hazard. Work is to be stopped until the identified hazards are evaluated and controlled to a level that is as low as reasonably achievable with input from the client, project team and the HSS department and in accordance with safe work practices. Refer to the HSSP, Stop Work Authority.
- Discuss stop work situations with the Site Safety Representative (SSR) Health, Safety and Security Coordinator (HSSC), Subject Matter Expert (SME) or a representative of the HSS department, including reporting of incidents and safety observations in accordance with the HSS Process (HSSP), Event Reporting and Investigation.

4.2 Site Safety Representative (SSR)

- Be present at the site to oversee the project or appoint another on-site employee as a backup SSR (with approval from the PM).
- Ensure the project safety plan containing flammable and combustible liquids information is reviewed with project team members and subcontractors as part of project safety orientation and toolbox safety meetings.
- Communicate project safety requirements to all employees and subcontractors and document all safety meetings, unsafe acts or conditions and corrective actions.
- Inform PM/PO of important developments or questions regarding project and task safety.
- Assist with reporting of incidents and safety observations in accordance with the HSSP, Event Reporting and Investigation.

4.3 Health, Safety and Security (HSS) department

- Support project safety plan development (when requested by the PM) including flammable and combustible liquids hazard information and appropriate safety controls based on this SWP and site-specific concerns.
- Evaluate site conditions related to flammable and combustible liquids through field safety audits and inspections when requested by the client, the PO or other management, or when required by local regulations.

- Provide technical support, consultation and training materials that are consistent with this SWP, when requested or applicable.
- Review and update this SWP on a biennial basis or more frequently if required.

4.4 Health, Safety and Security Coordinator (HSSC)

- Promote awareness, understanding and use of this SWP by project team members.
- Facilitate application of this SWP in the context of local regulatory requirements and integration of this SWP into project safety plans.
- Inform the HSS department if this SWP does not adequately address local regulatory requirements.

4.5 Employees, subcontractors and visitors

- Review, understand and comply with project safety plans.
- Do not undertake any activities involving flammable and combustible liquids unless properly trained and authorised, with all required safety controls in place.
- Follow all flammable and combustible liquids safety practices defined in this SWP and other practices as defined by the site owner or occupant or as required by local regulations. In the event of a conflict, the more stringent requirements will be followed.
- Report safety events, issues or concerns (e.g., incidents, injuries, illnesses, near miss, observations of safe or unsafe acts or conditions, etc.) to the PM, SSR or other supervisor and in accordance with the HSSP, Event Reporting and Investigation.
- Exercise stop work authority if any task is perceived to be unsafe or if more information is needed to proceed safely. Refer to the HSSP, Stop Work Authority.

5. KEY DEFINITIONS

Boiling point – The boiling point of a liquid at a pressure of 14.7 pounds per square inch absolute (psia)/760 millimetres of mercury (mm Hg).

Container – Any can, barrel or drum used to contain or transport flammable or combustible liquids.

Drum or barrel – A cylindrical container that holds more than 5 gallons but no more than 60 gallons.

Intermediate bulk container (IBC) – Any container ≤793 gallons/3,000 litres (L). Portable tanks are a type of IBC. United Nations (UN) and other regulations permit the shipping of combustible liquids and some flammable liquids in many types of IBCs. NFPA 30 rules limit the types of IBCs allowed in buildings and also sets limits on permissible liquid types:

- Class I liquids may only be stored in NFPA-approved metal IBCs.
- Class II and III liquids may be stored in NFPA-approved composite or metal IBCs.

NOTE - Many IBCs approved for transportation are NOT approved for storage.

Fire area – Area of a building separated from the remainder of the building by construction having a fire resistance of at least one hour and having all communicating openings properly protected by an assembly having a fire resistance rating of at least one hour.

Flammable liquids – The following table contains the Global Harmonisation System (GHS) classification definitions. The GHS definitions do not include references to "combustibles." See Section 9.7.1 for a table comparing GHS and NFPA flammable liquid categories.

Categories based on Global Harmonisation System

Category 1	Flash point <73°F/23°C and initial boiling point ≤95°F/35°C
Category 2	Flash point <73°F/23°C and initial boiling point >95°F/35°C
Category 3	Flash point ≥73°F/23°C and ≤140°F/60°C Note: When a Category 3 liquid with a flash point at or above 100°F/37.8°C is heated for use to within 30°F/16.7°C of its flash point, it shall be handled in accordance with the requirements for a Category 3 liquid with a flash point below 100°F/37.8°C
Category 4	Flash point ≥140°F/60°C and ≤200°F/93°C Note: When a Category 4 flammable liquid is heated for use to within 30°F/16.7°C of its flash point, it shall be handled in accordance with the requirements for a Category 3 liquid with a flash point at or above 100°F/37.8°C

Flash point – The minimum temperature at which a liquid gives off vapour within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the liquid. The flash point is normally an indication of susceptibility to ignition.

GHS – The GHS is an acronym for *The Globally Harmonised System of Classification and Labelling of Chemicals*. The GHS is a system for standardising and harmonising the classification and labelling of chemicals. Additional information is provided in the SWP, Communication of Chemical Hazards.

Portable tank – A closed container having a liquid capacity over 60 gallons/227 L to a maximum of 660 gallons/2,498 L and not intended for fixed installation.

Safety can – An approved container of not more than 5 gallon/19 L capacity, having a spring-closing lid and spout cover and designed to safely relieve internal pressure when subjected to fire exposure.

Storage Tank – A temporary or permanent tank with a capacity >793 gallons/3,000 L.

6. WORK PRACTICES

Ramboll employees may work at facilities where flammable and combustible liquids are used and stored, and improper work practices could result in harm or injury. Additionally, employees and subcontractors may perform tasks or create a work environment where flammable and combustible liquids are used and stored. Project teams are expected to be familiar with the content of this SWP, locally applicable regulatory requirements and any project-specific requirements. In the event of conflicting requirements for work practices, the more stringent set of requirements will be followed. These requirements must be outlined in the project safety plan.

6.1 Storage – containers and portable tanks

This section applies only to the storage of flammable or combustible liquids in drums or other containers (including flammable aerosols) not exceeding 60 gallons/227 L individual capacity and portable tanks of less than 660 gallon/2,498 L individual capacity. A portable tank is a closed container which has a liquid capacity of over 60 gallons/227 L and is not intended for fixed installations. This section does not apply to the following:

- Storage of containers in bulk plants, service stations, refineries, chemical plants and distilleries
- Flammable liquids in the fuel tanks of a motor vehicle, aircraft, boat or portable or stationary engine
- Flammable paints, oils, varnishes and similar mixtures used for painting or maintenance when not kept for more than 30 days

Only containers and portable tanks that are approved by the local regulatory authority may be used to store flammable and combustible liquids.

Top-mounted emergency vents on containers and portable tanks must be capable of limiting internal pressure under fire exposure conditions to 10 pounds per square inch gauge (psig)/10 kilopascal or 30% of the bursting pressure of the tank, whichever is greater. Portable tanks are also required to have at least one pressure-activated vent with a minimum capacity of 6,000 ft^3/170 m^3 of free air at 14.7 psia/101 kilopascal and 60°F/15.6°C. These vents must be set to open at not less than 5 psig/34.5 kilopascal. If fusible vents are used, they shall be actuated by elements that operate at a temperature not exceeding 300°F/149°C.

6.2 Storage – indoor general requirements

Flammable liquids have strict storage requirements when stored inside buildings.

- Flammable and combustible liquids will be stored in their original containers. If the container labels are damaged or missing, the SSR will replace the label with a new one that is compliant with the SWP, Communication of Chemical Hazards. Safety data sheets (SDS) will also be retained in the work area and/or employees will be instructed how to search for SDS using the Chemical Information health and safety page on Rambla.
- Flammable or combustible liquids shall not be stored in areas used for exits, stairways or other passageways that are normally used for pedestrian traffic.

- Flammable or combustible liquids must not be stored in single containers (or enclosed piping systems) that exceed limits outlined in Section 6.1.
- Small gas cylinders [e.g., 3 inch x 10 inch/7.6 centimetres (cm) x 25.4 cm or similar size] containing propane, MAPP gas (UN 1060 stabilised methylacetylene-propadiene) or liquefied petroleum gas (LPG) may not be stored inside flammable liquid storage cabinets or indoor flammable liquid storage rooms.
- Small amounts of flammable liquids at Ramboll industrial facilities which are incident to the primary business may be handled and stored outside of flammable liquid storage cabinets or indoor storage rooms. The amounts of incidental flammable materials are limited as an NFPA Maximum Allowable Quantity (MAQ), as follows:
    - Category 1 Flammable Liquid – 25 gallons/95 L
    - Category 2, 3 or 4 Flammable Liquids (e.g., toluene and gasoline) – 120 gallons/454 L
    - Category 2, 3 or 4 Flammable Liquids – 660 gallons/2,498 L when in a single portable storage tank

NOTE – The above indoor storage limits apply only to industrial operations. Construction activities are limited to 25 gallons/95 litres of flammable liquids kept outside a flammable liquids' storage cabinet. Also note that the above limits do not apply to any material with a flashpoint >200°F/93.3°C because it is not considered a Category 1-4 flammable liquid.

- Quantities of flammable and combustible liquids in excess of the above limits shall be stored in an acceptable or approved cabinet labelled in conspicuous lettering, "FLAMMABLE – KEEP FIRE AWAY". Quantities within storage cabinets and the number of cabinets per fire area will not exceed limits outlined in Section 6.3.
- Quantities in excess of the MAQ shall be stored inside a specifically designed storage room as outlined in Section 6.4.
- Materials which will react with water and create a fire hazard will not be stored in the same room with flammable and combustible liquids.
- Secondary containment(s) must be able to contain the largest container plus 20 minutes of water input from the facility fire extinguishing system.
- Buildings or portions thereof, used for any of the following must be provided with secondary containment to prevent the flow of liquids to adjoining areas:
    - Storage of liquids (including corrosive, flammable, toxic and combustible) where the capacity of an individual vessel exceeds 55 gallons/208 L, or the aggregate capacity of multiple vessels exceeds 1,000 gallons/3,785 L.
    - Storage of solids where the capacity of an individual vessel exceeds 550 pounds/248 kilograms (kg), or the aggregate capacity of multiple vessels exceeds 10,000 pounds/4,524 kg.

6.3 Storage – flammable liquid storage cabinets

Another fundamental means of fire protection is the use of flammable storage cabinets. Flammable storage cabinets must be constructed in the following manner:

- Bottom, top and sides of cabinet shall be at least No. 18 gauge sheet steel.
- Cabinet must be doubled walled with 1 inch/2.5 cm airspace.
- Joints shall be riveted, welded or made tight by some equally effective means.
- Door shall have a three-point latch.
- Door sill shall be raised at least 2 inches/5 cm above the cabinet bottom to retain spilled liquid within the cabinet.
- Cabinets must be equipped with self-closing doors.
- Cabinet vents must be plugged unless provided mechanical ventilation to outdoor air through a system suitable for conveyance of flammable vapours, or unless the cabinet is located outdoors.
- Cabinets must be grounded.
- Cabinet shall have a "FLAMMABLE—KEEP FIRE AWAY" label, which will be conspicuously displayed.
- Maximum storage within cabinets – The amount of liquid storage in cabinets and location of cabinets, are regulated. No more than 60 gallons/227 L of Category 1, 2 or 3 liquids, nor more than 120 gallons/454 L of Category 4 liquids may be stored in a storage cabinet.
- Maximum storage within a Fire Area – According to NFPA 304.3.2, not more than three cabinets may be located in a single fire area. NFPA allows an exception for industrial occupancies where groups of cabinets in the same fire area may present if separated by 100 feet/30.5 meters (m).
- Fire protection – Place at least one fire extinguisher with the appropriate rating at least 10 ft/3 m but no more than 30 feet/9 m away from the flammable liquid storage cabinet. Refer to Section 9 for additional country- or region-specific fire extinguisher information.

6.4 Storage – indoor storage room

There are two primary types of dedicated indoor storage areas for flammable and combustible liquids: liquid storage rooms and liquid warehouses. Liquid warehouse requirements are not applicable to Ramboll operations and are not covered in this SWP. Indoor storage rooms will meet the following:

- Electrical wiring and equipment located inside storage rooms shall be approved for Class I, Division 1, Hazardous Locations.
- Every storage room shall be provided with either a gravity or a mechanical exhausting system. Such a system shall commence not more than 12 inches/30.5 cm above the floor and be designed to provide for a completed change of air within the room at least 6 times per hour. Any mechanical exhausting and lighting fixtures shall be controlled by the same switch located outside the door.
- At least one aisle or access way of at least 3 feet/1 m width shall be maintained within every storage room.
- Containers over 30 gallons/114 L capacity shall not be stacked upon each other.

- Fire protection – At least one portable fire extinguisher with the appropriate rating must be located outside of, but not more than 10 feet/3 m from, the door opening into any room used for storage of more than 60 gallons/227 L of flammable and combustible liquids. Refer to Section 9 for additional country- or region-specific fire extinguisher information.
- Quantity limits – The maximum quantity of flammable liquids stored inside rooms will depend on the fire resistance of the room's design and the presence (or absence) of fire protection.

6.5 Storage - outdoors

- Flammable or combustible liquids shall not be stored in areas used for exits, stairways or passageways normally used for pedestrian traffic.
- A group (or pile) of storage containers (not more than 60 gallons/227 L each) that are stored together shall not exceed a combined total of 1,100 gallons/4,164 L.
- Each group (or pile) of containers shall be separated by a clearance distance of 5 feet/1.5 m.
- Each group (or pile) of containers shall not be closer than 20 feet/6.1 m to a building or to other combustible materials.

NOTE – Safety cans of flammable and combustible liquids may not be stored beneath office trailers or other elevated structures not designed for this purpose.

- The storage area shall be graded in a manner to contain spills or shall be surrounded by a curb or earth dike at least 12 inches/30.5 cm in height (6 inches/15 cm for industrial facilities) and lined with 50 millilitre (mil) plastic sheeting or suitable alternate liner. Permanent containment areas may use concrete or other impervious containment material.
    - The total volume must equal 110% of the largest tank volume or 10% of the combined total volume within the diked area, whichever is greater.
    - If the diked area is uncovered and subject to rainfall, then it should be able to contain a 24 hour rainfall from a 25 year storm in addition to the above volume.
- Tanks with integral secondary containment do not also require a diked area for secondary containment.
- Portable tanks and IBCs shall not be nearer than 20 feet/6.1 m from any building, whether the building is temporary or permanent.
- Two or more portable tanks or IBCs, grouped together, having a combined capacity in excess of 2,200 gallons/8,328 L, shall be separated by a clearance distance of 5 feet/1.5 m.
- Individual portable tanks and IBCs exceeding 1,100 gallons/4,164 L shall be separated by a clearance distance of 5 feet/1.5 m.
- Within 200 feet/61 m of each portable tank, there shall be access provided with a clearance distance of 12 feet/3.7 m, to allow for access by emergency vehicles.

- Storage areas shall be kept clear of weeds, debris and other combustible material not necessary to the storage.
- Portable tanks shall be provided with the appropriate emergency venting devices.
- Fire protection – At least one portable fire extinguisher having a rating of greater than 20-B units shall be located between 25 and 75 feet/7.6 and 22.9 m from the storage area. Refer to Section 9 for additional country- or region-specific fire extinguisher information.

6.6 Dispensing

- Flammable liquids shall be kept in closed containers when not in use (i.e., when not actively dispensing).
- Areas where flammable or combustible liquids are transferred at one time, in quantities greater than five gallons, from one tank to another tank or container, shall be separated from other operations by 25 feet/7.6 m or with partition constructed of materials with a fire resistance of at least one hour.
- Open flames, smoking and other sources of ignition are prohibited within at least 50 feet/15 m where Category 1 flammable liquids are dispensed or used. Approved “No Smoking” signs shall be posted in such areas.

NOTE – Gasoline and toluene are Category 2 flammables.

- Drainage into secondary containment or other means of containment, shall be provided to control spills.
- Adequate natural or mechanical ventilation shall be provided to maintain the concentration of flammable vapour at or below 10% of the lower flammability limit (LFL).
- Transfer of flammable liquids from one container to another shall be done only when containers are electrically interconnected (bonded) and grounded
- Wiring and electrical equipment in areas where flammable liquids are installed must be electrically rated as appropriate for the Class of flammable liquids dispensed.
- Flammable or combustible liquids shall be drawn from or transferred into vessels, containers or tanks within a building or outside through a closed piping system, from safety cans, by means of a device drawing through the top or from a container or portable tanks, by gravity or pump, through an approved self-closing valve.

NOTE: Transferring by utilising the effects of air pressure on a container or portable tank is prohibited.

- Dispensing units shall be protected against collision damage.

- Dispensing devices and nozzles for flammable liquids shall be of an approved type.
- At least one fire extinguisher with appropriate rating shall be located in the immediate dispensing area. Refer to Section 9 for additional country- or region-specific fire extinguisher information.
- "NO SMOKING OR OPEN FLAME" signs shall be posted in refuelling areas.

6.7 Fuel dispensing from temporary storage tanks

This section applies to temporary fuel dispensing at project/field sites and covers both temporary storage tanks and mobile refuelling. For fuel tanks staged at a project/field site, the following guidance supports compliance with NFPA 395 but local authorities may have more stringent requirements:

- The size of an aboveground fuel storage tank (AST) is limited to 1,100 gallons/4,164 L capacity.
- Tank must be located no closer than 40 feet/12 m to any building.
- Tank base must be on the same level as the vehicles being fuelled.
- Tank markings must include the name of the product and will be marked with "Flammable – Keep Fire Away" and "Keep 40 Feet (12 Meters) from Buildings" or alternate markings as required by local authorities.
- Dispensing hose and equipment must be listed and designed for fuel dispensing.
- Tanks must be vented.

NOTE - NFPA 359 does not require secondary containment until temporary tanks exceed 1,100 gallons/4,164 L. However, Ramboll requires secondary containment as outlined in Section 6.5 of this procedure.

6.8 Mobile re-fuelling services

The fuelling of vehicles directly from a tank vehicle (tank wagon, bulk transport trailer, bulk truck, etc.) is subject to NFPA 30A. Refuelling by mobile tank trucks is permitted, provided that the requirements in this section are implemented.

- Mobile refuelling tank trucks must travel to vehicles for refuelling. Mobile refuelling tank trucks that remain stationary will need to be treated as a temporary storage tank (Section 6.7) including the associated drainage, impounding and separation distances of NFPA 30.
- A bulk mobile tank may not be disengaged from its tractor and used as a stationary fuel tank.
- Dispensing of Class I or Class II liquids from a tank vehicle to a motor vehicle located at construction, commercial, industrial, governmental or manufacturing establishments and intended for fuelling vehicles used in connection with their business require the following:

NOTE – Local authorities (fire department) may need to inspect the job site.

- The tank vehicle complies with the requirements covered in NFPA 385, Standard for Tank Vehicles for Flammable and Combustible Liquids.
- The dispensing hose does not exceed 50 feet/15 m.
- The dispensing nozzle is a listed automatic-closing type without a latch-open device.
- Night-time deliveries shall be only made in adequately lighted areas.
- The tank vehicle flasher light shall be in operation while dispensing.
- Fuel expansion space shall be left in each fuel tank to prevent overflow in the event of temperature increase.
- Spill prevention measures must be provided for mobile dispensing, as follows:
    - Individuals who perform fuelling must be present and alert at all times while conducting dispensing operations.
    - Drip pans and plastic sheeting will be placed under the point of dispensing. Fuel must not be allowed contact the ground.
    - Sorbents, pads and other spill prevention supplies will be available during all dispensing operations to prevent and clean up any spill to the ground including drips from the dispensing nozzle.

6.9 Transporting fuel in vehicles

This section applies to the transportation of fuel applicable to Ramboll's work. Quantities larger than outlined below may require vehicle placarding, shipping papers, licensing, SDS and other documentation in the vehicle in accordance with applicable requirements of the local regulatory authority. Drivers must be trained on the applicable regulations and practices [e.g., USDOT Materials of Trade (MOT) exemption, annual fire extinguisher training, etc.]. Refer to the SWP, Hazardous Material Shipping and Transport for more information.

- For fuel transported in containers, the containers must be approved by the local regulatory authority.
- Gasoline must only be transported in approved 5 gallon/19 L (maximum) metal safety cans.
- Containers must be secured to the body of the vehicle.
- A fire extinguisher appropriate for liquid fuel fires will be mounted in the vehicle. Refer to Section 9 for additional country/region-specific fire extinguisher information.

6.10 LPG storage

Refer to the SWPs, Material Storage and Handling and Process Safety for guidance related to LPG storage.

7. TRAINING & COMPETENCY

The HSS training programme includes new employee induction training, supervised on-the-job training and annual completion of online modules or classroom instruction related to safety requirements and work practices. Training assignments vary based on employee roles and training classification. Completion of assigned training will be documented by a training completion certificate, which will be stored in the employee's electronic training record on Ramboll Academy or equivalent learning management system. Refer to the HSSP, Training Programme for additional information.

7.1 Training requirements specific to storage and use of flammable and combustible liquids

In addition to the HSS training programme, employees who perform this work will receive the following supplemental or external training:

- **Fire extinguisher training** – Employees who are designated or expected to use fire extinguishers to fight incipient-stage fires will receive annual fire extinguisher training.

8. DOCUMENTATION

The following documentation is required, specific to flammable and combustible liquids.

- **Fire extinguisher inspections** – Fire extinguishers required by this procedure must be inspected every 30 days and documented on tags affixed to each extinguisher (or equivalent documentation).
- **Fire extinguisher annual maintenance** – Annual maintenance documentation may be generated internally but is preferable to be provided by a fire equipment service company. This documentation will be kept available at the site or location where the fire extinguisher is used.
- **Fire extinguisher training records** – Documentation of annual fire extinguisher training will be maintained in Ramboll Academy or equivalent learning management system and made available at the site or location where the fire extinguisher is used.

9. INTERNATIONAL TILTS

9.1 Asia/Pacific

9.2 Brazil

9.3 Canada

9.4 Europe

9.5 Mexico

9.6 Middle East

9.7 Nordics

9.8 United Kingdom (UK)

9.9 United States (US)

NFPA. NFPA 30 Flammable and Combustible Liquids Code.

NFPA. NFPA 30A Code for Motor Fuel Dispensing Facilities and Repair Garages.

NFPA. NFPA 385 Standard for Tank Vehicles for Flammable and Combustible Liquids.

NFPA. NFPA 395 Standard for the Storage of Flammable and Combustible Liquids at Farms and Isolated Sites.

Occupational Safety and Health Administration (OSHA) 29 CFR 1926.152: Flammable Liquids. https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.152

OSHA 29 CFR 1910.106: Hazardous Materials Flammable Liquids https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.106

U.S. Department of Transportation (USDOT). 49 CFR 173. Hazardous Materials Regulations, General Requirements for Shipments and Packaging. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-173?toc=1

USDOT. 49 CFR 178. 49 CFR 178. Hazardous Materials Regulations, Specifications for Packaging. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-178?toc=1

9.9.1 GHS and comparable NFPA class flammables

In the US, OSHA has adopted the GHS definitions but many reference existing to NFPA 30 definitions (Class I flammables and Class II and III combustibles).

Categories based on GHS		**Comparable NFPA Class**	
Category 1	Flash point <73°F/23°C and initial boiling point ≤ 95°F/35°C	Class IA	Flash point below 73°F/23 °C and boiling point below 100°F/38 °C

Categories based on GHS		Comparable NFPA Class	
Category 2	Flash point <73°F/23°C and initial boiling point >95°F/35°C	Class IB	Flash point below 73°F/23 °C and boiling point at or above 100°F/38 °C
Category 3	Flash point ≥73°F/23°C and ≤140°F/60°C When a Category 3 liquid with a flash point at or above 100°F/37.8°C is heated for use to within 30°F/16.7°C of its flash point, it shall be handled in accordance with the requirements for a Category 3 liquid with a flashpoint below 100°F/37.8°C.	Class IC	Flash point at or above 73°F/23°C but below 100°F/38°C
Category 4	Flash point ≥140°F/60°C and ≤200°F/93°C When a Category 4 flammable liquid is heated for use to within 30°F/16.7°C of its flash point, it shall be handled in accordance with the requirements for a Category 3 liquid with a flash point at or above 100°F/37.8°C.	Class IIIA	Flash point at or above 140ºF/60ºC and below 200ºF/93.3ºC When a combustible liquid is heated to within 30ºF/16.7ºC of its flash point, it shall be handled in accordance with the requirements for Class IC liquids.

9.9.2 Fire extinguisher type and purpose

The letter designations on fire extinguishers in the US are described below along with the symbols used to represent the different fire classes. The most common fire extinguisher used at project sites and in facilities typically is a multi-purpose extinguisher (i.e., Type ABC).

Class A - A fire extinguisher labelled with **letter "A"** is for use on Class A fires. Class A fires are fires that involve ordinary combustible materials such as cloth, wood, paper, rubber and many plastics.

Class B - A fire extinguisher labelled with **letter "B"** is for use on Class B fires. Class B fires are fires that involve flammable and combustible liquids such as gasoline, alcohol, diesel oil, oil-based paints, lacquers, etc. and flammable gases.

Class C - A fire extinguisher labelled with **letter "C"** is for use on Class C fires. Class C fires are fires that involve energised electrical equipment.

Class D - A fire extinguisher labelled with **letter "D"** is for use on Class D fires. Class D fires are fires that involve combustible metals such as magnesium, titanium and sodium.

Class K - A fire extinguisher labelled with **letter "K"** is for use on Class K fires. Class K fires are fires that involve vegetable oils, animal oils or fats in cooking appliances. This is for commercial kitchens, including those in restaurants, cafeterias and catering companies.

9.9.3 Fire extinguisher size designations

The size designations on fire extinguisher are explained below.

- The A rating is a water equivalency rating. Each A is equivalent to 1.25 gallons/4.7 L of water. For example, 4A = 5 gallons/19 L of water.
- The B:C rating is equivalent to the square footage that the extinguisher can cover. For example, 20 B:C = 20 square feet (ft^2)/1.9 square meters (m^2) of coverage.
- The C rating indicates it is suitable for use on electrically energised equipment.

9.9.4 Fire extinguisher use in facilities

Fixed-location fire extinguishers for offices, laboratories and manufacturing facilities must be selected and positioned based on the potential type and size of fire that can occur. Refer to the following table for guidance.

Type of fire	Facility/Industry fire extinguisher placement
Class A	The NFPA recommends that locations such as offices, classrooms and assembly halls that contain mainly Class A combustible materials have one 2-A extinguisher for every 3,000 ft^2/280 m^2. (Standard for Portable Fire Extinguishers: NFPA 10 [2010], Table 6.2.1.1, Fire Extinguisher Size and Placement for Class A Hazards). OSHA requires that all employees have access to an extinguisher within 75 feet/23 m travel distance [29 CFR 1910.157(d)(2)]. Note: Uniformly spaced standpipe systems or hose stations connected to a sprinkler system for emergency use can be used instead of Class A portable fire extinguishers, if they meet the respective requirements of [29 CFR 1910.158] or [29 CFR 1910.159], provide total coverage of the area to be protected and employees are trained at least annually in their use [29 CFR 1910.157(d)(3)].
Class B	Locations that contain Class B flammables, such as workshops, storage areas, research operations, garages, warehouses or service and manufacturing areas requires that all

<table>
<tr><th>Type of fire</th><th>Facility/Industry fire extinguisher placement</th></tr>
<tr><td></td><td>employees have access to an extinguisher within 50 feet/15 m travel distance [29 CFR 1910.157(d)(4)].
<table>
<tr><th>Hazard</th><th>Extinguisher</th><th>Spacing</th></tr>
<tr><td>Light (Low) - Small amounts of flammable liquids used for copy machines, art departments, etc., that are stored safely and kept in closed containers.</td><td>5-B
10-B</td><td>30 feet/9.2 m
50 feet/15.3 m</td></tr>
<tr><td>Ordinary (Moderate) - The total amount of flammable liquids present in greater amounts than expected under low-hazard locations. This can include garages, workshops or support service areas.</td><td>10-B
20-B</td><td>30 feet/9.2 m
50 feet/15.3 m</td></tr>
<tr><td>Battery charging station where maintenance is performed, batteries are removed from equipment or electrolyte is present (International Fire Code)</td><td>4A-20B:C</td><td>20 feet/6.1 m</td></tr>
<tr><td>Extra (High) - Locations where flammable liquids are present and used in large quantities. This includes areas used for storage, production, woodworking (finishing), vehicle repair, aircraft and boat servicing or where painting, dipping and coating, operations are performed with flammable liquids.</td><td>40-B
80-B</td><td>30 feet/9.2 m
50 feet/15.3 m</td></tr>
</table>
(Adapted from Standard for Portable Fire Extinguishers, NFPA 10 (2010), Table 6.3.1.1, Fire Extinguisher Size and Placement for Class B Hazards)</td></tr>
<tr><td>Class C</td><td>Class C extinguishers are required where energised electrical equipment is used. The extinguisher size and spacing is based on its Class A or B hazard [29 CFR 1910.157(d)(5)].</td></tr>
<tr><td>Class D</td><td>Locations where combustible metal powders, flakes, shavings or similarly sized materials are generated at least once every two weeks must install Class D portable fire extinguishers not more than 75 feet/23 m from the hazard [29 CFR 1910.157(d)(6)].</td></tr>
<tr><td>Class K</td><td>Locations where potential fire hazards from combustible cooking media (vegetable or animal oils and fats) exist must install Class K extinguishers at a maximum travel distance of 30 feet/9.2 m. [NFPA 10, Standard for Portable Fire Extinguishers. See Section 6.6, Installations for Class K Hazards].</td></tr>
</table>

9.9.5 Fire extinguisher use for construction operations

Fire extinguisher needs for construction are different from (but still similar to) requirements for permanently-mounted fire extinguishers outlined above. Construction-related fire extinguisher requirements are outlined in the following table.

- Hose reels may be substituted for fire extinguishers if:
    - A .5 inch/1.3 cm diameter garden-type hose line, not to exceed 100 feet/30.5 m in length and equipped with a nozzle which is capable of discharging a minimum of 5 gallon per minute/19 L per minute, with a minimum hose stream range of 30 feet/9.2 m horizontally, mounted on hose racks or reels. The number and location will be sufficient the hose stream can be applied to all points in the area.
    - One hundred feet or less of 1.5 inch/3.8 cm hose, with a nozzle capable of discharging water at 25 gallons per minute/95 L per minute or more. The hose line will reach all points in the area. If the fire hose connections are not compatible with local firefighting equipment, adapters or equivalent will be provided to permit connections.

Standard (29 CFR 1926)	Location during construction work	Type	Distance
150 (c)(1)(I)	Building area	2A	100 feet/30.5 m
150(c)(1)(iv)	Each floor	2A	Immediately adjacent to entrance
150(c)(1)(iv)	Multi-story building	2A	Adjacent to stairway
150(c)(1)(vi)	5 gallons of flammable/combustible or 5 pounds of flammable gas	10B	50 feet/15.3 m
151(c)(6)	Open yard storage suitable for hazard	2A	100 feet/30.5 m
152(d)(1)	Flammable liquid storage room	20B	10 feet/3 m, outside
152(d)(2)	Outside flammable liquid storage area	20B	25 feet/7.6 m - 75 feet/23 m
152(d)(4)	Vehicles used for dispensing or transporting of flammable or combustible liquids	20B:C	On Vehicle
152(g)(11)	Service or fuel area	20B:C	75 feet/23 m
153(1)	LPG storage area	20B:C	75 feet/23 m
International Fire Code	Welding, cutting or heating areas	2A-20B:C	30 feet/9.2 m
550(a)(14)(I)	Crane cabs	5 B:C	On crane

9.9.6 Fire extinguisher guidance for transportation of hazardous materials

Vehicles transporting fuel shall be equipped with at least one 10 pound/4.5 kg fire extinguisher, either BC or ABC dry chemical and mounted to the vehicle in order to be easily accessible. Fire extinguisher ratings for 10 pound/4.5 kg size will be 4A:80B:C or similar.

NOTE - Apply the same fire extinguisher requirement to vehicles transporting flammable gasses like acetylene.

9.9.7 Fire extinguisher inspection and maintenance

- Fire extinguishers must be visually inspected monthly. The purpose of the inspections is to verify that fire extinguishers:
  - Are still at their designated locations and properly mounted to a wall, column or post.
  - Are charged.
  - Have unobstructed access.
- Inspections are documented on a tag attached to each extinguisher (or equivalent documentation method).
- Annual maintenance must be conducted by a qualified fire equipment service company which is documented on a tag attached to each extinguisher.

9.10 Other regions

- International Code Council (ICC). International Fire Code (IFC). https://codes.iccsafe.org/content/IFC2021P1
- Uniform Fire Code - The uniform fire code is no longer maintained (last release in 1997) and superseded by the subsequent releases of the IFC, published by ICC.

10. ADDITIONAL INFORMATION

11. REVISION SUMMARY

ATTACHMENT 11
SAFETY DATA SHEETS

Safety Data Sheet

Effective date: 11 May 2023 **Revision**: 11 May 2023

Trade Name: Alconox® Powdered Precision Cleaner

1 Identification of the substance/mixture and of the supplier

1.1 GHS Product identifier

Trade Name: Alconox® Powdered Precision Cleaner

Product number: 1101, 1103, 1104, 1104-1, 1112, 1112-1, 1125, 1150

1.2 Application of the substance / the mixture: Cleaning material/Detergent

1.2.1 Recommended dilution ratio: 1 – 2% in water

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer:
Alconox Inc.
30 Glenn St
White Plains, NY 10603
(914) 948-4040

Supplier:
Not Applicable

Emergency telephone number:
ChemTel Inc
North America: 1-888-255-3924
International: +1 813-248-0573

2 Hazards identification

2.1 Classification of the substance or mixture:

In compliance with EC regulation No. 1272, 29CFR1910/1200 and GHS requirements.

Hazard-determining components of labeling:
Tetrasodium Pyrophosphate
Sodium tripolyphosphate
Sodium Alkylbenzene Sulfonate

2.2 Label elements:

Eye damage, category 1.

Skin irritation, category 2.

Product at recommended dilution:

Eye irritation, category 2B

Hazard pictograms:

Signal word: Danger

Hazard statements:
H315 Causes skin irritation.
H318 Causes serious eye damage.

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.

Hazardous Elements at Use Dilution:

Hazard Pictograms:

Signal Word: Warning

Hazard Statements:

H320 Causes eye irritation

Precautionary statements:

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.
P501 Dispose of contents and container as instructed in Section 13

Additional information: None.

Hazard description

Hazards Not Otherwise Classified (HNOC): May cause surfaces to become slippery if wet. Use caution in areas of foot traffic if on floors.

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, 29CFR1910/1200 and GHS Requirements, 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: Not determined or not available.

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 or 68411-30-3	Sodium Alkylbenzene Sulfonate	Acute Tox. 4; H303 Skin Irrit. 2; H315 Eye Dam. 1; H318	8-22
CAS number: 7722-88-5	Tetrasodium Pyrophosphate	Skin Irrit. 2; H315 Eye Irrit. 2; H319	2-16

Hazardous components at use dilution (percentages by weight):

Identification	Chemical Name	Classification	Wt. %
CAS number: 7758-29-4	Sodium tripolyphosphate	Eye Irrit. 2; H319	0.12 - 0.28
CAS number: 68081-81-2 or 68411-30-3	Sodium Alkylbenzene Sulfonate	Eye Irrit. 2; H319	0.08 – 0.22
CAS number: 7722-88-5	Tetrasodium Pyrophosphate	Eye Irrit. 2; H319	0.02 – 0.16

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.

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.

First aid measure at recommended dilution:

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.

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.

After swallowing:
Rinse mouth thoroughly. Seek medical attention if irritation, discomfort, or vomiting develops.

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:

No expected hazards under normal use condition.

Avoid breathing mist or vapor if aerosolized.
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.

8 Exposure controls/personal protection

8.1 Control parameters:

a) 7722-88-5, Tetrasodium Pyrophosphate, ACGIH TWA 10 mg/m3
b) 7758-29-4, Sodium Tripolyphosphate, ACGIH TWA 10 mg/m3
c) Dusts, non-specific OEL, Irish Code of Practice
  (i) Total inhalable 10 mg/m3 (8hr)
  (ii) Respirable 4 mg/m3 (8hr)
  (iii) Tetrasodium Pyrophosphate, OSHA TWA 5 mg/m3, (8hr)

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 use conditions.

Protection of skin:
Select glove material impermeable and resistant to the substance.

Eye protection:
Safety goggles or glasses, or appropriate eye protection. Recommended to comply with ANSI Z87.1 and/or EN 166.

General hygienic measures:
Wash hands before breaks and at the end of work.
Avoid contact with skin, eyes and clothing.

Exposure Control and Personal Protective Equipment at recommended dilution:

Under normal use and operational conditions, no special personal protective equipment or engineering controls will be necessary. Handle with care.

9 Physical and chemical properties

Appearance (physical state, color):	White and cream colored flakes - powder	**Explosion limit lower**: **Explosion limit upper**:	Not determined or notavailable. Not determined or notavailable.
Odor:	Not determined or not available.	**Vapor pressure at 20°C**:	Not determined or notavailable.
Odor threshold:	Not determined or not available.	**Vapor density**:	Not determined or notavailable.
pH-value:	9.5 (1% aqueous solution)	**Relative density**:	Not determined or notavailable.

Melting/Freezing point:	Not determined or not available.	**Solubilities**:	Not determined or notavailable.
Boiling point/Boiling range:	Not determined or not available.	**Partition coefficient (n-octanol/water)**:	Not determined or notavailable.
Flash point (closed cup):	Not determined or not available.	**Auto/Self-ignition temperature**:	Not determined or notavailable.
Evaporation rate:	Not determined or not available.	**Decomposition temperature**:	Not determined or notavailable.

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**: Not determined or not available.
10.2 **Chemical stability**: Not determined or not available.
10.3 **Possibility hazardous reactions:** Not determined or not available.
10.4 **Conditions to avoid**: Not determined or not available.
10.5 **Incompatible materials**: Not determined or not available.
10.6 **Hazardous decomposition products**: Not determined or not available.

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 damage.

Tetrasodium Pyrophosphate: Risk of serious damage to eyes.

Product information at recommended dilution:

Eye irritation may occur upon direct contact with eyes. No specific hazards for skin contact, inhalation, or chronic exposure are expected within normal use parameters.

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

12.1 Toxicity:

Sodium Alkylbenzene Sulfonate: Fish, LC50 1.67 mg/l, 96 hours.
Sodium Alkylbenzene Sulfonate: Aquatic invertebrates, EC50 Daphnia 2.9 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: ADR, ADN, DOT, IMDG, IATA	None
14.2 UN Proper shipping name: ADR, ADN, DOT, IMDG, IATA	None
14.3 Transport hazard classes: ADR, ADN, DOT, IMDG, IATA	**Class:** None **Label:** None **LTD. QTY:** None

US DOT
Limited Quantity Exception: None

Bulk:	**Non Bulk:**
RQ (if applicable): None	**RQ (if applicable):** None
Proper shipping Name: None	**Proper shipping Name:** None
Hazard Class: None	**Hazard Class:** None
Packing Group: None	**Packing Group:** None
Marine Pollutant (if applicable): No additional information.	**Marine Pollutant (if applicable):** No additional information.

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 as active.
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.

Germany MAK: Not classified.
EC 648/2004 – This is an industrial detergent. Contains >30% phosphate, 15-30% anionic surfactant, <5% EDTA salts
EC 551/2009 – This is not a laundry or dishwasher detergent
EC 907/2006 – Contains no enzymes, optical brighteners, perfumes, allergenic fragrances, or preservative agents

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.
H318 Causes serious eye damage.

NFPA: 1-0-0
HMIS: 1-0-0

At recommended dilution:
NFPA: 1-0-0
HMIS: 1-0-0

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.