

**DES Waste Management Division
29 Hazen Drive; PO Box 95
Concord, NH 03302-0095**

**SAMPLING AND ANALYSIS PLAN
Troy Mills Landfill Superfund Site
Troy, Cheshire County, New Hampshire
NHDES Site #: 198405082
Project Type: Superfund
Project Number: 104**

Prepared For:
New Hampshire Department of Environmental Services
Waste Management Division
Hazardous Waste Remediation Bureau
29 Hazen Drive
Concord, NH 03302-0095
Phone Number: 603-271-3649
Contact Name: Mr. Michael Summerlin, P.E.
Contact Email: michael.summerlinjr@des.nh.gov

Prepared By:
GZA GeoEnvironmental, Inc.
5 Commerce Park North, Suite 201
Bedford, NH 03110
Phone Number: (603) 232-8765
Contact Name: Ms. Tanya Justham
Contact Email: tanya.justham@gza.com
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SAMPLING AND ANALYSIS PLAN

Troy Mills Landfill Superfund Site

Wright Avenue

Troy, New Hampshire

NHDES No. 198405082

October 2018

File No. 04.0190325.28

PREPARED FOR:

Hazardous Waste Remediation Bureau (HWRB)

Waste Management Division

New Hampshire Department of Environmental Services

29 Hazen Drive, Concord, New Hampshire

GZA GeoEnvironmental, Inc.

5 Commerce Park North, Suite 201 | Bedford, NH 03110-6984
603-623-3600

Offices Nationwide

www.gza.com

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Bedford, New Hampshire

For:

Hazardous Waste Remediation Bureau (HWRB)
Waste Management Division
New Hampshire Department of Environmental Services (NHDES)
29 Hazen Drive
Concord, N.H.



US Environmental Protection Agency
Remedial Project Manager
Richard W. Hull

October 25, 2018

Date



New Hampshire Department of Environmental Services
Project Manager
Michael Summerlin, P.E.

October 25, 2018

Date



GZA Principal-in-Charge
Steven R. Lamb, P.E.

October 25, 2018

Date



GZA Project Manager
Tanya P. Justham

October 25, 2018

Date

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1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) has been prepared to provide site-specific information regarding ongoing activities at the Troy Mills Landfill Superfund Site (Site) located in Troy, New Hampshire. The SAP has been prepared consistent with and references the current New Hampshire Department of Environmental Services (NHDES) Hazardous Waste Remediation Bureau (HWRB) Master Quality Assurance Project Plan (Master QAPP), Environmental Protection Agency (EPA) RFA#18008, available on the NHDES website.¹ The HWRB Master QAPP generally describes the data quality objectives (DQOs), analytical procedures and measurements, including laboratory quality-control protocols necessary to achieve DQOs, and data-assessment procedures for the evaluation and identification of any data limitations.

The objective of this SAP is to outline the project plan for supplemental investigation activities planned for 2018, procedures and protocols, DQOs, quality assurance sampling and documentation, and other project requirements.

Any deviations from the procedures contained within this SAP shall be approved by the NHDES Project Manager and the Quality Assurance (QA) Coordinator in advance, following concurrence with the EPA.

1.1 Site Description and History

The Site is an undeveloped 2-acre former drum disposal area located in Troy, New Hampshire (Cheshire County) about 1.5 miles south of the Center of Troy (refer to **Figure 1**). The 2-acre Site is a portion of a larger 10-acre landfill within the 270-acre property formerly owned by Troy Mills, Inc. (Troy Mills). The landfill was used by Troy Mills for the disposal of solid wastes including fabric scraps from the textile mill. Drummed solids and liquids were primarily disposed within the 2-acre area currently referred to as the Site, including the Lower Drum Area and Upper Drum Area. The remaining 8 acres of landfill located to the north of the Site is generally referred to as the solid waste landfill (refer to **Figure 1**). Access to the Site is off Rockwood Pond Road via a separately owned, private gravel pit access road in Fitzwilliam, New Hampshire.

The Site is bordered by the following:

- To the north by an 8-acre solid waste landfill that is separately regulated by the NHDES Solid Waste Bureau under facility identification number 261;
- To the east by a former railroad bed currently used as a walking, all-terrain vehicle, and snowmobile trail, and beyond by undeveloped land;
- To the west by the main Site access road, a wetland area, and Rockwood Brook; and
- To the south by the eastern branch of Rockwood Brook and beyond by undeveloped land.

The Site and a portion of the 8-acre solid waste landfill is encompassed by a Groundwater Management Zone (GMZ) comprising 16.86 acres and including downgradient land beyond the landfill area. Rockwood Brook flows south to north and continues downstream to Sand Dam Pond, a recreational area

¹ http://des.nh.gov/organization/divisions/waste/hwrp/documents/hwrp_master_qapp.pdf

located approximately 1 mile north of the Site. The former drum disposal area is located in an area outside of the 100-year floodplain of Rockwood Brook.

Troy Mills, Inc. (TMI) disposed of hazardous substances that were generated at its acrylic fabric manufacturing facility in Troy between 1967 and 1978. An estimated 6,000 to 10,000 55-gallon drums of waste liquid and sludge containing mostly plasticizers such as bis(2-ethylhexyl)phthalate and a petroleum-based solvent known as Varsol™ (also known as Stoddard solvent, or mineral spirits) were disposed of on site. Other drummed waste included pigments, surplus mixes, and tank residuals of vinyl resins, paint resins, and top coating products. Between 1979 and 2005, several investigations of the Site have occurred. Investigation findings identified volatile organic compounds (VOCs), semi-VOCs, and inorganics in groundwater, leachate, surface soil, surface water, and sediment in and around the drum disposal area.

In September 2003 the Site was listed on the National Priorities List and a time-critical removal action was initiated. Between 2004 and 2005, EPA completed a drum and flammable liquid removal and contaminated soil/sludge removal action; constructed three light non-aqueous phase liquid (LNAPL) interceptor trenches; and constructed a 2-foot-thick permeable soil cap over the excavation area. A subsequent remedial investigation of the Site by EPA identified a plume of groundwater contamination consisting of organic contaminants (alkylbenzenes, chlorinated solvents, phthalates, and toluene). It was concluded that the contaminants of concern were naturally biodegrading and that removal of the buried drums eliminated the primary source of on-going contamination to groundwater.

1.2 Summary of Site Hydrogeology

Based on information collected by others, bedrock underlying the Site is comprised of biotite schist of the Littleton Formation.² The biotite schist at the Site is typically dark gray, hard, folded, with high angle foliation and fractures, and quartz veins. Seams of granite, quartz, and pegmatite are also present within the schist. Bedrock fractures were found trending both northeast and northwest.

The overburden primarily consists of a sand unit, ablation till, and lodgment till. The sand layer is typically less than 6 feet in thickness where it remains in place and is mostly saturated in the low area west of the access road. The ablation till is at its thickest beneath the southwestern part of the former drum disposal area, where it is up to 40 feet thick. This unit gradually thins toward Rockwood Brook, where it is less than 10 feet thick, and is very thin to absent near the eastern edge of the former drum disposal area where the bedrock is shallow. The lodgment till is thickest at the bottom of the valley floor near Rockwood Brook, where boring logs indicate a thickness of greater than 35 feet. This till unit thins eastward toward the eastern edge of the former drum disposal area.

Groundwater flow in the shallow overburden has been measured by others to be to the west or northwest, toward Rockwood Brook. The hydraulic gradient is reportedly quite steep to the east of the access road, reflecting the low permeability of the till deposits in which the water table occurs. It has been concluded that the vertical gradients are generally downward or neutral except in areas where groundwater is rising to discharge into a stream or wetland.

² Final Feasibility Study, Troy Mills Landfill Superfund Site, Troy, New Hampshire, prepared by Metcalf & Eddy, Inc, dated September 2005.

1.3 Brief Summary of Previous Investigations and Contaminants-of-Concern

From 1979 to the present, multiple investigations have been conducted at the Site. These investigations are briefly summarized herein and are further described in the Final Feasibility Study (FS), prepared by Metcalf & Eddy, Inc. (M&E), dated September 2005.

Under the State of New Hampshire hazardous waste remediation program, TMI completed a Phase I investigation of the drum disposal area in August 1981, a Phase II investigation in December 1981, and a Phase III investigation in July 1982. Based on the findings, TMI entered into a Consent Agreement with NHDES in January of 1985 that required TMI to submit a waste analysis plan, a preliminary risk assessment, a remedial investigation/feasibility study (RI/FS), and an engineering design of the selected remedial alternative. A preliminary human health risk assessment, completed in March 1986, concluded that a Level 2 risk assessment should be conducted since concentrations of volatile organic compounds (VOCs) in groundwater indicated a potentially elevated risk. The required remedial investigation (RI) was conducted in 1987. The risk assessment was completed during 1991 (Weston, 2003) and concluded that risk to human health was negligible; however, it was later determined that the Site had not been thoroughly characterized.

A Phase I Pre-Design study, conducted during 1995, identified LNAPLs in newly installed wells and a leachate outbreak. Subsequent analyses indicated that concentrations of contaminants in groundwater exceeded the New Hampshire Ambient Groundwater Quality Standards (AGQS) (Weston, 2003). The Pre-Design study recommended a containment remedy and further evaluation of the potential for intrinsic remediation of site groundwater (GEI Consultants, Inc., 1995).

A Phase II Pre-Design report, completed during September 1998, proposed the installation of a hanging slurry wall combined with product collection and a flow-through (intrinsic) treatment gate downgradient of the buried drum area and the leachate outbreak. In addition, the NHDES questioned the conclusion made in the Phase II Pre-Design report that only a small percentage of the drums remaining in the drum disposal area were still intact and contained liquid. Instead, the NHDES supported a containment-based remedial action, and during April 2000 agreed to a modified version of a containment-based remedial action originally proposed during 1995 with the condition of commitment by TMI to long-term operation, maintenance, and monitoring (Weston, 2003).

During September 2000, TMI requested to defer remediation of the drum disposal area to 2003/2004 due to unfavorable corporate and financial market conditions. During December 2000, NHDES approved the deferral schedule provided during September, based on the remote location of the Site, combined with monitoring data that did not suggest an imminent and substantial threat to public health or the environment. TMI filed for Chapter 11 bankruptcy on November 2, 2001.

During September 2003, the Site was listed on the National Priorities List and a time-critical removal action was initiated. During July 2004, EPA's Superfund Remedial Program retained M&E under the Remedial Action Contract to initiate a RI to determine if additional remedial actions would be needed after the completion of the removal action. The RI documented the nature and extent of residual contamination and evaluated risks to human health and the environment from current or expected future exposures to residual contamination. Five additional wells were installed at the Site and groundwater, surface water, soils, and sediments were sampled during December of 2004.

Between 2004 and 2005, the EPA completed a drum and flammable liquid removal and contaminated soil/sludge removal action; constructed three LNAPL interceptor trenches; and constructed a 2-foot-thick

permeable soil cap over the excavation area. The 8-acre solid waste landfill was used as a staging area during the drum removal and consequently some grading and cover improvements were performed on portions of the solid waste landfill following completion of the drum removal. A subsequent RI of the Site was completed by M&E during July 2005 for EPA. The RI identified a plume of groundwater contamination, approximately 8 to 9 acres in area, consisting of organic contaminants (alkylbenzenes, chlorinated solvents, phthalates, and toluene). It was concluded that the contaminants of concern (COCs) were naturally biodegrading and that removal of the buried drums eliminated the primary source of on-going contamination to groundwater.

The 2005 RI/FS completed by M&E also included the establishment of RAOs and preliminary remediation goals; identification and screening of potential treatment and containment technologies, and the development and evaluation of remedial alternatives. It was concluded by M&E that the primary contaminants posing human health risks and hazards were DEHP in leachate and various organics and inorganics in groundwater.

Pursuant to the ROD, EPA concluded that the selected remedy for contaminated groundwater, LNAPL, and residual soil contamination include the following remedial components:

- Maintenance of the LNAPL interceptor trenches;
- Maintenance of a permeable soil cap;
- MNA of groundwater contaminants including the monitoring of groundwater, surface water, sediment, leachate, and wetland soil;
- Institutional controls (ICs); and
- Five-year reviews.

The first statutory five-year review was completed by EPA during September 2010 to document the status of the selected remedy relative to its being protective of human health and the environment. The trigger for the five-year review was the initiation of the ROD-specified cleanup actions completed during the fall of 2005. The five-year review documented that the remedy was currently protective of human health and the environment as envisioned by the ROD. However, in order for the remedy to be considered protective over the long term, the following actions were recommended:

- With regard to effectiveness of ICs, report violations and vandalism to the State and the Town for response with appropriate follow-up monitoring and enforcement actions. Repair damaged wells, post warning signs at the inner gate and former drum disposal area, and consider fencing the former drum disposal area to restrict access by all-terrain vehicles;
- Conduct a supplemental investigation of the residual LNAPL source area and further evaluate effectiveness of the interceptor trenches in capturing remaining LNAPL;
- Perform supplemental hydrogeologic studies to confirm hydrostratigraphy and the COC fate and transport in groundwater to confirm the effectiveness of the MNA management of migration remedy at the Site and to better forecast time to cleanup; and
- Perform a hydrologic evaluation within the transition zone between groundwater and surface water in the Rockwood Brook Wetland Study area and Rockwood Brook. Review existing data from nearby

groundwater monitoring wells relative to appropriate benchmark ecological risk screening values applied to receptor exposures within the ground water – surface water transition zone.

During 2008 and 2009, approximately 2 to 3 acres of the solid waste landfill were capped under a Consent Decree with NHDES by a third party unrelated to the Site.

Between 2011 and 2013, GZA performed phased supplemental LNAPL investigations to further delineate the LNAPL source area and aid the evaluation of potential focused remedial alternatives in the vicinity of the LNAPL interceptor trenches and former drum disposal area. GZA concluded the following with regard to the persistence of LNAPL:

- LNAPL present in the vicinity of the interceptor trench area appeared to be both laterally and vertically discontinuous, particularly under high water table conditions. The lack of discernible connectivity within the LNAPL in this area was likely a reflection of the combined influences of historical downgradient LNAPL recovery from the trench network, upgradient source reduction and hydraulic influences stemming from cap installation;
- The results of LNAPL recovery testing, when combined with the historical record of product thicknesses in wells near the interceptor trenches, indicated that the LNAPL appeared to have transitioned away from a mobile state and toward a condition where LNAPL pore concentrations exist at or below residual saturation levels under current Site conditions (i.e., an immobile state);
- While historically effective, the interceptor trenches were no longer readily recovering free product. The cessation of LNAPL recovery from the trenches may be at least partially attributed to the previously-mentioned transition toward residual-dominated (i.e., immobile LNAPL) conditions in the trench area;
- Field screening and analytical data collected during subsurface explorations, as well as the data collected during a Laser-Induced Florescence survey performed during 2012 at TRY_B10, did not support the existence of a significant continuing LNAPL source in overburden within the former drum disposal area; and
- Although based on spatially and temporally limited data, the results of the free product laboratory analysis suggested weathering and mass transfer from the LNAPL did not appear to be significantly changing the chemical composition of the LNAPL. The lack of an appreciable change in composition is consistent with the recalcitrant nature of the primary LNAPL constituent DEHP.

Pursuant to the ROD, the interceptor trenches were to “continue to be maintained and operated until LNAPL levels dissipate, at which time, they will be kept available for continued monitoring as part of the groundwater component of the remedy.” The ROD further states that “if continued monitoring is no longer necessary, the interceptor trenches will be decommissioned in a manner determined appropriate at that time.”

Based on GZA’s understanding of Site conditions, it was recommended in the May 2013 Investigation Report that trench decommissioning coinciding with excavation, removal, and off-site disposal of accessible LNAPL-impacted soil be performed. This work was largely completed by January 2014 with final Site restoration occurring during May 2014. Work associated with the decommissioning of the interceptor trenches was summarized in “Completion Report – Trench Decommissioning” dated July 2014. The following LNAPL gauging wells (C-series wells) and groundwater monitoring wells (201-series wells) located in the vicinity of the interceptor trenches were also decommissioned during the

removal of the trenches (refer to **Appendix B** for an historical figure depicting the locations of the 201 series wells):

- MW-C1S
- MW-C3S
- MW-C5S
- MW-C8S
- MW-201M
- MW-201P
- MW-C2S
- MW-C4S
- MW-C7S
- MW-201D
- MW-201S

An Explanation of Significant Differences (ESD) was issued during 2014 to document changes in the New Hampshire Ambient Groundwater Quality Standards and to update other State and federal ARARs.

The Second FYR dated September 2015 stated that the remedy is currently protective of human health and the environment. In order for the remedy to be protective in the long term, however, the following actions should be considered:

- Site security options to limit trespassing and Site access. EPA will review options with State and Town officials including but not limited to: erect additional fences and signage; relocate the gate; determine in consultation with State and Town officials whether there are other effective means to limit trespassing and access. If trespassing persists, EPA will consider whether a revised human health risk assessment is needed;
- Institutional control (IC) options to prevent potential exposure to contaminated soils. EPA, in consultation with State and Town officials, will consider modification of existing ICs, more effective enforcement of existing ICs, or implementation of additional ICs to limit exposure to contaminated soils; and
- Evaluate extent of contaminated sediment and conduct toxicity evaluation and ecological risk assessment. EPA, in consultation with State, will evaluate on-site wetlands to determine the current nature and extent of contaminated sediment and if some areas need to be re-assessed relative to ecological risk to benthic invertebrates through chemical analysis and toxicity testing.

Based on refinement of the CSM indicating that the plume was limited to a narrow area within overburden groundwater along the northern side of the former drum disposal area with the primary plume axis trending along the east to west flow path, 17 on-site groundwater monitoring wells were determined to be superfluous. The following wells were decommissioned during the fall 2014 monitoring activities:

- P-1
- M-2
- M-3
- M-5
- M-6
- MW-101
- MW-109
- MW-108
- MW-502
- MW-504
- MW-505
- MW-506
- MW-507
- MW-202S
- MW-202D
- MW-602S
- MW-603

** well TRY_MW-106 was planned for decommissioning; however, it could not be located.*

Site security enhancements were completed during 2017 to fulfill the recommendation for the Site access issue identified during the second FYR and with the goal of limiting unauthorized access to the Site and conveying Site exposure concerns to potential trespassers.

As a component of the Second FYR, it was concluded that bis(2-ethylhexyl)phthalate (DEHP) is likely to persist in the aqueous phase in groundwater at the Site due to rate-limited mass transfer from remaining residual non-aqueous mass and general recalcitrance of this contaminant in anaerobic groundwater environments. This finding was supported by the results of the trend analyses included in the Second FYR that were performed using monitoring data collected prior to and during 2015. The trend analyses for DEHP included in the second FYR are currently considered unreliable due to the potential for biased data; however, relatively high concentrations of DEHP exceeding the New Hampshire AGQS were consistently observed at well TRY_MW-205 between 2005 and 2014. Because TRY_MW-205 is located outside and cross-gradient to the drum removal area, a recommendation was made in the Spring 2016 Monitoring Round Data Report to perform surficial geophysics (e.g., ground penetrating radar [GPR]) and focused test pit explorations in this area to explore whether a separate source may exist outside of the drum removal area.

Areas of possible buried metal were identified during the surficial geophysical survey conducted in May 2017 and confirmed during test pit excavations in August 2017. In general, the observed landfilled materials and soil impacts were relatively benign; however, the residual waste material from the 55-gallon drum observed in TRY_TP-1 indicates that a potential continuing source of contamination to groundwater is located within the area of monitoring wells TRY_MW-205, TRY_MW-803, and TRY_MW-804.

1.4 Interim Cleanup Levels and Ambient Groundwater Quality Standards

Interim Cleanup levels (ICLs) for contaminants of concern were established in the ROD for groundwater and leachate (refer to **Appendix C**). Groundwater data results will also be compared against New Hampshire AGQS included in Env-Or 600. Refer to the table below for a summary of the contaminants of concern and the associated ICLs and AGQS for groundwater and leachate. Refer to the attached **Table 1** for a summary of all test methods including respective laboratory reporting detection limits (RDLs) and action limits being performed on groundwater and other media at the Site.

Contaminants of Concern and Associated ROD ICL and AGQS Criteria

Contaminants of Concern	CAS No.	ROD ICLs (µg/L)	NH AGQS (µg/L)
Groundwater			
1,4 Dioxane	123-91-1	3	0.32
Benzene	71-43-2	5	5
Tetrachloroethene (PCE)	127-18-4	5	5
Trichloroethene (TCE)	79-01-6	5	5
Vinyl Chloride	75-01-4	2	2
Benzo(a)pyrene	50-32-8	0.2	0.2
benzo(b)fluoranthene	205-99-2	0.1 *	0.1
bis(2-Ethylhexyl)phthalate (Di[2-Ethylhexyl]phthalate) (DEHP)	117-81-7	6	6
Dibenzo(a,h)anthracene	53-70-3	0.1 *	0.1
Pentachlorophenol	87-86-5	1	1
1,2,4-Trimethylbenzene	95-63-6	330 *	330
1,3,5-Trimethylbenzene	108-67-8	330 *	330
2-Butanone (MEK) (Methyl Ethyl Ketone)	78-93-3	4,000 *	4,000

Contaminants of Concern	CAS No.	ROD ICLs (µg/L)	NH AGQS (µg/L)
P-Isopropyltoluene (4-Isopropyltoluene)	99-87-6	260 *	260
cis-1,2 Dichloroethene	156-59-2	70	70
n-Butylbenzene	104-51-8	260 *	260
n-Propylbenzene	103-65-1	260 *	260
Tetrahydrofuran (THF)	109-99-9	154	600
Toluene	108-88-3	1,000	1,000
Naphthalene	91-20-3	20	100
Arsenic	7440-38-2	10	10
Boron	7440-42-8	620	620
Manganese	7439-96-5	300	840
Leachate			
bis(2-Ethylhexyl)phthalate (Di [2-Ethylhexyl]phthalate) (DEHP)	117-81-7	40	6

Note:

ROD ICLs = Interim Cleanup Levels found in the ROD

* ROD Explanation of Significant Differences (ESD) March 2014 increased the ICLs to match the AGQS.

AGQS = New Hampshire Ambient Groundwater Quality Standards

The AGQS for Tetrahydrofuran changed from 154 µg/L to 600 µg/L in June 2015; the AGQS for naphthalene and 1,4-dioxane changed from 20 µg/L to 100 µg/L and from 3 µg/L to 0.32 µg/L, respectively, in September 2018.

Boron will not be analyzed at the present time. Future sampling rounds will consider the analysis of Boron.

Wetland soil analytical results will be compared to Soil Remediation Standards included in Env-Or 600 (see **Table 1**). Surface water and leachate data results will be compared to NHDES Surface Water Quality Regulations (Env-Wq 1700, see **Table 1**). Sediment laboratory analytical data will be compared with historical analytical data relative to long-term trends in sediment quality in addition to published, peer-reviewed screening level contaminant lists included in NHDES' Draft Evaluation of Sediment Quality Guidance Document, dated April 2005, that includes the National Oceanic and Atmospheric Administration Screening Quick Reference Tables (NOAA SQuiRT Tables). Current SQuiRT Tables are located on the NOAA website.³ Note that comparison is for screening purposes only as there are no sediment regulatory criteria, site-specific cleanup standards, or remediation goals established for this Site. The results of the screening analysis will be used as a tool to efficiently identify contaminants that may pose a threat to ecological receptors and focus further site activities on those contaminants should they be identified.

In accordance with the ROD, groundwater and leachate cleanup levels must be met at the completion of the remedial action. Data generated will be reviewed by EPA at least once every five years to ensure that results are indicative that the remedy selected for the Site continues to provide adequate protection of human health and the environment. The next five-year review is scheduled for completion in September 2020.

As identified in **Table 1**, some action limits cannot be obtained by the analytical laboratory using the selected test methods. The data will be included and evaluated in the project reporting deliverables. The

³ http://archive.orr.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf.

evaluation of the data will be qualitative relative to the historical trends of those particular analytes. In the future, as the concentrations of the contaminants-of-concern of various media appear to decline closer to the action limits established, consideration will be given to the need for use of alternative test methods that may be able to achieve lower detection limits where needed.

1.5 Data Quality Objectives

The primary data quality objective for the long-term sampling/monitoring program is that all measurements be representative of the actual Site conditions and that all data resulting from field, sampling, and analysis activities be comparable. Comparability is the extent to which data from one data set can be compared directly to similar or related data sets and/or decision-making standards. Data comparability will be achieved by continuity of acceptable laboratory practices, method analysis, sample collection procedures and sample handling.

Based on the preliminary information relating to types of contaminants, environmental media of concern, and potential exposure pathways previously identified, response action objectives (RAOs) were developed by EPA for the Site to mitigate, restore, and/or prevent existing and future potential threats to human health and the environment.⁴ Relative to the scope of this SAP, the RAOs, among other things, included limiting migration of groundwater contaminants beyond the Groundwater Management Zone (GMZ) to downgradient areas, and over time, restoring all Site groundwater to safe drinking water levels. MNA has been shown to be occurring naturally and is being established at the Site as the primary mechanism to achieve the management of migration RAO. The primary DQOs of MNA include collecting data of known and sufficient quality to accomplish the following:

- Confirm water quality in compliance wells.
- Collect sufficient data to be able to evaluate the effectiveness of MNA at the Site and ensure natural attenuation processes are continuing to degrade the contaminants-of-concern.
- Collect sufficient data to assess contaminated groundwater impact to leachate seeps, Rockwood Brook surface water and sediment, and wetland soil.

In order to meet the Site's DQOs and to ensure the integrity of the samples and chain of custody forms (CoCs), all site wells must either be locked or within a secure area (e.g., a locked chain link fence).

Performance acceptance criteria for all new data generated for this project will be based on principal Data Quality Indicators including precision, bias, representativeness, completeness, comparability, and sensitivity. Consistent with the HWRB Master QAPP, Section 1.4, for data generated by Absolute Resource Associates (ARA) laboratory and ARA's subcontractor for Per- and Polyfluoroalkyl Substances (PFAS) analysis, Maxxam Analytics (Maxxam), the RDLs and the acceptance limits for accuracy and precision have been accepted for use on this project. ARA is the current laboratory with whom NHDES has a contract.

Table 1 includes a summary of the test methods being performed and the associated RDLs. The MDLs have not been included in **Table 1** as all the RDLs are below the action limits established for the Site, with the exception of a few compounds. For those specific compounds identified, as the concentrations of Site contaminants approach the action limits, an evaluation of the need for alternative test methods that could achieve the necessary RDLs will be conducted.

⁴ Region 1 Record of Decision, Troy Mills Landfill Superfund Site, Troy, New Hampshire, dated September 2005.

Completeness is considered to be the percentage of planned data collection that has to be complete in order to be considered sufficient for the intended use. The goal is to achieve a minimum of 90 percent (%) data completeness for analyzed samples.

All data points of all types must be accurately located in 3-dimensional space. The expected accuracy for Global Positioning System (GPS) data collection activities for the Site shall be within 1 foot. The expected accuracy for elevation data for the Site shall be one one-hundredth of a foot.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

In September of 2017, the responsibility for operating and maintaining the remedy at the Site was officially transferred from EPA to the NHDES. GZA has been retained by the NHDES to provide remedial consulting services for the project.

Within GZA, Mr. Steven R. Lamb will be responsible for the overall contract management, ensuring that established protocols and procedures are used, and Ms. Tanya Justham will be responsible for the management of day-to-day activities, staff scheduling, and assuring that the technical objectives are achieved relative to the project. Ms. Tanya Justham will be the designated Quality Assurance (QA) Officer for the project and in this role, will oversee all QA aspects including assisting NHDES with the development of this SAP and data validation reports to confirm that data quality documentation is appropriate and that QA goals have been met.

Refer to **Appendix A** for an illustration of project organization and responsibilities of those individuals involved in the project.

3.0 FIELD MONITORING AND SAMPLING PROTOCOL

The following subsections discuss general methodology for performing sampling and analysis as part of the overall field activities including specific sampling procedures and data management requirements that will be implemented during the monitoring program. Field activities will be conducted in accordance with this SAP, unless Site conditions require modifications. Any modifications shall be approved by NHDES in advance, following concurrence with EPA.

Specific standard operating procedures (SOPs) are included in **Appendix B** and referenced herein.

3.1 Multi-Media Sampling and Analysis

Multi-media sampling at the Site includes sampling of groundwater, surface water, leachate, sediment and wetland soils (refer to **Table 2**).

Figure 1A illustrates the monitoring locations at the Site.

Figure 1B is an aerial view of the Locus and Site Exploration Plan.

Table 1 summarizes all Contaminants of Concern, analytes, associated ICLs (ROD), standards, such as AGQS (Env-Or 600), and the associated Laboratory RDLs.

Table 2 summarizes the selected locations to be sampled, analytical parameters, sampling procedure, and the rationale for selecting groundwater wells.

Table 3 summarizes specific analytical methods, sample volume, containers, preservatives and hold time requirements.

Table 4 summarizes monitoring well construction information, which includes well diameter, geologic unit the well is screened within, screen interval depth, etc.

Table 5 summarizes the specific Quality Control (QC) sampling requirements for the monitoring rounds.

Analytical samples will be analyzed by the NHDES contract laboratory, ARA, in Portsmouth, New Hampshire. Samples going to ARA will be transported using the unique ARA CoC in the SAP. ARA subcontracts out the PFAS analysis to Maxxam in Ontario, Canada.

Laboratory analysis of aqueous carbon dioxide, methane/ethane/ethene and volatile fatty acids, when required, will be subcontracted by GZA to Microseeps. All samples going to Microseeps will be transported using a Microseeps CoC.

The GZA project manager will coordinate sample pick-up/delivery arrangements directly with ARA. Refer to the chain-of-custody SOP in **Appendix B**. The laboratory Turn-Around-Time (TAT) requested for all samples will be the standard 10 business day TAT.

3.1.1 Water Level / LNAPL Thickness Measurements and Well Depth Measurements

A synoptic water level round utilizing each available monitoring well (refer to **Table 2**) shall be conducted in accordance with the Water Level / LNAPL Thickness Measurement SOP in the shortest possible time prior to beginning sampling to assess groundwater flow directions. If LNAPL is encountered in any well, LNAPL thickness measurements will be collected in accordance with the SOP. Refer to **Figure 1** for the well locations.

Groundwater elevations will be measured as depth-to-water at the Site using an electronic water level indicator probe. Groundwater elevations will be calculated by subtracting the depth-to-groundwater from the reference elevation associated with each well (top of polyvinyl chloride [PVC] riser or metal casing).

The depth to the bottom of the monitoring well will be confirmed in each well included in **Table 2** based on the following:

- If a bladder pump has been installed in a monitoring well, the depth to the bottom of the monitoring well will be confirmed at such time when the bladder pump is removed for repairs or maintenance activities, or if a significant increasing trend in the turbidity values has been observed; and
- In monitoring wells where there has been no bladder pump installed, the depth to the bottom of the monitoring well will be confirmed once every five years, during the sampling event just prior to the Five-Year review.

The synoptic water level round shall also include the brook stage measurement at surface water sampling location TRY_SW-4, where a permanent stream gage has been mounted.

3.1.2 Groundwater Sampling Procedures

Groundwater monitoring wells identified in **Table 2** and illustrated on **Figure 2** will be purged and sampled using low flow methodology and either a bladder pump (dedicated if funding permits or non-dedicated) or a peristaltic pump and dedicated polyethylene tubing. However, on occasion there may be circumstances where sampling a well using a stainless steel bottom dispensing bailer to collect samples may be more appropriate. Refer to the respective SOPs. The rationale or purpose for sampling these wells is included in **Table 2**. Calibration of the field equipment will be performed in accordance with the SOP.

Prior to the installation of any new bladder pump or tubing in a well, GZA will check for the presence of LNAPL. If LNAPL is detected, its thickness will be recorded, no equipment will be installed, and groundwater will not be sampled.

Dedicated stainless steel/Teflon pump assemblies have been previously installed in select wells and include either a QED T1250 model for 2-inch diameter monitoring wells or a QED T1300 model for 1.5-inch diameter monitoring wells. Refer to **Table 4** for specific information regarding the pump models used at each well location, the pump length and diameter, and the bladder capacity for each type of pump. In addition, select wells that currently have no dedicated pump will be purged and sampled using a non-dedicated QED Sample Pro Bladder pump or a peristaltic pump and dedicated tubing. These monitoring wells will be purged and sampled using low flow methodology in accordance with the applicable SOP. The rationale for sampling groundwater monitoring wells is included in **Table 2**.

Because of the potential presence of PFAS in common consumer products and in equipment typically used to collect groundwater samples and the low detection limits associated with laboratory PFAS analysis, special handling and care must be taken when collecting samples for PFAS analysis. The PFAS sampling SOP in the SAP outlines general practices for collecting PFAS samples and provides a summary of non-acceptable field and sampling materials (likely to contain PFAS) and acceptable alternatives.

Due to the nature of PFAS, additional QC samples are required, including an equipment blank on the non-dedicated water level meter and a field blank. A field blank is a sample that is prepared in the field to evaluate the potential for cross contamination of a sample from ambient conditions. A container of analyte-free laboratory-grade deionized water is taken to the field for use in making a field blank. The container is then opened in the field, thus exposing it to the ambient field conditions, and poured into the appropriate sample containers. The sample containers are then sent to the laboratory for analysis (e.g., treated as a sample).

Refer to **Tables 2** and **3** for the specific laboratory analyses planned and **Table 5** for all required QC sampling including equipment blanks, duplicate samples, etc., with respect to groundwater sampling.

Decontamination of non-dedicated equipment will be completed in accordance with the SOP. Liquid investigation derived waste (IDW) generated from decontamination activities will be discharged to the ground surface or placed into 5-gallon plastic containers, as appropriate, and stored with the lid on. GZA will arrange for appropriate disposal of wastes and unused decon materials, as appropriate, from the Site on behalf of NHDES. Purge water will be discharged to the ground surface.

3.1.3 Leachate Sampling Procedures

Field sampling will include the collection of leachate samples from the discharge area of the culvert west of the site access road (TRY_SW-LEACHATE) and at the discharge area immediately upgradient of the old beaver dam (TRY_SW-LEACH-B), as illustrated on **Figure 1**. In addition, should flow be observed on the east (uphill) side of the access road at the entrance of the culvert, a third leachate sample will be collected (TRY_SW-LEACH-A).

These areas continue to be the only ongoing leachate seeps observed since 2006. The rationale for the leachate sample(s) is to monitor for change in leachate composition. Should additional seeps be identified in the future, GZA will consult with NHDES and EPA as to whether or not they should be incorporated into the sampling program.

Leachate samples will be collected as a grab sample in accordance with the Leachate Sampling SOP. Refer to **Section 4.2** below and **Table 5** for all required QC sampling including equipment blanks, duplicate samples, etc., with respect to leachate sampling.

3.1.4 Surface Water and Sediment Sampling Procedures

Collection of surface water and sediment samples at the locations illustrated on **Figure 1** will occur as data needs require. Refer to **Table 2** for sampling locations and associated analyses.

The rationale for sampling at TRY_SW-1 is to characterize upstream surface water quality during the sampling event for comparison with downstream surface water quality. At one location (TRY_SW-3) a co-located sediment sample (TRY_SED-3) has been collected in the past; the rationale for sampling this location was to monitor possible impacts from groundwater migrating from the former drum disposal area to downstream sediment and surface water. The rationale for sampling at TRY_SW-4 is to characterize surface water quality both at the confluence of Rockwood Brook's east and west branches and downgradient of the leachate sampling area. A surface water location, SW-100, has been added to monitor possible impacts from groundwater migrating from the former drum disposal area to downstream surface water.

Surface water and sediment sampling will occur in accordance with the Surface Water and Stream Sediment Sampling Procedure. Refer to **Table 2** and **Table 3** for sampling locations and associated analyses. Refer to **Table 5** for all required QC sampling including equipment blanks, duplicate samples, etc., with respect to surface water and sediment sampling.

3.1.5 Wetland Soil Sampling Procedures

The collection of wetland soil samples at locations illustrated on **Figure 1** will occur as data needs require. Refer to **Table 2** for sampling locations and associated analyses.

The rationale for sampling at the locations is to monitor possible impact from groundwater migrating from the former drum disposal area to the wetland.

Wetland soil samples will be collected at a depth of 0 to 6 inches beneath the leaf litter in accordance with the Wetland Soil Sampling SOP. Decontamination of soil sampling equipment will be performed in accordance with the Decontamination SOP. Refer to **Tables 2** and **3** for the specific laboratory analyses planned and **Table 5** for all required QC sampling including equipment blanks, duplicate samples, etc., with respect to wetland soil sampling.

Please note that the locations of downstream wetland soil samples may be compromised and may require adjustment based on the extent of localized flooding associated with continued beaver activity at the Site. GZA will consult with NHDES and EPA before any adjustments are made.

3.2 Other Planned Activities

Other planned activities during fall 2018 include the following:

- Re-measuring the well bottom depth at well TRY_MW-702SX and at TRY_M-1 next time the bladder pump is removed.
- Continued observation of the groundwater in sample tubes at several well locations which periodically retract down the tubing (variable lengths, but between 0.1 feet and 1 foot down the tubing) while the bladder is in its filling cycle. As long as the observation remains intermittent, pump maintenance is not necessary at this time; however, increased observation of the water retraction will require the removal and rehabilitation of the affected bladder pump.
- Continued replacement or cleaning of locks securing the well standpipes as needed due to the buildup of dirt and rust.
- Prior to performing the Fall 2018 monitoring round, GZA performed an assessment of the sampling method effectiveness of collecting a per- and polyfluoroalkyl substances (PFAS) sample using the Teflon bladders and tubing installed at the Site. GZA selected the bladder pump from TRY_MW-501D for the assessment because it had a recently-dedicated bladder pump and no history of detections of DEHP. GZA removed the dedicated QED T-1250 bladder pump from the well, drained the pump and associated tubing, and rinsed the exterior with PFAS-free deionized (DI) water. The pump, along with the dedicated fittings and sample tubing, were inserted into a 2-inch diameter polyvinyl chloride (PVC) riser that was capped at the bottom. The pipe was filled with PFAS-free DI water and approximately three pump and tubing volumes purged from the PVC riser through the bladder pump. After the purge, the pump and riser were drained and refilled with fresh DI water. A water sample was collected through the bladder pump and submitted to Alpha Analytical of Westborough, Massachusetts for analysis of PFAS. PFAS was not detected above the reporting limit for any of the PFAS analytes; therefore, PFAS samples will be collected directly from the selected monitoring wells using the installed sampling equipment.

4.0 QUALITY CONTROL

The following describes the QC steps used to demonstrate reliability and confidence in the monitoring data collected for this project and includes field equipment maintenance and calibration, field QC sample collection, and data verification and validation.

4.1 Equipment Maintenance and Calibration

The following table provides the preventive maintenance steps for the typical equipment anticipated for the types of monitoring and sampling activities addressed by this SAP to ensure proper functioning of field equipment for the project. Manufacturer's equipment manuals and any manufacturer-provided repair kits will be on Site at all times. Calibration procedures are included in **Appendix B**.

Field Equipment - Preventive Maintenance

INSTRUMENT	ACTIVITY	FREQUENCY
Solinst Electronic Water Level Indicator	Battery Check	Daily
Geotech Oil-Water Interface Probe		
QED Model MP-10 Controller		
Photoionization Detector MiniRae 2000/3000	Calibration and Calibration Check – pre-sampling event	Once Prior to Sampling Event
	Battery check Calibration – beginning of day Calibration check – after morning calibration Calibration check – end of day	Daily
	Calibration and Calibration Check – pre-sampling event	Once Prior to Sampling Event
	Battery check Calibration check – beginning of the first day Calibration check – end of each day Calibration, if needed – after each calibration check (See SOP and below for specifics)	Daily
YSI 600XL/XLM or In-Situ SmarTROLL Multi-Parameter Water Quality Meter		
Hach 2100P or 2100Q Turbidity Meter		

Notes:

In the case of field equipment failure, backup equipment will be delivered to the Site from GZA's office(s)/vendors. This equipment is suitable to use on this project because it can meet the requirements included in the SOPs in **Appendix B**. Every reasonable effort shall be made to ensure the low-flow cells, sample tubing, and turbidity meters are shielded from the elements.

The following table provides performance requirements of applicable field equipment and required corrective actions should equipment fail.

Field Equipment - Calibration and Corrective Action

Instrument	Calibration Frequency ¹	Calibration Standards	The Acceptance Criteria for the Daily Calibration Checks ²	Corrective Action
YSI 600 XL/XLM or In-Situ SmarTROLL 1.) <i>Dissolved Oxygen and temperature</i>	Calibration Check ¹ at the beginning of the first day and any non-consecutive sampling days.	Calibrate to 100% water saturated air and use 0 mg/L DO check	0-0.5 mg/L for the 0 mg/L DO	<p><u>Calibration Checks</u></p> <p>– If outside the criteria during the check, calibrate only the parameter(s) that was out of range.</p> <p>– If still out of range replace the appropriate calibration standards and recalibrate /check.</p> <p>– If recalibration is unsuccessful, replace the unit.</p>
2.) <i>Oxygen Reduction Potential</i>		Zobell solution (calibration and check)	+/- 5%	
3.) <i>Specific Conductance</i>		Calibrate to 1,413 µS/cm and use 718 µS/cm to check *	+/- 5%	
4.) <i>pH</i>		Calibrate to pH 4, 7 and 10 and use pH 7 to check	+/- 5%	
Hach 2100 P or 2100Q Turbidity Meter	Calibration of any parameter not within range during the calibration check. Calibration Check at the end of the day.	Calibrate to <0.1, 10, 20, 100, and 800 NTUs as appropriate for each meter. Use 20 NTUs to check 2100P and the 10 NTU to check the 2100Q. (use StablCal Formazin Primary Turbidity Standards)	+/- 5% for 2100P +/- 10% for 2100Q	<p><u>End of the day Calibration Check</u></p> <p>– If outside the criteria at the end of the day, the data for that day will be qualified by GZA.</p>
MiniRae 2000/3000	Daily Calibration at the beginning of each day Calibration Check at the beginning of the day after calibration Calibration check at the end of the day	Connect detector to isobutylene-in-air standard. After 15 seconds, the detector reading should equal the response value as indicated on the calibration gas cylinder used.	+/- 15 %	<p><u>Daily Calibration</u></p> <p>– Recalibrate appropriate standards. If value(s) are still outside the acceptance criteria, replace with a different unit.</p> <p><u>Morning Calibration Check</u></p> <p>– If outside the criteria during the morning check, replace the appropriate calibration standards and recalibrate /check. If recalibration is unsuccessful, replace the unit.</p> <p><u>End of the day Calibration Check</u></p> <p>– If outside the criteria at the end of the day, the data will be qualified by GZA.</p>

Notes:

- The morning and end-of-the-day checks are a check of the instrument against the calibration standards and are in “measurement” mode on a run/measurement screen. This is not recalibration but rather a check.
- * It is permissible to calibrate with either of the specific conductivity standards and use the other standard to check the calibration.

In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions.

All field instruments shall be successfully calibrated (including a calibration check) in the office prior to the field event (within one week) to ensure that the equipment is working properly and meets the QA criteria. The calibration/calibration check shall be documented on the calibration log.

Calibration checks, made in the run mode, shall be performed at the beginning of the first sampling day to ensure the equipment is in calibration and again at the end of the day of use to ensure that the instruments have remained in calibration throughout the day. After the first day, calibration checks shall be performed at the end of each day of use, at a minimum, to ensure that the instruments have remained in calibration. However, if an instrument is not used for a day (for example: over the weekend) or if the field team leader determines it is necessary, then the next sampling day would be considered the “first” sampling day again, where the calibration check is performed both at the beginning of that sampling day and at the end of that day, after which the schedule would revert back to checking the calibration at the end of the day only.

If the calibration check is unsuccessful for any parameter, that parameter must be calibrated and the calibration must be checked again. If the end of the day check is unsuccessful for any parameter, the data collected that day for that parameter shall be qualified in its use.

In addition, should any erratic or illogical readings occur between calibrations/calibration checks, the calibration shall be re-checked for those parameters and the instrument shall be recalibrated as necessary in order to ensure that representative measurements are obtained. All calibration and check values shall be documented on the calibration log maintained by each user. Refer to the Calibration of YSI and Hach Field Instruments SOP in **Appendix B** for specific calibration procedures.

4.2 Field Quality Control

The following provides a general description of the field QC sampling that will occur for the project. Refer to **Table 5** that includes a summary of QC samples to be collected.

Field Quality Control Requirements

QC Sample	Frequency	Acceptance Criteria	Corrective Action
Trip Blanks ¹ (separate trip blanks may be required for aqueous VOCs, 1,4-dioxane, and PFAS)	There shall be only one trip blank per CoC per sample cooler , except when trip blanks require different preservatives for different methods.	No contaminants are detected	Flag in project reports See Section 5.3.1 below
Duplicate ²	<ul style="list-style-type: none"> One duplicate per batch of 20 samples, per matrix, per parameter, per sampling method. If less than 20 samples are collected, then a minimum of one duplicate per matrix, per parameter, per sampling method is collected. 	Duplicate results are within +/- 30% for aqueous samples and 50% for solid samples	Flag in project report See Section 5.3.1 below

QC Sample	Frequency	Acceptance Criteria	Corrective Action
Field Blank ³	At a minimum, field blanks shall be collected by each person collecting PFAS samples.	No contaminants are detected	Flag in project reports See Section 5.3.1 below
Equipment Blank ⁴	<p>If dedicated equipment used, an initial equipment blank is required. No additional equipment blanks are required.</p> <p>If non-dedicated equipment (other than the water level meter) is used, one equipment blank per sampling event, per equipment type is required.</p>	No contaminants are detected	Flag in project reports See Section 5.3.1 below

Notes:

1. Trip blanks will be prepared by the appropriate laboratory and maintained at all times with the sample containers. The trip blank(s) will be designated “TRIP BLANK” only. HCL preserved trip blanks are required for VOCs (1 VOA vial). Separate unpreserved trip blanks are required for 1,4-dioxane using method 8260 SIM (1 VOA Vial). A PFAS trip blank typically consists of one Trizma preserved 250 ml polypropylene bottle.
2. Duplicate samples are not intended to be blind duplicate samples. They will be designated with a “DUP” after the well designation (e.g., NHP_MW-X DUP). See **Table 5** for analysis.
3. Field blank samples shall be designated “FIELD BLANK” only. Note that a comment is required on the chain-of-custody indicating the name of the person who collected the sample (i.e., Smith). Refer to section 3.1.2 Groundwater Sampling and **Table 5** for more information on field blanks.
4. Equipment blank samples will be designated as “EQUIP BLANK” only. Note that a comment is required on the chain-of-custody indicating what the equipment blank is for (e.g., water level meter). Refer to **Table 5** for analysis.

4.3 Data Verification and Validation

Data review, which includes a GZA in-house examination to ensure data have been recorded, transmitted, and processed correctly and data verification, which includes the evaluation of completeness, correctness, and conformance / compliance of a specific data set will be performed by GZA’s Project Manager or QA Officer at the end of each sampling event. As in the past, data collected will be compared to historical data to make sure it follows the same trends. If any of the samples don’t follow the trends, then further investigation may be warranted.

Field water quality data collected / measured will be reviewed in the field by the GZA QA Officer/Field Team Leader daily for all matrices. Review will generally consist of the following: 1) review of calibration data and end of the day check; and 2) review of raw data and field notes for outliers or inconsistencies that may indicate a problem with the equipment or sampling procedure.

All laboratory data generated by the New Hampshire Division of Public Health Services (NHDPHS) and EPA laboratories will be reviewed by NHDPHS and EPA personnel, respectively, and will not require third-party validation. All laboratory data generated by the current NHDES contract lab or other laboratories that may be used will be reviewed by GZA and will not require third-party validation.

NHDPHS Lab will evaluate Field Quality Control samples for all samples analyzed by the NHDPHS Lab and will flag any data that does not meet the acceptance criteria under Field Quality Control Requirements listed in **Section 4.2** above. No other laboratories perform this function. GZA will be

required to perform this task for all other laboratories that generate data and include their findings in their report of the sampling event.

The NHDPHS laboratory report will consist of the following:

- The Completed Chain of Custody.
- Data Qualifier Description Page.
- Sample Summary Page: includes lab IDs, Corresponding Client Sample IDs, Matrix, Date/Time Collected and Date Received.
- Analytical Report Comments and Qualifiers Page.
- Analytical Results Pages: Method Citation, results, units, RDL, prep date, analyzed date, Regulatory Limit, if applicable and Qualifier Code.

The ARA laboratory report will consist of the following:

- Both Excel and PDF components.
- A cover sheet.
- A summary of samples/ analyses requested.
- Data pages (Results, Reporting limits, analysis info, qualifiers, etc.)
- Case Narrative.
- Associated Method Blank data.
- Associated LCS data.
- Method specific Duplicates or Matrix spikes (as requested).
- The Completed Chain of Custody.

The Maxxam laboratory report will consist of the following:

- Both Excel and PDF components.
- A cover sheet.
- A summary of samples/analyses requested.
- Data pages (Results, Reporting limits, analysis info, qualifiers, etc.)
- Case Narrative
- Associated Method Blank data.
- Associated LCS data.
- Method specific Duplicates or Matrix spikes (as requested).
- The Completed Chain of Custody.

The Microseeps laboratory report will consist of the following:

- The Completed Chain-of-Custody form.
- Both excel and PDF components.
- Data Qualifiers.
- Analytical Results Pages: lab project number, client project name, client project number, matrix, lab sample number, sampled date and time, received date, method number, results, units, practical quantitation limits (PQLs), analysis date and personnel initials, and qualifier codes.
- QC Pages: prep methods, analysis methods and results; units, true spike concentrations, RDLs, % recovery and control limits, for method blanks, LCS, LCSD, and MS/MSD samples.

The EPA laboratory report will consist of the following in addition to the sampling results:

- The completed chain of custody.
- Data qualifier description page.
- Lab QC data.

Data validation requirements for the project will be evaluated at each Five-Year review, or as otherwise deemed necessary by the NHDES with concurrence from the EPA.

4.4 Quality Assurance Field Audits

GZA QA field audits shall be conducted by the GZA QA Officer during monitoring events and will include observation of all sampling-related activities including equipment calibration, multi-media sampling, QC sampling, and decontamination activities to ensure that all procedures and techniques are conducted in accordance with this SAP and the current HWRB Master QAPP. The GZA project manager and GZA QA Officer will be present during NHDES / EPA field audits (unless the audits are unannounced).

Field audits will be performed during the sampling round as scheduled by NHDES and EPA. Additionally, field audits will be conducted as necessary such as if the field team is changed or the SOPs for the project change significantly. If corrective action is needed, additional field audits will be conducted to ensure all procedures and techniques used at the Site are conducted in accordance with this SAP and the HWRB Master QAPP.

The results of a GZA field audit that result in corrective actions will be reported to the NHDES project manager and the NHDES QA Coordinator verbally and noted in the field log book. Audit findings and corrective actions will be discussed with the NHDES project manager and the NHDES QA Coordinator to resolve the findings and corrective actions to the satisfaction of NHDES.

5.0 DOCUMENTATION

In order to comply with Waste Management Division Submittal Guidelines,⁵ the Department requests that all reports be submitted electronically through the OneStop program.⁶ Nicole Gianunzio may be

⁵ http://des.nh.gov/organization/divisions/waste/orcb/documents/electronic_submittal_guidelines.pdf

⁶ <https://www2.des.state.nh.us/OnestopDataProviders/DESLogin.aspx>

contacted at 271-7379 for assistance. Additionally, the Department requires GZA to ensure that all of the laboratory data generated from the current sampling event is uploaded to the NHDES' Environmental Monitoring Database (EMD).

5.1 Documentation of Field Activities

In accordance with the HWRB Master QAPP, field personnel shall use field logbooks and/or pre-printed field worksheets to accurately document on-Site conditions, field measurements (when not using a SmarTROLL to record low-flow test data), sample collection information, field instrument readings, calibration information, and other pertinent Site-related information obtained during monitoring activities. **All information shall be recorded using ball point pens with black ink.** Sharpies can bleed through pages and smudge, making the documentation hard to read.

A permanently bound field logbook (per person) with individually numbered pages is maintained for field sampling information not recorded on field forms (e.g., calibration sheets, low flow purge forms, CoC forms). All entries into the field logbook are made with permanent black ink, and corrections are made using a single line through the error with the initials and date of the individual who made the correction. The unused bottom portion of each page shall be lined-out, initialed, and dated. The field notes in general shall include a description of field conditions that includes, as a minimum:

- Site location.
- On-site conditions.
- Date, start, and finish times of the work and weather conditions.
- Name and initials of person making entry.
- Names of other personnel present, if any.
- Names of visitors, if any.
- Purpose and summary of proposed work effort.
- Field instrument and calibration information.
- Sample collection information.
- Details of any deviation from the field operations plan or standard operating procedures, including who authorized the deviation.
- Field observations / measurements.
- Sampling equipment used (including make model and serial number) and equipment calibration documentation (including standards used, lot numbers and expiration dates).
- Field screening methods, if used, and a description of screening locations and results.
- Location, description and unique identifier for all photographs taken in association with the field activity.
- Any other pertinent information.

Field worksheets to be completed in the field include the water level worksheet; the daily calibration logs; and groundwater, surface water, sediment, and pore water quality worksheets, as applicable. All entries into the field forms are made with permanent black ink, and corrections are made using a single line through the error with the initials and date of the individual who made the correction. The unused bottom

portion of each page shall be lined-out, initialed, and dated. Refer to the appropriate SOPs for a copy of the individual field worksheets and the specific information required for each form.

GZA's Project Manager will be responsible for ensuring that the field files are entered into the project record. Information recorded in other Site documents other than the field logbooks (e.g., sampling worksheets, calibration logs, chain-of-custody forms) will not be repeated in logbooks except in summary form, as necessary.

5.2 Chain-of-Custody Procedures

Samples and unused sample containers shall remain in the sample collector's view at all times, unless locked in a vehicle or other secure place in accordance with the Chain of Custody SOP included in **Appendix B**. It is the sampler's responsibility to ensure that the samples are not tampered with prior to their delivery to the analytical lab. The GZA QA Officer/Field Team Leader will review the chain-of-custody forms at the end of each day to ensure all data has been entered properly. The chain-of-custody form shall be completed to provide documentation that traces sample possession and handling from the time of collection through delivery to the analytical lab and shall accompany the samples at all times. All information shall be recorded in permanent black ink. The chain-of-custody is a legal document that may be used for litigation purposes.

5.2.1 Sample Identification

In order to properly transfer sample results into the NHDES EMD (Environmental Monitoring Database) samples must be identified using the designated NHDES station identification.

- All sample IDs must have "TRY_" as a prefix (except trip blanks and equipment blanks). This includes any samples going to outside labs so that later this data may be uploaded into the NHDES EMD;
- The sample ID has to be 15 characters or less, including the "TRY_";
- Equipment Blanks must be labeled "EQUIP BLANK" without any other designation. The equipment from which the equipment blank was collected will be documented in the field log book and indicated in the comments section of the CoC;
- Trip Blanks must be labeled "TRIP BLANK" without any other designation. Only one trip blank per matrix, per CoC, per parameter, per cooler is permitted.
- Sample duplicates are identified by adding "DUP" to the end of the station ID. The duplicate sample must be labeled "DUP" not "Dup" and there must be one space between the sample ID and DUP (example "TRY_MW-102 DUP"). Blind duplicates are not allowed. The space and "DUP" will not count toward the 15 character maximum;
- Field blank samples must be designated "FIELD BLANK" only. Note that a comment is required to be recorded on the chain-of-custody indicating the name of the person who collected the sample (i.e., S. Perkins); and
- All new sample IDs shall be approved by the NHDES Project Manager and the QA Coordinator in advance.

5.3 Reports

The applicable laboratories will provide the analytical data reports along with a copy of the pertinent QC data. All field reports will be provided to the GZA Project Manager.

After each sampling round, a draft water quality report shall be prepared and submitted to NHDES and EPA within 60 days after GZA's receipt of the analytical results. Draft report submittals will include a complete bookmarked PDF, an MS Word version of the report text and MS Excel version of all tables. The report will be extensive, evaluating the sampling results for the event and making recommendations, with supporting figures, graphs, etc., as identified below.

GZA will submit all final reports electronically through the OneStop filing system on the NHDES website. GZA will also upload the sampling results from all outside laboratories (including the EPA Lab in Chelmsford, Massachusetts, as applicable) directly into the NHDES EMD through OneStop, once the final report has been approved and uploaded.

Each sampling report will contain the following information (intending to also reflect the requirements of Env-Or 606.18):

- A brief introduction that references the SAP, WSA, and applicable contract and that describes completed sampling activities, results and any unusual or noteworthy observations regarding the data and the site.
- Site Background Information.
- Detailed summary of field activities since previous report, including sampling methodologies.
- A quality assurance/quality control (QA/QC) Section (refer to **Section 5.3.1** below).
- A detailed written analysis of the data collected, including:
 - An evaluation of the groundwater analytical data to determine whether groundwater clean-up standards have been met,
 - An evaluation to determine whether an increase or decrease in COC concentration trends is observed in site groundwater.
- An updated Site Conceptual Model.
- Recommendations for the following:
 - Additional remedial activities.
 - Modifications to the current monitoring program or to the SAP, including sampling program optimization.
 - Evaluation of well status (e.g., extent of fouling; need for redevelopment, repair, or pump replacement; assessment of flush-mount wells to be converted to above ground casing (or the reverse); and need for additional wells).
- Updated site map reflecting current site features.
- Updated Well Construction Table (**Table 4** from the SAP).
- Groundwater Potentiometric Surface Map.
- Data visualization maps for COCs (e.g., isoconcentration contour maps, 3-dimensional models).

- Summary table of current and historical groundwater level and elevation data for all existing site wells.
- Summary table of current and historical compounds detected at all existing site wells, highlighting any compounds that exceed clean-up goals.
- Summary table of current and historical field parameter data (i.e., pH, DO, ORP, temperature, Specific Conductivity, and turbidity) for all existing site wells.
- Graphs of COC concentrations showing historical trends (for those parameters that remain above AGQS anywhere across the site).
- Copies of all field sampling worksheets/forms/logs and appropriate field logbook pages.
- A list of equipment used, including make and model (and serial number if available).
- All calibration information including calibration standards used, lots numbers, expiration dates, calibration checks, calibration results and completed calibration logs.
- A copy of all complete laboratory reports, applicable data validation reports, and the CoCs. The lab reports shall be individually bookmarked in the last appendix in the report.

5.3.1 Quality Assurance/Quality Control Section of Report

Each technical report shall include general statements summarizing whether or not the quality control criteria in this SAP and the HWRB Master QAPP were met in the field and in the laboratory, as well as any deviations from the SAP. The report will include a discussion of any field and lab QA/QC problems and how they were resolved. GZA will note anything unusual that is anticipated to affect the quality or usability of the data.

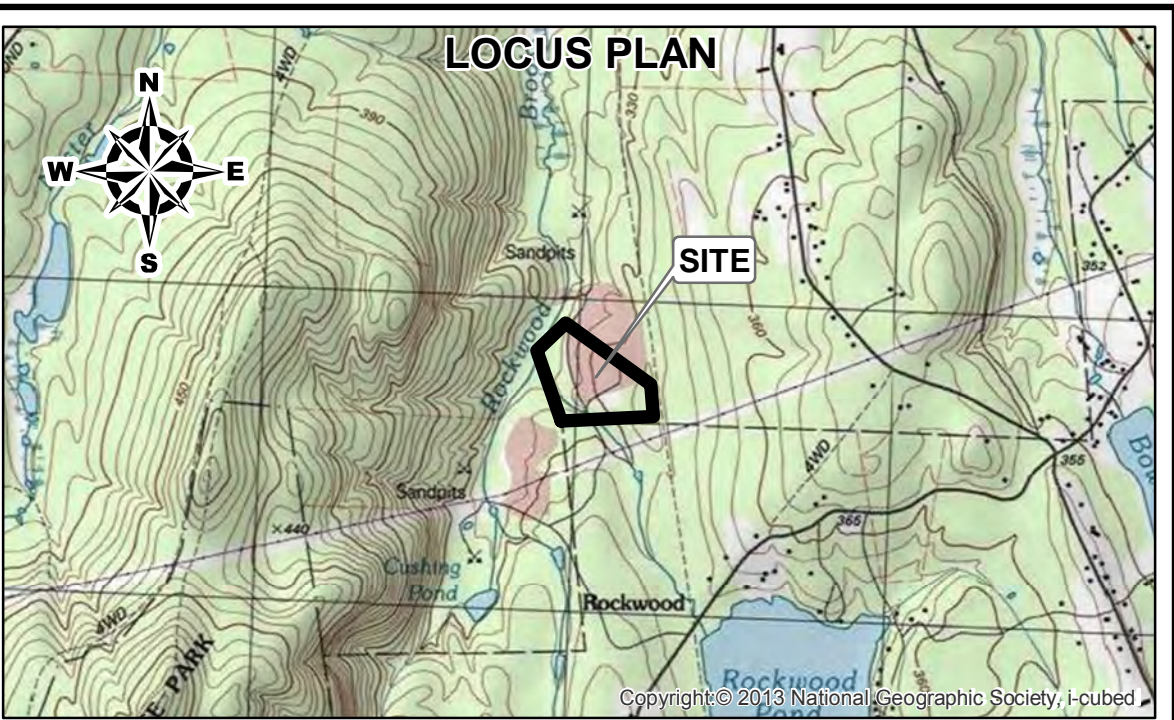
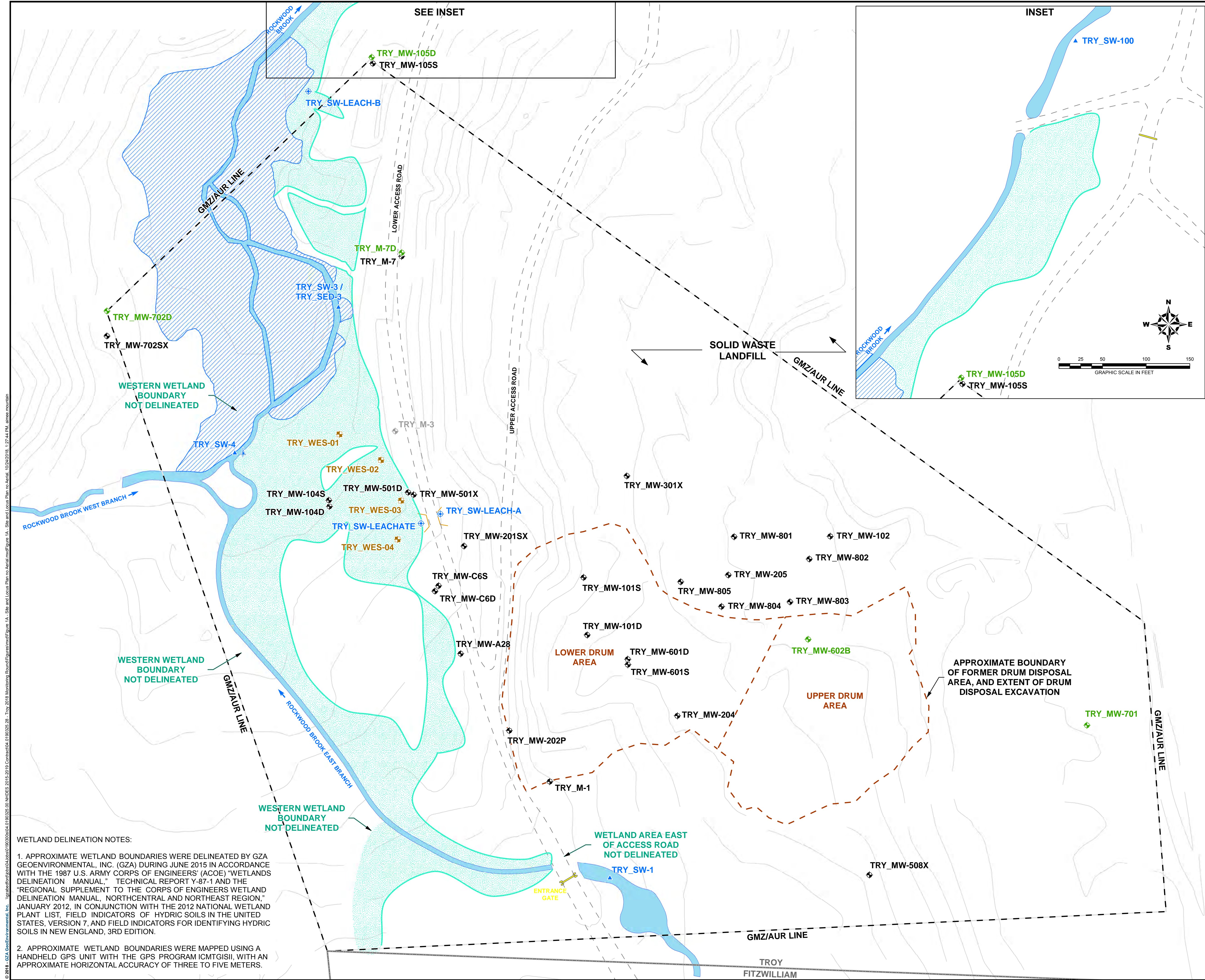
Examples for situations where the QA criteria were not met which would be included within a technical report:

- How does that affect the usability of the data?
- Can we use the data? If not, why not?
- Was any corrective action needed and what, if any, measures were taken?
- What changes are recommended for the future?

Examples of possible issues to be included within a technical report:

- Were contaminants found in the equipment blanks?
- Were any samples broken in transport to the lab?
- Did the lab report any difficulties, issues?
- Were the sample tags mixed up in the field if the results look abnormal?

Figures



- LEGEND:**
- MW-701 BEDROCK MONITORING WELL
 - MW-601 OVERBURDEN MONITORING WELL
 - WES-01 WETLAND SOIL SAMPLE LOCATION
 - SW-1 SURFACE WATER AND/OR SEDIMENT SAMPLE LOCATION
 - SW-LEACH-A LEACHATE SAMPLE LOCATION
 - PERMANENTLY INSTALLED STAFF GAUGE
 - M-3 GZA DECOMMISSIONED WELL
 - STREAM FLOW DIRECTION
 - CONTOURS
 - APPROXIMATE LOCATION OF FORMER DRUM DISPOSAL AREA
 - APPROXIMATE WETLAND BOUNDARY
 - CULVERT
 - ENTRANCE GATE
 - GMZ/AUR
 - GRAVEL ACCESS ROAD
 - TOWN LINE
 - APPROXIMATE EXTENT OF FORMER PONDING
 - APPROXIMATE WETLAND AREA
 - SURFACE WATER

NOTES:

1. BASE PLAN IS FROM NHDES GPS DATA POINTS TAKEN ON SEPTEMBER 29, 2011.

2. THE GROUNDWATER MANAGEMENT ZONE (GMZ)/ACTIVITY AND USE RESTRICTION (AUR) LINE IS FROM "GROUNDWATER MANAGEMENT ZONE & ACTIVITY AND USE RESTRICTION PLAN, TROY MILLS LANDFILL, TROY, NEW HAMPSHIRE". PREPARED BY TF MORAN, INC., DATED DECEMBER 18, 2006, REVISED JANUARY 17, 2007 AND MARCH 19, 2007.

3. A SURVEY OF THE SITE WELLS WAS CONDUCTED DURING FEBRUARY 2005 BY CONKLIN & SOROKA OF CHESHIRE, CONNECTICUT. THE BENCHMARK POINT USED FOR THIS SURVEY WAS MONITORING WELL TRY_M-3; ITS ELEVATION WAS ESTABLISHED AS 1037.65 (PVC) ACCORDING TO THE PLAN TITLED "TOPOGRAPHIC SURVEY DEPICTING MONITORING WELL LOCATIONS, LAND OF TROY MILLS LANDFILL." THE HORIZONTAL DATUM USED TO IDENTIFY SITE MONITORING WELLS IS NAD 83/96 PER NHDOT BASE STATION, FOLLOWING THE NEW HAMPSHIRE STATE PLANE PROJECTION, IN UNITS OF U.S. SURVEY FEET.

4. SURFACE WATER SAMPLING LOCATION SW-100 IS LOCATED ON ROCKWOOD BROOK TO THE NORTH OF THE NORTHERNMOST CORNER OF THE GMZ/AUR LINE. THE LOCATION OF SW-100 WAS DETERMINED IN THE FIELD AND RECORDED WITH A HANDHELD GPS UNIT IN THE SPRING OF 2016.

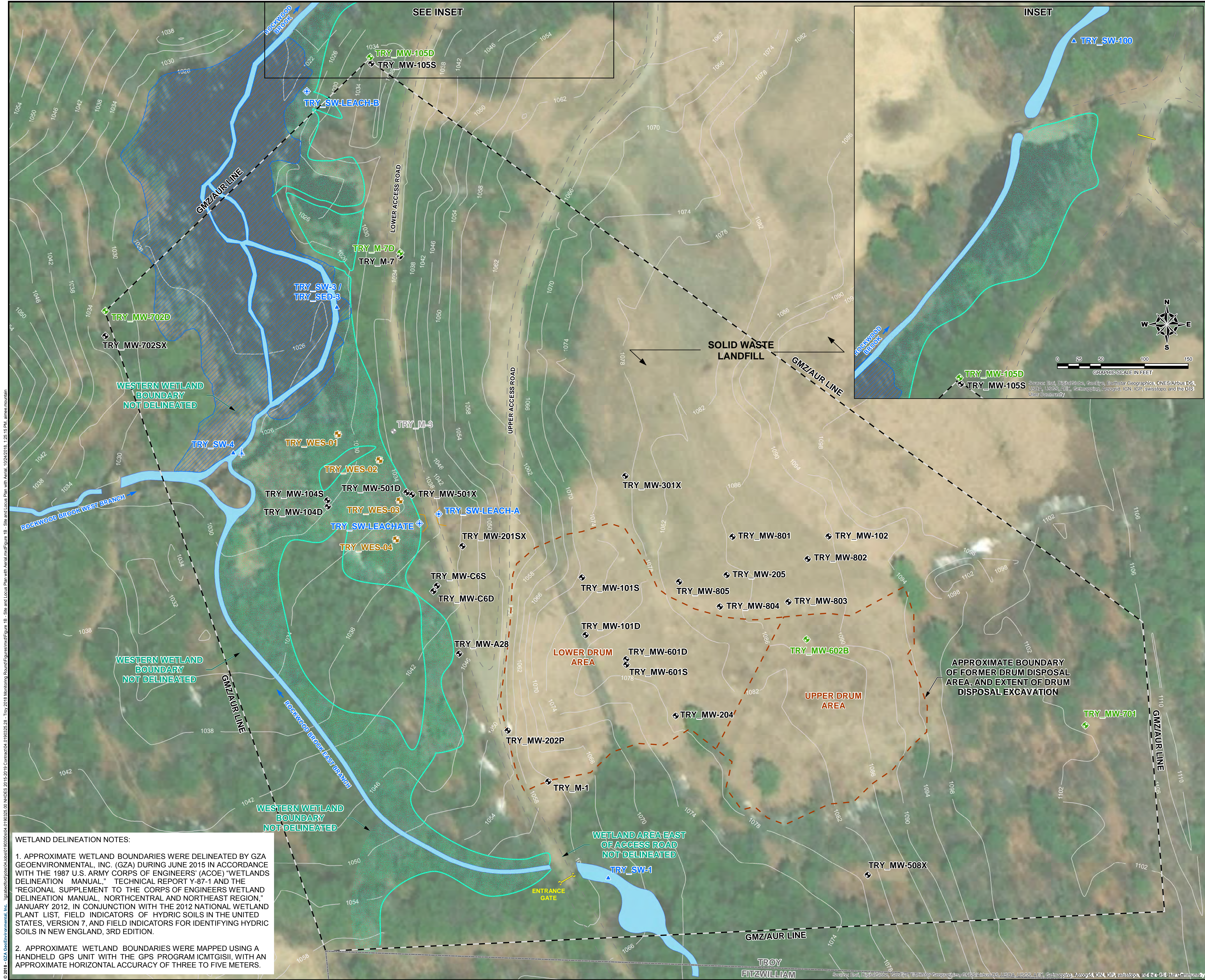
UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR THE USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

**TROY MILLS LANDFILL
SUPERFUND SITE
TROY, NEW HAMPSHIRE**

LOCUS AND SITE EXPLORATION PLAN

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: NHDES/EPA	
PROJ MGR: TPJ	REVIEWED BY: SRL	CHECKED BY: CGL	FIGURE 1A
DESIGNED BY: TPJ	DRAWN BY: ADM	SCALE: 1 in = 50 ft	
DATE: OCT 2018	PROJECT NO: 04.0190325.28	REVISION NO: 1	

© 2018 - GZA GeoEnvironmental, Inc. Upgraded and Revised 10/30/2018 01:00:00:00. NHDES 3315-2018 Contract 04.0190325.28. Troy Mills Landfill Superfund Site, Site and Locus Plan no Aerial, 10/24/2018 1:27:44 PM, amsw.mountain



LOCUS PLAN

0 1,000 2,000 4,000 6,000
GRAPHIC SCALE IN FEET

LEGEND:

- MW-701 BEDROCK MONITORING WELL
- MW-601 OVERBURDEN MONITORING WELL
- WES-01 WETLAND SOIL SAMPLE LOCATION
- SW-1 SURFACE WATER AND/OR SEDIMENT SAMPLE LOCATION
- SW-LEACH-A LEACHATE SAMPLE LOCATION
- PERMANENTLY INSTALLED STAFF GAUGE
- M-3 GZA DECOMMISSIONED WELL
- STREAM FLOW DIRECTION
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- APPROXIMATE LOCATION OF FORMER DRUM DISPOSAL AREA
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- CULVERT
- ENTRANCE GATE
- GMZ/AUR
- GRAVEL ACCESS ROAD
- TOWN LINE
- APPROXIMATE EXTENT OF FORMER PONDING
- APPROXIMATE WETLAND AREA
- SURFACE WATER

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0 25 50 100 150
GRAPHIC SCALE IN FEET

UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR THE USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

**TROY MILLS LANDFILL
SUPERFUND SITE
TROY, NEW HAMPSHIRE**

LOCUS AND SITE EXPLORATION PLAN - AERIAL VIEW

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	PREPARED FOR: NHDES/EPA
PROJ MGR: TPJ DESIGNED BY: TPJ DATE: OCT 2018	REVIEWED BY: SRL DRAWN BY: ADM PROJECT NO. 04.0190325.28
CHECKED BY: CGL SCALE: 1 in = 50 ft REVISION NO. 1	FIGURE 1B

© 2018 - GZA GeoEnvironmental, Inc. 10/19/2018 04:01:00 0190325.28 - Troy Mills Landfill, Superfund Site, Aerial View, Figure 1B - Site and Locus Plan with Aerial Imagery. 10/19/2018 04:01:00 0190325.28 - Troy Mills Landfill, Superfund Site, Aerial View, Figure 1B - Site and Locus Plan with Aerial Imagery. 10/19/2018 04:01:00 0190325.28 - Troy Mills Landfill, Superfund Site, Aerial View, Figure 1B - Site and Locus Plan with Aerial Imagery.

Tables

Table 1 - Contaminants of Concern, Analytes, Associated ICLs, Standards and Lab Criteria
Troy Mills Landfill Superfund Site, Troy, New Hampshire

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GROUNDWATER			
Test Methods / Analytes	Laboratory Reporting Detection Limits (RDLs)	NHDES Ambient Groundwater Quality Standards (AGQS) Env-Or 600	ROD Interim Concentration Levels (ICLs)
Contaminants of Concern - ARA			
VOCs by EPA Method 8260C (µg/L)			
Vinyl Chloride	2	2	2
cis-1,2-Dichloroethene	2	70	70
2-Butanone(MEK)	10	4,000	4,000
Tetrahydrofuran(THF)	10	600	154
Benzene	2	5	5
Trichloroethene	2	5	5
Toluene	2	1,000	1000
Tetrachloroethene	2	5	5
n-Propyl benzene	2	260	260
1,3,5-Trimethylbenzene	2	330	330
1,2,4-Trimethylbenzene	2	330	330
p-Isopropyl toluene	2	260	260
n-Butyl benzene	2	260	260
Naphthalene	5	100 ⁴	20
SVOCs by EPA Method 8270D (µg/L)			
Naphthalene	0.5	100 ⁴	20
Pentachlorophenol	10	1	1
Bis-(2-ethylhexyl)phthalate	5	6	6
Benzo(b)fluoranthene	0.5	0.1	0.1
Benzo(a)pyrene	0.2	0.20	0.20
Dibenzo(a,h)anthracene	0.5	0.1	0.1
Metals by EPA Method 6020A (mg/L)			
Arsenic	0.005	0.01	0.05
Manganese	0.01	0.84	---
Boron ⁷	0.01	0.62	0.62
Contaminants of Interest - ARA			
1,4 Dioxane by 8260 SIMS (µg/L)	0.25	0.32 ⁵	---
Additional Analytes - ARA (PFAS samples subcontracted to Maxxam in Mississauga, Ontario, Canada)			
PFAS by EPA Method 537Mod (ng/L)			
Perfluorobutanoic acid (PFBA)	2.0	---	---
Perfluoropentanoic acid (PFPeA)	2.0	---	---
Perfluorohexanoic acid (PFHxA)	2.0	---	---
Perfluoroheptanoic acid (PFHpA)	2.0	---	---
Perfluorooctanoic acid (PFOA)	2.0	70	---
Perfluorononanoic acid (PFNA)	2.0	---	---
Perfluorodecanoic acid (PFDA)	2.0	---	---
Perfluoroundecanoic acid (PFUnA)	2.0	---	---
Perfluorododecanoic acid (PFDoA)	2.0	---	---
Perfluorotridecanoic acid (PFTeDA)	2.0	---	---
Perfluorotetradecanoic acid (PFTeDA)	2.0	---	---
Perfluorobutanesulfonic acid (PFBS)	2.0	---	---
Perfluorohexanesulfonic acid (PFHxS)	2.0	---	---
Perfluoroheptanesulfonic acid (PFHpS)	2.0	---	---
Perfluorooctanesulfonic acid (PFOS)	2.0	70	---
Perfluorodecanesulfonic acid (PFDS)	2.0	---	---
Perfluorooctanesulfonamide (PFOSA)	2.0	---	---
6:2 Fluorotelomersulfonate (6:2 FTS)	2.0	---	---
8:2 Fluorotelomersulfonate (8:2 FTS)	2.0	---	---

Notes:

- Interim Concentration Levels established in the Record of Decision (ROD)
- "---" indicates no standard was available for the analyte.
- µg/L = micrograms per liter; mg/L = milligrams per liter; ng/L = nanograms per liter
- The AGQS for naphthalene was increased from 20 µg/L to 100 µg/L on September 1, 2018.
- The AGQS for 1,4-dioxane was decreased from 3 µg/L to 0.32 µg/L on September 1, 2018.
- PFAS = Per- & Poly-Fluorinated Alkyl Substances. There are no ROD ICLs for PFAS.
- Boron will not be analyzed at the present time. Future sampling rounds will consider the analysis of Boron.
- Green Shaded cells indicate those parameters for which the laboratory can't achieve the action limit for an analyte. The evaluation of the data will be qualitative relative to the historical trends of those particular analytes. In the future, as the concentrations of the contaminants-of-concern of various media appear to decline closer to the action limits established, consideration will be given to the need for use of alternative test methods that may be able to achieve lower detection limits where needed.

Table 1 - Contaminants of Concern, Analytes, Associated ICLs, Standards and Lab Criteria
Troy Mills Landfill Superfund Site, Troy, New Hampshire

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LEACHATE				
Test Methods / Analytes	Laboratory Reporting Detection Limits (RDLs)	Ambient Groundwater Quality Standards (AGQS)	Surface Water Quality Criteria (Env-Wq 1700)	ROD Interim Leachate Cleanup Levels
Contaminants of Concern - ARA				
SVOCs by EPA Method 8270D (µg/L)				
<i>Bis-(2-ethylhexyl)phthalate</i>	5	6	3	40
Contaminants of Interest - ARA				
VOCs by EPA Method 8260C (µg/L)				
<i>Vinyl Chloride</i>	2	2	---	---
<i>cis-1,2-Dichloroethene</i>	2	100	11,600*	---
<i>2-Butanone(MEK)</i>	10	4,000	---	---
<i>Tetrahydrofuran(THF)</i>	10	600	---	---
<i>benzene</i>	2	5	5300	---
<i>Trichloroethene</i>	2	5	21,900	---
<i>Toluene</i>	2	1,000	---	---
<i>Tetrachloroethene</i>	2	5	890	---
<i>n-Propyl benzene</i>	2	260	---	---
<i>1,3,5-Trimethylbenzene</i>	2	330	---	---
<i>1,2,4-Trimethylbenzene</i>	2	330	---	---
<i>p-Isopropyl toluene</i>	2	260	---	---
<i>n-Butyl benzene</i>	2	260	---	---
<i>Naphthalene</i>	5	100 ⁵	620	---
SVOCs by EPA Method 8270D (µg/L)				
<i>Naphthalene</i>	0.5	20	620	---
<i>Pentachlorophenol</i>	10	1	4.05	---
<i>Benzo(b)fluoranthene</i>	0.5	0.05	---	---
<i>Benzo(a)pyrene</i>	0.2	0.20	---	---
<i>Dibenzo(a,h)anthracene</i>	0.5	0.01	---	---
Metals by EPA Method 6020A (mg/L)				
<i>Arsenic</i>	0.005	0.01	0.15	---
<i>Manganese</i>	0.010	0.84	---	---
<i>Hardness</i>	3.0	---	---	---

Notes:

1. Surface Water Quality Criteria (SWQC) standards assume the Protection of Aquatic Life in Freshwaters with chronic criteria. If a chronic criteria standard has not been established, GZA used the Freshwater Acute Criteria.
2. " * " indicates that the compound shown has two or more isomers. The sum of the concentrations of each isomer shall meet the SWQC.
3. " --- " indicates no standard was available for the analyte.
4. Green shaded cells indicate those parameters for which the laboratory can't achieve the action limit for an analyte.
5. The AGQS for naphthalene was increased from 20 µg/L to 100 µg/L on September 1, 2018.

Table 1 - Contaminants of Concern, Analytes, Associated ICLs, Standards and Lab Criteria
Troy Mills Landfill Superfund Site, Troy, New Hampshire

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SURFACE WATER		
Test Methods / Analytes	Laboratory Reporting Detection Limits (RDLs)	Surface Water Quality Criteria (Env-Wq 1700)
Contaminants of Interest - ARA		
VOCs by EPA Method 8260C (µg/L)		
<i>Vinyl Chloride</i>	2	---
<i>cis-1,2-Dichloroethene</i>	2	11,600*
<i>2-Butanone(MEK)</i>	10	---
<i>Tetrahydrofuran(THF)</i>	10	---
<i>benzene</i>	2	5300
<i>Trichloroethene</i>	2	21,900
<i>Toluene</i>	2	---
<i>Tetrachloroethene</i>	2	890
<i>n-Propyl benzene</i>	2	---
<i>1,3,5-Trimethylbenzene</i>	2	---
<i>1,2,4-Trimethylbenzene</i>	2	---
<i>p-Isopropyl toluene</i>	2	---
<i>n-Butyl benzene</i>	2	---
<i>Naphthalene</i>	5	620
SVOCs by EPA Method 8270D (µg/L)		
<i>Naphthalene</i>	0.5	620
<i>Pentachlorophenol</i>	10	4.05
<i>Bis-(2-ethylhexyl)phthalate</i>	5	3
<i>Benzo(b)fluoranthene</i>	0.5	---
<i>Benzo(a)pyrene</i>	0.2	---
<i>Dibenzo(a,h)anthracene</i>	0.5	---
Metals by EPA Method 6020A (mg/L)		
<i>Arsenic</i>	0.005	0.15
<i>Manganese</i>	0.010	---
<i>Hardness</i>	3.0	---

Notes:

1. There are no ROD Interim Cleanup Goals established for surface water.
2. Surface Water Quality Criteria (SWQC) standards assume the Protection of Aquatic Life in Freshwaters with chronic criteria. If a chronic criteria standard has not been established, GZA used the Freshwater Acute Criteria.
3. " * " indicates that the compound shown has two or more isomers. The sum of the concentrations of each isomer shall meet the SWQC.
4. " --- " indicates no standard was available for the analyte.
5. Green shaded cells indicate those parameters for which the laboratory can't achieve the action limit for an analyte.

Table 1 - Contaminants of Concern, Analytes, Associated ICLs, Standards and Lab Criteria
Troy Mills Landfill Superfund Site, Troy, New Hampshire

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WETLAND SOIL

Test Methods / Analytes	Laboratory Reporting Detection Limits (RDLs)	Soil Remediation Standards Env- Or 600 (Dry Weight)
Contaminants of Interest - ARA		
Metals by EPA Method 6020A (mg/kg dry)		
<i>Arsenic</i>	2.5	11
<i>Manganese</i>	5.0	1,000
Contaminants of Interest - ARA		
SVOCs by EPA Method 8270D (mg/kg, ABN)		
<i>Naphthalene</i>	0.05	5
<i>Pentachlorophenol</i>	1.0	3
<i>Bis(2-ethylhexyl)phthalate</i>	0.50	---
<i>Benzo(b)fluoranthene</i>	0.05	1
<i>Benzo(a)pyrene</i>	0.05	0.7
<i>Dibenzo(a,h)anthracene</i>	0.05	0.7
Contaminants of Interest - ARA (TOC samples subcontracted to Test America)		
Total Organic Carbon by Lloyd Kahn Method (mg/kg)	1,000	---

Notes:

1. There are no ROD Interim Cleanup Goals established for wetland soil.
2. "----" indicates no information available for that compound.
3. Laboratory reporting in dry weight for all wetland soil data results.

Table 1 - Contaminants of Concern, Analytes, Associated ICLs, Standards and Lab Criteria
Troy Mills Landfill Superfund Site, Troy, New Hampshire

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SEDIMENTS		
Test Methods / Analytes	Laboratory Reporting Detection Limits (RDLs)	SQuiRT TEC ⁵ (Dry Weight)
Contaminants of Interest - ARA		
VOCs by EPA Method 8260C (mg/kg dry)		
<i>Vinyl Chloride</i>	0.1	---
<i>cis-1,2-Dichloroethene</i>	0.1	---
<i>2-Butanone(MEK)</i>	0.5	---
<i>Tetrahydrofuran(THF)</i>	0.5	---
<i>benzene</i>	0.1	---
<i>Trichloroethene</i>	0.1	---
<i>Toluene</i>	0.1	---
<i>Tetrachloroethene</i>	0.1	---
<i>n-Propyl benzene</i>	0.1	---
<i>1,3,5-Trimethylbenzene</i>	0.1	---
<i>1,2,4-Trimethylbenzene</i>	0.1	---
<i>p-Isopropyl toluene</i>	0.1	---
<i>n-Butyl benzene</i>	0.1	---
<i>Naphthalene</i>	0.1	176
Metals by EPA Method 200.7/200.8 (mg/kg dry)		
<i>Arsenic</i>	2.5	9.79
<i>Manganese</i>	5.0	---
Contaminants of Interest - ARA		
SVOCs by EPA Method 8270D (mg/kg, ABN)		
<i>Naphthalene</i>	0.05	176
<i>Pentachlorophenol</i>	1.0	---
<i>Bis(2-ethylhexyl)phthalate</i>	0.50	---
<i>Benzo(b)fluoranthene</i>	0.05	---
<i>Benzo(a)pyrene</i>	0.05	150
<i>Dibenzo(a,h)anthracene</i>	0.05	33
Contaminants of Interest - ARA (TOC samples subcontracted to Test America)		
Total Organic Carbon by Lloyd Kahn Method (mg/kg)	1,000	---

Notes:

1. There are no ROD Interim Cleanup Goals established for sediment.
2. "---" indicates no information available for that compound.
3. Laboratory reporting in dry weight for all sediment data results.
4. Buchman, M.F., 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration. "TEC" is Threshold Effect Concentration, which is consensus-based and incorporates the Ontario Ministry of the Environment lowest-observed effect levels (LELs) (Persaud et al 1993) as well as data from up to five other sediment quality guidelines (when available), including:
 - threshold effects levels (TELs) (Smith et al. 1996); effects range-low (ER-L) values (Long and Morgan 1991),
 - threshold effect levels for *Hyalella azteca* in 28 day tests (TEL-HA28) (USEPA 1996a; Ingersoll et al. 1996),
 - minimal effect thresholds (MET) from EC and MENVIQ (1992), and
 - chronic equilibrium partitioning thresholds (SQAL) (Bolton et al. 1985; Zarba 1992; USEPA 1997a).
5. Green shaded cells indicate those parameters for which the laboratory can't achieve the action limit for an analyte.

Table 2 - Sample Locations and Analytical Parameters
Troy Mills Landfill Superfund Site, Troy, New Hampshire

SAMPLE LOCATION AND DESIGNATION	QC Samples (Table 5) ¹	WELL TYPE	SAMPLE METHOD	PARAMETERS ^{2,4}		SAMPLING RATIONALE
				PFAS ³ (11 Wells)	Other (for All Locations)	
GROUNDWATER (32 Locations Total)						
TRY_M-1		Overburden	QED T1300 Bladder Pump		<div>Comprehensive Water Level Round ⁵</div> <div>Well Depth: TRY_MW-702SX and TRY_M-1 (if feasible)</div> <div>Field Measurements: Water Levels, Dissolved Oxygen, Temperature, Oxygen Reduction Potential, Specific Conductance, pH, and Turbidity</div> <div>Laboratory Analyses: VOCs (8260C) SVOCs (8270) As & Mn (SW846 6020A) 1,4-Dioxane (8260 SIM)</div>	Monitoring contaminants migrating from the Lower Drum Area
TRY_M-7	DUP 1,4-Dioxane only	Overburden		x		Near northwestern compliance boundary.
TRY_M-7D		Bedrock				Near northwestern compliance boundary.
TRY_MW-A28 ⁶	DUP SVOCs only	Overburden	Peristaltic	x		Drilled in the location of soil boring TRY_SO-A28-8.1 in LNAPL Investigation
TRY_MW-C6S	DUP VOCs, 1,4-dioxane, As & Mn, PFAS only	Overburden		x		Downgradient of former drum removal area, was used to monitor LNAPL thickness.
TRY_MW-C6D		Overburden	QED T1250 Bladder Pump			
TRY_MW-101S		Overburden		x		In former drum disposal area. Monitor groundwater quality changes and natural attenuation.
TRY_MW-101D ⁶		Overburden				Side gradient of former drum disposal area.
TRY_MW-102		Overburden	QED SamplePro	x		Downgradient of former drum disposal area and within wetland.
TRY_MW-104S		Overburden				
TRY_MW-104D		Overburden	QED T1250 Bladder Pump			
TRY_MW-105S		Overburden		x		
TRY_MW-105D		Bedrock	QED SamplePro			Groundwater Management Zone sentinel monitoring wells
TRY_MW-201SX ⁶		Overburden	QED T1250 Bladder Pump			Downgradient of former drum removal area.
TRY_MW-202P		Overburden	QED SamplePro			Monitoring contaminants migrating from the Lower Drum Area
TRY_MW-204		Overburden	QED T1250 Bladder Pump			Former drum disposal area. Monitor groundwater quality changes and natural attenuation.
TRY_MW-205 ⁶		Overburden		x		Solid waste area, and area of groundwater impact adjacent to former drum disposal area. Monitor groundwater quality changes and natural attenuation.
TRY_MW-301X		Overburden	QED SamplePro			Solid waste area, and near/side gradient of drum disposal area. Monitor groundwater quality changes and natural attenuation.
TRY_MW-501X		Overburden				
TRY_MW-501D		Overburden	QED T1250 Bladder Pump			Downgradient of former drum removal area, and within area of groundwater impact. Monitor groundwater quality and natural attenuation.
TRY_MW-508X		Overburden	QED SamplePro			Background monitoring well.
TRY_MW-601S		Overburden				Former drum disposal area. Monitor groundwater quality changes and natural attenuation.
TRY_MW-601D		Overburden	QED T1250 Bladder Pump			
TRY_MW-602B		Bedrock		x		
TRY_MW-701		Bedrock		x		Near eastern compliance boundary and bedrock background.
TRY_MW-702SX		Overburden				Groundwater Management Zone sentinel monitoring wells
TRY_MW-702D		Bedrock				
TRY_MW-801		Overburden	QED SamplePro			
TRY_MW-802		Overburden				
TRY_MW-803 ⁶		Overburden				
TRY_MW-804 ⁶	DUP VOCs, SVOCs, As & Mn, PFAS only	Overburden	QED T1250 Bladder Pump	x		Investigation around TRY_MW-205 due to the observed high level of methane, trimethylbenzenes, and bis(2-ethylhexyl phthalate)
TRY_MW-805		Overburden	QED SamplePro	x		
LEACHATE						
TRY_SW-LEACHATE	DUP for All	N/A	Glass Jar		VOCs, SVOCs, Mn, As, & Hardness	See the Sampling and Analysis Plan for rationale
TRY_SW-LEACH-A						
TRY_SW-LEACH-B						
SURFACE WATER						
TRY_SW-1		N/A	Glass Jar		VOCs, SVOCs, Mn, As, & Hardness	See the Sampling and Analysis Plan for rationale
TRY_SW-3	DUP for All					
TRY_SW-4						
TRY_SW-100						
SEDIMENT (sediment samples will not be collected during 2018)						
TRY_SED-3	DUP for All	N/A	SS Scoop		VOCs/% solid, SVOCs, Mn, As, TOC & Grain Size	See the Sampling and Analysis Plan for rationale
WETLAND SOILS (wetland soil samples will not be collected during 2018)						
TRY_WES-01		N/A	SS Hand Auger or Shovel		SVOCs, Mn, As, & TOC	See the Sampling and Analysis Plan for rationale
TRY_WES-02						
TRY_WES-03	DUP for All					
TRY_WES-04						
EQUIPMENT BLANKS (Refer to Table 5 for QC samples)						
QED SamplePro Bladder Pump (collected after use/decon in TRY_MW-805)				x	VOCs, Mn & As, 1,4-dioxane, PFAS	Decontamination does not include Hexane & 2-propanol)
Water Level Probe (collected after use/decon in TRY_MW-804)					SVOCs	Decontamination includes Hexane & 2-propanol)

Notes:

1. Refer to **Table 5** for specific QC (quality control) sampling requirements and analysis (equipment blanks, etc.).
2. Refer to **Table 3** for specific information on trip blanks, containers, preservatives and hold times.
3. Per-and Polyfluoroalkyl Substances (PFAS).
4. Manganese is the only metal over the AGQS; Arsenic is a contaminant of concern. Arsenic will be sampled in groundwater every five years in the sampling round before the Five Year Review. We are no longer sampling for the following metals: Ag, Ba, Cd, Cr, Fe, Pb, Se and Mercury.
5. A comprehensive water level round will be conducted prior to the beginning of sampling.
6. These wells require decontamination of equipment using hexane and 2-propanol due to high levels of DEHP. All other wells may be decontaminated with a soap and water wash only.

TABLE 3 - Media, Analysis, Test Methods, Containers/Sample Volume, Preservation, and Hold Time
Troy Mills Landfill Superfund Site, Troy, New Hampshire

Parameters	Number of Samples Including Field QC ^{1,2}	Analytical Method	Containers (Type and Size)	Preservation Requirements ³	Maximum Holding Time
Absolute Resource Associates					
Groundwater Samples					
VOCs	32 field samples, 2 duplicates, 1 equipment blank; trip blanks	NHDES VOC Full List (8260C)	2 - 40-mL VOA ¹	HCL 4°C +/- 2°C	14 days
SVOCs ⁵	32 field samples; 2 duplicates; 1 equipment blanks	8270D	1 - 1L Amber	4°C +/-2°C	7 days to extract, 40 days to analyze
Total AS, Mn & Hardness	32 field samples, 2 duplicates; 1 equipment blank	SW846 6020A	1- 250 ml plastic	HNO ₃	6 months
1,4-Dioxane	32 field samples, 2 duplicates, 1 equipment blank, trip blanks,	8260C SIM	2 - 40-mL VOA ¹	4°C +/-2°C	14 days
Leachate Samples					
VOCs	2 field samples, 1 duplicate, trip blanks	NHDES VOC Full List (8260C)	2 - 40-mL VOA ¹	HCL 4°C +/- 2°C	14 days
SVOCs ⁵	2 field sample, 1 duplicate	8270D	1 - 1L Amber	4°C +/-2°C	7 days to extract, 40 days to analyze
Total Mn, As & Hardness	2 field sample, 1 duplicate	SW846 6020A	1- 250 ml plastic	HNO ₃	6 months
Surface Water Samples					
VOCs	4 field samples, 1 duplicate, trip blanks	NHDES VOC Full List (8260C)	2 - 40-mL VOA ¹	HCL 4°C +/- 2°C	14 days
SVOCs ⁵	4 field samples; 1 duplicate	8270D	1 - 1L Amber	4°C +/-2°C	7 days to extract, 40 days to analyze
Total Mn, As & Hardness	4 field samples; 1 duplicate	SW846 6020A	1- 250 ml plastic	HNO ₃	6 months
Maxxam Analytics (ARA Subcontractor)					
Groundwater Samples					
PFAS	11 field samples, 1 duplicate, 2 equipment blanks, 2 field blanks, trip blanks	EPA Method 537 Mod	2- 125 mL polypropylene ¹	Unpreserved 4°C +/-2°C	14 days
Absolute Resource Associates (TOC subcontracted to Test America, Grain Size subcontracted to SW Cole)					
Sediment Samples					
VOCs (dry weight determined in metals samples)	1 field sample, 1 duplicate, trip blanks	NHDES VOC Full List (8260C)	1 - 40-mL VOA ¹	Methanol, 4°C +/-2°C	14 days
Mn & As / dry weight ⁴	1 field sample; 1 duplicate	SW846 6020A	8 oz. glass	4°C +/-2°C	6 months
SVOCs ⁵	1 field sample; 1 duplicate	8270D	1- 4 oz. glass	4°C +/-2°C	14 days to extract, 40 days to analyze
Total Organic Carbon	1 field sample; 1 duplicate	Lloyd Kahn Method	1- 4 oz. glass	4°C +/-2°C	28 Days
Grain Size	1 field sample	ASTM E112-13	8 oz. glass	Unpreserved	None
Wetland Soil Samples					
Mn & As / dry weight	4 field samples; 1 duplicate	SW846 6020A	8 oz. glass	4°C +/-2°C	6 months
SVOCs ⁵	4 field samples; 1 duplicate	8270D	1- 4 oz. glass	4°C +/-2°C	14 days to extract, 40 days to analyze
Total Organic Carbon	4 field samples; 1 duplicate	Lloyd Kahn Method	1- 4 oz. glass	4°C +/-2°C	28 Days

Notes:

1. Trip blanks will be included with each cooler containing VOC samples. Trip blanks will include HCL-preserved blanks for aqueous VOC samples (1 VOA vial), unpreserved blanks for 1,4-Dioxane 8260 SIM method (2 VOA vials), unpreserved blanks for PFAS (2-125 mL polypropylene), and methanol preserved blanks for solid samples (1 VOA vial) as needed. There will be one temperature blank per cooler.
2. Refer specifically to **Table 5** for equipment blank details as well as other QC sampling requirements.
3. Note that the pH requirements for samples preserved via an acid are less than 2 units; via a base are greater than 12 units. .
4. Dry weight for sediment and soil samples are taken from an unpreserved sample by each laboratory.
5. "SVOCs" consist of semi-volatile organic compounds analyzed by EPA Method 8270D, including acid/base/neutral extractables.

Table 4 - Well Construction Information
Troy Mills Landfill Superfund Site, Troy, New Hampshire

Monitoring Well Designation	Well Type (2-in, 1.5-in etc.)	Screened Geologic Unit	Depth to Well Bottom ¹ (ft, referenced to measuring point)	2014, 2015, and 2016 Depth to Well Bottom ⁷ (ft, referenced to measuring point)	Screen Interval (ft, referenced to measuring point)	Screen Length (ft)	Reference Measuring Point	Height of Stickup of Measuring Point (ft)	Bladder Pump Model	Bladder Length in feet (L) / Diameter in inches (D) / & Capacity in mL (C)	Sampling Method	Historical Low Water Level ² (ft, referenced to measuring point)	Recommended Depth of Bladder Pump Intake (ft, referenced to measuring point)	Pump Intake Distance from Top of Screen (ft, referenced to measuring point)	Distance Between Pump Intake and Bottom of Well ³ (ft, referenced to measuring point)
TRY_M-1	1 1/2-in PVC	Overburden	67.3 ⁴	63.40	8.3-67.3 ⁴	59	PVC	0.64	QED T1300	3.8-ft L, 1-in D, 220-mL C	Low Flow	8.76	55.0	46.7	12.3
TRY_M-7	1 1/2-in PVC	Overburden	17.3	---	7.8-17.3	9.5	PVC	1.61	QED T1300	3.8-ft L, 1-in D, 220-mL C	Low Flow	8.76	15.8	8.0	1.5
TRY_M-7D	1 1/2-in PVC	Bedrock	81.36	81.50	50.8-80.8	30	PVC	1.49	N / A ⁶	N / A ⁶	Low Flow	5.58	74.0 ⁶	23.2 ⁶	6.8 ⁶
TRY_MW-A28	1 1/2-in PVC	Overburden	13.03	13.0	8.03	5	PVC	3.03	N / A ⁶	N / A ⁶	Low Flow	9.28	11.1 ⁶	3.1 ⁶	1.9 ⁶
TRY_MW-C6S	2-in PVC	Overburden	15.2	15.00	5.2-15.2	10	PVC	1.79	N / A ⁶	N / A ⁶	Low Flow	6.80	11.0 ^{6,9}	5.8 ⁶	4.2 ⁶
TRY_MW-C6D	2-in PVC	Overburden	37.97	37.97	28.0-38.0	10	PVC	2.50	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	7.18	33.0	5.0	5.0
TRY_MW-101S	2-in PVC	Overburden	29.40	29.4	19.4-29.4	10	PVC	1.71	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	21.30	24.4	5.0	5.0
TRY_MW-101D	2-in PVC	Overburden	67.12	67.1	57.1-67.1	10	PVC	2.50	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	18.86	62.1	5.0	5.0
TRY_MW-102	2-in PVC	Predominantly Overburden	36.2 ⁴	35.80	21.2-36.2 ⁴	15	Casing	2.89	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	25.31	34.0	13.0	2.2
TRY_MW-104S	2-in PVC	Overburden	17.7 ⁴	17.3	5-17 ^{4,5}	12	PVC	2.17	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	4.39	15.5	10.5	1.5
TRY_MW-104D	2-in PVC	Overburden	52.1 ⁴	52.4	37.1-52.1 ⁴	15	PVC	2.48	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	4.24	48.0	10.9	4.1
TRY_MW-105S	2-in PVC	Overburden	21.08	---	6.5-19.5 ⁴	13	PVC	---	QED T1250	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	11.58	17.5	11.0	3.6
TRY_MW-105D	2-in PVC	Bedrock	87.92	87.70	48.5-88.2 ⁴	39.7	PVC	1.89	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	12.65	68.0	19.5	20.2
TRY_MW-201SX	2-in PVC	Overburden	17.23	17.2	7.2-17.2	10	PVC	1.69	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	7.54	12.2	5.0	5.0
TRY_MW-202P	4-in PVC	Overburden	61.55	61.35	4.9-59.9 ⁴	55	PVC	1.96	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	9.97	52.5	47.6	7.4
TRY_MW-204	2-in PVC	Overburden	32.8	---	22.8-32.8	10	PVC	2.6	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	21.52	31.3	8.5	1.5
TRY_MW-205	2-in PVC	Overburden	39.1	---	29.1-39.1	10	PVC	2.07	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	33.42	37.6	8.5	1.5
TRY_MW-301X	2-in PVC	Overburden	52.5	52.50	42.5-52.5	10	PVC	2.42	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	35.55	47.5	5.0	5.0
TRY_MW-501X	2-in PVC	Overburden	14.04	14.00	4.0-14.0	10	PVC	2.02	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow ⁸	6.39	10.2 ⁹	6.2	3.8
TRY_MW-501D	2-in PVC	Overburden	31.85	31.85	21.9-31.9	10	PVC	2.17	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	6.22	26.9	5.0	5.0
TRY_MW-508X	2-in PVC	Overburden	9.7	10.0	4.7-9.7	5	PVC	2.9	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	6.45	8.1 ⁹	3.4	1.6
TRY_MW-601S	2-in PVC	Overburden	29.3	---	14.3-29.3	5	PVC	2.69	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	21.80	27.8	13.5	1.5
TRY_MW-601D	2-in PVC	Overburden	62.1	---	52.1-62.1	10	PVC	2.23	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	23.10	57.1	5.0	5.0
TRY_MW-602B	2-in PVC	Bedrock	47.5	---	37.5-47.5	10	PVC	2.12	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	21.76	42.5	5.0	5.0
TRY_MW-701	2-in PVC	Bedrock	78.3	---	18.3-78.3	60	PVC	3.18	QED T1250	1.2-ft L, 1.5-in D, 100-mL C	Low Flow	10.70	48.3	30.0	30.0
TRY_MW-702SX	2-in PVC	Overburden	15.4	14.90	5.4-15.4	10	PVC	3.9	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	7.95	11.7 ⁹	6.3	3.7
TRY_MW-702D	2-in PVC	Bedrock	46.4 ^{4,5}	46.70	19.4-46.4 ^{4,5}	27	PVC	2.44	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	6.55	33.0	13.6	13.4
TRY_MW-801	2-in PVC	Overburden	46.4	46.50	36.4-46.4	10	PVC	2.25	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	33.46	41.4	5.0	5.0
TRY_MW-802	2-in PVC	Overburden	35.6	35.70	25.6-35.6	10	PVC	2.1	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	29.18	32.4	6.8	3.2
TRY_MW-803	2-in PVC	Overburden	32.3	32.20	22.3-32.3	10	PVC	2.15	QED T1250	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	29.12	30.7	8.4	1.6
TRY_MW-804	2-in PVC	Overburden	36.0	36.10	26.0-36.0	10	PVC	2.32	QED T1250	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	31.71	33.9	7.9	2.1
TRY_MW-805	2-in PVC	Overburden	42.4	42.50	32.4-42.4	10	PVC	2.37	QED Sample Pro	1.2-ft L, 1.75 in D, 100-mL C	Low Flow	31.41	37.4	5.0	5.0

TABLE KEY:

in = Inch
ft = Feet
PVC = Polyvinyl chloride
LNAPL = Light Non-aqueous Phase Liquid
L = Length
D = Diameter
C = Capacity
mL = milliliters
"---" = No data available
N / A = Not applicable
No Purge/IR = No purge due to insufficient recharge

SPECIFIC NOTES:

- Depth to Well Bottom are field measured unless otherwise noted.
- Historical low water levels are compiled from water level measurements taken from 2006 to the present. This data is checked yearly and updated as necessary. Refer to Table 3 - Groundwater Level Measurements and Elevation Data for historical groundwater levels and elevations. The historical low water level for well TRY_MW-C6S was taken from the 11/19/12 measurement included on Table 4 - Summary of LNAPL Well Observations of the June 2013 Monitoring Report.
- The distance between pump intake and bottom of the well is calculated using the Depth to Well Bottom information.
- Downhole information was not verified during the October 8, 2008 camera survey.
- GZA notes that there appears to be a minor discrepancy between the historical information regarding the bottom of screen/well and that which was measured during 2014 by GZA in well TRY_MW-702D.
- Wells TRY_MW-A28 and TRY_M-7D have a 1.5-inch diameter, which is too small to accommodate a SamplePro Bladder pump; therefore, a peristaltic pump and dedicated poly tubing is used to sample these wells. The last three columns of the table (Recommended Depth of Bladder Pump Intake, etc.) refer to the intake depth of the poly tubing used for sampling. Well TRY_MW-C6S was also be sampled with a peristaltic pump during the May 2016 sampling round.
- Wells without 2014/2015 well bottom information contained dedicated sampling equipment preventing a well bottom measurement. TRY_MW-702SX was re-checked in 2016.
- This well had insufficient recharge for low flow sampling during 2016; a grab sample was collected instead.
- The depth of the pump intake at these wells should be adjusted prior to the next sampling round based on the historical low water level measurement. The proposed future tubing depth is displayed on this table.

Table 5 - Summary of Quality Assurance Samples to be Collected

Troy Mills Landfill Superfund Site, Troy, New Hampshire








Troy Mills Landfill Superfund Site	Associated Sampling Equipment	Sample ID	Designated NOTE to be used on Chain-of-Custody	Analyses ^{1,2,3}
GROUNDWATER EQUIPMENT BLANK SAMPLES				
(collected after sampling MW-805/after regular less stringent decon)	QED Sample Pro Bladder Pump	EQUIP BLANK	“QED Sample Pro/805”	VOCs, Mn, As, 1,4-Dioxane, PFAS
(collected after sampling TRY_MW-804/and more stringent Hexane decon)	Water Level	EQUIP BLANK	“Water Level/804”	SVOCs
DUPLICATE SAMPLES				
Groundwater	Peristaltic Pump	TRY_MW-A28 DUP	N/A	SVOCs
		TRY_MW-C6S DUP	N/A	VOCs, 1,4-Dioxane, As & Mn, PFAS
	Bladder Pump	TRY_M-7 DUP	N/A	1,4-Dioxane
		TRY_MW-804 DUP	N/A	VOCs, SVOCs, As, Mn & PFAS
Leachate	Clean Glass Jar	TRY_SW-LEACHATE DUP	N/A	VOCs, SVOCs, Mn, As & Hardness
Surface Water	Clean Glass Jar	TRY_SW-4	N/A	VOCs, SVOCs, Mn, As & Hardness
Sediment	N/A	TRY_SED-3	N/A	VOCs, SVOCs/% solid, Mn, As, TOC, grain size
Wetland Soil	N/A	TRY_WES-03	N/A	SVOCs, Mn, As & TOC
TRIP BLANK SAMPLES				
1 per cooler with VOCs, 1,4-dioxane, or PFAS samples	Preservatives (4°C +/- 2°C)	TRIP BLANK	1 trip blank per chain-of-custody per cooler per analyte	
VOCs (1 VOA Vial)	HCL			VOCs
1,4-Dioxane (2 VOA Vials)	None			1,4-dioxane
PFAS (2 125-mL polypropylene bottles)	None			PFAS
FIELD BLANK SAMPLES				
1 per person collecting PFAS samples (2 125-mL polypropylene bottles)	Preservatives (4°C +/- 2°C)	FIELD BLANK - "sampler last name"	Name of Sampler (e.g., S. Perkins)	PFAS
	None			
TEMPERATURE BLANKS				
Temperature Blank (1 per cooler)	N/A	TEMP BLANK	Check off box on COC that a temperature blank has been included in the cooler	Temperature

Notes:

1. Refer to **Table 3** in the SAP for specific test methods for each analyses.
2. Refer to **Table 2** in the SAP for a summary of individual parameters being sampled for at each well location.
3. It is not necessary to collect equipment blanks on bailers (if they are used) because separate bailers will be used at each location. It is not necessary to collect an on new bladder pumps as previous equipment blanks on new bladder pumps have contained no contamination. In addition, other equipment blanks confirm the decontamination procedures.

Appendix A – Project Organization and Responsibilities

APPENDIX A
Project Organization and Responsibilities
Troy Mills Landfill Superfund Site, Troy, New Hampshire
NHDES 198405082

 NHDES Project Manager Michael Summerlin 603-271-3649	
	 EPA Region I Remedial Project Manager Richard W. Hull 617-918-1882
 NHDES HWRB Acting Project QA Coordinator Robin Mongeon 603-271-7378	
	 GZA Contract Principal-in-Charge Steven R. Lamb 603-232-8741 GZA Technical Principal-in-Charge John C. Murphy 603-232-8712
 GZA Project Manager QA Officer Tanya P. Justham 603-232-8765 Cell phone: 603-493-1548	
	 GZA Health and Safety Manager Richard Ecord 781-278-3809
<p style="text-align: center;"><u>Laboratory Services</u></p> <p style="text-align: center;">Absolute Resources Associates Jane Stratton 603-436-2001</p> <p style="text-align: center;">Maxxam Analytics ARA Subcontract Lab for PFAS analysis Jane Stratton 603-436-2001</p> <p style="text-align: center;"><u>Data Validation</u> GZA</p>	 GZA Technical Field Staff Matt Bergen; Field Team Leader o: 603-232-8760 / c: 603-213-1138 Megan Murphy; Sampler o: 603-232-8731 / c: 603-325-7296 Erik Dyrness; Sampler o: 603-232-8724 / c: 603-213-4544 Leland Williams; Alternate Sampler o: 603-232-8743 / c: 603-325-7131 Brian Luhrs; Alternate Sampler o: 603-232-8771 / c: 603-667-8133 Al Jacobsen; Field Technician o: 603-232-8733 / c: 603-493-1599

Appendix B – Standard Operating Procedures (SOPs)

SOP B-1
In-Situ SmarTroll Equipment Set Up and Use

IN-SITU SMARTROLL EQUIPMENT SET UP AND USE

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides step-by-step instructions on how to set up the In-Situ smartTROLL meter (referred to as the Smartroll in this SOP) prior to use in the field and a brief overview of using the Smartroll with the low flow sampling SOP in the site-specific Sampling and Analysis Plan (SAP) at the at the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

The YSI Models 600XL/XLM multiparameter meters are slowly being phased out by YSI. The Smartroll is an acceptable replacement for the YSI 600XL/600XLM models. The Smartroll combines water quality sensors with the mobility of an Android or iOS mobile device (i.e., a rugged tablet). The Smartroll was chosen because it appears to meet all of the New Hampshire Department of Environmental Services (NHDES) Hazardous Waste Remediation Bureau (HWRB) requirements for field instrumentation and will eliminate or reduce the amount of data needed to be recorded on hand written worksheets. The HWRB requires that field personnel use a rugged field electronic tablet with the Smartroll to calibrate and record data in the field in order to view all data simultaneously and clearly. It is not acceptable to use a smartphone, iPod, or equivalent due to screen-size limitations. In-Situ recommends the use of an android operating system as that operating system will be fully supported going forward. While the HWRB also recommends the use of an android operating system, this SOP contains instructions for both Android and iOS operating systems.

Once the setup has been done, very little maintenance or updating should be required between sampling rounds. Because of the impermanent nature of technology and the regular software updates provided by InSitu, this document should be considered a living document that may require updates between sampling rounds. If any questions arise in the field that cannot be answered by local support staff, it is advisable to contact In-Situ tech support at 1-800-446-7488. They are available 24 hours a day, 7 days a week, 365 days a year.

USE OF TERMS

Android: a mobile device operating system developed by Google.

App: Refers to a mobile device application. In this case, either Android VuSitu or Apple iSitu.

Apple: Apple develops computer and mobile device software, applications, and hardware. Apple operates the Apple App Store where applications may be downloaded.

Apple App Store: The location on the internet, accessed through iTunes, where applications may be downloaded to an Apple device.

Battery pack: The Battery Pack is used with the Smartroll, enables wireless (Bluetooth) communication between the Apple tablet and the multiparameter meter, and supplies power to the multiparameter meter. The Battery Pack also provides an ambient temperature measurement and a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements.

Google Play: The location on the internet where applications may be downloaded to an Android device.

iSitu: Refers to the Apple-based application (app) downloaded from iTunes and installed on your iPad tablet. The iSitu app is a user interface and control application for the Smartroll and enables collection of water quality field parameters.

iTunes: The computer/laptop interface for working with Apple devices. The Apple App Store is accessible through iTunes.

OS: Operating system. In this case, the operating systems include Apple iOS and Android OS.

Power Pack: The Power Pack is used with the Smartroll, enables wireless (Bluetooth) communication between the Android tablet and the multiparameter meter, and supplies power to the multiparameter meter. The Power Pack also provides an ambient temperature measurement and a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements.

Sonde: In this SOP the sonde refers to the instrument that houses the probes (as referenced by YSI) or sensors (as referenced by In-Situ), e.g., pH, ORP.

Test Notes: This is the area in the software (VuSitu or iSitu) on the tablet where comments can be added. According to In-Situ, the test notes section can accept an unlimited number of characters.

VuSitu: refers to the Android-based application downloaded from the Google Play Store and installed on your Android tablet. The VuSitu App is a user interface and control application for the Smartroll and enables collection of water quality field parameters.

PRECAUTIONS

It is important to verify that the correct USB, power sources (Battery pack or Power pack) and cables are available for the devices in use. The USB, power sources and cables are not interchangeable between the Android and Apple products.

EQUIPMENT AND MATERIALS

- Rugged tablet

- WinSitu downloaded to a computer/laptop. The most current version of Win-Situ can be downloaded from the In-situ website¹.
- VuSitu or iSitu mobile app downloaded to the tablet.
 - The VuSitu mobile app runs on an Android tablet and is available from the Google Play store on the intranet.
 - The iSitu mobile app runs on an iOS tablet and is available from the Apple App Store accessed through iTunes on the internet.
- Appropriate USB, power sources (Battery pack or Power pack) and cables for the specific tablet application.
- Well Construction table from the SAP (**Table 4**).
- Low flow sampling criteria from the Low Flow Sampling SOP in the SAP.

TEMPLATE/INSTRUMENT SET UP

Prior to the first time use of the Smartroll, well-specific templates shall be created with In-Situ's Win-Situ software and transferred to the Smartroll compatible mobile tablet. The well information and the low flow sampling criteria to be put into the site-specific template are found in the well construction table (**Table 4**) and the Low Flow Sampling SOP in the SAP. Templates shall be saved and utilized for subsequent sampling events.

Before you set up the template, create a separate "Templates" folder in the site-specific folder on a computer/laptop (e.g., a "Templates" folder under the New Hampshire Plating Company Superfund Site folder on your computer).

Steps to create a template are as follows:

1. **Install Win-Situ** on a desktop or laptop computer.
2. Open **Win-Situ** software. Upon start-up, **Win-Situ** will ask if you want to connect to a device now. Select **No**.
3. Select the **Tools** drop-down option from the menu bar.
4. From the Tools drop-down menu select **LowFlow Setup**. Selecting the option will open a new window.
5. From the pop-up window, select **Create new template**.

Note: the "use existing template" option will allow you to make edits to the templates you have already created.

The template window can be navigated by utilizing the left and right arrows at the bottom of the screen. Select the right arrow to move to the next screen and the left arrow to

¹ <https://in-situ.com/support/type/software/>

return to the previous screen. **Note:** Any information added to a screen will automatically be saved whether moving to the next screen or returning to the previous screen.

Project and well-specific details shall be completed according to the SAP.

Any information that is unknown or likely to change between sampling events (e.g., operator name, equipment identification) may be left blank in the template and completed later with the VuSitu or iSitu app.

6. The first screen is for entering **Project Information** including:
 - a. **Operator Name:** Leave this blank. The operator's name will be added just prior to sampling at the specific location.
 - b. **Company Name:** Enter the contactor company name.
 - c. **Project Name:** Enter the well identification and Superfund site name as defined in the SAP in order to locate the well-specific template within the VuSitu and iSitu apps. For example: "NHP_MW-202S NHPC Superfund Site". The templates will be stored with the project name as the first "word" in the title and this will allow for easy organization.
 - d. **Site Name:** The Site Name may be left blank as it is not currently carried through the final test report. Instead, the Site name is entered into the Project Name field.
 - e. **Turbidity Make/Model:** Enter the information for the turbidity meter you typically use (i.e., Hach 2100Q or 2100P). **Note:** If this field is left blank, you will not be able to enter stabilization criteria on the Stabilization Parameters screen.
7. The second screen is for entering **Unit Preferences**.

Select the units indicated in parenthesis unless otherwise specified in the SAP: Well/Tubing (ft., in), Pumping (mL, mL/min), ORP (mV), DO (mg/L), Spec Cond ($\mu\text{S}/\text{cm}$), Turbidity (NTU) and Temperature ($^{\circ}\text{C}$).

Units can be changed by selecting an individual parameter and utilizing the drop-down menu to select the desired units.

8. The third screen is for entering **Well Information**.

Well information includes: well identification, well diameter, depth to water, well total depth, depth to top of screen and screen length. Measurements shall be from the designated measuring point of the well as defined in the Well Construction table (**Table 4**) in the SAP.

Notes:

- a. Enter the well identification (e.g., NHP_MW-202S) again here so it will appear on the Low-Flow Test Report as the Location Name.
- b. Depth to water is left blank in the template and entered as measured in the field just prior to purging and sampling at that location.

9. The fourth screen is for entering **Stabilization Parameters**.

The requirements for field parameter stabilization will be entered as defined in the SAP (e.g., specific conductance within ± 3 percent). If the stability criterion needs to be changed to a percentage, the percentage symbol box must contain a check-mark.

Note: if the turbidity meter make and model was not entered on the first screen, then the turbidity stabilization parameter cannot be changed here at this time. Either return to the first screen (by using the left arrow at the bottom of the screen) and enter the make and model now and then return to this screen and enter the turbidity stabilization parameter or the turbidity make, model and stabilization parameter will have to be entered in the field just prior to sampling.

10. The fifth screen is for entering **Pump Information**.

The pump information includes pump/model/type, internal pump volume (mL), tubing type, tubing inner diameter (in), tubing length (ft.), pump placement from top of well casing (ft.) and total system volume (mL).

Generally, pump information such as the pump type will be known for each well at each site and can be populated ahead of time. Equipment-specific information, such as a pump serial number, may be entered at the time of the sampling event.

Notes:

- a. **Tubing Length:** Leave this blank in the template.

The tubing length shall be entered in the field at the sampling location just prior to purging and sampling.

The length of tubing from the top of the measuring point (from the Well Construction table (**Table 4**) in the SAP) typically remains constant unless it needs to be adjusted to a new historical low water level. However; the tubing outside of the well (usually silicone tubing) is typically replaced more frequently and the length of tubing may vary. In order to calculate the minimum purge volume requirement (PVR) in the low flow procedure, the amount of tubing outside the well must be measured and added to the total tubing length, in the field. Once updated in the well-specific template, tubing length should be updated and/or verified each sampling round.

- b. The internal pump volume is left blank when using a peristaltic pump.
- c. The total system volume is automatically calculated on the template (e.g., 364.43 ml).

Once the tubing length is entered in the field, the total system volume that is automatically calculated by the software will include the length of tubing entered above (the length of tubing inside the well from the Well Construction table (**Table 4**) in the SAP and the length of tubing outside the well that was measured in the field) and the volume of water in the flow through cell (90 ml).

11. The sixth screen is for **Purging Information**

Purging information includes pumping rate, system purge time, sample rate and drawdown estimate.

Notes:

- a. The pumping rate will be entered in the field during purging.
- b. The system purge time is calculated for you. (The HWRB low flow procedure does not rely on this calculation; therefore it is ignored.)
- c. Set the sample rate (time between readings) to **5 minutes (05:00)**.

The readings shall not be less than 5 minutes apart.

Do not check the box to auto calculate the sample rate using the system purge time.

- d. The drawdown estimate in inches will be left blank.

12. After completing the appropriate information, the template will be saved in the computer by selecting the 'check-mark' at the bottom of the template window.

The screen will prompt you to automatically save the template in the "LowFlow Templates" set up in the Win-Situ app.

Instead, select the "Templates" folder that was previously set up in the site-specific (i.e., New Hampshire Plating Company Superfund Site) folder.

Note: When the VuSitu or iSitu application is open on the tablet, the software will automatically look for the templates in the default location, which is the LowFlow Templates folder in Win-Situ app. You must search for and access the templates from the "Templates" folder in the site-specific (i.e., New Hampshire Plating Company Superfund Site) folder in your computer.

13. Once the first site-specific template has been created and saved, subsequent site-specific templates can be made in two ways:

- a. Go into the Win-Situ app and select **Create new template** and create additional templates from scratch, or
- b. Additional templates can be created from existing Site templates.

Go into the Win-Situ app and select **Use Existing Template**. Open an existing template for that Site (in this case it would be the original template), scroll through the screens changing only the information that applies to the new location (e.g., well identification and other well information) and save that template. Changing the well identification creates a new template under a new name. Now there are two templates, the original one and the new one. Continue creating site-specific templates from any of the previous site-specific templates already created.

14. Transferring Templates

- a. To transfer the templates to an Android tablet, connect the tablet with the VuSitu app to the desktop or laptop computer containing the saved template using the USB cable.
 - 1) From the computer or laptop, open the tablet drive to access the VuSitu folder
 - 2) Once in the VuSitu folder, navigate to the site-specific **template** subfolder that is in the tablet.
 - 3) Drag and drop the saved templates from the site-specific “Templates” folder in the computer or laptop into the **template** subfolder in the tablet.

The templates will now be accessible under the **Low-Flow** menu option within the VuSitu App.
- b. To transfer the templates using an Apple iOS tablet, connect the tablet with the iSitu app to the desktop or laptop containing the saved template using the USB cable.
 - 1) Open iTunes on the computer or laptop.
 - 2) Access the tablet through iTunes.
 - 3) Drag and drop the template files from the computer or laptop to the site-specific **template** subfolder on the tablet.

The templates will now be accessible under the **Low-Flow** menu option within the iSitu App.
- c. Files may also be transferred via email if Wi-Fi or cellular service is available.

USING THE TEMPLATE WITHIN THE APP FOR ANDROID

1. Connecting to VuSitu
 - a. Open the VuSitu app on a compatible Android tablet by pressing the VuSitu app button.
 - b. Connect the Power Pack to the sonde using the appropriate cable.
 - c. Turn on the Power Pack.
 - d. The VuSitu app will attempt to auto connect to the Power Pack once powered on. If the device does not connect automatically, the user can manually connect by selecting ‘**Choose or Add a device**’ at the bottom of the screen. A list displaying the serial number of previously connected Power Packs will be displayed. If connecting for the first time to a Power Pack, the user will select ‘**Add New Device**’ at the top of the screen. The user will be taken from the VuSitu app to the Android’s Bluetooth settings where they can select the appropriate Power Pack. The serial number for the Power Pack is found under the USB dust cover.

Note: The ‘scan’ function may need to be utilized within the Bluetooth settings app to initially locate the Power Pack.

- e. After returning to the VuSitu app, the connected device is selected from the **‘Choose or Add a device’** page.

The serial number associated with the Sonde connected to your Power Pack is displayed on the tablet screen and will be included in the final Low-Flow Test Report following sampling.

2. To access saved templates and begin low flow sampling, select the menu drop-down option indicated by three horizontal parallel lines in the upper-left hand corner of the screen.

3. Select the **Low-Flow** option.

All templates that have been created in WinSitu and uploaded to the tablet will be stored in this **Low-Flow Testing** section.

4. Select the desired well template.

5. Once selected, a **Low-Flow Setup** screen will initiate.

All details previously entered using the Win-situ software will populate the Low-Flow Setup entries. Any data not previously entered can be input at this time.

This section can be navigated by selecting any of the four tabs displayed at the top of the screen: **Setup, Criteria, Well, Details**. **All information entered on these four tabs must be verified prior to starting a low flow test.**

Selecting the calculator icon in the ‘Setup’ tab and adjacent to the sample interval, will bring up a new page displaying manual inputs for a ‘calculated sample interval.’ Displayed data must be verified. **Note:** Any corrections to this data will initiate a recalculation in the sample interval. After saving and returning to the ‘Setup’ tab, the sample interval will be manually corrected back to “5:0” to indicate a 5 minute sampling interval.

Note: The Depth to Water criteria displayed within the ‘criteria’ tab must be manually corrected to ‘feet’ by selecting the gear icon adjacent to the depth to water category. The stabilization criteria for the well’s diameter will also be manually entered on this screen.

6. Selecting the **Details** tab allows the user to enter information on weather conditions and test notes. Refer to the Low Flow SOP in the SAP for a detailed list of information that must be included in the “test notes” section. The *Records and Documentation* section in this SOP includes a table with current information that must be entered as “test notes”.

At this point, if no additional information needs to be entered, then sampling would occur following the low flow sampling procedures outlined in the Low Flow SOP in the SAP. The Preliminary Procedures Section of the Low Flow SOP details any additional information that may be entered prior to beginning a test. The following steps provide a brief overview of VuSitu use during well purging activity.

1. Once the information has been entered and the user is ready to begin the test, press the **Start** button.

2. The app will prompt the user to ensure the flow cell has been filled with water before continuing. Once this is verified, select **Continue**.
3. The app is now running and recording parameters.
The first sample interval will complete before you see data on the screen.
You can enter the depth to water and other information such as turbidity and flow rate as each set of readings for the other parameters appear.
Well details may be edited during the test by selecting **Edit Properties**.
Note: Editing properties or otherwise navigating away from the test screen after a test has been started will restart the sample interval timer and the series of readings.
4. When it's time to stop collecting parameters and start sample collection, select the **Finish Test** button.
The app will confirm with the user that the test has indeed finished collecting parameters. The test cannot be restarted once **Finish Test** is selected.
5. You will be brought to a page labeled **Post Stabilization** where you must enter all final details and notes including site-specific test note requirements (see *Records and Documentation* below).
6. Select **Add Sample** from the bottom of the screen. Enter the sample identification and analytical parameters.
7. When finished entering sample information, select **next** to advance to the next screen. **Do not select "Complete" at this time.**
8. After ensuring the appropriate test notes and other information have been entered on the Post Stabilization screen, select **Complete** to bring up the Low-Flow Test Report. At this point, no additional revisions or additions of information can be made.
9. The Low-flow Test Report is saved by selecting **Save to...** at the bottom of the screen and selecting the "VuSitu" folder. The report will save to the folder in the tablet and may be dragged and dropped to a computer once connected via USB or Bluetooth.
Once that is complete, the report can also be emailed if Wi-Fi or cellular service is available. To email the report, select "Email" from the list of options. From here the user may email the files to the desired email address.
10. After saving the files, press the **Close** option at the bottom of the screen. The app will return to the Low-Flow testing screen where additional testing can begin.

USING THE TEMPLATE WITHIN THE APP FOR APPLE

1. The iSitu app can be opened by pressing on the iSitu app on a compatible iOS tablet.
2. After opening iSitu, the app will prompt the user to turn on the battery pack.
Note: Verify the appropriate battery pack is connected to the sonde and that the Apple tablet has the Bluetooth option powered on.

3. Once recognized, the LED light on the battery pack will turn from red to green and the tablet will display live readings.
4. To access saved templates and begin low flow sampling, select the **gear** icon at the bottom of the screen. Once selected, an option to **launch** Low-Flow will appear.
5. Selecting **launch** will open a blank low-flow criteria template.
6. To select a saved template, press **template** on the bottom of the screen.

All files previously uploaded from a desktop or laptop or files previously created on the app will be displayed here.

7. After selecting the desired template, press **load** at the bottom of the screen.

All information previously entered will auto-populate the **Low-Flow Criteria**. Any information not entered previously may be entered now. Please verify all information entered in the template is correct.

Note: The Depth to Water criteria displayed within the ‘Low-Flow Criteria’ tab is reported in inches and cannot be changed to ‘feet’. The stabilization criteria for the well’s diameter should be manually entered in inches on this screen. The table below indicates the maximum allowable drawdown rate in inches.

Maximum Allowable Drawdown Over One 5 Minute Period	
Inside Diameter of Inner Casing (Inches)	Drawdown Rate (Inches per 5 Minutes)
3 or less	0.24
3.5 - 5	0.12
6	No drawdown allowed

8. Selecting the **details tab** allows the user to enter information on weather conditions and test notes. Refer to the Low Flow SOP in the SAP for a detailed list of information that must be included in the “test notes” section. The *Records and Documentation* section in this SOP includes a table with current information that must be entered as “test notes”.

At this point, if no additional information needs to be entered, then sampling would occur following the low flow sampling procedures outlined in the Low Flow SOP in the SAP. The Preliminary Procedures Section of the Low Flow SOP details any additional information that may be entered prior to beginning a test. The following steps provide a brief overview of iSitu use during well purging activity.

1. To begin Low-Flow testing, the user must scroll through all criteria pages by swiping or selecting **next** in order to get to the last criteria page.
2. On the last criteria page, select **start** at the bottom to begin the test.
3. The app is now running and recording parameters.

The first sample interval will complete before you see data on the screen.

You can enter the depth to water and other information such as turbidity and flow rate as each set of readings for the other parameters appear.

Note: When using iSitu, details may not be edited during the test but may be edited after completion of the test (during the Post Stabilization phase). At this point, sampling would occur following the low flow sampling procedures outlined in Low Flow SOP in the SAP.

4. When it's time to stop collecting parameters and start sample collection, select **Finish Low-Flow** from the bottom of the screen.
5. You will be brought to a page labeled Post Stabilization where you must enter all additional sample information and notes including site-specific test note requirements (see *Records and Documentation* below).
6. Next, select **Grab Sample** from the bottom of the Post Stabilization screen. Enter the sample identification and analytical parameters.
7. When finished, select **next** to be brought back to the Post Stabilization page.
8. After ensuring the appropriate test notes and other information have been entered on the Post Stabilization screen, select **next** to bring up the Low-Flow Test Report. This automatically saves the Low-Flow Test Report, at which point, no additional additions or revisions of information can be made.
9. After selecting **next**, a copy of the low-flow report will be displayed. If transferring via a computer, files may be found by selecting the iSitu app within Apple's iTunes software. To email the report, if Wi-Fi or cellular service is available, select the envelope icon at the bottom of the screen.
10. After saving the files, press the **Home** option at the top of the screen. The app will return to the Low-Flow testing screen where additional testing can begin.

RECORDS AND DOCUMENTATION

A field log must be kept each time ground water monitoring activities are conducted in the field. The Low-Flow Test Report (which replaces the hand written Low Flow Sampling Worksheet) generated by the VuSitu and iSitu software is an approved worksheet for use by field sampling staff.

In addition to the information populated in the template, the following must be entered prior to initiating a low-flow test or in the "test notes" section of either application, either before, during or immediately following purging/sampling, as appropriate:

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler's full name or first initial and full last name (not just initials)
Pump serial number
Bladder pumps: add pump type; add pump serial number if not dedicated. Add MP-

10 serial number
Turbidity meter model and serial number (or similar unique designation (i.e., last four digits).
Static water level from measuring point
Total tubing length (inside & outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
The following information should have been entered <u>PRIOR</u> to starting the low flow test (continued):
Maximum allowable drawdown rate
Is #14 tubing used at this location?
The following information must be captured in the test notes:
Pump start time
Indicator parameters stable? If “no”, which parameters were out?
Record total volume purged before sample collection to compare to PVR
Minimum PVR reached?
2-hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24-hour clock time)
All samples collected, including QC samples (i.e., VOCs, DUPs, FIELD BLANKs) recorded on the “Sample” page
Final water level
Total volume purged (recorded in test notes only) and delete “Estimated Purge Volume”
Final Pressure setting and fill/discharge cycle and rate for bladder pumps
Measured Well depth, if required. If measured, note variation in total depth of well compared to that previously documented.
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

The low flow forms shall be transferred to the field lead’s laptop at a minimum of twice a day: Once in the middle of the day and again at the end of the day to allow the field lead/quality

assurance personnel to review the documentation prior to leaving the site or completing the field event.

The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it is not captured before a test is finished, it may be entered on the form by hand in the office from the field log book.

Also, it has been noted that if the Smartroll gets disconnected from the tablet at any time, the manually entered notes data is lost if not previously saved. If the information is in the logbook, it can be re-entered.

All field forms shall be included in the applicable groundwater monitoring report submitted following the sampling program.

REFERENCES

The In-Situ Smartroll Equipment Set Up & Use SOP included in the current NHDES HWRB Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA #18008.

In-Situ, 2013. *Operators Manual for smarTROLL™ MP Handheld Instrument 0099172*. Rev. 003. November 2013.

In-Situ, 2016. *Operator's Manual for smarTROLL™ MP Handheld Instrument for Android 0099552*. Rev. 002. February 2016.

SOP B-2
Water Level / LNAPL Thickness Measurements

WATER LEVEL / LNAPL THICKNESS MEASUREMENTS

PURPOSE

This Standard Operating Procedure (SOP) *Water Level / LNAPL Thickness Measurements* is to establish guidelines for the manual determination of both the depth to water and, when required, the thickness of Light Non-Aqueous Phase Liquid (LNAPL) in monitoring wells at the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

In general, water-level measurements are used to construct water table or potentiometric surface maps and to determine flow direction as well as other aquifer characteristics. Therefore, a synoptic water level measurement round shall be conducted from all wells included in the Water Level Worksheet, and on **Table 4** in the SAP, in the shortest possible time (preferably within a 24-hour period) before any purging and sampling activities begin.

The synoptic water level round shall also include the brook stage measurement at surface water sampling location TRY_SW-4, where a permanent stream gage has been mounted.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the United States Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

EQUIPMENT AND MATERIALS

- Health & Safety Plan (HASP) and appropriate personal protective clothing and gear.
- Site-specific Sampling and Analysis Plan (SAP) and boring logs.
- Logbook, pencil/pen/sharpies and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read. Sharpies may be used to make a reference mark on the PVC or casing for the water level measurement.
- Water Level and LNAPL Thickness Worksheets (see attached).
- Gate keys / well keys and other applicable field equipment to open wells.
- Photoionization detector (PID), if required.
- Electronic water level meter of appropriate lengths (e.g., 100 feet, 200 feet, and 300 feet, and measures in increments of 0.01 feet).
- Decontamination supplies in accordance with the Decontamination SOP in the SAP.

GENERAL INFORMATION

All monitoring wells shall be locked at all times, or within a secure locked area, when not being accessed to collect data or samples to ensure the integrity of the well. Since the wells are not within a secure locked area at Troy, all site wells at Troy require secure locks.

If water level measurements are being completed for the first time following well installation (or if it does not already exist), a survey mark/physical notch shall be placed on the top of the riser or casing as a reference point for future groundwater level measurements. If the top of the riser or casing is not level, make the reference point the highest point. The measurement reference point must be documented on the Water Level Worksheet. In the event there is no inner casing, the water level shall be measured from the outer steel casing at the location of the hasp, or the metal label on the rim of the flush mounted wells where marked. Refer to **Table 4** in the SAP and the attached Water Level Worksheet for correct reference points.

All field personnel must be made aware of the measurement reference point, top of casing (TOC) or top of PVC pipe (TOPVC) being used, in order to ensure the collection of comparable data.

Before measurements are made, water levels in monitoring wells should be allowed to stabilize for a minimum of 24 hours after well construction and development. In low yield situations, recovery of water levels to equilibrium may take longer. All measurements should be made to an accuracy of 0.01 feet.

All equipment shall be decontaminated and checked, (e.g., batteries) prior to use to ensure that they are in proper working condition, and then decontaminated after each use. All equipment shall be decontaminated in accordance with the decontamination SOP in the SAP.

SURFACE WATER LEVEL MEASUREMENT

As part of the synoptic water level round, a surface water measurement (height of water column in the brook) will be collected from a permanently-mounted stream gage located midstream at surface water sampling location TRY_SW-4. Refer to the Site Map, **Figure 1**. The distance from the bottom of the stream to the top of the surface water shall be measured and recorded to the nearest one one-hundredth of a foot on the Water Level Worksheet and later recorded on the Surface Water Worksheet in the Surface Water SOP. Additional measurements will be collected concurrent with the sampling of groundwater well cluster TRY_MW-104 and again when TRY_SW-4 is sampled. Additional measurements may be collected on an as needed basis during the monitoring event.

WATER LEVEL MEASUREMENT PROCEDURES

Care should be taken to minimize water column disturbance. Use the following procedures to collect water level measurements:

1. Open the well and monitor the headspace with the appropriate air monitoring instrument to determine the presence of volatile organic compounds (if applicable). Record results in field log/worksheet.
2. In field book/field sheet, note if the lock was damaged or missing and any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box, standpipe, etc.
3. Turn on the water level meter and adjust the sensitivity control.
4. Lower the electronic water level meter probe and measuring tape into the well from the reference point (e.g., top of PVC riser or casing) until the water surface is reached as indicated by a tone and/or the light display. If LNAPL is known or suspected in a monitoring well, use an interface probe to check, measure and record the presence of a LNAPL layer. Refer to the LNAPL Thickness Measurement Procedure below.
5. Read and record measurement (to 0.01 feet) along with the date, time on the attached Water Level Worksheet. In addition, note the reference point used (top of PVC riser or casing) if different from the reference point on the worksheet.
6. For any well not previously sampled by GZA, remove the tubing from the well and measure the length of all downhole tubing to verify the tubing intake. Inspect the tubing for integrity. Record length of downhole tubing and observations on the Water Level Worksheet. Replace tubing and secure to the tubing in the well.
7. The depth to the bottom of the monitoring well should be confirmed in each well included on **Table 4** and recorded on the Water Level Worksheet once every five years, during the sampling event just prior to the 5-year review, unless otherwise requested. Refer to **Table 2** to determine if depth measurements are required. Highlight any significant deviations in the depth to the bottom from the reported depth to bottom. If a bladder pump has been installed in a monitoring well, the depth to the bottom of the monitoring well will be confirmed at such time when the bladder pump is removed for repairs or maintenance activities, or if a significant increasing trend in the turbidity values has been observed.
8. Remove all downhole equipment used for the water level measurement and secure the well cap and lock.
9. Decontaminate all the equipment entering the well(s) in accordance with the Decontamination SOP in the SAP. The decontamination procedure for water level meters shall include the probes and, at a minimum, the length of tape used in that well. **NOTE: Refer to Table 2 in the SAP for the few locations that require equipment decontamination with hexane and 2-propanol.**
10. Collect the stream gage measurement at surface water sampling location TRY_SW-4, where a permanent stream gage has been mounted. The distance from the bottom of the stream to the top of the surface water shall be measured and recorded to the nearest one one-hundredth of a foot on the Water Level Worksheet as well as the Surface Water Worksheet.

LNAPL THICKNESS MEASUREMENT PROCEDURE

Care should be taken to minimize water column disturbance. Use the following procedures to collect LNAPL thickness measurements:

1. Open the well cover and monitor the headspace with the appropriate air monitoring instrument to determine the presence of volatile organic compounds (if applicable).
2. Lower the Oil Water Interface Probe and measuring tape into the well until the LNAPL surface is reached as indicated by a solid audio tone. Record the distance from the reference point to the LNAPL surface on the LNAPL Thickness Worksheet.
3. Continue to lower the probe and measuring tape into the well until the LNAPL/water interface is reached as indicated by a beeping audio tone. Record the distance from the reference point to LNAPL/water interface on the LNAPL Thickness Worksheet.
4. Calculate the thickness by taking the difference between the two measurements and record on the LNAPL Thickness Worksheet.
5. If there is no measureable LNAPL thickness; however, globules are observed on the water surface or on the probe tip, record the thickness as "Trace".
6. On the LNAPL Thickness Worksheet, note if the lock was damaged or missing and any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box, standpipe, etc.
7. Remove all downhole equipment used for the LNAPL thickness measurement and replace well cap and locking steel caps.
8. Decontaminate all the equipment entering the well(s) in accordance with the Decontamination SOP in the SAP. The decontamination procedure for water level meters shall include the probes and, at a minimum, the length of tape used in that well.
NOTE: Refer to Table 2 in the SAP for the few locations that require equipment decontamination with hexane and 2-propanol.

RECORDS AND DOCUMENTATION

All water level/ LNAPL thickness information should be recorded on the attached Water Level and LNAPL Thickness Worksheets.

QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

Equipment blanks may be required to ensure that the equipment has been properly decontaminated and that the decontamination procedures are adequate. Refer to **Table 5** in the SAP for specific QA/QC requirements.

REFERENCES

Water Level Measurement Procedure included in the current Hazardous Waste Remediation Bureau Master QAPP, EQA RFA #18008.

ATTACHMENTS

Water Level Worksheet

LNAPL Thickness Worksheet

-Synoptic Water Level Worksheet

Water Level Worksheet

Troy Mills Landfill Superfund Site, Troy, New Hampshire

Date: _____

Field Personnel: _____

Monitoring Well Designation	Well Type (2-in, 1.5-in etc.)	Measuring Point	Reported Depth to Well Bottom (ft., referenced to measuring point)	Measured Depth To Water (ft., referenced to measuring point)	Measured Depth to Well Bottom (ft., referenced to measuring point) <u>Only</u> if specified in SAP & as noted below.	Comments
TRY_M-1	1 1/2-in PVC	PVC	67.3 ²			Measure depth next time pump is removed
TRY_M-7	1 1/2-in PVC	PVC	17.3			
TRY_M-7D	1 1/2-in PVC	PVC	81.36			
TRY_MW-A28	1 1/2-in PVC	PVC	13.03			
TRY_MW-C6S	2-in PVC	PVC	15.2			
TRY_MW-C6D	2-in PVC	PVC	38.0			
TRY_MW-101S	2-in PVC	PVC	29.40			
TRY_MW-101D	2-in PVC	PVC	67.12			
TRY_MW-102	2-in PVC	Casing	36.2 ²			
TRY_MW-104S	2-in PVC	PVC	17.7 ^{2,3}			
TRY_MW-104D	2-in PVC	PVC	52.1 ²			
TRY_MW-105S	2-in PVC	PVC	21.08			
TRY_MW-105D	2-in PVC	PVC	87.92			
TRY_MW-201SX	2-in PVC	PVC	17.23			
TRY_MW-202P	4-in PVC	PVC	61.55			
TRY_MW-204	2-in PVC	PVC	32.8			
TRY_MW-205	2-in PVC	PVC	39.1			
TRY_MW-301X	2-in PVC	PVC	52.5			
TRY_MW-501D	2-in PVC	PVC	31.85			
TRY_MW-501X	2-in PVC	PVC	14.04			
TRY_MW-508X	2-in PVC	PVC	9.7			
TRY_MW-601S	2-in PVC	PVC	29.3			
TRY_MW-601D	2-in PVC	PVC	62.1			
TRY_MW-602B	2-in PVC	PVC	47.5			
TRY_MW-701	2-in PVC	PVC	78.3			

Water Level Worksheet

Troy Mills Landfill Superfund Site, Troy, New Hampshire

Date: _____

Field Personnel: _____

Monitoring Well Designation	Well Type (2-in, 1.5-in etc.)	Measuring Point	Reported Depth to Well Bottom (ft., referenced to measuring point)	Measured Depth To Water (ft., referenced to measuring point)	Measured Depth to Well Bottom (ft., referenced to measuring point) <u>Only</u> if specified in SAP & as noted below.	Comments
TRY_MW-702SX	2-in PVC	PVC	15.4			Measure depth in 2018
TRY_MW-702D	2-in PVC	PVC	46.4 ^{2,3}			
TRY_MW-801	2-in PVC	PVC	46.4			
TRY_MW-802	2-in PVC	PVC	35.6			
TRY_MW-803	2-in PVC	PVC	32.3			
TRY_MW-804	2-in PVC	PVC	36.0			
TRY_MW-805	2-in PVC	PVC	42.4			
Surface Water Location ⁴						
TRY_SW-4	NA	NA	NA		NA	

Notes:

1. NA = not applicable
2. Downhole information was not verified during the October 8, 2008 camera survey.
3. GZA notes that there appears to be a minor discrepancy between the historical information regarding the bottom of screen/well and that which was measured in July 2008 by GZA in three wells (TRY_MW-702S, TRY_MW-702D, & TRY_MW-104S).
4. The depth of water measurement at TRY_SW-4 is reference to the permanently installed stream gage at that location

-LNAPL Thickness Worksheet

Troy Mills Landfill Superfund Site, Troy, New Hampshire

Field Personnel: _____

[illegible]

SOP B-3
Organic / Inorganic Monitoring Utilizing a PID / FID

ORGANIC/INORGANIC VAPOR MONITORING UTILIZING A PID/FID

PURPOSE

The purpose of this standard operating procedure (SOP) is to provide general guidance for conducting field measurement of organic and inorganic vapors/gases utilizing a photoionization detector (PID) or flame ionization detector (FID) at the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

This procedure is covers the screening of environmental media (water, soil, sediment and air monitoring) utilizing the following instruments:

1. Thermo Environmental Instruments, Inc., (TEI) Organic Vapor Meter (OVM), Model 580B;
2. MiniRae 2000 Portable VOC Monitor (Model PGM-7600);
3. MiniRae 3000 Portable VOC Monitor (Model PGM-7320); and
4. Foxboro Toxic Vapor Analyzer (Model TVA-1000A), which offers both PID and FID detection.

This SOP includes calibration/operation procedures for the aforementioned detectors as well as procedures for field screening of environmental media and air. In addition to this SOP, manufacturer specific instruction manuals should also be consulted prior to detector usage.

The selection of an appropriate detector, detector lamp, calibration gas standard, correction factor/response factor, screening mode, alarm limits, etc., shall be determined prior to site mobilization and defined in the Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP), and/or site-specific Health and Safety Plan (HASP).

The MiniRae 2000 or 3000 instruments have been selected for this project. In addition to this SOP, manufacturer specific instruction manuals shall be on site during each sampling event. If either of these instruments is not available, one of the other instruments listed above may be substituted. Document the change in the final report.

Any modifications to this SOP shall be approved by NHDES in consultation with EPA in advance, documented in the site logbook, and presented in the final report.

EQUIPMENT AND MATERIALS

- PID or FID, including probe assembly and hydrophobic filter (water trap) assembly;
- Spare batteries and/or battery charger;
- Detector lamp (selection based on the ionization potential (IP) of the site contaminants of concern (COCs);

- Calibration gas (100 parts per million [ppm] isobutylene-in-air and zero air); with regulator
Note: The calibration standard must be valid within the expiration date;
- Tedlar® Sampling Bag (minimum 1 L capacity) Note: 1 bag per calibration standard is required;
- Teflon tubing (0.25"OD x 0.17"ID) for connections to the Tedlar® Sampling Bag;
- Masterflex® Silicon Tubing L/S 15 (0.39"OD x 0.19"ID) or equivalent for connections to the Tedlar® Sampling Bag;
- Tubing cutters;
- Tools (including sparkless, adjustable wrench);
- Field screening containers (i.e., 8-ounce or 16-ounce glass "driller" jars with screw caps, quart-size or smaller polyethylene Ziploc® bags); and
- Aluminum foil

I. CALIBRATION/OPERATION

Regardless of the make and model of the selected PID or FID, the detector should be fully charged and calibrated on site, prior to the start of daily field activities. During precipitation events and/or extreme heat/cold, the detector may be calibrated at an off-site location or site vehicle as long as the exhaust of all running vehicles is directed away from the area where the detector is being calibrated. At the end of the field day, the detector should be checked against the calibration standard(s) to confirm that calibration has been maintained throughout the day. In the event that the detector readings appear to be irregular or drifting while in use, the instrument should be checked against the calibration standard and/or recalibrated prior to collection of additional field measurements.

For ease of calibration, refer to the below applicable calibration procedures for the selected field detector. The *Special Notes* section at the end of this document and the manufacturer specific instruction manual provide additional details regarding lamp selection, instrument calibration, correction factors/response factors, ionization potentials, etc. Additional information such as setting alarm limits, maintenance, troubleshooting, etc. may also be found in the instruction manual. Manufacturer specific instruction manuals for the specific instruments used shall be onsite during each sampling event.

1. Thermo Environmental Instruments, Inc., Organic Vapor Meter, Model 580B

A. Preparation for Calibration and Use

1. Allow the temperature of the unit to equilibrate to its surroundings. This could take up to 15 minutes depending on the difference between the temperature of the environment where the detector was stored prior to use and the temperature on site. Note: The range of operating temperatures for this instrument is 32°F to 105°F.

2. Attach probe tip and hydrophobic (water trap) filter by screwing it to the detector inlet. Ensure that the probe tube, filter, and detector inlet fittings are tight. Note: Do not operate the 580-B without a water trap filter installed. Operating without it could cause the pump to strain and/or be damaged, and could prevent the sample from reaching the unit. The filter should be replaced when clogged, visibly dirty, and after high field measurements.
3. Insert the three-pronged shorting (power) plug into the **RUN/CHG** port located on the back of the unit. Align the red marks on the plug and socket. The nub should be on the top of the plug. Warning: If the plug is inserted improperly, or twisted, the fuses in the unit could burn out, rendering the unit inoperable. With the power plug inserted, the LCD screen should indicate "Lamp Out."
4. Turn on the detector by depressing the **ON/OFF** button. Continue depressing the **ON/OFF** button until the pump is activated. This will also activate the UV lamp. Once the lamp is lit, the display will show the concentration of what is being drawn into the detector. Measurements will be displayed as parts per million (ppm).
5. Allow the instrument to "warm up" prior to calibrating, by running it for ~ 5 minutes. During this time, fill the Tedlar® Sampling Bag with the calibration reference standard.

B. Calibration

1. Press the **MODE/STORE** button.
2. The display will read "LOG THIS VALUE? MAX PPM =." Press **-/CRSR**.
3. The display will read "R/COM, -/PARAM, +/ACCESS, S/CLOCK." Press **-/CRSR**.
4. The display will read "CONC. METER, MAX HOLD." Press **-/CRSR**.
5. The display will read "FREE SPACE =." Press **-/CRSR**.
6. The display will read "RESET TO CALIBRATE." Press **RESET**.
7. The display will read "RESTORE BACKUP + = YES." Press **-/CRSR**.
8. The display will read "ZERO GAS RESET WHEN READY." Ensure that the unit is drawing clean ambient air or from a zero air source. Press **RESET**.
9. The unit will read, "MODEL 580 ZEROING." When it has finished zeroing it will read "SPAN PPM = 0100 '+' TO CONTINUE."
10. Frequently rental units will come from the vendor set for 100 ppm isobutylene-in-air standard. If you are utilizing this standard, skip the next two steps. If your calibration gas is not 100 ppm isobutylene-in-air standard, conduct the following:

- a. Hold down the **RESET** button with one finger. Use another finger to move the cursor with the **-/CRSR** button. While still holding down the **RESET** button, use the **+ /INC** button to increase each digit (Note that there is no decrease button. When you get to nine, the next push of the button will return the unit back to zero).
 - b. Match the number to the concentration on your gas cylinder.
11. Press the **+ /INC** button.
12. The screen will read "SPAN GAS, RESET WHEN READY." Connect the probe tip to a FULL Tedlar® Sampling Bag of 100 ppm isobutylene-in-air standard. Press the **RESET** button. If the pump sounds like its restricted, the bag is not open enough.
13. The display will read, "MODEL 580 CALIBRATING," followed by "RESET TO CALIBRATE." Press the **MODE/STORE** button to return to the run mode.
14. While in the run mode, the instrument should read 100 ppm. Remove the gas source and the instrument should read 0 ppm. These measurements serve as "post-calibration" checks. In the event that the unit does not read within +/- 5% of the standard concentration or ambient air concentration of 0 ppm, recalibrate. If the detector cannot be recalibrated to measure within 5% of the calibration standard(s), the instrument should be taken out of service and replaced with a properly functioning unit. All calibration information should be documented on the attached *PID/FID Daily Calibration Field Sheet*.
15. The unit is now ready for use. Refer to section V. and VI. for guidance relative to field screening of environmental media and air quality monitoring.

C. Post Use Calibration Check and Shut Down

1. Complete an end-of-the-day calibration check. While the instrument is in the run mode, connect the probe tip to a FULL Tedlar® Sampling Bag of 100 ppm isobutylene-in-air standard. **NOTE:** Use a *fresh* bag of cal gas for the calibration check. A bag filled in the morning may not be accurate in the afternoon, especially if the bag was exposed to sunlight. Record this measurement on the attached *PID/FID Daily Calibration Field Sheet*. If the measurement does not fall within 5% of the calibration standard, the field data will need to be qualified. For multiple days of field use, if the instrument fails the end-of-the-day check on two consecutive days, the unit should be replaced.
2. Turn off the detector by depressing the **ON/OFF** button. Continue depressing the **ON/OFF** button until the pump shuts off.
3. Remove the power plug from the **RUN/CHG** port.
4. Remove the probe tip and water trap filter by unscrewing it from the detector inlet.
5. If recharging is required, attach the battery charger plug into the **RUN/CHG** port. Plug the associated AC adapter into a wall outlet.

2. MiniRae 2000 Portable VOC Monitor (Model PGM-7600)

[Note that this instrument is not waterproof or water resistant. Do not use it during precipitation events without proper protection from the elements]

A. Preparation for Calibration and Use

1. Allow the temperature of the unit to equilibrate to its surroundings. This could take up to 15 minutes depending on the difference between the temperature of the environment where the detector was stored prior to use and the temperature on site. Note: The range of operating temperatures for this instrument is 14°F to 104°F.
2. Attach probe tip and hydrophobic (water trap) filter by screwing it to the detector inlet. Ensure that the probe tube, filter, and detector inlet fittings are tight. Note: Do not operate the MiniRae 2000 without a water trap filter installed. Operating without it could cause the pump to strain and/or be damaged, and could prevent the sample from reaching the unit. The filter should be replaced when clogged, visibly dirty, and after high measurements.
3. Turn on the detector by depressing the **MODE** button.
4. Allow the instrument to “warm up” prior to calibrating, by running it for ~ 5-10 minutes. During this time the unit will display its setting during the warm up sequence. When it has finished its warm up, readings will be in parts per million (ppm).
5. Fill the Tedlar® Sampling Bag with the calibration reference standard.

B. Calibration

1. To enter the calibration mode, simultaneously press the **MODE** and **N/-** buttons until the screen displays “Calibrate/ select Gas?”
2. Press the **Y/+** button.
3. Ensure that the unit is drawing clean ambient air or from a zero air source.
4. “Fresh air cal?” is displayed. Press **Y/+**.
5. The unit will display “zero in progress” followed by “wait” and a 15 second countdown.
6. When the unit is finished zeroing it will display “zeroed! reading 0.0 ppm.”
7. Press the **MODE** button once.
8. Frequently rental units will come from the vendor set for 100 ppm isobutylene-in-air standard. If you are utilizing this standard, skip the next four steps. If your calibration gas is not 100 ppm isobutylene-in-air standard, change the span value by conducting the following:

- a. From the "Span cal" screen, press the **N/-** button twice or until the screen reads "Change span value." Press **Y/+**.
 - b. The screen will read "Cal gas = isobutylene, Span value = 0100.0." Press the **MODE** button to move the cursor, and the **Y/+** and **N/-** buttons to increase/ decrease the span value to match the concentration of the calibration gas standard.
 - c. When finished changing the value, press and hold the **MODE** button.
 - d. The screen will read "Save?" Press the **Y/+** button to save. The screen will read "Saved."
9. Press the **MODE** button again until "Span cal" is displayed.
10. Press **Y/+**. The screen will read "Cal gas = Isobutylene, Span value = 0100.0, Apply gas now!"
11. Open and connect a FULL Tedlar® Sampling Bag of 100 ppm isobutylene-in-air standard to the probe tip. The unit will recognize the gas and start to span. The screen will read "Wait...." while it counts down from 30 seconds. Some newer units will display "Update data" after the countdown. If the pump sounds like its restricted, the bag is not open enough.
12. When the countdown is finished the screen will read "cal'ed reading = 100 ppm" It should read within a few ppm of the span value.
13. Press **MODE** once. The screen will read "cal done turn off gas". Press the **MODE** button twice to return to the run mode.
14. While in the run mode, the instrument should read 100 ppm. Remove the gas source and the instrument should read 0 ppm. These measurements serve as "post-calibration" checks. In the event that the unit does not read within +/- 5% of the standard concentration or ambient air concentration of 0 ppm, recalibrate. If the detector cannot be recalibrated to measure within 5% of the calibration standards, the instrument should be taken out of service and replaced with a properly functioning unit. All calibration information should be documented on the attached *PID/FID Daily Calibration Field Sheet*.
15. The unit is now ready for use. Refer to section V. and VI. for guidance relative to field screening of environmental media and air quality monitoring.

C. Post Use Calibration Check and Shut Down

1. Complete an end-of-the-day calibration check. While the instrument is in the run mode, connect the probe tip to a FULL Tedlar® Sampling Bag of 100 ppm isobutylene-in-air standard. **NOTE:** Use a *fresh* bag of cal gas for the calibration check. A bag filled in the morning may not be accurate in the afternoon, especially if the bag was exposed to sunlight. Record this measurement on the attached *PID/FID Daily Calibration Field Sheet*. If the measurement does not fall within 5% of the calibration standard, the field data will need to be qualified.

For multiple days of field use, if the instrument fails the end-of-the-day check on two consecutive days, the unit should be replaced.

2. Turn off the detector by depressing the **MODE** button for 5 seconds. The unit will beep once per second during the power-down sequence with a countdown timer showing the number of seconds remaining. The message "Off!"... flashes on the LCD display and then the display will go blank indicating that the monitor is turned off.
3. Remove the probe tip and water trap filter by unscrewing it from the detector inlet.
4. If recharging is required, attach the battery charger plug into the DC jack on the instrument. Plug the associated AC adapter into a wall outlet. The unit will turn on and display the message "Deep discharge?". This message will be displayed three times. If a deep discharge is not applied, the unit will move directly on to the charge mode.

3. MiniRae 3000 Portable VOC Monitor (Model PGM-7320)

[Note that this instrument is not waterproof or water resistant. Do not use it during precipitation events without proper protection from the elements]

A. Preparation for Calibration and Use

1. Allow the temperature of the unit to equilibrate to its surroundings. This could take up to 15 minutes depending on the difference between the temperature of the environment where the detector was stored prior to use and the temperature on site. Note: The range of operating temperatures for this instrument is -4°F to 122°F.
2. Attach probe tip and hydrophobic (water trap) filter by screwing it to the detector inlet. Ensure that the probe tube, filter, and detector inlet fittings are tight. Note: Do not operate the MiniRae 3000 without a water trap filter installed. Operating without it could cause the pump to strain and/or be damaged, and could prevent the sample from reaching the unit. The filter should be replaced when clogged, visibly dirty, and after high measurements.
3. Turn on the detector by depressing the **Φ** (MODE) button.
4. Allow the instrument to "warm up" prior to calibrating, by allowing it to run for ~ 5 minutes. During this time the unit will display its setting during the warm up sequence. When it has finished its warm up, readings will be in parts per million (ppm).
5. Test the pump by blocking the pump flow. The alarm should sound and the pump icon should flash. Push the **Y/+** button to clear the alarm. Note: Do not use a unit that does not pass the pump test.
6. Fill the Tedlar® Sampling Bag with the calibration reference standard.

B. Calibration

Zero (Fresh Air) Cal

1. To enter the calibration mode, simultaneously press the **Φ** button and **N/-** buttons until the screen displays “Calibrate/ select Gas?”
2. Press the **Y/+** button to select the cylinder icon/calibration.
3. Ensure that the unit is drawing clean ambient air or from a zero air source.
4. Select “Zero Calib” and press the **Y/+** button.
5. The screen will read “Apply zero gas.....” If using zero air, apply it now.
6. Press **Y/+** to select “Start”.
7. The unit will display “Zeroing...” for 30 seconds.
8. When it is finished, the screen will display “Zero is done! Reading = #.#”. Note: If the reading is >0.3 ppm, ensure that the air is clean and zero the unit again. If the reading remains >0.3 ppm ensure that the filter is clean and re-zero.
9. The screen will return to the Calibration screen.

Span Cal

1. Select the “Span Calib” and press the **Y/+** button.
2. The screen will read; C. Gas = Isobutylene, Span = 100 ppm, Change? Note: If the span value on the screen is different from the isobutylene in the Tedlar® Sampling Bag, adjust it now.
3. If the gas is 100 ppm isobutylene-in-air, press the **N/-** button.
4. Open and connect a FULL Tedlar® Sampling Bag of 100 ppm isobutylene-in-air standard to the probe tip and then press the **Y/+** button.
5. The screen will read, “Calibrating....” with a 30 second countdown.
6. When the span calibration is finished, the screen will read; “Span 1 is done Reading=100.0 ppm”. Note: The reading should range between 95 and 105 (within 5% of the calibration standard). If it differs from this, recalibrate. If after two attempts, the detector cannot be recalibrated to fall within this range, the instrument should be taken out of service and replaced with a properly functioning unit. All calibration information should be documented on the attached *PID/FID Daily Calibration Field Sheet*.
7. The unit is now ready for use. Refer to section V. and VI. for guidance relative to field screening of environmental media and air quality monitoring.

C. Post Use Calibration Check and Shut Down

1. Complete an end-of-the-day calibration check. While the instrument is in the run mode, connect the probe tip to a FULL Tedlar® Sampling Bag of 100 ppm isobutylene-in-air standard. NOTE: Use a *fresh* bag of cal gas for the calibration

check. A bag filled in the morning may not be accurate in the afternoon, especially if the bag was exposed to sunlight. Record this measurement on the attached *PID/FID Daily Calibration Field Sheet*. If the measurement does not between 95 and 105 ppm, the field data will need to be qualified. For multiple days of field use, if the instrument fails the end-of-the-day check on two consecutive days, the unit should be replaced.

2. Turn off the detector by depressing the Φ button for 3 seconds. A 5-second countdown to shutoff begins. Once the countdown stops, the instrument is off. Release the Mode key. When you see "Unit off..." release your finger from the [MODE] key. The instrument is now off. Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.
3. Remove the probe tip and water trap filter by unscrewing it from the detector inlet.
4. If recharging is required, plug the AC/DC adapter's barrel connector into the instrument's cradle and plug the AC/DC adapter into the wall outlet. Place the instrument into the cradle, press down, and lean it back. The instrument locks in place and the LED in the cradle glows. The instrument begins charging automatically and the "Primary" LED in the cradle blinks green to indicate charging. During charging, the diagonal lines in the battery icon on the instrument's display are animated and you see the message "Charging..." When the instrument's battery is fully charged, the battery icon is no longer animated and shows a full battery. The message "Fully charged!" is shown. The cradle's LED glows continuously green.

4. Foxboro Toxic Vapor Analyzer, Model TVA-1000A (FID only)

A. Preparation for Calibration and Use

1. Allow the temperature of the unit to equilibrate to its surroundings. This could take up to 15 minutes depending on the difference between the temperature of the environment where the detector was stored prior to use and the temperature on site. Note: The range of operating temperatures for this instrument is 32°F to 122°F
2. Connect the close area sampler (contains water trap or charcoal filter) to the sample probe nut and sleeve. Manually turn the probe nut until tight. Connect the data transfer cable to the FID via the swage lock fitting adjacent to the H₂ valve.
3. Ensure the H₂ tank contains enough H₂ to complete the intended work scope. The detector uses approximately 150 pounds per square inch (psi) per hour of operation. Refill the hydrogen tank with H₂, if necessary using the refill plumbing

and sparkless wrench. If the TVA H₂ cylinder must be refilled, heed the following warnings:

- Hydrogen gas is a fire and explosion hazard when exposed to heat or flames. The lower explosive limit (LEL) is 4%.
 - Always use ultra-high purity grade hydrogen (99.999% pure). It is also referred to as Grade 5 or zero grade.
 - **DO NOT** fill the H₂ cylinder near the unit while it is on or charging.
 - **DO NOT** connect or disconnect any electrical device to the instrument in a hazardous location.
 - **DO NOT** attempt to fill the internal cylinder without the supplied hydrogen-filling adapter.
 - **DO NOT** fill the internal H₂ tank in a hazardous location.
 - **DO NOT** exceed 2500 p.s.i. on the TVA cylinder pressure gauge. Internal damage may occur.
 - **DO NOT** leave the H₂ filling adapter attached to the H₂ tank. Put it back in the case when not in use.
 - Replace the H₂ cylinder cap when the cylinder is not in use.
 - When the TVA H₂ cylinder is full, **ALWAYS** purge the H₂ filling adapter to atmosphere prior to disconnecting it from the supply tank. To purge, rotate the red knob to the fill position until no gas is heard exiting the fill adapter.
4. Check the pressure in the small TVA H₂ cylinder. It has a gauge on one end. It is shipped disconnected from the unit. If it has less than 500 psi, it should be filled.
5. If the H₂ cylinder does not need to be refilled proceed to step f. If the H₂ needs to be filled, complete the following:
- a. Connect the H₂ filling-adapter to a H₂ supply cylinder. Do not use Teflon tape. Use an adjustable or 1 1/8" sparkless wrench. Note that the threads are reversed (counterclockwise to tighten).
 - b. Open the H₂ cylinder knob.
 - c. Turn the red knob on the fill adapter to the "Fill" position. A steady flow of gas will be heard coming from the end of the adapter. This is to purge the adapter of any impurities.
 - d. Turn the red adapter knob so it is in the "Off" position.
 - e. Connect the small TVA H₂ tank to the filling adapter. It is also reverse threaded.
 - f. Put the red knob on the fill adapter in the "Fill" position.

- g. Observe the pressure gauge on the end of the small TVA cylinder. When the gauge reads 2500 p.s.i., turn the red knob to the off position.
- h. Turn off the H₂ supply cylinder knob.
- i. Remove the small TVA H₂ cylinder from the fill adapter.
- j. Vent the fill adapter before removing it from the supply tank.
 - 1) Put the red knob in the "Fill" position.
 - 2) Observe the pressure gauge.
 - 3) Disconnect the adapter once the fill adapter gauge reads zero.

Note: Do not leave the H₂ filling adapter attached to the H₂ tank. Put it back in the case when not in use. Replace the hydrogen cylinder cap when the cylinder is not in use.

- 6. Screw the H₂ cylinder into the analyzer sidepack.
- 7. Turn the red H₂ supply knob on the back of the unit to the on position and wait 4 or 5 minutes. This is to allow the hydrogen to fill the internal lines. Note that the unit might not light if a start-up is attempted immediately after the H₂ is turned on.
- 8. Press the **ON** button. The unit will perform self test diagnostics for ~ 15 seconds and then the main menu will be displayed.
- 9. Press the **CONTROL** button. The menu on the screen will read "CONTROL MENU" at the top of the screen.
- 10. Press **1** (1 = Turn Pump On). The screen will read "MAIN MENU".
- 11. Press the **CONTROL** button again.
- 12. Press **2** (2=ignite). The pump will start to run followed by the muffled "pop" of the flame starting. The screen will read "MAIN MENU".
- 13. Press **1** (1=Run).
- 14. The screen will read "Please wait..." It will then display the FID readings in ppm. Let the unit warm up for approximately 30 minutes prior to calibration. Note: This is a good time to fill one Tedlar® Sampling Bag with methane (CH₄). A second bag should be filled with zero grade air if a reliable zero can't be performed in ambient air.
- 15. Once the unit has warmed up in the run mode, press EXIT.

B. Calibration (FID only)

- 1. The screen will read "MAIN MENU". Press **2** (2=Setup). Press **5** (5=OthrSetting). Press **4** (4=UserOptions). Press **3** (3=CalMode). Select AUTO or MANUAL. Note: If AUTO (factory setting) is selected, the instrument analyzes the calibration gas and automatically accepts the value when it is stable. If MANUAL is selected, the operator manually accepts the value once the gas

- measurements (in counts) are stable. Press EXIT repeatedly to return to the "SETUP MENU".
2. The screen will read "SETUP MENU". Press **1** (1=Calib).
 3. The screen will read "CALIBRATION MENU". Press **4** (4=GasConc).
 4. The screen will display the set span concentration. Verify that the concentration of the calibration gas being used matches the displayed concentration. If the value differs, conduct the following:
 - a. Press **Enter** to change the gas concentration to a new value.
 - b. Use the up and down keys to adjust the concentration.
 - c. Press Enter (Enter=Accept) once the correct span concentration has been entered. The screen will read "Accepted". Press EXIT to return to the CALIBRATION MENU.
 5. The screen will read "CALIBRATION MENU". Press **5** (5=Response Factor).
Note: The Response Factor should be set to 1.0 if the instrument is to be used to measure the same gas it was calibrated with. If the gas to be measured is NOT the same compound for which the instrument was calibrated against, the Response Factor may not be 1.0. Refer to the *TVA-1000 Series Instruction Manual Response Factors Part Number 50039, dated January 28, 2009* (attached) and adjust accordingly. If the value differs, conduct the following:
 - a. Press **Enter** to change the response factor to a new value.
 - b. Type in the appropriate response factor.
 - c. Press Enter (Enter=Accept) to store the value. The screen will read "Accepted". Press EXIT to return to the CALIBRATION MENU.
 6. Press **1** (1=Zero) if zero gas is to be used for calibrating zero or press **2** (2=Backgrnd) if clean ambient air is to be used for zero. Select one or the other. Press Enter (Enter=Accept).
 7. The screen will read "Apply zero gas FID." If in a clean ambient air environment, press **Enter** (Enter=Start). The screen will read "Calibrating....FID. Note: If ambient air is questionable (i.e. landfill) apply a Tedlar® Sampling Bag filled with zero air before pressing **Enter**."
 8. The screen will read "Calibrating FID...." Followed by "Accepted" and then return to the CALIBRATION MENU. The zero reference is stored. If setting a span reference point, which is the same as setting the zero reference except that a span gas is used rather than a zero gas, Press **3** (3=Span).
 9. The screen will display "Span Cal". Press **Enter** (Enter=Start).
 10. The screen will read "Apply span gas FID". Verify that the set span value matches the gas being used. Apply the span gas by opening and connecting a

FULL Tedlar® Sampling Bag of the span gas to the probe tip. Press **Enter** (Enter=Start).

11. The screen will read “Calibrating... FID” followed by “Accepted” and the return to the CALIBRATION MENU. The span reference is stored.
12. When finished with the calibration, return to the MAIN MENU by pressing EXIT twice and press 1 (1=run). Prior to field screening, verify the calibration accuracy. Check the zero in ambient air and the span gas that was used for calibration. In the event that the unit does not read within +/- 5% of the standard concentrations, recalibrate. If the detector cannot be recalibrated to measure within 5% of the calibration standards, the instrument should be taken out of service and replaced with a properly functioning unit. All calibration information should be documented on the attached *PID/FID Daily Calibration Field Sheet*.
13. The unit is now ready for use. Refer to section V. and VI. for guidance relative to field screening of environmental media and air quality monitoring.

C. Post Use Calibration Check and Shut Down

1. Complete an end-of-the-day calibration check. While the instrument is in the run mode, connect the probe tip to a FULL Tedlar® Sampling Bag of scan standard. **NOTE:** Use a *fresh* bag of cal gas for the calibration check. A bag filled in the morning may not be accurate in the afternoon, especially if the bag was exposed to sunlight. Record this measurement on the attached *PID/FID Daily Calibration Field Sheet*. If the measurement does not between 95 and 105 ppm, the field data will need to be qualified. For multiple days of field use, if the instrument fails the end-of-the-day check on two consecutive days, the unit should be replaced.
2. Press “ON” then “CONTROL” to open the main menu. Press “1” to turn off the pump.
3. Turn off the detector by depressing the “OFF” button.
4. Close the H₂ tank valve.
5. Unscrew the H₂ cylinder. Note: Leaving the cylinder in the detector will result in a slow leak of H₂ not realized until the detector’s next use.
6. Remove the close area sampler and sample probe. Disconnect the data transfer cable from the detector.
7. If recharging is required, plug the output of the charger into the mating connector marked CHRG in the instrument. Then, insert the charger plug into the appropriate wall outlet. A green power indicator is ON when the charger is operating. A yellow indicator is activated when the charger is connected to the instrument and the instrument is ON. Normal charge time for a fully discharged battery is approximately 16 hours, or two hours of charge for every hour of use.

II. FIELD SCREENING

A. Soil/Sediment Screening for VOCs

1. Screen environmental media following sample collection. Ideally the samples should be screened immediately following collection but there may be circumstances which result in a delay. Note: If samples are to be collected for laboratory analysis, keep these samples separate from media that will be field screened.
2. Fill a glass drillers jar or Ziploc® bag.
 - a. If using glass jars:
 - 1) Fill the jars half way.
 - 2) Cut two (2) aluminum foil squares (approximately 3-inch by 3-inch).
 - 3) Seal the top of the jar with aluminum foil and secure the lid.
 - b. If using Ziploc® bag:
 - 1) Half fill the Ziploc® bag.
3. Secure the bag by zipping it closed or using a zip tie. Vigorously shake the sample jar or bag for ~ 30 seconds, 1-2 times during a 10-15-minute period to allow inorganic/organic vapors to be transferred from the media to the air space above it (headspace).
4. Minimize the duration that the screening containers containing soil/sediment are exposed to direct sunlight. Note: If ambient temperatures are below 40°F, the samples should be moved into heated space, either building or field vehicle and allowed to warm prior to screening.
5. Prior to screening environmental media, measure the ambient air or background concentrations. Record this information in on the boring log, field book, as or other appropriate field data collection sheet.
6. Use the FID/PID probe to screen the media.
 - a. If using glass jars, remove the cover and insert the probe tip through the aluminum foil.
 - b. If using Ziploc® bags, unzip the corner of the bag (1-2") or insert the probe tip directly through the bag.
8. Record the maximum reading, which generally occurs within 2-5 seconds. Note: The probe should not make contact soil/sediment or liquid contained in the sample container. Record the maximum concentration measured by the detector onto a boring log, test pit log, or appropriate field data collection sheet as ppm above background.

9. If screening of media shall be performed directly on soil or sediment cores, record the measurements along the length of the core starting at the top of the sample run and progressing in one (1) foot intervals the entire length of the core, as well as additional zones where staining or strong odors are observed. If the media is contained within plastic liners, use a knife or screw driver to poke a hole through the liner, to facilitate field screening. Note: The probe tip should not be used to puncture the core liner as it could damage the probe. In addition, soil/sediment could be forced into the probe tip, resulting in the unit being inoperable.

B. Air Quality Monitoring for VOCs

1. Use the FID/PID probe to measure the ambient air or background concentrations around the perimeter of the work area. Record this information on the boring log, field book, or other appropriate field data collection sheet.
2. Once background concentrations have been established, begin collecting measurements within the work area which may include the source area, and breathing zone. The detector should be operated as close to the area being monitored as technically feasible. Record this information in a field book, or other appropriate field data collection sheet.
3. If the air quality measurements are being collected in the “breathing zone” of the work area, compare field measurements to the range of concentrations included HASP to confirm that a hazardous atmosphere does not exist. If safe breathing zone concentrations are not being maintained, the use of additional personal protective equipment (PPE) or termination of work activities may be required.

III. RECORDS AND DOCUMENTATION

Calibration as well as the detector lamp energy, calibration standard, and correction factor/response factors, maintenance for each piece of equipment, etc. will be documented on the calibration logs and included in the reports. A calibration log is provided at the end of this SOP. Field screening measurements shall be recorded on applicable data collection sheets, boring logs and/or field book, unless otherwise specified in the approved SAP/QAPP or project specific work plan.

IV. SPECIAL NOTES

1. For site COCs, which include volatile organic compound (VOCs) and Semi-Volatile Compounds (SVOCs), knowing the ionization potential (IP) is critical in determining the appropriate detector and lamp for field screening. Note that a single detector and lamp combination does not exist for all potential site COCs. The manufacturer’s instruction manual and/or additional outside references must be consulted in order to assist with proper instrument and lamp selection.
2. An appropriately selected detector will consist of a lamp with energy greater than the highest IP identified for the site COCs. As a general rule of thumb, if site COC have IPs

- less than 11.8 electron volts (eV), it is possible to use a PID for field screening. If the IP is greater than 11.8 and/or if methane may also be screened on site, a FID is required. Confirm with the project manager and/or health and safety officer that the detector and lamp that has been selected is appropriate for the site COCs.
3. The detectors included in this SOP are capable of utilizing a range of lamp energies (i.e. 9.8eV, 10.0 eV, 10.6 eV, 11.7 eV and 11.8 eV). Note that lower energy lamps are more sensitive and “see” fewer compounds than high energy lamps. The higher energy lamps (11.7 eV and 11.8 eV) should be used only when COCs with IPs greater than 10.6 eV are anticipated. Refer to Appendix F (attached) from the *Thermo Environmental Instruments, Inc., Organic Vapor Meter (OVM), Model 580B*, instruction manual dated January 9, 1996, for the IPs of common organic solvents and gases.
 4. The Correction Factor (CR) or Response Factor (RF) are synonymous and are utilized to adjust the sensitivity of a PID/FID to directly measure a particular gas compared to the calibration gas. The lower the CF/RF is, the more sensitive a PID/FID is to a gas or vapor. The greater the toxicity of the gas or vapor, the greater the sensitivity the meter needs to be. CFs/RFs permit the calibration of the instrument to one gas while directly reading the concentration of another. This eliminates the need for multiple calibration gases. A 100 ppm isobutylene-in-air standard is frequently used to calibrate PIDs/FIDs since it is approximately the midpoint of the range of the instrument sensitivities. It is non-toxic, and non-flammable at a concentration of 100 ppm. Historically PIDs were calibrated with benzene but with the health risks associated with exposure to benzene, the use of this as a calibration standard has been phased out. Any ionizable gas may be used for calibration. Note that the CFs/RFs tend to be detector and/or manufacturer specific. Refer to the manufacturer’s instruction manual when selecting the CF/RF and calibration gas. Refer to the *Thermo Environmental Instruments, Inc., TVA-1000 Series Instruction Manual Response Factors Part Number 50039*, dated January 28, 2009 for Response Factors.
 5. PID/FID sensor and lamp cleaning is not required on a regular basis; however, it should be considered routine maintenance and conducted in accordance with the manufacturer’s instruction manual. Indications that a sensor and lamp may need to be cleaned could include the inability to calibrate successfully or a detector which is very sensitive to moisture. If liquid of any sort has been drawn into the instrument, the lamp and sensor should be cleaned immediately. The use of the water trap will help prevent accidental drawing of liquid into the sensor.

V. REFERENCES

Thermo Environmental Instruments, Inc., TVA-1000 Series Instruction Manual Response Factors Part Number 50039, dated January 28, 2009.

Note: The following references are the manufacture instruction manuals. The appropriate manual for the instrument(s) being used shall be on site during each sampling event.

Thermo Environmental Instruments, Inc., Organic Vapor Meter (OVM), Model 580B, instruction manual dated January 9, 1996.

MiniRae 2000 Portable VOC Monitor, Model PGM-7600, instruction manual (Revision E) dated May 2005.

MiniRae 3000 Portable VOC Monitor, Model PGM-7320, instruction manual (Revision C) dated August 2010.

Foxboro Portable Toxic Vapor Analyzer, Model TVA-1000A, instruction manual dated September 1994.

VI. ATTACHMENTS

PID/FID Daily Calibration Log

RAE Systems, A Guideline for PID Instrument Response, Technical Note TN-106

-PID / FID Daily Calibration Log

TROY MILLS INSTRUMENT CALIBRATION / MAINTENANCE LOG

Date:	Time:	Field Personnel:
Meter: (circle one) YSI: Model 600XL or 600XLM In-Situ: SmartROLL		Rental Company:
Multimeter Serial Numbers (Sonde & Meter):		
Probe Pre-cleaned Certification Provided By (Personnel):		Date:
Temperature Calibration: Personnel:		Date:
Manufacturer's Accuracy Range of Sensor: +/- 0.2°C Vendor's check results Unit: NIST: Difference:		

* When performing calibration checks, wait for temperature and parameter readings to stabilize before recording the results.*

BEGINNING CALIBRATION CHECK

Date:	Time:	Personnel:					
Calibration Check	Value of Standard	Check Results	Acceptable Range	Within Range (yes/no)	Lot #	Expiration Date	Comments
Zero DO check (mg/l)	0		0 to 0.5 mg/L				
pH 7 check	7		+/- 5%				Range 6.65 - 7.35 pH
Specific Conductance (µS/cm) Second standard used for check			+/- 5%				Range 682 - 754 µS/cm (718) or Range 1342 - 1484 µS/cm (1413)
ORP check - Zobell (mV) Zobell Solution _____ °C			+/- 5%				See Chart on Page 2 for ORP Zobell Solution mV Value Based on Temperature
Turbidity Standard (NTU) 2100P	20		+/- 5%				Range 19.0 - 21.0 NTU (2100P)
Turbidity Standard (NTU) 2100Q	10		+/- 10%				Range 9.0 - 11.0 NTU (2100Q)

- Notes:
- 1) If the post calibration check is not within the acceptable range the meter must be recalibrated.
 - 2) All calibration checks must be made in the run mode (on a run/measurement screen) or on the live readings screen, not the calibration mode.
 - 3) If the lot numbers and expiration dates are the same as the initial calibration, place a check mark ✓ in the appropriate box.
 - 4) Either standard (718 or 1413 µS/cm) may be used to calibrate specific conductance; the second standard is used to check it.
 - 5) Record N/A (Not Applicable) in the boxes for the turbidity meter that was not used.

Calibration Check Performed by: _____ (Print) _____ (Sign)

END OF DAY INSTRUMENT CALIBRATION CHECK

Calibration Check	Value of Standard	Check Results	Acceptable Range	Within Range (yes/no)	Lot #	Expiration Date	Comments
Date:		Personnel:					
Time:							
Zero DO check (mg/l)	0		0 to 0.5 mg/L				
pH 7 check	7		+/- 5%				Range 6.65 - 7.35 pH
Specific Conductance (µS/cm) Second standard used for check			+/- 5%				Range 682 - 754 µS/cm (718) or Range 1342 - 1484 µS/cm (1413)
ORP check - Zobell (mV) Zobell Solution _____ °C			+/- 5%				See Chart on Page 2 for ORP Zobell Solution mV Value Based on Temperature
Turbidity Standard (NTU) 2100P ⁵	20		+/- 5%				Range 19.0 - 21.0 NTU (2100P)
Turbidity Standard (NTU) 2100Q ⁵	10		+/- 10%				Range 9.0 - 11.0 NTU (2100Q)

- Notes:
- 1) If the end of the day calibration check is not within the acceptable range, the data collected that day for that parameter shall be qualified in its use.
 - 2) All calibration checks must be made in the run mode (on a run/measurement screen), not the calibration mode.
 - 3) If the lot numbers and expiration dates are the same as the initial calibration, place a check mark ✓ in the appropriate box.
 - 4) Either standard (718 or 1413 µS/cm) may be used to calibrate specific conductance; the second standard is used to check it.
 - 5) Record N/A (Not Applicable) in the boxes for the turbidity meter that was not used.

Calibration Check Performed by: _____ (Print) _____ (Sign)

List wells sampled using this equipment on this day ONLY IF DATA NEEDS TO BE QUALIFIED.

INSTRUMENT CALIBRATION

Date: _____		Time: _____			
Multimeter Calibration	Value of Standard	Check as Completed	Lot #	Expiration Date	Comments
DO (% saturation)	100%				Allow time for stabilization per manufacturer
DO mg/l reading					Record these values immediately after calibration
DO Temp. (°C) reading					
DO (0% Saturation)-SmarTROLL	0%				2 point DO Calibration for SmarTROLL only (100 & 0%)
pH 1st Standard	7				
2nd Standard	4				
3rd Standard	10				
Specific Conductance (µS/cm)					One standard is used to calibrate, second one to check (1413 and 718 standards) Using one standard for both is unacceptable.
Zobell Solution _____ °C					See Chart below for ORP Zobell Solution mV Value Based on Temperature
ORP using Zobell Solution					

Additional Information for Dissolved Oxygen Calibration

Barometric Pressure of Meter: _____ mm Hg [BP inches _____ x 25.4 + BP _____ mm Hg]

Dissolved Oxygen Charge (YSI Meters): _____ (Acceptable Range: 25 to 75) You MUST change the membrane if charge is out of range.

Inspected DO membrane/RDO CAP for nicks or bubbles (check as completed) _____ Personnel: _____

Changed YSI Dissolved Oxygen Membrane and Electrolyte Solution (circle one) YES or NO

Replaced SmarTROLL Rugged Dissolved Oxygen CAP (circle one) YES or NO

HACH 2100P or 2100Q * Turbidimeter Calibration	Value of Standard	Check as Completed	Lot #	Expiration Date	Comments
Turbidity 1st Standard (blank)	<0.1 NTU				Calibrate w/ StablCal® Formazin Primary Turbidity Standards
2nd Standard	20 NTU				
3rd Standard	100 NTU				
4th Standard	800 NTU				

HACH Model (circle one) P or Q Serial Number: _____ Rental Company: _____

* NOTE: the 2100Q does not have a <0.1 standard, record N/A (not applicable) in the <0.1 standard boxes as appropriate.

Calibration Performed by _____

Print Name

Signature

Zobell Solution mV Value Based on Temperature for ORP Calibration								
Calibration Check Range Values (+/- 5%)								
Round off temperature to whole number (e.g., 23.5 °C rounds up to 24 °C)								
Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%
-3	267	254-280	10	251	238-264	23	234	222-246
-2	266	253-279	11	249	237-261	24	232	220-244
-1	265	252-278	12	248	236-260	25	231	219-243
0	264	251-277	13	247	235-259	26	230	219-242
1	262	249-275	14	245	233-257	27	228	217-239
2	261	248-274	15	244	232-256	28	227	216-238
3	260	247-273	16	243	231-255	29	226	215-237
4	258	245-271	17	241	229-253	30	225	214-236
5	257	244-270	18	240	228-252	31	223	212-234
6	256	243-269	19	239	227-251	32	222	211-233
7	254	241-267	20	238	226-250	33	221	210-232
8	253	240-266	21	236	224-248	34	219	208-230
9	252	239-265	22	235	223-247	35	218	207-229

*-RAE Systems, A Guideline for PID Instrument Response,
Technical Note TN-106*

A GUIDELINE FOR PID INSTRUMENT RESPONSE



CORRECTION FACTORS AND IONIZATION ENERGIES*

RAE Systems PIDs can be used for the detection of a wide variety of gases that exhibit different responses. In general, any compound with ionization energy (IE) lower than that of the lamp photons can be measured.* The best way to calibrate a PID to different compounds is to use a standard of the gas of interest. However, correction factors have been determined that enable the user to quantify a large number of chemicals using only a single calibration gas, typically isobutylene. In our PIDs, correction factors can be used in one of three ways:

1. Calibrate the monitor with isobutylene in the usual fashion to read in isobutylene equivalents. Manually multiply the reading by the correction factor (CF) to obtain the concentration of the gas being measured.
2. Calibrate the unit with isobutylene in the usual fashion to read in isobutylene equivalents. Call up the correction factor from the instrument memory or download it from a personal computer and then call it up. The monitor will then read directly in units of the gas of interest.
3. Calibrate the unit with isobutylene, but input an equivalent, "corrected" span gas concentration when prompted for this value. The unit will then read directly in units of the gas of interest.

* The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like H_2O_2 and NO_2 give weak response even when their ionization energies are well below the lamp photon energy.

Example 1:

With the unit calibrated to read isobutylene equivalents, the reading is 10 ppm with a 10.6 eV lamp. The gas being measured is butyl acetate, which has a correction factor of 2.6. Multiplying 10 by 2.6 gives an adjusted butyl acetate value of 26 ppm. Similarly, if the gas being measured were trichloroethylene (CF = 0.54), the adjusted value with a 10 ppm reading would be 5.4 ppm.

Example 2:

With the unit calibrated to read isobutylene equivalents, the reading is 100 ppm with a 10.6 eV lamp. The gas measured is m-xylene (CF = 0.43). After downloading this factor, the unit should read about 43 ppm when exposed to the same gas, and thus read directly in m-xylene values.

Example 3:

The desired gas to measure is ethylene dichloride (EDC). The CF is 0.6 with an 11.7 eV lamp. During calibration with 100 ppm isobutylene, insert 0.6 times 100, or 60 at the prompt for the calibration gas concentration. The unit then reads directly in EDC values.

Conversion to mg/m³

To convert from ppm to mg/m³, use the following formula:

$$\text{Conc. (mg/m}^3\text{)} = \frac{[\text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)}]}{\text{molar gas volume (L)}}$$

For air at 25°C (77°F), the molar gas volume is 24.4 L/mole and the formula reduces to:

$$\text{Conc. (mg/m}^3\text{)} = \text{Conc. (ppmv)} \times \text{mol. wt. (g/mole)} \times 0.041$$

For example, if the instrument is calibrated with a gas standard in ppmv, such as 100 ppm isobutylene, and the user wants the display to read in mg/m³ of hexane, whose m.w. is 86 and CF is 4.3, the overall correction factor would be $4.3 \times 86 \times 0.041$ equals 15.2.

Correction Factors for Mixtures

The correction factor for a mixture is calculated from the sum of the mole fractions X_i of each component divided by their respective correction factors CF_i :

$$CF_{mix} = 1 / (X_1/CF_1 + X_2/CF_2 + X_3/CF_3 + \dots X_i/CF_i)$$

Thus, for example, a vapor phase mixture of 5% benzene and 95% n-hexane would have a CF_{mix} of $CF_{mix} = 1 / (0.05/0.53 + 0.95/4.3) = 3.2$. A reading of 100 would then correspond to 320 ppm of the total mixture, comprised of 16 ppm benzene and 304 ppm hexane.

For a spreadsheet to compute the correction factor and TLV of a mixture see the appendix at the end of the CF table.

TLVs and Alarm Limits for Mixtures

The correction factor for mixtures can be used to set alarm limits for mixtures. To do this one first needs to calculate the exposure limit for the mixture. The Threshold Limit Value (TLV) often defines exposure limits. The TLV for the mixture is calculated in a manner similar to the CF calculation:

$$TLV_{mix} = 1 / (X_1/TLV_1 + X_2/TLV_2 + X_3/TLV_3 + \dots X_i/TLV_i)$$

In the above example, the 8-h TLV for benzene is 0.5 ppm and for n-hexane 50 ppm. Therefore the TLV of the mixture is $TLV_{mix} = 1 / (0.05/0.5 + 0.95/50) = 8.4$ ppm, corresponding to 8.0 ppm hexane and 0.4 ppm benzene. For an instrument calibrated on isobutylene, the reading corresponding to the TLV is:

$$Alarm\ Reading = TLV_{mix} / CF_{mix} = 8.4 / 3.2 = 2.6\ ppm$$

A common practice is to set the lower alarm limit to half the TLV, and the higher limit to the TLV. Thus, one would set the alarms to 1.3 and 2.6 ppm, respectively.

CALIBRATION CHARACTERISTICS

A. Flow Configuration. PID response is essentially independent of gas flow rate as long as it is sufficient to satisfy the pump demand. Four main flow configurations are used for calibrating a PID:

1. Pressurized gas cylinder (Fixed-flow regulator):

The flow rate of the regulator should match the flow demand of the instrument pump or be slightly higher.

2. Pressurized gas cylinder (Demand-flow regulator):

A demand-flow regulator better matches pump speed differences, but results in a slight vacuum during calibration and thus slightly high readings.

3. Collapsible gas bag: The instrument will draw the calibration gas from the bag at its normal flow rate, as long as the bag valve is large enough. The bag should be filled with enough gas to allow at least one minute of flow (~ 0.6 L for a MiniRAE, ~0.3 L for MultiRAE).

4. T (or open tube) method: The T method uses a T-junction with gas flow higher than the pump draw. The gas supply is connected to one end of the T, the instrument inlet is connected to a second end of the T, and excess gas flow escapes through the third, open end of the T. To prevent ambient air mixing, a long tube should be connected to the open end, or a high excess rate should be used. Alternatively, the instrument probe can be inserted into an open tube slightly wider than the probe. Excess gas flows out around the probe.

The first two cylinder methods are the most efficient in terms of gas usage, while the bag and T methods give slightly more accurate results because they match the pump flow better.

B. Pressure. Pressures deviating from atmospheric pressure affect the readings by altering gas concentration and pump characteristics. It is best to calibrate with the instrument and calibration gas at the same pressure as each other and the sample gas. (Note that the cylinder pressure is not relevant because the regulator reduces the pressure to ambient.) If the instrument is calibrated at atmospheric pressure in one of the flow configurations described above, then 1) pressures slightly above ambient are acceptable but high pressures can damage the pump and 2) samples under vacuum may give low readings if air leaks into the sample train.

C. Temperature. Because temperature effects gas density and concentration, the temperature of the calibration gas and instrument should be as close as possible to the ambient temperature where the unit will be used. We recommend that the temperature of the calibration gas be within the instrument's temperature specification (typically 14° to 113° F or -10° to 45° C). Also, during actual measurements, the instrument should be kept at the same or higher temperature than the sample temperature to avoid condensation in the unit.

D. Matrix. The matrix gas of the calibration compound and VOC sample is significant. Some common matrix components, such as methane and water vapor can affect the VOC signal.

PIDs are most commonly used for monitoring VOCs in air, in which case the preferred calibration gas matrix is air. For a MiniRAE, methane, methanol, and water vapor reduce the response by about 20% when their concentration is 15,000 ppm and by about 40% at 30,000 ppm. Despite earlier reports of oxygen effects, RAE PID responses with 10.6 eV lamps are independent of oxygen concentration, and calibration gases in a pure nitrogen matrix can be used. H₂ and CO₂ up to 5 volume % also have no effect.

E. Concentration. Although RAE Systems PIDs have electronically linearized output, it is best to calibrate in a concentration range close to the actual measurement range. For example, 100 ppm standard gas for anticipated vapors of 0 to 250 ppm, and 500 ppm standard for expected concentrations of 250 to 1000 ppm. The correction factors in this table were typically measured at 50 to 100 ppm and apply from the ppb range up to about 1000 ppm. Above 1000 ppm the CF may vary and it is best to calibrate with the gas of interest near the concentration of interest.

F. Filters. Filters affect flow and pressure conditions and therefore all filters to be used during sampling should also be in place during calibration. Using a water trap (hydrophobic filter) greatly reduces the chances of drawing water aerosols or dirt particles into the instrument. Regular filter replacements are recommended because dirty filters can adsorb VOCs and cause slower response time and shifts in calibration.

G. Instrument Design. High-boiling (“heavy”) or very reactive compounds can be lost by reaction or adsorption onto materials in the gas sample train, such as filters, pumps and other sensors. Multi-gas meters, including EntryRAE, MultiRAE and AreaRAE have the pump and other sensors upstream of the PID and are prone to these losses. Compounds possibly affected by such losses are shown in green in the table, and may give slow response, or in extreme cases, no response at all. In many cases the multi-gas meters can still give a rough indication of the relative concentration, without giving an accurate, quantitative reading. The ppbRAE and MiniRAE series instruments have inert sample trains and therefore do not exhibit significant loss; nevertheless, response may be slow for the very heavy compounds and additional sampling time up to a minute or more should be allowed to get a stable reading.

TABLE ABBREVIATIONS

CF = Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)

NR = No Response

IE = Ionization Energy (values in parentheses are not well established)

C = Confirmed Value indicated by “+” in this column; all others are preliminary or estimated values and are subject to change

ne = Not Established ACGIH 8-hr. TWA

C## = Ceiling value, given where 8-hr.TWA is not available

DISCLAIMER

TN-106 is a general guideline for Correction Factors (CF) for use with PID instruments manufactured by RAE Systems. The CF may vary depending on instrument and operation conditions. For the best accuracy, RAE Systems recommends calibrating the instrument to target gas. Actual readings may vary with age and cleanliness of lamp, relative humidity, and other factors as well. For accurate work, the instrument should be calibrated regularly under the operating conditions used. The factors in this table on the following pages were measured in dry air (40 to 50% RH) at room temperature, typically at 50 to 100 ppm. CF values may vary above about 1000 ppm.

Updates

The values in this table on the following pages are subject to change as more or better data become available. Watch for updates of this table on the Internet at <http://www.raesystems.com>.

IE data are taken from the CRC Handbook of Chemistry and Physics, 73rd Edition, D.R. Lide (Ed.), CRC Press (1993) and NIST Standard Ref. Database 19A, NIST Positive Ion Energetics, Vers. 2.0, Lias, et.al., U.S. Dept. Commerce (1993). Exposure limits (8-h TWA and Ceiling Values) are from the 2005 ACGIH Guide to Occupational Exposure Values, ACGIH, Cincinnati, OH 2005. Equations for exposure limits for mixtures of chemicals were taken from the 1997 TLVs and BEIs handbook published by the ACGIH (1997).

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C ₂ H ₄ O	NR	+	6	+	3.3	+	10.23	C25
Acetic acid	Ethanoic Acid	64-19-7	C ₂ H ₄ O ₂	NR	+	22	+	2.6	+	10.66	10
Acetic anhydride	Ethanoic Acid Anhydride	108-24-7	C ₄ H ₆ O ₃	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C ₃ H ₆ O	1.2	+	0.9	+	1.4	+	9.71	500
Acetone cyanohydrin	2-Hydroxyisobutyronitrile	75-86-5	C ₄ H ₇ NO					4	+	11.1	C5
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C ₂ H ₃ N					100		12.19	40
Acetylene	Ethyne	74-86-2	C ₂ H ₂					2.1	+	11.40	ne
Acrolein	Propenal	107-02-8	C ₃ H ₄ O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic acid	Propenoic Acid	79-10-7	C ₃ H ₄ O ₂			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C ₃ H ₃ N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C ₃ H ₆ O	4.5	+	2.4	+	1.6	+	9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C ₃ H ₅ Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	NH ₃	NR	+	10.9	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	C ₇ H ₁₄ O ₂	11	+	2.3	+	0.95	+	<9.9	100
Amyl alcohol	1-Pentanol	75-85-4	C ₅ H ₁₂ O			5				10.00	ne
Aniline	Aminobenzene	62-53-3	C ₆ H ₇ N	0.50	+	0.48	+	0.47	+	7.72	2
Anisole	Methoxybenzene	100-66-3	C ₇ H ₈ O	0.89	+	0.58	+	0.56	+	8.21	ne
Arsine	Arsenic trihydride	7784-42-1	AsH ₃			1.9	+			9.89	0.05
Benzaldehyde		100-52-7	C ₇ H ₆ O					1		9.49	ne
Benzene		71-43-2	C ₆ H ₆	0.55	+	0.47	+	0.6	+	9.25	0.5
Benzonitrile	Cyanobenzene	100-47-0	C ₇ H ₅ N			1.6				9.62	ne
Benzyl alcohol	α-Hydroxytoluene, Hydroxymethylbenzene, Benzenemethanol	100-51-6	C ₇ H ₈ O	1.4	+	1.1	+	0.9	+	8.26	ne
Benzyl chloride	α-Chlorotoluene, Chloromethylbenzene	100-44-7	C ₇ H ₇ Cl	0.7	+	0.6	+	0.5	+	9.14	1
Benzyl formate	Formic acid benzyl ester	104-57-4	C ₈ H ₈ O ₂	0.9	+	0.73	+	0.66	+		ne
Boron trifluoride		7637-07-2	BF ₃	NR		NR		NR		15.5	C1
Bromine		7726-95-6	Br ₂	NR	+	1.30	+	0.74	+	10.51	0.1
Bromobenzene		108-86-1	C ₆ H ₅ Br			0.6		0.5		8.98	ne
2-Bromoethyl methyl ether		6482-24-2	C ₃ H ₇ OBr			0.84	+			~10	ne
Bromoform	Tribromomethane	75-25-2	CHBr ₃	NR	+	2.7	+	0.5	+	10.48	0.5
Bromopropane, 1-	n-Propyl bromide	106-94-5	C ₃ H ₇ Br	150	+	1.5	+	0.6	+	10.18	ne
Butadiene	1,3-Butadiene, Vinyl ethylene	106-99-0	C ₄ H ₆	0.8		0.6	+	1.1		9.07	2
Butadiene diepoxide, 1,3-	1,2,3,4-Diepoxybutane	298-18-0	C ₄ H ₆ O ₂	25	+	3.5	+	1.2		~10	ne
Butane		106-97-8	C ₄ H ₁₀			67	+	1.2		10.53	800
Butanol, 1-	Butyl alcohol, n-Butanol	71-36-3	C ₄ H ₁₀ O	70	+	4.7	+	1.4	+	9.99	20
Butanol, t-	tert-Butanol, t-Butyl alcohol	75-65-0	C ₄ H ₁₀ O	6.9	+	2.9	+			9.90	100
Butene, 1-	1-Butylene	106-98-9	C ₄ H ₈			0.9				9.58	ne
Butoxyethanol, 2-	Butyl Cellosolve, Ethylene glycol monobutyl ether	111-76-2	C ₆ H ₁₄ O ₂	1.8	+	1.2	+	0.6	+	<10	25
Butoxyethyl Acetate, 2-	2-Butoxyethyl acetate; 2-Butoxy-ethanol acetate; Butyl Cellosolve acetate; Butyl glycol acetate; EGBEA; Ektasolve EB acetate	112-07-2	C ₈ H ₁₆ O ₃			1.27	+				20
Butyl acetate, n-		123-86-4	C ₆ H ₁₂ O ₂			2.6	+			10	150
Butyl acrylate, n-	Butyl 2-propenoate, Acrylic acid butyl ester	141-32-2	C ₇ H ₁₂ O ₂			1.6	+	0.6	+		10
Butylamine, n-		109-73-9	C ₄ H ₁₁ N	1.1	+	1.1	+	0.7	+	8.71	C5
Butyl cellosolve	see 2-Butoxyethanol	111-76-2									
Butyl hydroperoxide, t-		75-91-2	C ₄ H ₁₀ O ₂	2.0	+	1.6	+			<10	1

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Butyl mercaptan	1-Butanethiol	109-79-5	C ₄ H ₁₀ S	0.55	+	0.52	+			9.14	0.5
Butyraldehyde	Butanal	123-72-8	C ₄ H ₈ O			1.87	+			9.82	20
Camelinal HRJ						1.1	+	0.32	+		
Camelinal HRJ/JP-8 50/50						0.89	+	0.41	+		
CamelinalHRJ						1.15	+				
CamelinalHRJ/JP-8						1.07	+				
Carbon disulfide		75-15-0	CS ₂	4	+	1.2	+	0.44		10.07	10
Carbon tetrachloride	Tetrachloromethane	56-23-5	CCl ₄	NR	+	NR	+	1.7	+	11.47	5
Carbonyl sulfide	Carbon oxysulfide	463-58-1	COS							11.18	
Cellosolve	see 2-Ethoxyethanol										
CFC-14	see Tetrafluoromethane										
CFC-113	see 1,1,2-Trichloro-1,2,2-trifluoroethane										
Chlorine		7782-50-5	Cl ₂					1.0	+	11.48	0.5
Chlorine dioxide		10049-04-4	ClO ₂	NR	+	NR	+	NR	+	10.57	0.1
Chlorobenzene	Monochlorobenzene	108-90-7	C ₆ H ₅ Cl	0.44	+	0.55	+	0.39	+	9.06	10
Chlorobenzotrifluoride, 4-	PCBTF, OXSOL 100 p-Chlorobenzotrifluoride	98-56-6	C ₇ H ₄ ClF ₃	0.74	+	0.63	+	0.55	+	<9.6	
Chloro-1,3-butadiene, 2-	Chloroprene	126-99-8	C ₄ H ₅ Cl			3					10
Chloro-1,1-difluoroethane, 1-	HCFC-142B, R-142B	75-68-3	C ₂ H ₃ ClF ₂	NR		NR		NR		12.0	ne
Chlorodifluoromethane	HCFC-22, R-22	75-45-6	CHClF ₂	NR		NR		NR		12.2	1000
Chloroethane	Ethyl chloride	75-00-3	C ₂ H ₅ Cl	NR	+	NR	+	1.1	+	10.97	100
Chloroethanol	Ethylene chlorhydrin	107-07-3	C ₂ H ₅ ClO							10.52	C1
Chloroethanol, 2-	2-Chloroethanol; 2-Chloroethyl alcohol; Ethylene chlorhydrin	107-07-3	C ₂ H ₅ ClO			2.88	+			10.5	5
Chloroethyl ether, 2-	bis (2-chloroethyl) ether	111-44-4	C ₄ H ₈ Cl ₂ O	8.6	+	3.0	+				5
Chloroethyl methyl ether, 2-	Methyl 2-chloroethyl ether	627-42-9	C ₃ H ₇ ClO			3					ne
Chloroform	Trichloromethane	67-66-3	CHCl ₃	NR	+	NR	+	3.5	+	11.37	10
Chloro-2-methylpropene, 3-	Methallyl chloride, Isobutenyl chloride	563-47-3	C ₄ H ₇ Cl	1.4	+	1.2	+	0.63	+	9.76	ne
Chloropicrin		76-06-2	CCl ₃ NO ₂	NR	+	~400	+	7	+		0.1
Chlorotoluene, o-	o-Chloromethylbenzene	95-49-8	C ₇ H ₇ Cl			0.5		0.6		8.83	50
Chlorotoluene, p-	p-Chloromethylbenzene	106-43-4	C ₇ H ₇ Cl					0.6		8.69	ne
Chlorotrifluoroethene	CTFE, Chlorotrifluoroethylene Genetron 1113	79-38-9	C ₂ ClF ₃	6.7	+	3.9	+	1.2	+	9.76	5
Chlorotrimethylsilane		75-77-4	C ₃ H ₉ ClSi	NR		NR		0.82	+	10.83	ne
Cresol, m-	m-Hydroxytoluene, 3-Methylphenol	108-39-4	C ₇ H ₈ O	0.57	+	0.50	+	0.57	+	8.29	5
Cresol, o-	ortho-Cresol; 2-Cresol; o-Cresylic acid; 1-Hydroxy-2-methylbenzene; 2-Hydroxytoluene; 2-Methyl phenol	95-48-7	C ₇ H ₈ O			1	+			8.14	5
Cresol, p-	para-Cresol; 4-Cresol; p-Cresylic acid; 1-Hydroxy-4-methylbenzene; 4-Hydroxytoluene; 4-Methyl phenol	106-44-5	C ₇ H ₈ O			1.4	+			8.34	5
Crotonaldehyde	trans-2-Butenal	123-73-9 4170-30-3	C ₄ H ₆ O	1.5	+	1.1	+	1.0	+	9.73	2
Cumene	Isopropylbenzene	98-82-8	C ₉ H ₁₂	0.58	+	0.54	+	0.4	+	8.73	50
Cyanogen bromide		506-68-3	CNBr	NR		NR		NR		11.84	ne
Cyanogen chloride		506-77-4	CNCl	NR		NR		NR		12.34	C0.3
Cyclohexane		110-82-7	C ₆ H ₁₂	3.3	+	1.4	+	0.64	+	9.86	300
Cyclohexanol	Cyclohexyl alcohol	108-93-0	C ₆ H ₁₂ O	1.5	+	0.9	+	1.1	+	9.75	50
Cyclohexanone		108-94-1	C ₆ H ₁₀ O	1.0	+	0.9	+	0.7	+	9.14	25

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Cyclohexene		110-83-8	C ₆ H ₁₀			0.8	+			8.95	300
Cyclohexylamine		108-91-8	C ₆ H ₁₃ N			1.2				8.62	10
Cyclopentane 85% 2,2-dimethylbutane 15%		287-92-3	C ₅ H ₁₀	NR	+	15	+	1.1		10.33	600
Cyclopropylamine	Aminocyclopropane	765-30-0	C ₃ H ₇ N	1.1	+	0.9	+	0.9	+		ne
Decamethylcyclopentasiloxane		541-02-6	C ₁₀ H ₃₀ O ₅ Si ₅	0.16	+	0.13	+	0.12	+		ne
Decamethyltetrasiloxane		141-62-8	C ₁₀ H ₃₀ O ₃ Si ₄	0.17	+	0.13	+	0.12	+	<10.2	ne
Decane		124-18-5	C ₁₀ H ₂₂	4.0	+	1.4	+	0.35	+	9.65	ne
Diacetone alcohol	4-Methyl-4-hydroxy-2-pentanone	123-42-2	C ₆ H ₁₂ O ₂			0.7					50
Dibromochloromethane	Chlorodibromomethane	124-48-1	CHBr ₂ Cl	NR	+	5.2	+	0.7	+	10.59	ne
Dibromo-3-chloropropane, 1,2-	DBCP	96-12-8	C ₃ H ₅ Br ₂ Cl	NR	+	1.7	+	0.43	+		0.001
Dibromoethane, 1,2-	EDB, Ethylene dibromide, Ethylene bromide	106-93-4	C ₂ H ₄ Br ₂	NR	+	1.7	+	0.6	+	10.37	ne
Dichlorobenzene, o-	1,2-Dichlorobenzene	95-50-1	C ₆ H ₄ Cl ₂	0.54	+	0.64	+	0.38	+	9.08	25
Dichlorodifluoromethane	CFC-12	75-71-8	CCl ₂ F ₂			NR	+	NR	+	11.75	1000
Dichlorodimethylsilane		75-78-5	C ₂ H ₆ Cl ₂ Si	NR		NR		1.1	+	>10.7	ne
Dichloroethane, 1,2-	EDC, 1,2-DCA, Ethylene dichloride	107-06-2	C ₂ H ₄ Cl ₂			NR	+	0.6	+	11.04	10
Dichloroethene, 1,1-	1,1-DCE, Vinylidene chloride	75-35-4	C ₂ H ₂ Cl ₂			0.82	+	0.8	+	9.79	5
Dichloroethene, c-1,2-	c-1,2-DCE, <i>cis</i> -Dichloroethylene	156-59-2	C ₂ H ₂ Cl ₂			0.8				9.66	200
Dichloroethene, t-1,2-	t-1,2-DCE, <i>trans</i> -Dichloroethylene	156-60-5	C ₂ H ₂ Cl ₂			0.45	+	0.34	+	9.65	200
Dichloro-1-fluoroethane, 1,1-	R-141B	1717-00-6	C ₂ H ₃ Cl ₂ F	NR	+	NR	+	2.0	+		ne
Dichloromethane	see Methylene chloride										
Dichloropentafluoropropane	AK-225, mix of ~45% 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) & ~55% 1,3-Dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)	442-56-0 507-55-1	C ₃ HCl ₂ F ₅	NR	+	NR	+	25	+		ne
Dichloropropane, 1,2-		78-87-5	C ₃ H ₆ Cl ₂					0.7		10.87	75
Dichloro-1-propene, 1,3-		542-75-6	C ₃ H ₄ Cl ₂	1.3	+	0.96	+			<10	1
Dichloro-1-propene, 2,3-		78-88-6	C ₃ H ₄ Cl ₂	1.9	+	1.3	+	0.7	+	<10	ne
Dichloro-1,1,1- trifluoroethane, 2,2-	R-123	306-83-2	C ₂ HCl ₂ F ₃	NR	+	NR	+	10.1	+	11.5	ne
Dichloro-2,4,6- trifluoropyridine, 3,5-	DCTFP	1737-93-5	C ₅ Cl ₂ F ₃ N	1.1	+	0.9	+	0.8	+		ne
Dichlorvos**	Vapona; O,O-dimethyl O-dichlorovinyl phosphate	62-73-7	C ₄ H ₇ Cl ₂ O ₄ P			0.9	+			<9.4	0.1
Dicyclopentadiene	DCPD, Cyclopentadiene dimer	77-73-6	C ₁₀ H ₁₂	0.57	+	0.48	+	0.43	+	8.8	5
Diesel Fuel**		68334-30-5	m.w. 226			0.9	+				11
Diesel Fuel #2 (Automotive)**		68334-30-5	m.w. 216	1.3		0.7	+	0.4	+		11
Diethylamine		109-89-7	C ₄ H ₁₁ N			1	+			8.01	5
Diethylaminopropylamine, 3-		104-78-9	C ₇ H ₁₈ N ₂			1.3					ne
Diethylbenzene	see Dowtherm J										
Diethyl ether	Diethyl ether; Diethyl oxide; Ethyl oxide; Ether; Solvent ether	60-29-7	C ₄ H ₁₀ O			1.74	+			9.51	400
Diethylene glycol butyl ether	2-(2-Butoxyethoxy)ethanol, BDG, Butyldiglycol, DB Solvent	112-34-5	C ₈ H ₁₈ O ₃			4.6	+				5
Diethylene glycol monobutyl ether acetate	Butyldiglycol acetate, DB Acetate, Diethylene glycol monobutyl ether acetate	124-17-4	C ₁₀ H ₂₀ O ₄			5.62	+				ne
Diethylmaleate		141-05-9	C ₈ H ₁₂ O ₄			4					ne
Diethyl sulfide	see Ethyl sulfide										
Diglyme	see Methoxyethyl ether	111-96-6	C ₆ H ₁₄ O ₃								

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Diisobutyl ketone	DIBK, 2,2-dimethyl-4-heptanone	108-83-8	C ₉ H ₁₈ O	0.71	+	0.61	+	0.35	+	9.04	25
Diisopropylamine		108-18-9	C ₆ H ₁₅ N	0.84	+	0.74	+	0.5	+	7.73	5
Diisopropylcarbodiimide, N,N'-	DIPC	693-13-0	C ₇ H ₁₄ N ₂			0.42	+				ne
Diisopropylethylamine	'Hünig's base', N-Ethyl-diisopropylamine, DIPEA, Ethyl-diisopropylamine	7087-68-5	C ₈ H ₁₉ N			0.7	+				ne
Diketene	Ketene dimer	674-82-8	C ₄ H ₄ O ₂	2.6	+	2.0	+	1.4	+	9.6	0.5
Dimethylacetamide, N,N-	DMA	127-19-5	C ₄ H ₉ NO	0.87	+	0.8	+	0.8	+	8.81	10
Dimethylamine		124-40-3	C ₂ H ₇ N			1.5				8.23	5
Dimethyl carbonate	Carbonic acid dimethyl ester	616-38-6	C ₃ H ₆ O ₃	NR	+	~70	+	1.7	+	~10.5	ne
Dimethyl disulfide	DMDS	624-92-0	C ₂ H ₆ S ₂	0.2	+	0.20	+	0.21	+	7.4	ne
Dimethyl ether	see Methyl ether										
Dimethylethylamine	DMEA	598-56-1	C ₄ H ₁₁ N	1.1	+	1.0	+	0.9	+	7.74	~3
Dimethylformamide, N,N-	DMF	68-12-2	C ₃ H ₇ NO	0.7	+	0.7	+	0.8	+	9.13	10
Dimethylhydrazine, 1,1-	UDMH	57-14-7	C ₂ H ₈ N ₂			0.8	+	0.8	+	7.28	0.01
Dimethyl methylphosphonate	DMMP, methyl phosphonic acid dimethyl ester	756-79-6	C ₃ H ₉ O ₃ P	NR	+	4.3	+	0.74	+	10.0	ne
Dimethyl sulfate		77-78-1	C ₂ H ₆ O ₄ S	~23		~20	+	2.3	+		0.1
Dimethyl sulfide	see Methyl sulfide										
Dimethyl sulfoxide	DMSO, Methyl sulfoxide	67-68-5	C ₂ H ₆ OS			1.4	+			9.10	ne
Dioxane, 1,4-		123-91-1	C ₄ H ₈ O ₂			1.3				9.19	25
Dioxolane, 1,3-	Ethylene glycol formal	646-06-0	C ₃ H ₆ O ₂	4.0	+	2.3	+	1.6	+	9.9	20
Dowtherm A	see Therminol®**										
Dowtherm J (97% Diethylbenzene)**		25340-17-4	C ₁₀ H ₁₄			0.5					
DS-108F Wipe Solvent	Ethyl lactate/Isopar H/ Propoxypropanol ~7:2:1	97-64-3 64742-48-9 1569-01-3	m.w. 118	3.3	+	1.6	+	0.7	+		ne
Epichlorohydrin	ECH Chloromethyloxirane, 1-chloro-2,3-epoxypropane	106-89-8	C ₂ H ₅ ClO	~200	+	8.5	+	1.4	+	10.2	0.5
Ethane		74-84-0	C ₂ H ₆			NR	+	15	+	11.52	ne
Ethanol	Ethyl alcohol	64-17-5	C ₂ H ₆ O			9.6	+	3.1	+	10.47	1000
Ethanolamine**	MEA, Monoethanolamine	141-43-5	C ₂ H ₇ NO	5.6	+	1.6	+			8.96	3
Ethene	Ethylene	74-85-1	C ₂ H ₄			9	+	4.5	+	10.51	ne
Ethoxyethanol, 2-	Ethyl cellosolve, Ethylene glycol monoethyl ether	110-80-5	C ₄ H ₁₀ O ₂			1.3				9.6	5
Ethyl acetate	Acetic ester; Acetic ether; Ethyl ester of acetic acid; Ethyl ethanoate	141-78-6	C ₄ H ₈ O ₂			3.8	+			10.01	400
Ethyl acetoacetate		141-97-9	C ₆ H ₁₀ O ₃	1.4	+	1.2	+	1.0	+	<10	ne
Ethyl acrylate		140-88-5	C ₅ H ₈ O ₂			2.4	+	1.0	+	<10.3	5
Ethyl lactate	Acetic ester; Acetic ether; Ethyl ester of acetic acid; Ethyl ethanoate	141-78-6	C ₄ H ₈ O ₂					2.18	+	10.01	400
Ethylamine		75-04-7	C ₂ H ₇ N			0.8				8.86	5
Ethylbenzene		100-41-4	C ₈ H ₁₀	0.52	+	0.65	+	0.51	+	8.77	100
Ethyl caprylate	Ethyl octanoate	106-32-1	C ₁₀ H ₂₀ O ₂		+	0.52	+	0.51	+		
Ethylenediamine	1,2-Ethanediamine; 1,2-Diaminoethane	107-15-3	C ₂ H ₈ N ₂	0.9	+	0.8	+	1.0	+	8.6	10
(Ethylenedioxy)diethanethiol, 2,2'-	1,2-Bis(2-mercaptoethoxy)ethane, 3,6-Dioxo-1,8-octane-dithiol	14970-87-7	C ₆ H ₁₄ O ₂ S ₂			1.3	+				ne
Ethylene glycol**	1,2-Ethandiol	107-21-1	C ₂ H ₆ O ₂			16	+	6	+	10.16	C100
Ethylene glycol, Acrylate**	2-hydroxyethyl Acrylate	818-61-1	C ₅ H ₈ O ₃			8.2				≤10.6	
Ethylene glycol dimethyl ether	1,2-Dimethoxyethane, Monoglyme	110-71-4	C ₄ H ₁₀ O ₂	1.1		1.1		0.7		9.2	ne

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Ethylene glycol monobutyl ether acetate	1,2-Dimethoxyethane, Monoglyme	110-71-4	C ₄ H ₁₀ O ₂	1.1		1.1		0.7		9.2	ne
Ethylene glycol, monothio		60-24-2	C ₂ H ₆ OS			1.5				9.65	
Ethylene oxide	Oxirane, Epoxyethane	75-21-8	C ₂ H ₄ O			13	+	3.5	+	10.57	1
Ethyl ether	Diethyl ether	60-29-7	C ₄ H ₁₀ O			1.1	+			9.51	400
Ethyl 3-ethoxypropionate	EEP	763-69-9	C ₇ H ₁₄ O ₃	1.2	+	0.75	+				ne
Ethyl formate		109-94-4	C ₃ H ₆ O ₂					1.9		10.61	100
Ethyl-1-hexanol, 2-	Isooctyl alcohol	104-76-7	C ₈ H ₁₈ O			1.9	+				ne
Ethyl hexyl acrylate, 2-	Acrylic acid 2-ethylhexyl ester	103-11-7	C ₁₁ H ₂₀ O ₂			1.1	+	0.5	+		ne
Ethylidenenorbornene	5-Ethylidene bicyclo(2,2,1) hept-2-ene	16219-75-3	C ₉ H ₁₂	0.4	+	0.39	+	0.34	+	≤8.8	ne
Ethyl (S)-(-)-lactate see also DS-108F	Ethyl lactate, Ethyl (S)-(-)-hydroxypropionate	687-47-8 97-64-3	C ₅ H ₁₀ O ₃	13	+	3.2	+	1.6	+	~10	ne
Ethyl mercaptan	Ethanethiol	75-08-1	C ₂ H ₆ S	0.60	+	0.56	+			9.29	0.5
Ethyl sulfide	Diethyl sulfide	352-93-2	C ₄ H ₁₀ S			0.5	+			8.43	ne
Formaldehyde	Formalin	50-00-0	CH ₂ O	NR	+	NR	+	1.6	+	10.87	C0.3
Formamide		75-12-7	CH ₃ NO			6.9	+	4		10.16	10
Formic acid		64-18-6	CH ₂ O ₂	NR	+	NR	+	9	+	11.33	5
Furfural	2-Furaldehyde	98-01-1	C ₅ H ₄ O ₂			0.92	+	0.8	+	9.21	2
Furfuryl alcohol		98-00-0	C ₅ H ₆ O ₂			0.80	+			<9.5	10
Gasoline #1		8006-61-9	m.w. 72			0.9	+				300
Gasoline #2, 92 octane		8006-61-9	m.w. 93	1.3	+	1.0	+	0.5	+		300
Glutaraldehyde	1,5-Pentanedial, Glutaric dialdehyde	111-30-8	C ₅ H ₈ O ₂	1.1	+	0.8	+	0.6	+		C0.05
Glycidyl methacrylate	2,3-Epoxypropyl methacrylate	106-91-2	C ₇ H ₁₀ O ₃	2.6	+	1.2	+	0.9	+		0.5
Halothane	2-Bromo-2-chloro-1,1,1-trifluoroethane	151-67-7	C ₂ HBrClF ₃					0.6		11.0	50
HCFC-22	see Chlorodifluoromethane										
HCFC-123	see 2,2-Dichloro-1,1,1-trifluoroethane										
HCFC-141B	see 1,1-Dichloro-1-fluoroethane										
HCFC-142B	see 1-Chloro-1,1-difluoroethane										
HCFC-134A	see 1,1,1,2-Tetrafluoroethane										
HCFC-225	see Dichloropentafluoropropane										
Heptane, n-		142-82-5	C ₇ H ₁₆	45	+	2.8	+	0.60	+	9.92	400
Heptanol, 4-	Dipropylcarbinol	589-55-9	C ₇ H ₁₆ O	1.8	+	1.3	+	0.5	+	9.61	ne
Hexamethyldisilazane, 1,1,1,3,3,3-**	HMDS	999-97-3	C ₆ H ₁₉ NSi ₂			0.2	+	0.2	+	~8.6	ne
Hexamethyldisiloxane	HMDSx	107-46-0	C ₆ H ₁₈ OSi ₂	0.33	+	0.27	+	0.25	+	9.64	ne
Hexane, n-		110-54-3	C ₆ H ₁₄	350	+	4.3	+	0.54	+	10.13	50
Hexanol, 1-	Hexyl alcohol	111-27-3	C ₆ H ₁₄ O	9	+	2.5	+	0.55	+	9.89	ne
Hexene, 1-		592-41-6	C ₆ H ₁₂			0.8				9.44	30
HFE-7100	see Methyl nonafluorobutyl ether										
Histoclear (Histo-Clear)	Limonene/corn oil reagent		m.w. ~136	0.5	+	0.4	+	0.3	+		ne
Hydrazine**		302-01-2	H ₄ N ₂	>8	+	2.6	+	2.1	+	8.1	0.01
Hydrazoic acid	Hydrogen azide		HN ₃							10.7	
Hydrogen	Synthesis gas	1333-74-0	H ₂	NR	+	NR	+	NR	+	15.43	ne
Hydrogen cyanide	Hydrocyanic acid	74-90-8	HCN	NR	+	NR	+	NR	+	13.6	C4.7
Hydrogen iodide**	Hydriodic acid	10034-85-2	HI			~0.6				10.39	
Hydrogen peroxide		7722-84-1	H ₂ O ₂	NR	+	NR	+	NR	+	10.54	1
Hydrogen sulfide		7783-06-4	H ₂ S	NR	+	3.3	+	1.5	+	10.45	10
Hydroxyethyl acrylate, 2-	Ethylene glycol monoacrylate	818-61-1	C ₅ H ₈ O ₃			8.2	+				ne

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Hydroxypropyl methacrylate		27813-02-1 923-26-2	C ₇ H ₁₂ O ₃	9.9	+	2.3	+	1.1	+		ne
Iodine**		7553-56-2	I ₂	0.1	+	0.1	+	0.1	+	9.40	C0.1
Iodomethane	Methyl iodide	74-88-4	CH ₃ I	0.21	+	0.22	+	0.26	+	9.54	2
Isoamyl acetate	Isopentyl acetate	123-92-2	C ₇ H ₁₄ O ₂	10.1		2.1		1.0		<10	100
Isobutane	2-Methylpropane	75-28-5	C ₄ H ₁₀			100	+	1.2	+	10.57	ne
Isobutanol	2-Methyl-1-propanol	78-83-1	C ₄ H ₁₀ O	19	+	3.8	+	1.5		10.02	50
Isobutene	Isobutylene, Methyl butene	115-11-7	C ₄ H ₈	1.00	+	1.00	+	1.00	+	9.24	ne
Isobutyl acetate	2-methylpropyl ethanoate, β-methylpropyl acetate	110-19-0	C ₆ H ₁₂ O ₂			2.1	+			9.97	150
Isobutyl acrylate	Isobutyl 2-propenoate, Acrylic acid Isobutyl ester	106-63-8	C ₇ H ₁₂ O ₂			1.5	+	0.60	+		ne
Isoflurane	1-Chloro-2,2,2-trifluoroethyl difluoromethyl ether, forane	26675-46-7	C ₃ H ₂ ClF ₅ O	NR	+	NR	+	48	+	~11.7	ne
Isooctane	2,2,4-Trimethylpentane	540-84-1	C ₈ H ₁₈			1.2				9.86	ne
Isopar E Solvent	Isoparaffinic hydrocarbons	64741-66-8	m.w. 121	1.7	+	0.8	+				ne
Isopar G Solvent	Photocopier diluent	64742-48-9	m.w. 148			0.8	+				ne
Isopar K Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 156	0.9	+	0.5	+	0.27	+		ne
Isopar L Solvent	Isoparaffinic hydrocarbons	64742-48-9	m.w. 163	0.9	+	0.5	+	0.28	+		ne
Isopar M Solvent	Isoparaffinic hydrocarbons	64742-47-8	m.w. 191			0.7	+	0.4	+		ne
Isopentane	2-Methylbutane	78-78-4	C ₅ H ₁₂			8.2					ne
Isophorone		78-59-1	C ₉ H ₁₄ O					3		9.07	C5
Isoprene	2-Methyl-1,3-butadiene	78-79-5	C ₅ H ₈	0.69	+	0.63	+	0.60	+	8.85	ne
Isopropanol	Isopropyl alcohol, 2-propanol, IPA	67-63-0	C ₃ H ₈ O	500	+	4.6	+	2.7		10.12	200
Isopropyl acetate		108-21-4	C ₅ H ₁₀ O ₂			2.6				9.99	100
Isopropyl ether	Diisopropyl ether	108-20-3	C ₆ H ₁₄ O			0.8				9.20	250
Jet fuel JP-4	Jet B, Turbo B, F-40 Wide cut type aviation fuel	8008-20-6 + 64741-42-0	m.w. 115			1.0	+	0.4	+		ne
Jet fuel JP-5	Jet 5, F-44, Kerosene type aviation fuel	8008-20-6 + 64747-77-1	m.w. 167			0.6	+	0.5	+		29
Jet fuel JP-8	F-34, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 165			0.94	+	0.3	+		30
Jet fuel A-1	F-34, Kerosene type aviation fuel	8008-20-6 + 64741-77-1	m.w. 145			0.67					34
Jet Fuel TS	Thermally Stable Jet Fuel, Hydrotreated kerosene fuel	8008-20-6 + 64742-47-8	m.w. 165	0.9	+	0.6	+	0.3	+		30
JP-10						0.7	+	0.5	+		
JP5, Petroleum/camelinal						1.05	+				
JP5/Petroleum						0.98	+				
Limonene, D-	(R)-(+)-Limonene	5989-27-5	C ₁₀ H ₁₆			0.33	+			~8.2	ne
Kerosene C10-C16 petro.distillate	see Jet Fuels	8008-20-6									
MDI	see 4,4'-Methylenebis (phenylisocyanate)										
Maleic anhydride	2,5-Furandione	108-31-6	C ₄ H ₂ O ₃							~10.8	0.1
Mercapto-2-ethanol	β-Mercaptoethanol, 2-Hydroxyethylmercaptan, BME, Thioethylene glycol	60-24-2	C ₂ H ₆ OS			1.5	+			9.65	0.2
Mesitylene	1,3,5-Trimethylbenzene	108-67-8	C ₉ H ₁₂	0.36	+	0.35	+	0.3	+	8.41	25
Methallyl chloride	see 3-Chloro-2-methylpropene										
Methane	Natural gas	74-82-8	CH ₄	NR	+	NR	+	NR	+	12.61	ne
Methanol	Methyl alcohol, carbinol	67-56-1	CH ₄ O	NR	+	NR	+	2.5	+	10.85	200
Methoxyethanol, 2-	Methyl cellosolve, Ethylene glycol monomethyl ether	109-86-4	C ₃ H ₈ O ₂	4.8	+	2.4	+	1.4	+	10.1	5

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Methoxyethoxyethanol, 2-	2-(2-Methoxyethoxy)ethanol Diethylene glycol monomethyl ether	111-77-3	C ₅ H ₁₂ O ₃	2.3	+	1.2	+	0.9	+	<10	ne
Methoxyethyl ether, 2-	bis(2-Methoxyethyl) ether, Diethylene glycol dimethyl ether, Diglyme	111-96-6	C ₆ H ₁₄ O ₃	0.64	+	0.54	+	0.44	+	<9.8	ne
Methyl acetate		79-20-9	C ₃ H ₆ O ₂	NR	+	6.6	+	1.4	+	10.27	200
Methyl acrylate	Methyl 2-propenoate, Acrylic acid methyl ester	96-33-3	C ₄ H ₆ O ₂			3.7	+	1.2	+	(9.9)	2
Methylamine	Aminomethane	74-89-5	CH ₅ N			1.2				8.97	5
Methyl amyl ketone	MAK, 2-Heptanone, Methyl pentyl ketone	110-43-0	C ₇ H ₁₄ O	0.9	+	0.85	+	0.5	+	9.30	50
Methylaniline, N-	MA; (Methylamino) benzene; N-Methyl aniline; Methylphenylamine; N-Phenylmethylamin	100-61-8	C ₇ H ₉ N			0.68	+			7.32	2
Methyl bromide	Bromomethane	74-83-9	CH ₃ Br	110	+	1.7	+	1.3	+	10.54	1
Methyl-2-butanol, 2-	tert-Amyl alcohol, tert-Pentyl alcohol	75-85-4	C ₅ H ₁₂ O			1.62	+			10.16	100
Methyl t-butyl ether	MTBE, tert-Butyl methyl ether	1634-04-4	C ₅ H ₁₂ O			0.9	+			9.24	40
Methyl cellosolve	see 2-Methoxyethanol										
Methyl chloride	Chloromethane	74-87-3	CH ₃ Cl	NR	+	NR	+	0.74	+	11.22	50
Methylcyclohexane		107-87-2	C ₇ H ₁₄	1.6	+	0.97	+	0.53	+	9.64	400
Methylene bis (phenyl-isocyanate), 4,4'-**	MDI, Mondur M		C ₁₅ H ₁₀ N ₂ O ₂	Very slow ppb level response							0.005
Methylene chloride	Dichloromethane	75-09-2	CH ₂ Cl ₂	NR	+	NR	+	0.89	+	11.32	25
Methyl ether	Dimethyl ether	115-10-6	C ₂ H ₆ O	4.8	+	3.1	+	2.5	+	10.03	ne
Methyl ethyl ketone	MEK, 2-Butanone	78-93-3	C ₄ H ₈ O	0.86	+	1.0	+	1.1	+	9.51	200
Methylhydrazine	Monomethylhydrazine, Hydrazomethane	60-34-4	C ₂ H ₆ N ₂	1.4	+	1.2	+	1.3	+	7.7	0.01
Methyl isoamyl ketone	MIAK, 5-Methyl-2-hexanone	110-12-3	C ₇ H ₁₄ O	0.8	+	0.76	+	0.5	+	9.28	50
Methyl isobutyl ketone	MIBK, 4-Methyl-2-pentanone	108-10-1	C ₆ H ₁₂ O	0.9	+	0.8	+	0.6	+	9.30	50
Methyl isocyanate		624-83-9	C ₂ H ₃ NO	NR	+	4.6	+	1.5		10.67	0.02
Methyl isothiocyanate		551-61-6	C ₂ H ₃ NS	0.5	+	0.45	+	0.4	+	9.25	ne
Methyl mercaptan	Methanethiol	74-93-1	CH ₄ S	0.65		0.54		0.66		9.44	0.5
Methyl methacrylate		80-62-6	C ₅ H ₈ O ₂	2.7	+	1.5	+	1.2	+	9.7	100
Methyl nonafluorobutyl ether	HFE-7100DL	163702-08-7, 163702-07-6	C ₅ H ₃ F ₉ O			NR	+	~35	+		ne
Methyl-1,5-pentanediamine, 2- (coats lamp)**	Dytek-A amine, 2-Methyl pentamethylenediamine	15520-10-2	C ₆ H ₁₆ N ₂			~0.6	+			<9.0	ne
Methyl propyl ketone	MPK, 2-Pentanone	107-87-9	C ₅ H ₁₂ O			0.93	+	0.79	+	9.38	200
Methyl-2-pyrrolidinone, N-	NMP, N-Methylpyrrolidone, 1-Methyl-2-pyrrolidinone, 1-Methyl-2-pyrrolidone	872-50-4	C ₅ H ₉ NO	1.0	+	0.8	+	0.9	+	9.17	ne
Methyl salicylate**	Methyl 2-hydroxybenzoate	119-36-8	C ₈ H ₈ O ₃	1.3	+	0.9	+	0.9	+	~9	ne
Methylstyrene, α-	2-Propenylbenzene	98-83-9	C ₉ H ₁₀			0.5				8.18	50
Methyl sulfide	DMS, Dimethyl sulfide	75-18-3	C ₂ H ₆ S	0.49	+	0.44	+	0.46	+	8.69	ne
Methyl vinyl ketone	MVK, 3-Buten-2-one	78-94-4	C ₄ H ₆ O			0.93	+			9.65	ne
Methyltetrahydrofuran	2-MeTHF, Tetrahydro-2- methylfuran, Tetrahydrosilvan	96-47-9	C ₅ H ₁₀ O			2.44	+			9.22	ne
Mineral spirits	Stoddard Solvent, Varsol 1, White Spirits	8020-83-5 8052-41-3 68551-17-7	m.w. 144	1.0		0.69	+	0.38	+		100
Mineral Spirits	Viscor 120B Calibration Fluid, b.p. 156-207°C	8052-41-3	m.w. 142	1.0	+	0.7	+	0.3	+		100

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Monoethanolamine	see Ethanolamine										
Mustard	HD, Bis (2-chloroethyl) sulfide	505-60-2 39472-40-7 68157-62-0	C ₄ H ₈ Cl ₂ S			0.6					0.0005
Naphtha	see VM & P Naphtha										
Naphthalene	Mothballs	91-20-3	C ₁₀ H ₈	0.45	+	0.42	+	0.40	+	8.13	10
Nickel carbonyl (in CO)	Nickel tetracarbonyl	13463-39-3	C ₄ NiO ₄			0.18				<8.8	0.001
Nicotine	3-(1-Methyl-2-pyrrolidyl)pyridine	54-11-5	C ₁₀ H ₁₄ N ₂			1.98	+				ne
Nitric oxide		10102-43-9	NO	~6		5.2	+	2.8	+	9.26	25
Nitrobenzene		98-95-3	C ₆ H ₅ NO ₂	2.6	+	1.9	+	1.6	+	9.81	1
Nitroethane		79-24-3	C ₂ H ₅ NO ₂					3		10.88	100
Nitrogen dioxide		10102-44-0	NO ₂	23	+	16	+	6	+	9.75	3
Nitrogen trifluoride		7783-54-2	NF ₃	NR		NR		NR		13.0	10
Nitromethane		75-52-5	CH ₃ NO ₂					4		11.02	20
Nitropropane, 2-		79-46-9	C ₃ H ₇ NO ₂					2.6		10.71	10
Nonane		111-84-2	C ₉ H ₂₀			1.4				9.72	200
Norpar 12	n-Paraffins, mostly C ₁₀ -C ₁₃	64771-72-8	m.w. 161	3.2	+	1.1	+	0.28	+		ne
Norpar 13	n-Paraffins, mostly C ₁₃ -C ₁₄	64771-72-8	m.w. 189	2.7	+	1.0	+	0.3	+		ne
Octamethylcyclotetrasiloxane		556-67-2	C ₈ H ₂₄ O ₄ Si ₄	0.21	+	0.17	+	0.14	+		ne
Octamethyltrisiloxane		107-51-7	C ₈ H ₂₄ O ₂ Si ₃	0.23	+	0.18	+	0.17	+	<10.0	ne
Octane, n-		111-65-9	C ₈ H ₁₈	13	+	1.8	+			9.82	300
Octene, 1-		111-66-0	C ₈ H ₁₆	0.9	+	0.75	+	0.4	+	9.43	75
Pentachloropropane	1,1,1,3,3-pentachloropropane	23153-23-3	C ₃ H ₃ Cl ₅					1.25	+		0.1
Pentane		109-66-0	C ₅ H ₁₂	80	+	8.4	+	0.7	+	10.35	600
Peracetic acid**	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C ₂ H ₄ O ₃	NR	+	NR	+	2.3	+		ne
Peracetic/Acetic acid mix**	Peroxyacetic acid, Acetyl hydroperoxide	79-21-0	C ₂ H ₄ O ₃			50	+	2.5	+		ne
Perchloroethene	PCE, Perchloroethylene, Tetrachloroethylene	127-18-4	C ₂ Cl ₄	0.69	+	0.57	+	0.31	+	9.32	25
Propylene glycol methyl ether, 1-Methoxy-2-propanol	PGME	107-98-2	C ₆ H ₁₂ O ₃	2.4	+	1.5	+	1.1	+		100
Propylene glycol methyl ether acetate, 1-Methoxy-2-acetoxypropane, 1-Methoxy-2-propanol acetate	PGMEA	108-65-6	C ₆ H ₁₂ O ₃	1.65	+	1.0	+	0.8	+		ne
Phenol	Hydroxybenzene	108-95-2	C ₆ H ₆ O	1.0	+	1.0	+	0.9	+	8.51	5
Phosgene	Dichlorocarbonyl	75-44-5	CCl ₂ O	NR	+	NR	+	8.5	+	11.2	0.1
Phosgene in Nitrogen	Dichlorocarbonyl	75-44-5	CCl ₂ O	NR	+	NR	+	6.8	+	11.2	0.1
Phosphine (coats lamp)		7803-51-2	PH ₃	28		3.9	+	1.1	+	9.87	0.3
Photocopier Toner	Isoparaffin mix					0.5	+	0.3	+		ne
Picoline, 3-	3-Methylpyridine	108-99-6	C ₆ H ₇ N			0.9				9.04	ne
Pinene, α-		2437-95-8	C ₁₀ H ₁₆			0.31	+	0.47		8.07	ne
Pinene, β-		18172-67-3	C ₁₀ H ₁₆	0.38	+	0.37	+	0.37	+	~8	100
Piperylene, isomer mix	1,3-Pentadiene	504-60-9	C ₅ H ₈	0.76	+	0.69	+	0.64	+	8.6	100
Propane		74-98-6	C ₃ H ₈			NR	+	1.8	+	10.95	2500
Propanol, n-	Propyl alcohol	71-23-8	C ₃ H ₈ O			5.5		1.7		10.22	200
Propene	Propylene	115-07-1	C ₃ H ₆	1.5	+	1.4	+	1.6	+	9.73	ne
Propionaldehyde	Propanal	123-38-6	C ₃ H ₆ O			1.9				9.95	ne
Propyl acetate, n-		109-60-4	C ₅ H ₁₀ O ₂			3.5				10.04	200
Propyl acetate	Propylacetate; n-Propyl ester of acetic acid	109-60-4	C ₅ H ₁₀ O ₂			2.27	+			10.04	200

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Propylamine, n-	1-Propylamine, 1-Aminopropane	107-10-8	C ₃ H ₉ N	1.1	+	1.1	+	0.9	+	8.78	ne
Propylene carbonate**		108-32-7	C ₄ H ₆ O ₃			62	+	1	+	10.5	ne
Propylene glycol	1,2-Propanediol	57-55-6	C ₃ H ₈ O ₂	18		4.2	+	1.6	+	<10.2	ne
Propylene glycol propyl ether	1-Propoxy-2-propanol	1569-01-3	C ₆ H ₁₄ O ₂	1.3	+	1.0	+	1.6	+		ne
Propylene oxide	Methyloxirane	75-56-9 16088-62-3 15448-47-2	C ₃ H ₆ O	~240		6.6	+	2.9	+	10.22	20
Propyleneimine	2-Methylaziridine	75-55-8	C ₃ H ₇ N	1.5	+	1.3	+	1.0	+	9.0	2
Propyl mercaptan, 2-	2-Propanethiol, Isopropyl mercaptan	75-33-2	C ₃ H ₈ S	0.64	+	0.66	+			9.15	ne
Pyridine		110-86-1	C ₅ H ₅ N	0.78	+	0.7	+	0.7	+	9.25	5
Pyrrolidine (coats lamp)	Azacyclohexane	123-75-1	C ₄ H ₉ N	2.1	+	1.3	+	1.6	+	~8.0	ne
RR7300 (PGME/PGMEA)	70:30 PGME:PGMEA (1-Methoxy-2-propanol: 1-Methoxy-2-acetoxyp propane)	107-98-2	C ₄ H ₁₀ O ₂ / C ₆ H ₁₂ O ₃			1.4	+	1.0	+		ne
Sarin	GB, Isopropyl methylphosphonofluoridate	107-44-8 50642-23-4	C ₄ H ₁₀ FO ₂ P			~3					
Shell SPK						1.26	+				
Shell SPK						1.29	+	0.4	+		
Shell SPK 50/50						1.02	+	0.41	+		
Shell SPK/JP-8						1.11	+				
Stoddard Solvent see Mineral Spirits		8020-83-5									
Styrene		100-42-5	C ₈ H ₈	0.45	+	0.43	+	0.4	+	8.43	20
Sulfur dioxide		7446-09-5	SO ₂	NR		NR	+	NR	+	12.32	2
Sulfur hexafluoride		2551-62-4	SF ₆	NR		NR		NR		15.3	1000
Sulfuryl fluoride	Vikane	2699-79-8	SO ₂ F ₂	NR		NR		NR		13.0	5
Tabun**	Ethyl N, N-dimethylphosphoramidocyanidate	77-81-6	C ₅ H ₁₁ N ₂ O ₂ P			0.8					15ppt
Tallow HRJ						1.09	+				
Tallow HRJ						0.95	+	0.36	+		
Tallow HRJ/JP-8						1.14	+				
Tallow HRJ/JP-8 50/50						0.9	+	0.39	+		
Tetrachloroethane, 1,1,1,2-		630-20-6	C ₂ H ₂ Cl ₄					1.3		~11.1	ne
Tetrachloroethane, 1,1,2,2-		79-34-5	C ₂ H ₂ Cl ₄	NR	+	NR	+	0.60	+	~11.1	1
Tetrachlorosilane		10023-04-7	SiCl ₄	NR		NR		15	+	11.79	ne
Tetraethyllead	TEL	78-00-2	C ₈ H ₂₀ Pb	0.4		0.3		0.2		~11.1	0.008
Tetraethyl orthosilicate	Ethyl silicate, TEOS	78-10-4	C ₈ H ₂₀ O ₄ Si			0.7	+	0.2	+	~9.8	10
Tetrafluoroethane, 1,1,1,2-	HFC-134A	811-97-2	C ₂ H ₂ F ₄			NR		NR			ne
Tetrafluoroethene	TFE, Tetrafluoroethylene, Perfluoroethylene	116-14-3	C ₂ F ₄			~15				10.12	ne
Tetrafluoromethane	CFC-14, Carbon tetrafluoride	75-73-0	CF ₄			NR	+	NR	+	>15.3	ne
Tetrahydrofuran	THF	109-99-9	C ₄ H ₈ O	1.9	+	1.7	+	1.0	+	9.41	200
Tetramethyl orthosilicate	Methyl silicate, TMOS	681-84-5	C ₄ H ₁₂ O ₄ Si	10	+	1.9	+			~10	1
Therminol® D-12**	Hydrotreated heavy naphtha	64742-48-9	m.w. 160	0.8	+	0.51	+	0.33	+		ne
Therminol® VP-1**	Dowtherm A, 3:1 Diphenyl oxide: Biphenyl	101-84-8 92-52-4	C ₁₂ H ₁₀ O C ₁₂ H ₁₀			0.4	+				1
Toluene	Methylbenzene	108-88-3	C ₇ H ₈	0.54	+	0.45	+	0.51	+	8.82	50
Tolylene-2,4-diisocyanate	TDI, 4-Methyl-1,3-phenylene-2,4-diisocyanate	584-84-9	C ₉ H ₆ N ₂ O ₂	1.4	+	1.4	+	2.0	+		0.002
Trichlorobenzene, 1,2,4-	1,2,4-TCB	120-82-1	C ₆ H ₃ Cl ₃	0.7	+	0.9	+			9.04	C5
Trichloroethane, 1,1,1-	1,1,1-TCA, Methyl chloroform	71-55-6	C ₂ H ₃ Cl ₃			NR	+	1	+	11	350

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Trichloroethane, 1,1,2-	1,1,2-TCA	79-00-5	C ₂ H ₃ Cl ₃	NR	+	NR	+	0.9	+	11.0	10
Trichloroethene	TCE, Trichloroethylene	79-01-6	C ₂ HCl ₃	0.62	+	0.54	+	0.43	+	9.47	50
Trichloromethylsilane	Methyltrichlorosilane	75-79-6	CH ₃ Cl ₃ Si	NR		NR		1.8	+	11.36	ne
Trichlorotrifluoroethane, 1,1,2-	CFC-113	76-13-1	C ₂ Cl ₃ F ₃			NR		NR		11.99	1000
Triethylamine	TEA	121-44-8	C ₆ H ₁₅ N	0.95	+	0.9	+	0.65	+	7.3	1
Triethyl borate	TEB; Boric acid triethyl ester, Boron ethoxide	150-46-9	C ₆ H ₁₅ O ₃ B			2.2	+	1.1	+	~10	ne
Triethyl phosphate	Ethyl phosphate	78-40-0	C ₆ H ₁₅ O ₄ P	~50	+	3.1	+	0.60	+	9.79	ne
Trifluoroethane, 1,1,2-		430-66-0	C ₂ H ₃ F ₃					34		12.9	ne
Trimethylamine		75-50-3	C ₃ H ₉ N			0.9				7.82	5
Trimethylbenzene, 1,3,5- see Mesitylene		108-67-8									25
Trimethyl borate	TMB; Boric acid trimethyl ester, Boron methoxide	121-43-7	C ₃ H ₉ O ₃ B			5.1	+	1.2	+	10.1	ne
Trimethyl phosphate	Methyl phosphate	512-56-1	C ₃ H ₉ O ₄ P			8.0	+	1.3	+	9.99	ne
Trimethyl phosphite	Methyl phosphite	121-45-9	C ₃ H ₉ O ₃ P			1.1	+		+	8.5	2
Turpentine	Pinenes (85%) + other diisoprenes	8006-64-2	C ₁₀ H ₁₆	0.37	+	0.4	+	0.29	+	~8	20
Undecane		1120-21-4	C ₁₁ H ₂₄			2				9.56	ne
Varsol see Mineral Spirits											
Vinyl acetate		108-05-4	C ₄ H ₆ O ₂	1.5	+	1.2	+	1.0	+	9.19	10
Vinyl bromide	Bromoethylene	593-60-2	C ₂ H ₃ Br			0.4				9.80	5
Vinyl chloride	Chloroethylene, VCM	75-01-4	C ₂ H ₃ Cl			2.0	+	0.6	+	9.99	5
Vinyl-1-cyclohexene, 4-	Butadiene dimer, 4-Ethenylcyclohexene	100-40-3	C ₈ H ₁₂	0.6	+	0.56	+			9.83	0.1
Vinylidene chloride see 1,1-Dichloroethene											
Vinyl-2-pyrrolidinone, 1-	NVP, N-vinylpyrrolidone, 1-ethenyl-2-pyrrolidinone	88-12-0	C ₆ H ₉ NO	1.0	+	0.8	+	0.9	+		ne
Viscor 120B see Mineral Spirits—Viscor 120B Calibration Fluid											
V. M. & P. Naphtha	Ligroin; Solvent naphtha; Varnish maker's & painter's naphtha	64742-89-8	m.w. 111 (C ₈ -C ₉)	1.7	+	0.97	+				300
Xylene, m-	1,3-Dimethylbenzene	108-38-3	C ₈ H ₁₀	0.50	+	0.44	+	0.40	+	8.56	100
Xylene, o-	1,2-Dimethylbenzene	95-47-6	C ₈ H ₁₀	0.56	+	0.45	+	0.43		8.56	100
Xylene, p-	1,4-Dimethylbenzene	106-42-3	C ₈ H ₁₀	0.48	+	0.39	+	0.38	+	8.44	100

* The term "ionization energy" is more scientifically correct and replaces the old term "ionization potential." High-boiling ("heavy") compounds may not vaporize enough to give a response even when their ionization energies are below the lamp photon energy. Some inorganic compounds like H₂O₂ and NO₂ give weak response even when their ionization energies are well below the lamp photon energy.

** Compounds indicated in green can be detected using a MiniRAE 3000, UltraRAE 3000 or ppbRAE 3000 with slow response, but may be lost by adsorption on a MultiRAE, EntryRAE and AreaRAE. Response on multi-gas meters can give an indication of relative concentrations, but may not be quantitative and for some chemicals no response is observed.

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SOP B-4
Calibration of YSI, In-Situ and Hach Field Instruments

CALIBRATION OF YSI, IN-SITU AND HACH FIELD INSTRUMENTS

PURPOSE

This Standard Operating Procedure (SOP) provides a general framework for calibrating field instruments used to measure water quality parameters for groundwater and surface water at the Troy Mills Landfill Superfund Site in Troy, New Hampshire. Water quality parameters include temperature, pH, dissolved oxygen (DO), specific conductance, oxidation reduction potential (ORP) and turbidity.

This SOP is written for instruments where the probe readings for pH, DO and specific conductance are automatically corrected for temperature (i.e., YSI Models 600XL/XLM and the In-Situ smarTROLL™ multiparameter meter [referred to as the Smartroll in this SOP]). Meters measuring pH must be calibrated using three pH standards (4, 7 and 10). Turbidity must be taken with a separate meter (i.e., Hach 2100P or 2100Q).

The YSI Models 600XL/XLM multiparameter meters are slowly being phased out by YSI; therefore, this SOP also includes instructions on calibrating the In-Situ Smartroll multiparameter meter. The Smartroll combines water quality sensors with the mobility of an Android™ or iOS™ mobile device (i.e., a rugged tablet). The VuSitu™ mobile app runs on an Android device and the iSitu® mobile app runs on an iOS device. The Smartroll was chosen because it appears to meet all of the New Hampshire Department of Environmental Services (NHDES) requirements for field instrumentation and will eliminate or reduce the amount of data needed to be recorded on hand written worksheets. NHDES requires that field personnel use a rugged field electronic tablet with the Smartroll to calibrate and record data in the field in order to view all data simultaneously and clearly; **it is not acceptable to use a smartphone, iPod, or equivalent due to screen-size limitations.**

This SOP includes the calibration procedure for both the Hach 2100P and 2100Q turbidity meters. The instructions for the 2100P are included as the NHDES Hazardous Waste Remediation Bureau has a number of 2100P units that are still in service and may be used at any given site.

Any modifications to this SOP shall be approved in advance by the NHDES Project Manager and Quality Assurance (QA) Coordinator, in consultation with the United States Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

For ground water monitoring, the instrument must be equipped with a clear flow-through cell with a maximum capacity of 250 milliliters and the display/logger or computer display screen needs to be large enough to simultaneously display the readouts of each probe in the instrument. Turbidity samples must be taken at a point before the flow-through cell and analyzed in a separate meter. A three-way stopcock is needed to divert sample flow prior to the flow-through cell so that an aliquot can be collected for the turbidity reading. Turbidity cannot be measured in or after a flow-through cell because the flow-through cell acts as a sediment trap. This procedure is applicable for use with the current SOPs in the site-specific Sampling and Analysis Plan (SAP).

HEALTH AND SAFETY WARNINGS

Read all labels on the standards and note any warnings on the labels. Wear appropriate personal protection equipment (e.g., gloves and eye shields) when handling the standards. If necessary, consult the Safety Data Sheets for additional safety information on the chemicals in the standards.

CALIBRATION ACCEPTANCE CRITERIA

All field instruments shall be calibrated successfully and have a successful calibration check in the office prior to the field event (within one week) to ensure that the equipment is working properly and meets the QA criteria in the SAP. The calibration/calibration check shall be documented on the Calibration Log.

For this project, once the equipment is calibrated and checked prior to the sampling event, it is not necessary to recalibrate or check the calibration at the beginning of each sampling day. Instead, calibration checks made in the run mode shall be performed at the beginning of the first sampling day to ensure the equipment is in calibration and again at the end of the first day of use to ensure that the instruments have remained in calibration throughout the day. At a minimum after the first day of use, calibration checks shall be performed at the end of each day of use to ensure that the instruments have remained in calibration. However, if an instrument is not used for a day (i.e., over the weekend) or if the field team leader determines it is necessary, then the next sampling day would be considered the “first” sampling day. In such an instance, the calibration check will be performed both at the beginning and end of that sampling day. From thereafter, the calibration check schedule would be performed at the end of the day only.

If one or more parameters are not within the appropriate range during the calibration check, only those parameters shall be recalibrated and checked again. See individual parameters in this SOP for specific instructions. In general, if the calibration or calibration check is not successful, recalibrate using a new standard solution with a different lot number and recheck. Then, if the calibration or calibration check is still unsuccessful, replace the meter with a backup unit. Backup instruments shall be fully calibrated, checked and used in place of the inoperable unit.

In addition, should any erratic or illogical readings occur during the field day and between calibrations/calibration checks, the calibration shall be re-checked for those parameters and recalibrated, as necessary, in order to ensure that representative measurements are obtained. All calibration and check values shall be documented on the Calibration Log maintained by each user (see attached log).

If a calibration check at the end of the day is not within the acceptable range for a parameter, the data collected that day for that parameter shall be qualified in its use. This qualification shall be documented on the Calibration Log and the field sheets/logs for the appropriate sampling locations. For example: pH measurements are collected as part of the low flow sampling procedure. If the afternoon pH calibration check was not within the acceptable range that day, then the pH data collected by that instrument on that day would be qualified as useful only for

determining stabilization and not as representative pH measurements of the water being sampled. That qualification would then be documented on the Calibration Log and the sampling worksheet for each of the locations where the instrument was used.

WEATHER CONDITIONS

Normally, everyday calibration procedures are performed in the field. However, under adverse weather conditions, it is permissible to perform the beginning-of-day calibration and/or calibration check in the office or other facility just prior to going into the field. It is also permissible under similar conditions to perform the end-of-day calibration check off-site. The calibration solutions must be brought into the field with the multiparameter meters and protected from extreme temperatures.

EQUIPMENT AND MATERIALS

The following is a list of equipment and materials required for calibration:

- Manufacturer's instruction manuals (including the instrument specifications) to accompany the instruments into the field;
- Multi-meter sonde and handheld meter (YSI 600XL/XLM or In-Situ Smartroll). At least one meter shall have a built-in barometer;
- Calibration solutions:
It is advisable to have a sufficient number of extra bottles of each standard on hand in case of complications (especially the conductivity standards). Be sure that the standards are not near their expiration dates (e.g., greater than one month from expiration).
 - Small wet sponge or paper towel for DO 100% saturation calibration,
 - “Zero” (0) milligrams per liter (mg/l) DO check standard (minimum of two bottles from two separate lots for the Smartroll),
 - pH buffers 4, 7 and 10,
 - 1,413 microsiemens per centimeter ($\mu\text{S}/\text{cm}$) and 718 $\mu\text{S}/\text{cm}$ standards for specific conductance. One to use for calibration and the other one to use for checking the calibration, and
 - Zobell Solution for ORP;
- Separate turbidimeter (Hach 2100P or 2100Q Turbidity meter) with calibration standards: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) as appropriate for each meter;
- Calibration cup/Storage cup;
- Cooler (for storage of calibration solutions);
- Laboratory-grade deionized (DI) water;
- Paper towels;
- Kimwipes;

- NIST certified thermometer, degrees Celsius (if the vendor has not verified the accuracy of the instrument temperature sensor);
- Calibration Log;
- If using the Smartroll, you **MUST** request the following specific equipment from the vendor as they may not automatically be provided with the Smartroll:
 - The appropriate blue tooth connection for the operating system of the tablet (no smartphones or iPods) you are using (i.e., Power Pack for Android™ or the Battery Pack for the iOS™ [Apple product]). The power pack, or battery pack, enables wireless communication between the device and the probe and supplies power to the probe; they are not interchangeable,
 - A ring stand and clamp,
 - A spare RDO probe, and
 - The Smartroll MP Storage and Calibration cup.

The Storage and Calibration cup (referred to as the storage cup when discussing the Smartroll in this SOP) is a rugged alternative to the standard calibration cup. This storage cup is not provided with the Smartroll multiparameter meters from In-Situ. The vendor orders them separately from In-Situ and you must specifically request the storage cup from the vendor.

Do not use the larger and more flexible calibration cup referred to in the manual (with or without the probe guard) for the following reasons: 1) the probe guard makes it hard to see the probes, making rinsing and drying the probes between each standard unnecessarily difficult; 2) the large cup requires more calibration solution; 3) the calibration cup is flimsy; and 4) the flexible collar makes it harder to connect to the rest of the calibration apparatus and instrument.

GENERAL INFORMATION

This SOP requires that the manufacturer's instruction manuals (including the instrument specifications) accompany the instruments into the field.

In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested and inspected according to the manufacturer's instructions. It is assumed that most of this equipment will be rented and is not owned by the contractor. Any reference made to a vendor applies to the owner/renter of the equipment.

All calibration solutions shall be stored at room temperature or at cool/stable temperatures in the field. Storage of calibration solutions in an insulated cooler kept in the shade will help to maintain calibration solution integrity.

All calibration solutions shall be placed into the calibration cup (or, in the case of the Smartroll, the storage cup) to calibrate the instrument and to check the calibration. The calibration cup shall be rinsed with DI water and dried with paper towels or Kimwipes between each standard. The probes shall not be put directly into the bottles of calibration solutions from the vendor. The

volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor. See manufacturer's instructions for additional information. Do not pour the used calibration solutions back into their original bottles.

While calibrating or measuring, make sure there are no air bubbles lodged on or between the probes.

Calibration standard values, check results, temperature and barometer checks, and maintenance for each piece of equipment shall be documented on the Calibration Logs and included in the reports. This information includes dates, personnel, calibration standards expiration dates, etc. A Calibration Log is provided at the end of this SOP.

GENERAL PRELIMINARY CALIBRATION PROCEDURES

1. Prior to calibration, all instrument probes must be cleaned in accordance with the manufacturer's instructions, preferably by the vendor if the unit is to be rented. Failure to perform this proper maintenance step can lead to erratic measurements. The vendor is required to provide written documentation (which will be included in sampling reports) that indicates the equipment was cleaned, who cleaned it and the date of the cleaning.
2. Program the multi-probe instrument so that the following parameters to be measured will be displayed: temperature in °C; pH; DO in % for calibration and mg/l for measurements; DO charge in millivolts; specific conductance in $\mu\text{S}/\text{cm}$; and ORP in millivolt (mV). The DO charge is not applicable for the Smartroll.
3. Allow all calibration standards to equilibrate to the ambient temperature.
4. Mark the "date opened" on each new bottle of calibration solution. Record the lot number and expiration date on the Calibration Log.

I. MULTIPARAMETER METER CALIBRATION PROCEDURES

TEMPERATURE (this section applies to both YSI and In-Situ models)

This procedure is not to be done in the field.

For instrument probes that rely on the temperature sensor, each temperature sensor must be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST) prior to the sampling event. A temperature check is required once a year for each instrument, at a minimum.

The temperature check shall be performed prior to the field event, preferably via the vendor if the unit is rented. If the check is not performed by the vendor, then it must be performed by field personnel prior to using the unit. Verification and documentation, including accuracy, dates and personnel, of this procedure are required. The documentation shall be recorded on the Calibration Log and included in any sampling reports.

Temperature Sensor Accuracy Procedure for YSI and In-Situ Meters

1. Allow a container filled with water to come to room temperature.
2. Place a NIST thermometer and the instrument's temperature sensor into the water and wait for both temperature readings to stabilize.
3. Compare the two measurements and record the results on the Calibration Log. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (typically ± 0.15 °C or ± 0.2 °C). Check the manual that came with the instrument. If the measurements do not agree, the instrument may not be working properly and the vendor/manufacturer may need to be consulted or the unit replaced.

A. YSI 600XL/XLM Calibration/Calibration Check Procedures

Preliminary/general steps to set up the instrument for calibration:

1. Make sure that the cable is connected to the sonde and the handheld display.
 - a. Align the pins on the cable with the pins on the sonde, and then twist the outer portion of the connector until the connection is secure.
 - b. Align the pins on the cable with the pins on the handheld display and then twist the outer portion of the connector until the connection is secure.
2. Turn on the instrument and allow it to warm up according to the manufacturer's instructions.
3. Select Calibrate from the Main Menu.

YSI - DISSOLVED OXYGEN

The YSI instrument measures dissolved oxygen (DO) content in water using a membrane electrode. The instrument is calibrated to 100% DO saturation and then the calibration is checked with a 0% saturated DO solution.

The DO probe's membrane and electrolyte solution shall be replaced prior to the sampling event and replaced as needed thereafter. Failure to perform this step may lead to erratic measurements. If the vendor changes the membrane and electrolyte solution, they must send the appropriate documentation with each unit. If there is no documentation with the unit, the field personnel will have to replace the membrane and electrolyte solution before the sampling event begins. Documentation shall be noted on the Calibration Log.

YSI - DO Calibration/Calibration Check Procedure

1. Record the DO charge on the worksheet. Note: According to manufacturer, the DO charge should be between 25-75 millivolts for the probe to be working correctly. If the DO charge is outside this range, replace the membrane and electrolyte solution prior to calibration.

2. Gently dry the temperature sensor and remove any droplets of water from the DO probe's sensor membrane according to manufacturer's instructions. Inspect the DO membrane for air bubbles and nicks. If any are found, replace the membrane and electrolyte solution.
3. Place a wet sponge or a wet paper towel on the bottom of the DO calibration container to create a 100 percent water-saturated air environment.
4. Place the DO probe loosely into the calibration container to prevent the escape of moisture evaporating from the sponge or paper towel while allowing pressure equilibration before calibration. Do not allow the probe to come into contact with the wet sponge or paper towel. **The storage cup must be vented to the atmosphere.** Do not screw the calibration cup tightly onto the sonde.
5. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). Make sure that the instrument is turned on during this time to allow the DO probe to warm-up according to the manufacturer's directions. Make sure that both the DO reading and the temperature have stabilized before starting the calibration sequence.
6. Select calibration mode; then select "DO %".
7. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument using an on-site hand held barometer, unless the instrument already has a temperature-compensated barometer.
8. Record the barometric pressure on the Calibration Log.
9. The instrument should indicate that the calibration is in progress. Observe the readings for percent dissolved oxygen and temperature. When they show no significant change for approximately 30 seconds, press enter. After calibration, the instrument should display dissolved oxygen in mg/l (% DO is only used for calibration).
10. Record the initial DO reading in mg/l and temperature reading in °C on the Calibration Log immediately after calibration.
11. To check the calibration, select monitoring/run mode (on a run/measurement screen), remove the probe from the container and place it into a 0.0 (zero) mg/l DO standard.

Wait until the "mg/l DO" and temperature readings have stabilized. Record the zero mg/l DO reading on the Calibration Log. The instrument must read 0 to 0.5 mg/l DO. If the instrument reads above 0.5 mg/l or reads a negative value, it will be necessary to clean the probe and change the membrane and electrolyte solution. If this is unsuccessful, use a new 0.0 mg/l DO standard. If these measures are still unsuccessful, consult the manufacturer/vendor or replace the unit.

If the afternoon calibration check is not within the acceptable range, then the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

Remove probe from the zero DO standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes.

YSI - PH (ELECTROMETRIC)

The YSI instrument measures the pH of a sample electrometrically using a glass electrode. Three standards are needed for the calibration: pH 4, 7 and 10. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes between standards.

YSI - pH Calibration/Calibration Check Procedure

1. Allow the buffered standards to equilibrate to the ambient temperature.
2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.
3. Remove probe from its storage container, rinse with DI water, and gently blot dry with a Kimwipe. Use caution during drying, such that the dissolved oxygen probe membrane is not disturbed.
4. Select the calibration mode for a three-point pH calibration.
5. Immerse probe into the initial standard, pH 7.
6. Enter the buffered standard value (e.g., pH 7) into the instrument. Wait until temperature and pH readings stabilize. If the readings do not change within 30 seconds, press enter to accept the calibration.
7. Remove probe from the initial standard, rinse with DI water, and gently blot dry.
8. Immerse probe into the second standard (pH 4). Repeat step 6.
9. Remove probe from the second standard, rinse with DI water, and gently blot dry.
10. Immerse probe into the third standard (pH 10) and repeat step 6.
11. Remove probe from the third standard, rinse with DI water, and gently blot dry.
12. To check the calibration, select monitoring/run mode (on a run/measurement screen) and immerse the probe into the pH 7 buffer solution. Wait for the temperature and pH readings to stabilize. Record the pH value on the Calibration Log. The value must be pH 7 +/-5% (pH 6.65-7.35). If the calibration check failed, recalibrate the instrument using fresh standards for all three values and check it again. If re-calibration fails, clean the pH probe, recalibrate and check the calibration. If the calibration check fails again, consult the manufacturer/vendor or replace the unit.

If the afternoon calibration check is not within the acceptable range, then the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

Remove probe from the pH 7 check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes.

YSI - SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C. When monitoring groundwater, surface water or pore water, use the specific conductance readings and record in $\mu\text{S}/\text{cm}$.

Most instruments are calibrated against a single standard which is near, (above or below) the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the range of measurements. Specific conductivity standards concentrations are generally dependent on expected field conditions and availability. However, there have been some issues with the stability of some of the standards in the field. Unless specified in a site-specific SAP, NHDES and EPA Region 1 have agreed that specific conductivity is, in general, a non-critical measurement and it is more important to use standards that are stable in the field even though the actual field measurements may not be bracketed by the high and low standards.

Therefore, the HWRB recommends using the following standards as they have been field tested, are readily available from most vendors, and are acceptable for use by EPA: a 1413 $\mu\text{S}/\text{cm}$ standard and a 718 $\mu\text{S}/\text{cm}$ standard. It is acceptable to use either one of the standards to calibrate and the other to check the calibration. **The use of only ONE standard to both calibrate and check the calibration is NOT ACCEPTABLE**, as the second standard is used to check the linearity of the instrument in the range of measurements.

In general, the 718 $\mu\text{S}/\text{cm}$ standard will be used to calibrate and a 1413 $\mu\text{S}/\text{cm}$ standard used to check the calibration. **It is advisable to have a sufficient number of extra bottles of each standard on hand in case of complications. Be sure that the standards are not near their expiration dates (e.g., greater than one month from expiration).** Rinse the calibration cup with DI water and dry it between standards.

Preliminary Cleaning Procedure

Before calibrating for specific conductance, clean the probe according to the manufacturer. In general, dip a small cleaning brush in DI water and insert it into each hole 15-20 times. Rinse with DI water and dry thoroughly.

YSI - Specific Conductance Calibration/Calibration Check Procedure

1. Allow the calibration standards to equilibrate to the ambient temperature.
2. Remove the probe from its storage container, rinse the probe with a small amount of the first (718 $\mu\text{S}/\text{cm}$) specific conductance standard, discard the rinsate and place the probe into the standard. Be sure that the temperature sensor and the probe's vent hole are fully immersed in the standard. Gently move the sonde up and down to dislodge any air bubbles from the conductivity cell.
3. Allow at least one minute for temperature equilibrium before proceeding.

4. Select the calibration mode for specific conductance. Enter the calibration value of the standard being used (718 $\mu\text{S}/\text{cm}$). Allow the temperature and specific conductance to stabilize. If the reading does not change within 30 seconds, press enter to accept the calibration.
5. Remove probe from the specific conductance check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels.
6. To check the calibration, select the monitoring/run mode (a run/measurement screen). Remove the probe from the first standard, rinse the probe with DI water and then a small amount of the second (1413 $\mu\text{S}/\text{cm}$) standard, discard the rinsate and place the probe into the second standard. The second standard will serve to verify the linearity of the instrument. Wait until the specific conductance and temperature readings have stabilized. Read the specific conductance value from the instrument and record the value on the Calibration Log. Compare the value to the standard. The value must be $\pm 5\%$

When the 718 $\mu\text{S}/\text{cm}$ standard is used to calibrate, 5% of the 1413 $\mu\text{S}/\text{cm}$ solution is 1342-1484 $\mu\text{S}/\text{cm}$. When the 1413 $\mu\text{S}/\text{cm}$ standard is used to calibrate, 5% of the 718 $\mu\text{S}/\text{cm}$ solution is 682-754 $\mu\text{S}/\text{cm}$.

If the applicable range is not met, check the calibration using a fresh solution with a different lot number from that used in the initial calibration check. Then, if the range is not met, recalibrate using a fresh calibration solution with a different lot number and check again.

If this range is still not met, calibrate using the second calibration solution and repeat the process above. If this is not successful, consult the manufacturer/vendor or replace the unit.

For example: if the 718 $\mu\text{S}/\text{cm}$ standard is used to calibrate, then the 1413 $\mu\text{S}/\text{cm}$ solution is used to check the calibration. If the 1413 $\mu\text{S}/\text{cm}$ solution is not within the acceptable range of 1342-1484 $\mu\text{S}/\text{cm}$, then check the calibration with a fresh 1413 $\mu\text{S}/\text{cm}$ solution with a different lot number. If this range is still not met, recalibrate the instrument using a new 718 $\mu\text{S}/\text{cm}$ standard from a different lot number and check again.

If the acceptable range is still not met, calibrate the instrument using the 1413 $\mu\text{S}/\text{cm}$ standard and check the calibration with a 718 $\mu\text{S}/\text{cm}$ solution. If the 718 $\mu\text{S}/\text{cm}$ solution is not within the acceptable range of 682-754 $\mu\text{S}/\text{cm}$, then check the calibration with another 718 $\mu\text{S}/\text{cm}$ solution with a different lot number. If this range is still not met, recalibrate the instrument using a new 1413 $\mu\text{S}/\text{cm}$ standard from a different lot number and check again.

If that does not solve the problem, consult the manufacturer/vendor or replace the unit.

If the afternoon calibration check is not within the acceptable range then the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

Remove probe from the specific conductance check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels.

YSI - OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent. A Zobell solution is required to calibrate ORP. Read the warning on the label before use.

YSI ORP Calibration/Calibration Check Procedure

1. Allow the Zobell solution calibration standard to equilibrate to ambient temperature.
2. Remove the probe from its storage container, rinse the probe with DI water, gently blot dry with a Kimwipe and place it into the standard.
3. Select monitoring/run mode.
4. Wait for the probe temperature to stabilize, and then read the temperature. Record the temperature reading on the Calibration Log.
5. Look up the mV value at this temperature from the temperature / mV chart found below and on the Calibration Log. These values have been rounded to the nearest whole number. Record this value on the Calibration Log.
6. Select the calibration mode for ORP. Enter the temperature-corrected ORP value into the instrument. Once the temperature and ORP values stabilize, press enter to accept the calibration.
7. To check the calibration, select monitoring/run mode (on a run/measurement screen). Immerse the probe in the Zobell solution. Wait until the ORP and temperature readings have stabilized. Read the temperature and the ORP on the instrument. Record the values on the Calibration Log. The instrument value must be within +/- 5% of the mV value for the current temperature. See the chart below for the check range. If it is not within +/- 5%, recalibrate using a new Zobell solution. If the re-calibration is not successful, consult the manufacturer/vendor or replace the unit. For the afternoon calibration check, the instrument must be within +/- 5% of the mV value for the current temperature or the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

Remove the probe from the ORP check standard, rinse with DI water, and gently blot dry. Rinse the calibration cup with DI water and dry it with paper towels or Kimwipes.

Zobell Solution mV Values Based on Temperature for ORP Calibration
Calibration Check Range Values (+/- 5%)
(Round off temperature to whole number, e.g., 23.5 °C rounds up to 24 °C)

Temp . °C	ORP Zobell Solution mV Value	Calibratio n Check Range Values +/- 5%	Temp . °C	ORP Zobell Solution mV Value	Calibratio n Check Range Values +/- 5%	Temp . °C	ORP Zobell Solution mV Value	Calibratio n Check Range Values +/- 5%
-3	267	254-280	10	251	238-264	23	234	222-246
-2	266	253-279	11	249	237-261	24	232	220-244
-1	265	252-278	12	248	236-260	25	231	219-243
0	264	251-277	13	247	235-259	26	230	219-242
1	262	249-275	14	245	233-257	27	228	217-239
2	261	248-274	15	244	232-256	28	227	216-238
3	260	247-273	16	243	231-255	29	226	215-237
4	258	245-271	17	241	229-253	30	225	214-236
5	257	244-270	18	240	228-252	31	223	212-234
6	256	243-269	19	239	227-251	32	222	211-233
7	254	241-267	20	238	226-250	33	221	210-232
8	253	240-266	21	236	224-248	34	219	208-230
9	252	239-265	22	235	223-247	35	218	207-229

B. In-Situ Smartroll Calibration Procedures

When using the Smartroll, calibrate all parameters first, then select the “live readings” screen on the tablet display and check all the parameters after the calibration procedure has been completed.

Preliminary/general steps to set up the instrument for calibration:

1. Make sure that the cable is connected to the instrument and the battery/power pack.
 - a. Align the pins on the cable with the pins on the probe (sonde), and then twist the outer portion of the connector until the connection is secure.
 - b. Align the pins on the cable with the pins on the battery/power pack, and then twist the outer portion of the connector until the connection is secure.
2. Storage cup

Use the storage cup that was specifically requested under the equipment section above to calibrate the instrument (the same type of storage/calibration cup as the YSI unit). **Do not use** the larger and more flexible calibration cup referred to in the manual. The storage cup is not referenced in the user manual because it is sold separately.

If there is a metal sleeve in the storage/calibration cup, it must be removed before use so that the probes are visible.

Unscrew the bottom of the calibration cup and pull the sleeve out prior to calibration. Remember to put the sleeve back in before you send the unit back to the vendor.

3. Press the power button on the battery/power pack.
4. Turn on the tablet.
5. Tap on the VuSitu or iSitu icon to open the application in the tablet. Connect to the instrument via Bluetooth. If using more than one Smartroll, be sure to connect to the Bluetooth device you are using and not others around you. The serial number of the Bluetooth battery pack connected to the multiparameter meter will be displayed on your tablet.
6. Tap the **Calibration** icon (it looks like a laboratory beaker) on the bottom left of the tablet to access a list of sensors that are available for calibration.
7. Then tap the first parameter to be calibrated.
8. Calibration of each parameter should take no more than 1 or 2 minutes and is often quicker than 1 minute. If any parameter calibration reads “nominal”, but is within the allowable range, you may accept the calibration. Often waiting another minute will allow the reading to stabilize. If any parameters indicate that they did not stabilize, perform the calibration procedure again.

IN-SITU - DISSOLVED OXYGEN

The In-Situ instrument measures DO content in water using an optical sensor.

The Smartroll performs a two-part calibration for DO: 100% saturation and 0% saturation. The meter should automatically detect all standard calibration solution values. If you are using a non-standard calibration solution, you have the option to manually enter the value.

In-Situ - DO Calibration Procedure

1. Inspect the rugged dissolved oxygen (RDO) cap for air bubbles and nicks. If any are found, replace the RDO cap.
2. Tap the **Calibration** icon on the tablet display to access a list of sensors that are available for calibration.
3. Tap **RDO Saturation** on the tablet display.
4. Select the two-point calibration method to calibrate the sensor: Tap **100% and 0% Saturation**.
5. Remove (unscrew) the bottom of the storage cup and place a water-saturated sponge or a small amount of water (cannot touch DO probe) in the end cap to create a 100 percent water-saturated air environment.
6. Place the probe loosely into the storage cup in order to vent the storage cup to barometric pressure. **The storage cup must be vented to the atmosphere.** Do not screw the storage cup tightly onto the meters.
7. Tap **Start** on the tablet display.

8. Allow the confined air to become saturated with water vapor.
9. The instrument will indicate that the calibration is in progress.
10. When the instrument indicates that the calibration is stable, record the initial DO reading in % and mg/l, and temperature reading in °C, on the Calibration Log.
11. Tap the **Accept** button on the tablet display.
12. Remove the sponge, dry the storage cup with paper towels or Kimwipes and add fresh sodium sulfite solution (zero DO solution) to the fill line.
13. Place the instrument into the storage cup, and tap **Start**.
14. When the instrument indicates that the calibration is stable, tap the Accept button.
15. Remove probe from the storage cup containing the zero DO standard, rinse well with DI water, and gently blot dry.
16. Rinse the storage cup well with DI water and dry it with paper towels or Kimwipes.
17. Tap on the left arrow “sensor calibration” in the top left corner of the tablet display to return to the calibration menu to select the next parameter.

RDO SALINITY SETTING

The Smartroll RDO does not include automatic salinity compensation, so you must set it manually.

1. From the main menu, select **Connected Instrument**.
2. Select **Instrument Settings**.
3. From the Instrument Settings menu select **Salinity Setting**.
4. Select the appropriate setting for your sampling environment (e.g., fresh, brackish, or salt water). The typical setting is fresh water.

IN SITU - PH (ELECTROMETRIC)

The pH of a sample is determined electrometrically using a glass electrode. Three standards are needed for the calibration: pH 4, 7 and 10. The meter should automatically detect all standard calibration solution values.

In-Situ - pH Calibration Procedure

1. Tap the **Calibration** icon on the tablet display to access a list of sensors that are available for calibration.
2. Tap **pH Sensor**.
3. Tap **3-Point Calibration**.
4. Fill the storage cup to the fill line with the first calibration buffer (pH 4).
5. Place the instrument into the storage cup, and tap **Start** on the tablet display.

6. When the instrument indicates that the calibration is stable, tap the **Accept** button on the tablet display.
7. Remove probe from the storage cup containing the standard, rinse with DI water, and gently blot dry.
8. Rinse the storage cup with DI water and dry it with paper towels or Kimwipes.
9. Fill the cup to the fill line with the second calibration buffer (pH 7).
10. Place the instrument into the storage cup, and tap **Start** on the tablet display.
11. When the instrument indicates that the calibration is stable, tap the **Accept** button on the tablet display.
12. Remove probe from the storage cup containing the standard, rinse with DI water, and gently blot dry.
13. Rinse the storage cup with DI water and dry it with paper towels or Kimwipes.
14. Fill the cup with the third calibration buffer (pH 10).
15. Place the instrument into the storage cup, and tap **Start** on the tablet display.
16. When the instrument indicates that the calibration is stable, tap the **Accept** button on the tablet display.
17. The tablet will automatically return to the initial pH Calibration screen (where the 3-point calibration was selected).
18. Remove probe from the storage cup containing the standard, rinse with DI water, and gently blot dry.
19. Rinse the storage cup with DI water and dry it with paper towels or Kimwipes.
20. Tap on the left arrow “sensor calibration” in the top left corner of the tablet display to return to the calibration menu to select the next parameter.

IN-SITU - SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C. When monitoring groundwater, surface water, or pore water, use the specific conductance readings and record in $\mu\text{S}/\text{cm}$.

Most instruments are calibrated against a single standard that is near (above or below) the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the anticipated range of measurements. Specific conductivity standards concentrations are generally dependent on expected field conditions and availability. However, there have been some issues with the stability of some of the standards in the field. Unless specified in a site-specific SAP, NHDES and EPA Region 1 have agreed that specific conductivity is, in general, a non-critical measurement and it is more important to use standards that are stable in the field even though the actual field measurements may not be bracketed by the high and low standards.

Therefore, the HWRB recommends using a 1413 $\mu\text{S}/\text{cm}$ standard and a 718 $\mu\text{S}/\text{cm}$ standard as they have been field tested, are readily available from most vendors, and are acceptable for use by EPA. It is acceptable to use either one of the standards to calibrate and the other to check the calibration.

The use of only ONE standard to both calibrate and check the calibration is NOT ACCEPTABLE, as the second standard is used to check the linearity of the instrument in the range of measurements.

In general, the 718 $\mu\text{S}/\text{cm}$ standard will be used to calibrate and a 1413 $\mu\text{S}/\text{cm}$ standard used to check the calibration. **It is advisable to have a sufficient number of extra bottles of each standard on hand in case of complications. Be sure that the standards are not near their expiration dates and are from different lots.** Rinse the storage cup with DI water and dry it between standards.

The meter should automatically detect all standard calibration solution values. If you are using a non-standard value calibration solution (e.g., 718 $\mu\text{S}/\text{cm}$), you have the option to manually enter the value.

Preliminary Cleaning Procedure

Before calibrating for specific conductance, clean the probe according to the manufacturer. Avoid damaging the plastic material of the conductivity cell. In general, gently wipe the conductivity cell with a soft polyurethane foam swab, or a thin cotton pipe cleaner, and DI water using a gentle back-and-forth motion. Rinse the probe with DI water and dry thoroughly.

In-Situ - Specific Conductance Calibration Procedure (718 $\mu\text{S}/\text{cm}$ standard)

1. Tap the **Calibration** icon on the tablet display to access a list of sensors that are available for calibration.
2. Tap **Conductivity Sensor**.
3. Tap 1-Point Calibration.
4. Fill the storage cup to the fill line with 718 $\mu\text{S}/\text{cm}$ calibration standard.
5. Place the instrument into the storage cup, and tap **Start** on the tablet display.
6. The tablet app does not automatically recognize the value of the 718 $\mu\text{S}/\text{cm}$ standard. The value of the standard must be manually entered into the tablet app. To enter the value manually:
 - a. At the top of the screen there is white blank box to the left of “ $\mu\text{S}/\text{cm}$ ”;
 - b. Tap the blank box and a keyboard will appear.
 - c. Enter 718 and tap the return button.
 - d. The meter will start the calibration process.

Note: If using the 1413 $\mu\text{S}/\text{cm}$ calibration standard to calibrate, the tablet app will automatically recognize the value of the 1413 $\mu\text{S}/\text{cm}$ calibration standard; therefore, the value does not have to be manually entered.

7. When the instrument indicates that the calibration is stable, tap the **Accept** button on the tablet display.
8. Remove probe from the storage cup containing the standard, rinse with DI water, and gently blot dry.
9. Rinse the storage cup with DI water and dry it with paper towels or Kimwipes.
10. Tap on the left arrow “sensor calibration” in the top left corner of the tablet display to return to the calibration menu to select the next parameter.

IN-SITU - OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent. A Zobell solution is required to calibrate ORP. Read the warning on the label before use.

The meter should automatically detect all standard calibration solution values including the ORP standard corrected for temperature.

In-Situ - ORP Calibration Procedure

1. Tap the **Calibration** icon on the tablet display to access a list of sensors that are available for calibration.
2. Tap **ORP Sensor**.
3. Tap 1-Point Calibration
4. Fill the storage cup with Zobell calibration standard.
5. Place the instrument into the storage cup, and tap **Start** on the tablet display.
6. When the instrument indicates that the calibration is stable, record the ORP and temperature values on the Calibration Log.
7. Tap the **Accept** button on the tablet display.
8. Tap on the left arrow “sensor calibration” in the top left corner of the tablet display to return to the calibration menu to select the next parameter.

Once the last parameter has been calibrated, then tap on the left arrow on the tablet display and select “live readings” screen to perform the calibration check procedure.

C. In-Situ Smartroll Calibration Check Procedure

General procedure to check the parameter calibration:

1. Select the “live readings” screen on the tablet display.
2. Fill the storage cup to the fill line with the appropriate calibration check standard and insert the probe in the solution.
3. Wait until the temperature and parameter readings have stabilized (i.e., no changes in the temperature and parameter readings for minimum of 30 seconds).
4. Record the parameter reading on the Calibration Log.
5. Refer to each parameter below for instructions to follow if the check standard is outside the acceptable range.
6. Remove probe from the storage cup containing the check standard, rinse with DI water, and gently blot dry.
7. Rinse the storage cup with DI water and dry it with paper towels or Kimwipes.
8. Repeat these steps with each calibration check standard.

Acceptable Ranges for Check Standards:

1. In-Situ – DO Check (Zero DO standard)

The instrument must read 0 to 0.5 mg/l DO. If the instrument reads above 0.5 mg/l or reads a negative value, it will be necessary to recalibrate the instrument for both 100% and 0% saturation and check again. If this is unsuccessful, use a new Zero DO standard with a different lot number. If these measures are still unsuccessful, consult the manufacturer/vendor. It may be necessary to replace the RDO cap on the Smartroll or replace the unit.

If the afternoon calibration check is not within the acceptable range then the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

2. In Situ - pH Calibration Check (pH 7 standard)

The value must be pH 7 +/-5% (pH 6.65-7.35). If the calibration check failed, recalibrate the instrument using fresh standards, with different lot numbers from those used in the initial calibration, for all three values and check it again. If re-calibration fails, clean the pH probe, recalibrate and check the calibration again. If the calibration check fails again, consult the manufacturer/vendor or replace the unit.

If the afternoon calibration check is not within the acceptable range then the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

3. In-Situ - Specific Conductance Check (1413 $\mu\text{S}/\text{cm}$ standard)

When the 718 $\mu\text{S}/\text{cm}$ standard is used to calibrate, 5% of the 1413 $\mu\text{S}/\text{cm}$ solution is 1342-1484 $\mu\text{S}/\text{cm}$. When the 1413 $\mu\text{S}/\text{cm}$ standard is used to calibrate, 5% of the 718 $\mu\text{S}/\text{cm}$ solution is 682-754 $\mu\text{S}/\text{cm}$.

If the applicable range is not met, check the calibration using a fresh solution with a different lot number from that used in the initial calibration check. Then, if the range is not met, recalibrate using a fresh calibration solution with a different lot number and check again.

If this range is still not met, calibrate using the second calibration solution and repeat the process above. If this is not successful, consult the manufacturer/vendor or replace the unit.

For example: if the 718 $\mu\text{S}/\text{cm}$ standard is used to calibrate, then the 1413 $\mu\text{S}/\text{cm}$ solution is used to check the calibration. If the 1413 $\mu\text{S}/\text{cm}$ solution is not within the acceptable range of 1342-1484 $\mu\text{S}/\text{cm}$, then check the calibration with a fresh 1413 $\mu\text{S}/\text{cm}$ solution with a different lot number. If this range is still not met, recalibrate the instrument using a new 718 $\mu\text{S}/\text{cm}$ standard from a different lot number and check again.

If the acceptable range is still not met, calibrate the instrument using the 1413 $\mu\text{S}/\text{cm}$ standard and check the calibration with a 718 $\mu\text{S}/\text{cm}$ solution. If the 718 $\mu\text{S}/\text{cm}$ solution is not within the acceptable range of 682-754 $\mu\text{S}/\text{cm}$, then check the calibration with another 718 $\mu\text{S}/\text{cm}$ solution with a different lot number. If this range is still not met, recalibrate the instrument using a new 1413 $\mu\text{S}/\text{cm}$ standard from a different lot number and check again.

If that does not solve the problem, consult the manufacturer/vendor or replace the unit.

If the afternoon calibration check is not within the acceptable range then the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

4. In-Situ ORP Calibration Check (Zobell solution)

The Smartroll automatically corrects the ORP solution according to the temperature of the solution.

Wait until the ORP and temperature readings have stabilized. Read the ORP on the instrument. Record the check value on the Calibration Log, and compare the value to the ORP value of the standard at the time of calibration. The instrument must be $\pm 5\%$ of the mV value for the current temperature. See the chart below for the check range. If it is not within $\pm 5\%$, recalibrate using a new Zobell solution. If the re-calibration is not successful, consult the manufacturer/vendor or replace the unit. For the afternoon calibration check, the instrument must be within $\pm 5\%$ of the mV value for the current temperature or the data collected using the instrument that day must be qualified in its use as described above under Calibration Acceptance Criteria.

Zobell Solution mV Values Based on Temperature for ORP Calibration
Calibration Check Range Values (+/- 5%)
(Round off temperature to whole number, e.g., 23.5 °C rounds up to 24 °C)

Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%
-3	267	254-280	10	251	238-264	23	234	222-246
-2	266	253-279	11	249	237-261	24	232	220-244
-1	265	252-278	12	248	236-260	25	231	219-243
0	264	251-277	13	247	235-259	26	230	219-242
1	262	249-275	14	245	233-257	27	228	217-239
2	261	248-274	15	244	232-256	28	227	216-238
3	260	247-273	16	243	231-255	29	226	215-237
4	258	245-271	17	241	229-253	30	225	214-236
5	257	244-270	18	240	228-252	31	223	212-234
6	256	243-269	19	239	227-251	32	222	211-233
7	254	241-267	20	238	226-250	33	221	210-232
8	253	240-266	21	236	224-248	34	219	208-230
9	252	239-265	22	235	223-247	35	218	207-229

II. TURBIDITY CALIBRATION PROCEDURES

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidimeter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source. All turbidity vials must be free of scratches. If a vial is scratched, the vial must be replaced.

The HWRB low flow procedure requires that the turbidity meter shall have a calibration range from 0.00 to 800 (or 1000) NTUs.

Condensation (fogging) of Turbidity Vial:

Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at ambient temperature or immersing in a container of ambient temperature water for a short period. After warming, gently invert the sample cell to thoroughly mix the contents before measurement.

This procedure is based on the use of the Hach 2100P or the 2100Q turbidimeter and the commercially available StablCal® Formazin Primary Turbidity Standards appropriate for each meter.


A - Hach 2100P Turbidity Meter Calibration/Calibration Check Procedures

1. Use the commercially available StablCal® Formazin Primary Turbidity Standards: <0.1, 20, 100 and 800 NTUs.
2. Before performing the calibration procedure, make sure the cells containing the standards are not scratched. If a cell is scratched, the standard must be replaced.
3. Allow the calibration standards to equilibrate at the ambient temperature.
4. Turn on the meter.
5. The meter should be in the Auto Range. “Auto Rng” and 0.00 NTUs should show on the display. If not press the range key until it is in the auto range and reading to two (2) decimal points (e.g., 0.00).
6. Gently invert the standards to thoroughly mix the contents. **(DO NOT SHAKE)**.
7. Wipe the standards with a soft, lint-free cloth or Kimwipe to make sure the outside surfaces are dry and free from fingerprints and dust.
8. Insert the standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment.
9. Insert the first (blank) standard, <0.1 NTU, into the cell compartment and close the lid.
10. Press **CAL**. The “CAL” and “S0” icons will be displayed (the “0” will flash).
11. Press **READ**. The instrument will count down from 60 to 0, read the blank and use it to calculate a correction factor for the second, 20 NTU standard. The display will automatically increment to the next standard. The display will now show “S1” (with the 1 flashing) and “20 NTU”, the value of the second standard. Remove the <0.1 NTU standard from the compartment.
12. Insert the second, 20 NTU, standard into the cell compartment and close the lid.
13. Press **READ**. The instrument will count down from 60 to 0, measure the turbidity and store the value. The display will automatically increment to the next standard with the display showing “S2” (with the 2 flashing) and “100 NTU”, the value of the third standard. Remove the 20 NTU standard from the compartment.
14. Insert the third, 100 NTU, standard into the cell compartment and close the lid.
15. Press **READ**. The instrument will count down from 60 to 0, measure the turbidity and store the value. The display will automatically increment to the next standard. The display will show the “S3” (with the 3 flashing) and the 800 NTU standard, the value of the fourth standard. Remove the 100 NTU standard from the compartment.
16. Insert the fourth and last, 800 NTU, standard into the cell compartment and close the lid.
17. Press **READ**. The instrument will count down from 60 to 0, measure the turbidity and store the value. Then the display will increment back to the S0 display. Remove the 800 NTU standard from the compartment and close the lid.

18. Press **CAL** to accept the calibration. The instrument will return to the measurement mode automatically.
19. To check the calibration (in run mode), insert the 20 NTU standard into the cell compartment and close the lid.
20. Press **READ**. The meter will display a lamp symbol (which looks like a light bulb) indicating that the reading is in progress. The lamp turns off and the measurement value is displayed. Record the turbidity reading on the Calibration Log. The calibration check must be +/- 5% (19-21 NTUs). If not, recalibrate using all standards. If re-calibration is unsuccessful, use new standards, consult the manufacture/vendor or replace the unit.
21. Remove the 20 NTU check standard from the compartment and close the lid.

B - Hach 2100Q Turbidity Meter Calibration/Calibration Check Procedures

1. Use the commercially available StablCal® Formazin Primary Turbidity Standards: 20, 100 and 800 NTUs and the 10 NTU Verification Standard.
2. Before performing the calibration procedure, make sure the cells containing the standards are not scratched. If a cell is scratched, the standard must be replaced.
3. Allow the calibration standards to equilibrate at the ambient temperature.
4. Turn on the meter.
5. Push the **CALIBRATION** key to enter the Calibration mode.

The Calibration key is the graph symbol with 2 points in the lower left-hand side.  The screen shows the three standards (20, 100 & 800 NTUs). The 20 NTU standard is shown bolded with a box around it indicating that is the first standard to be calibrated.

6. Gently invert the standards to thoroughly mix the contents. **(DO NOT SHAKE)**
7. Wipe the standards with a soft, lint-free cloth or Kimwipe to make sure the outside surfaces are dry and free from fingerprints and dust.
8. Insert the first standard, 20 NTU, into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly. Note: the standard to be inserted is highlighted on the display screen.
9. Press **READ** (right hand key). The display shows Stabilizing and then shows the results accompanied by an audio beep. The display will automatically request the next standard by highlighting it and darkening the first standard. Remove the 20 NTU standard from the compartment.
10. Insert the second, 100 NTU, standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly.
11. Press **READ**. The display shows Stabilizing and then shows the results accompanied by an audio beep. The display will automatically request the next standard by highlighting it and darkening the previous standards. Remove the 100 NTU standard from the compartment.

12. Insert the third and last, 800 NTU, standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly.
13. Press **READ**. The display shows “Stabilizing” and then shows the results accompanied by an audio beep. Remove the 800 NTU standard from the compartment.
14. Push **DONE** to complete a 3-point calibration and review the calibration details (values of the three standards).
15. Push **STORE** to save the results.
16. After a calibration is complete, the meter automatically goes into the Verify Cal mode.
17. Insert the 10 NTU Verification Standard into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment and close the lid firmly.
18. Push **READ** (right hand key). The display shows Stabilizing and then shows the results and the tolerance range. The calibration check must be +/- 10% (9.0- 11.0 NTUs).
19. Push **DONE** to return to the reading display.
20. If the calibration verification (Cal Check) is not within the +/- 10% range, repeat the calibration verification. If that fails, recalibrate using all standards. If re-calibration is unsuccessful, use new standards, consult the manufacture/vendor or replace the unit.

OVERNIGHT STORAGE OF THE YSI AND IN-SITU INSTRUMENTS

Check with the vendor for the appropriate overnight storage of the probes. Some manufacturers/vendors may recommend storing the multiparameter probes overnight in a storage cup filled with pH 4 solution. If so, fill the storage cup with pH 4 solution, place the probes into the storage cup and seal tightly.

DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration information must be documented on the attached Calibration Log, including the instrument manufacturer, model number and identification number; standards used to calibrate the instruments, including source, lot numbers and expiration dates; date; personnel; the instrument readings; barometer reading; DO membrane inspection (if applicable); changed DO membrane and solution/RDO cap, etc. Each daily Calibration Log shall be dated and signed by the user.

REFERENCES

Calibration of Field Instruments SOP included in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA #18008.

Instruction manuals for the YSI Models 600XL/XLM Multiparameter Meter & Sonde, In-Situ smarTROLL Multiparameter Meter and Hach Models 2100P and 2100Q Portable Turbidity Meters.

ATTACHMENT

Instrument Calibration/Maintenance Log

-Instrument Calibration/Maintenance Log

TROY INSTRUMENT CALIBRATION / MAINTENANCE LOG

Date: _____	Time: _____	Field Personnel: _____
Meter: (circle one) YSI: Model 600XL or 600XLM In-Situ: SmartROLL Rental Company: _____		
Multimeter Serial Numbers (Sonde & Meter): _____		
Probe Pre-cleaned Certification Provided By (Personnel): _____		Date: _____
Temperature Calibration: Personnel: _____		Date: _____
Manufacturer's Accuracy Range of Sensor: +/- 0.2°C Vendor's check results Unit: _____ NIST: _____ Difference: _____		

** When performing calibration checks, wait for temperature and parameter readings to stabilize before recording the results.**

BEGINNING CALIBRATION CHECK

Date: _____	Time: _____	Personnel: _____
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Calibration Check	Value of Standard	Check Results	Acceptable Range	Within Range (yes/no)	Lot #	Expiration Date	Comments
Zero DO check (mg/l)	0		0 to 0.5 mg/L				
pH 7 check	7		+/- 5%				Range 6.65 - 7.35 pH
Specific Conductance (µS/cm) Second standard used for check			+/- 5%				Range 682 - 754 µS/cm (718) or Range 1342 - 1484 µS/cm (1413)
ORP check - Zobell (mV) Zobell Solution _____ °C			+/- 5%				See Chart on Page 2 for ORP Zobell Solution mV Value Based on Temperature
Turbidity Standard (NTU) 2100P	20		+/- 5%				Range 19.0 - 21.0 NTU (2100P)
Turbidity Standard (NTU) 2100Q	10		+/- 10%				Range 9.0 - 11.0 NTU (2100Q)

- Notes:
- 1) If the post calibration check is not within the acceptable range the meter must be recalibrated.
 - 2) All calibration checks must be made in the run mode (on a run/measurement screen) or on the live readings screen, not the calibration mode.
 - 3) If the lot numbers and expiration dates are the same as the initial calibration, place a check mark ✓ in the appropriate box.
 - 4) Either standard (718 or 1413 µS/cm) may be used to calibrate specific conductance; the second standard is used to check it.
 - 5) Record N/A (Not Applicable) in the boxes for the turbidity meter that was not used.

Calibration Check Performed by: _____ (Print) _____ (Sign)

END OF DAY INSTRUMENT CALIBRATION CHECK

Date: _____	Time: _____	Personnel: _____
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Calibration Check	Value of Standard	Check Results	Acceptable Range	Within Range (yes/no)	Lot #	Expiration Date	Comments
Zero DO check (mg/l)	0		0 to 0.5 mg/L				
pH 7 check	7		+/- 5%				Range 6.65 - 7.35 pH
Specific Conductance (µS/cm) Second standard used for check			+/- 5%				Range 682 - 754 µS/cm (718) or Range 1342 - 1484 µS/cm (1413)
ORP check - Zobell (mV) Zobell Solution _____ °C			+/- 5%				See Chart on Page 2 for ORP Zobell Solution mV Value Based on Temperature
Turbidity Standard (NTU) 2100P ⁵	20		+/- 5%				Range 19.0 - 21.0 NTU (2100P)
Turbidity Standard (NTU) 2100Q ⁵	10		+/- 10%				Range 9.0 - 11.0 NTU (2100Q)

- Notes:
- 1) If the end of the day calibration check is not within the acceptable range, the data collected that day for that parameter shall be qualified in it's use.
 - 2) All calibration checks must be made in the run mode (on a run/measurement screen), not the calibration mode.
 - 3) If the lot numbers and expiration dates are the same as the initial calibration, place a check mark ✓ in the appropriate box.
 - 4) Either standard (718 or 1413 µS/cm) may be used to calibrate specific conductance; the second standard is used to check it.
 - 5) Record N/A (Not Applicable) in the boxes for the turbidity meter that was not used.

Calibration Check Performed by: _____ (Print) _____ (Sign)

List wells sampled using this equipment on this day ONLY IF DATA NEEDS TO BE QUALIFIED.

INSTRUMENT CALIBRATION

Date: _____		Time: _____			
Multimeter Calibration	Value of Standard	Check as Completed	Lot #	Expiration Date	Comments
DO (% saturation)	100%				Allow time for stabilization per manufacturer
DO mg/l reading					Record these values immediately after calibration
DO Temp. (°C) reading					
DO (0% Saturation)-SmarTROLL	0%				2 point DO Calibration for SmarTROLL only (100 & 0%)
pH 1st Standard	7				
2nd Standard	4				
3rd Standard	10				
Specific Conductance (µS/cm)					One standard is used to calibrate, second one to check (1413 and 718 standards) Using one standard for both is unacceptable.
Zobell Solution _____ °C					See Chart below for ORP Zobell Solution mV Value Based on Temperature
ORP using Zobell Solution					

Additional Information for Dissolved Oxygen Calibration

Barometric Pressure of Meter: _____ mm Hg [BP inches _____ x 25.4 + BP _____ mm Hg]

Dissolved Oxygen Charge (YSI Meters): _____ (Acceptable Range: 25 to 75) You MUST change the membrane if charge is out of range.

Inspected DO membrane/RDO CAP for nicks or bubbles (check as completed) _____ Personnel: _____

Changed YSI Dissolved Oxygen Membrane and Electrolyte Solution (circle one) YES or NO

Replaced SmarTROLL Rugged Dissolved Oxygen CAP (circle one) YES or NO

HACH 2100P or 2100Q * Turbidimeter Calibration	Value of Standard	Check as Completed	Lot #	Expiration Date	Comments
Turbidity 1st Standard (blank)	<0.1 NTU				Calibrate w/ StablCal® Formazin Primary Turbidity Standards
2nd Standard	20 NTU				
3rd Standard	100 NTU				
4th Standard	800 NTU				

HACH Model (circle one) P or Q Serial Number: _____ Rental Company: _____

* NOTE: the 2100Q does not have a <0.1 standard, record N/A (not applicable) in the <0.1 standard boxes as appropriate.

Calibration Performed by _____

Print Name

Signature

Zobell Solution mV Value Based on Temperature for ORP Calibration								
Calibration Check Range Values (+/- 5%)								
Round off temperature to whole number (e.g., 23.5 °C rounds up to 24 °C)								
Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%	Temp. °C	ORP Zobell Solution mV Value	Calibration Check Range Values +/- 5%
-3	267	254-280	10	251	238-264	23	234	222-246
-2	266	253-279	11	249	237-261	24	232	220-244
-1	265	252-278	12	248	236-260	25	231	219-243
0	264	251-277	13	247	235-259	26	230	219-242
1	262	249-275	14	245	233-257	27	228	217-239
2	261	248-274	15	244	232-256	28	227	216-238
3	260	247-273	16	243	231-255	29	226	215-237
4	258	245-271	17	241	229-253	30	225	214-236
5	257	244-270	18	240	228-252	31	223	212-234
6	256	243-269	19	239	227-251	32	222	211-233
7	254	241-267	20	238	226-250	33	221	210-232
8	253	240-266	21	236	224-248	34	219	208-230
9	252	239-265	22	235	223-247	35	218	207-229

SOP B-5
Groundwater Well Sampling – Low Flow Using a Peristaltic Pump

GROUNDWATER WELL SAMPLING – LOW FLOW USING A PERISTALTIC PUMP

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) *Groundwater Sampling – Low Flow Using A Peristaltic Pump*, provides a general framework for collecting groundwater samples at the Troy Mills Landfill Superfund Site in Troy, New Hampshire that are indicative of total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions with minimal physical and chemical alterations from sampling operations.

The intent of this SOP is to enhance the quality of the samples being measured and to help ensure that the project-specific data quality objectives (DQOs) are met when low flow conditions are required. In this procedure, the user is required to monitor the rate at which the water level in the well drops, generally referred to herein as the drawdown rate. The procedure includes a reference table based on calculations that improve the potential that at least 90% of the water being pumped out of the well (i.e., the discharge water) was in contact with the formation and that no more than 10% of the discharge water is influenced by the stagnant water in the well riser. Total purge volume, stabilization of indicator field parameters [pH, turbidity, specific conductance, temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP)], and drawdown rate are used to indicate when conditions are suitable for sample collection. The SOP emphasizes the need to minimize hydraulic stress at the well and better enable collection of samples representative of the aquifer. This is accomplished by low pumping rates, negligible water level draw down rate and stabilization of water quality parameters. These requirements and parameters, upon meeting certain stability thresholds, indicate that the groundwater being pumped is reasonably representative of the formation interval in which the well is screened.

In low permeability formations or poorly installed monitoring wells it may not be possible to collect groundwater samples using the standard low flow procedure. Under such conditions a modified sampling procedure is employed. The conditions that will trigger switching from the standard low flow procedure to the modified procedure are:

1. The well is under artesian conditions.
2. The water level is within the well screen interval.
3. The well has been identified as having insufficient recharge on **Table 2** in the SAP for two consecutive rounds.
4. The water level falls below the top of the well screen interval while purging.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

This procedure is primarily designed for monitoring wells with a screen length or open interval

ten feet or less and with a water level above the top of the screen or open interval. Hereafter, the “screen or open interval” will be referred to only as “screen interval”.

The “Modified Sampling Procedure” will be used without further attempt to use the standard low flow procedure if the low flow procedure has been attempted unsuccessfully due to insufficient recharge at a well for two consecutive rounds. These wells will be identified on **Table 2** in the SAP.

PROCEDURE REQUIREMENTS

All measurements of field parameters must be obtained using a “flow-through cell”, except for turbidity. Turbidity must be collected at a point before the flow-through cell and measured with an instrument that is separate from the flow-through cell apparatus. A three-way stop cock (or “T” connection) attached to the tubing before the flow-through cell will be used to collect the turbidity samples. Transparent flow-through cells with a cell capacity of 250 milliliters (ml) or less are required. The transparency allows field personnel to watch for air bubbles and particulate build-up within the flow-through cell: These conditions may affect indicator field parameter values measured within the cell. The flow-through cell must be designed and used in a way that prevents air bubble entrapment in the cell. Placing the flow-through cell at an approximate 45 degree (°) angle with the outlet port facing upward can help remove bubbles from the flow-through cell. The flow-through cell must remain free of any air bubbles at all times. Otherwise, the monitoring probes may act erratically. When the pump is turned off, water in the flow-through cell must not drain out. Monitoring probes must be submerged in water at all times during the collection of field parameter data. Refer to the attached Low Flow Setup Diagram.

A small volume flow-through cell (250 ml or less) facilitates rapid turnover of water in the cell between measurements of the indicator field parameters. The pump’s flow rate must be able to “turn over” at least one flow-through cell volume between measurements. For example: The monitoring frequency for a 250 ml flow-through cell with a flow rate of 50 ml/minute would be every five minutes. **Note: The indicator field parameters shall be measured at a minimum frequency of five minute intervals.**

The YSI Models 600XL/XLM multiparameter meters that have previously been used with this low flow procedure are slowly being phased out by YSI; therefore, this SOP also includes instructions on using the In-Situ smarTROLL™ multiparameter meter (referred to as the Smartroll in this SOP) with a mobile tablet. The Smartroll was chosen because it appears to meet all of the NHDES Hazardous Waste Remediation Bureau (HWRB) requirements for field instrumentation and will eliminate or reduce the amount of data needed to be recorded on hand written worksheets. The HWRB requires that field personnel use a rugged electronic field tablet with the Smartroll to calibrate and record data in the field in order to view all data simultaneously and clearly; **it is not acceptable to use a smartphone, iPod, or equivalent due to screen-size limitations.**

The tablet used with the Smartroll must be set up in advance. Refer to the *Smartroll Tablet Set Up* section in this SOP and the *In-Situ Smartroll Equipment Set Up & Use* SOP in the SAP.

USE OF TERMS

Battery Pack: The Battery Pack is used with the Smartroll, enables wireless (Bluetooth) communication between the Apple tablet and the multiparameter meter, and supplies power to the multiparameter meter. The Battery Pack also provides an ambient temperature measurement and a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements.

Drawdown Rate: The rate at which the water level in the well riser drops as the well is purged and sampled.

Equipment Blank: is a sample of deionized (analyte-free) water that has been poured around and through sample collection equipment to evaluate the equipment decontamination procedures and the potential for cross-contamination between sample locations. Refer to **Table 5** in the SAP for equipment blank requirements.

Field Duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect a duplicate for each analyte group in consecutive order (e.g., volatile organic compound [VOC] original, VOC duplicate, metals original, metals duplicate).

Field Parameters: Field parameters (also referred to herein as “parameters” and “indicator parameters”) comprise those field analyses of water quality such as ORP, DO, pH, specific conductivity, temperature, and turbidity used as indicators of when purging operations are sufficient and sample collection may begin.

iOS: Refers to an Apple mobile operating system that powers Apple devices (i.e., iPad tablet).

iSitu: Refers to the Apple-based application (app) downloaded from iTunes and installed on your iPad tablet. The iSitu app is the user interface and control application for the Smartroll and enables collection of water quality field parameters.

Low-Flow Test: Reference to a low-flow test is specific to monitoring using an In-Situ Smartroll and is the recording of a set of parameters during monitoring of a particular well.

Matrix Spike/Matrix Spike Duplicates (MS/MSD): Primarily used by the laboratory in its quality assurance program. Refer to **Table 3** in the SAP for the sample volume to be collected.

Potentiometric Surface: The level to which water rises in a well that is constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

Power Pack: The Power Pack is used with the Smartroll, enables wireless (Bluetooth) communication between the Android tablet and the multiparameter meter, and supplies power to the multiparameter meter. The Power Pack also provides an ambient temperature measurement and a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements.

RDO cap: This refers to the optical Rugged Dissolved Oxygen (RDO) sensor that is housed in a cap and used to measure dissolved oxygen with the Smartroll.

Smartroll: The Smartroll is a multiparameter meter that allows you to collect water quality parameter data on a mobile tablet and eliminates or reduces the amount of data needed to be recorded on hand written worksheets.

Stabilization: A condition that is achieved when the drawdown rate and all indicator field parameter measurements are sufficiently stable (as described in the “Well Purging and Sampling Procedure” section), thereby allowing sample collection to begin (as long as the minimum purge volume requirement is met).

Temperature Blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip Blank (VOCs): A trip blank is a sample of analyte-free water taken to the sampling site along with the sample bottles, and returned to the laboratory for analysis (e.g., treated as a sample), to measure possible cross contamination of containers/samples during shipping to and from the site. Trip blanks must not contain any analytes at or above the quantitation limit of the test. One trip blank consists of two full volatile organic analysis (VOA) vials and is added to each sample cooler that contains VOC samples.

VuSitu: refers to the Android-based app downloaded from the Google Play Store and installed on your tablet. The VuSitu app is the Android-based user interface and control application for the Smartroll and enables collection of water quality field parameters.

Win-Situ: Refers to the Windows software downloaded from the In-Situ website¹ and installed on your laptop or desktop computer. Low-flow test templates used within iSitu and/or VuSitu are created in WinSitu and then transferred to the tablet.

BACKGROUND FOR IMPLEMENTATION

Prior to conducting the sampling event, information regarding well construction, development, screen length and water level records for each well to be sampled should be obtained and reviewed to determine the appropriate pump to be used, the location of the intake, and the potential groundwater recharge rate of the well. If this information is not available, a reconnaissance should be made prior to the actual sampling event to determine well depth, water level, etc., and possibly perform a pump test to determine the recharge rate of the well. Additionally, wells that have not been sampled in years should be redeveloped prior to conducting the actual sampling event, if possible.

¹ <https://in-situ.com/support/type/software/>

It is expected that the monitoring well screen, or open interval, has been properly located (both laterally and vertically) to intercept existing contaminant plumes or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation.

The down-well tubing intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate at a given well remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the tubing intake.

Significant chemical or permeability differences within the screen may require additional field work (e.g., interval sampling, borehole geophysics) to determine the optimum vertical location for the tubing intake and an appropriate pumping rate for purging and sampling more localized target zones. Primary flow zones (e.g., higher permeability and/or higher chemical concentrations) shall be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help ensure that the low stress procedure will not underestimate contaminant concentrations. Refer to **Table 4** in the SAP for well construction details and intake depths.

A goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help minimize sampling variability.

Cold weather considerations must be factored into a low flow sampling plan. It is recommended that low flow sampling be conducted when the air temperature is above 32° Fahrenheit (F) or 0° Celsius (C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the DQOs, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be implemented. Ice formation in the flow-through cell may cause the monitoring probes to act erratically. A transparent flow-through cell is required to observe whether ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All appropriate personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples shall be handled with suitable protection to skin, eyes, etc.

PRECAUTIONS

Consider the following precautions when planning to collect groundwater samples if the conditions listed below are expected to occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethane, ethene, dissolved oxygen) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing (e.g., constricting the flow) which results in a pressure change. The observation of bubbles in the tubing is indicative of groundwater degassing.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will help avoid this problem.

Direct sunlight and hot ambient air temperatures may cause the groundwater in the tubing and flow-through cell to heat up. This may cause the groundwater to degas, which will result in loss of VOCs and dissolved gases. When sampling under these conditions, shade the equipment from the sunlight (e.g., umbrella, tent). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid sunlight or ambient air heating up the groundwater in the tubing.

Condensation (fogging) of Turbidity Vial: Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at ambient temperature or immersing the sample cell in a container of ambient temperature water for a short period. After warming, gently invert the sample cell to thoroughly mix the contents before measurement.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water, which is denser than warm water, sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convection cell. "During low flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low flow

sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions” (Vroblesky, 2007).

Interferences may result from using contaminated equipment, cleaning materials and sample containers, or from uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems caused by ambient air interferences can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely inspected to ensure that it is free from contaminants, and equipment blanks also need to be collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site to determine whether the previous cleaning procedure removed the contaminants. If contaminants were detected, then a more rigorous or alternative cleaning procedure will be required.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. Federal regulations require the sampler to take the 40-hour OSHA health and safety training course and a yearly 8-hour refresher course prior to engaging in any field activities on Superfund Sites.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team must read, and be familiar with, the site Health and Safety Plan, the SAP, all relevant SOPs, and the current HWRB Master Quality Assurance Project Plan (HWRB Master QAPP), including the most recent amendments, before going on site for the sampling event. It is recommended that the field sampling leader attest to, and document that, they and their field team have read and understand these site documents.

EQUIPMENT AND MATERIALS

All equipment and materials must be identified and approved before use and must support site-specific DQOs.

- Appropriate health and safety gear.
- Informational materials to be brought to the site during the sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP, monitoring well construction data (e.g., well depth, inner casing diameter, screen interval), location maps, field data from prior sampling events, manuals

for sampling, diagrams to show how the equipment is to be set up, and the monitoring instruments' operation and maintenance manuals.

- A tablet that has been prepared for site use according to the *In-Situ Smartroll Equipment Set Up & Use* SOP in the SAP, if using the Smartroll multiparameter meter.
- Site and well keys, spare locks, and bolt cutters.
- Electronic water level meter and/or oil/water interface probe of appropriate lengths (e.g., 100 feet, 200 feet, 300 feet) that measures in increments of 0.01 feet.
- Adjustable rate Geotech Peristaltic Pump Series II Variable Speed pump 300 + 600 RPM (or similar pump) with Easy Load Peristaltic Pump Heads (that allows a 50 ml/minute flow rate using thin walled tubing in the sizes indicated below under silicon tubing) and a battery (e.g., marine, battery pack).

The use of piggybacked peristaltic pump heads is unacceptable as the arrangement may produce an uneven flow with potential to aerate the water and cause the loss of VOCs and dissolved gases. "Piggybacked" pump heads are defined as multiple heads stacked on a common drive axel (e.g., when the pump's standard rotor head is too large for a small tubing size, and a smaller rotor head is piggy-backed onto the standard rotor head).

- ¼" ID (inside diameter) x 3/8" OD (outside diameter) polyethylene, sample tubing for down-hole installation: enough to dedicate to each well. **NOTE:** The HWRB requires that a fiberglass measuring tape or other accurate measuring device be used when measuring and installing tubing.
- Silicon tubing (pharmaceutical or surgical grade only) for pump and connections (sized according to: ID" x OD" x Wall"). For sampling: Thin walled tubing size #16 (1/8" x ¼" x 1/16") and/or thin walled tubing size #14 (1/16" x 3/16" x 1/16") if necessary to reduce flow to 50 ml/minute. For connections: thick walled tubing size #15 (3/16" x 3/8" x 3/32") and possibly size #17 (1/4 x 3/8 x 1/16). Silicon tubing shall be connected to the well tubing by placing the silicon tubing over the well tubing (not inside the well tubing). Various sizes of silicon tubing shall be connected together by placing the end of the large tubing over the end of the smaller tubing. Make sure that tubing being connected together are sized appropriately so that the connections are snug and air bubbles do not form at the connections.
- YSI 600XL/XLM or In-Situ Smartroll Multiparameter unit with built in barometer and a 250 ml or less transparent flow-through cell, capable of measuring pH; ORP, millivolts (mV); DO, milligrams per liter (mg/l), 100% saturation for calibration; specific conductance, microsiemens (µS/cm); and temperature, °C.
- Appropriate calibration solutions for the multiparameter meter including: 0 mg/l DO for DO; Zobell solution for ORP; two different specific conductance standards, one standard is used to calibrate and the other standard is used to check the calibration (e.g., 718 and 1,413 µS/cm); and pH 4, 7, & 10 buffering solutions. A small wet sponge or paper towel for DO 100% saturation calibration. Extra DO membranes for the YSI or RDO caps for the Smartroll, in case of breakage.

- Hach 2100P or 2100Q Turbidity Meter.
- Calibration solutions for the Hach Turbidity meter: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) standards as appropriate for the selected meter.
- A three-way stopcock (recommended) or a “T” connector coupled with a clamp/valve is connected between the pump’s tubing and flow-through cell to divert sample flow to collect turbidity samples (e.g., Nalgene three-way stopcock with a plug bore of 4 mm [or 0.157 inch]: NNI No. 6470-0004, VWR catalog No. 59097-080). If using an in-line “T” connector, attach a short piece of tubing and a clamp/valve to the center branch of the “T” connector to serve as a sampling port for the turbidity samples.
- One-time use, 0.45 micron, in-line filters (transparent housing preferred) for dissolved metals, if required.
- Flow measurement supplies: graduated cylinder sized according to the flow rate (250 ml max, measured in 10 ml increments), stop watch, and a large graduated bucket to record the total volume of water purged from the well, in gallons or liters (milliliters where appropriate).
- Logbook, pencil/pen/sharpies and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.
- Field-data sheets, sample labels, and chain-of-custody records.
- Sample containers and spare containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags and packing materials.
- Clear tape – Place clear tape over sample container labels before sampling in the event the labels are not water proof labels. Alternatively, use plastic water proof labels.
- On-site Tools to include at least: a sharp knife with locking blade (or a tubing cutter, or other safe means of cutting tubing to desired length), bolt cutters, screwdrivers, pliers, 25’ measuring tape, hacksaw, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Decontamination equipment and supplies in accordance with the Decontamination SOP in the SAP, including appropriate size buckets and lids for containerization of liquids, if required.
- Trash bags to containerize solid waste.
- Laboratory grade deionized (DI) water.
- Flagging/spray paint as needed to demark well locations, if needed.
- Equipment to keep monitoring and sampling equipment off the ground (e.g., table, bucket or polyethylene sheeting). **Note: When using peristaltic pumps, it is highly recommended**

that the pump be placed on a table, or other surface, as close to the height of the well casing as possible to eliminate or reduce the buildup of air bubbles in the sample line between the peristaltic pump and the top of the casing.

- Equipment protection paraphernalia, including a tent/canopy/umbrella, to:
 - Adequately shade equipment and tubing to prevent temperature variations in the readings, bubbles from forming in the tubing and the acid preservative in the sample containers from volatilizing.
 - Protect both personnel and equipment from other elements including rain, wind, etc.
 - Keep the sampling equipment from freezing in the winter.
- If using the Smartroll:
 1. A rugged Android or Apple tablet is required.
 2. The following specific equipment **MUST** be requested from the vendor as they may not automatically be provided with the Smartroll:
 - a. The appropriate Bluetooth connection for the operating system of the tablet (no smartphones or iPods) you are using (i.e., the Power Pack for the Android or the Battery Pack for the Apple). The Power Pack or Battery Pack enables wireless communication between the corresponding tablet and the multiparameter meter and supplies power to the multiparameter meter; they are not interchangeable.
 - b. A ring stand and clamp.
 - c. A spare RDO cap.
 - d. The Smartroll MP Storage and Calibration Cup.

The Storage and Calibration Cup (referred to as the storage cup when discussing the Smartroll in this SOP) is a rugged alternative to the standard calibration cup. This storage cup is not provided with the Smartroll multiparameter meters from In-Situ. The vendor orders them separately from In-Situ and you must specifically request the storage cup from the vendor.

SMARTROLL TABLET SET UP

The Smartroll combines water quality sensors with the mobility of an Android or iOS (Apple) mobile device (i.e., a rugged tablet). The VuSitu app runs on an Android tablet and is available from the Google Play store, while the iSitu app runs on an iOS tablet and is available from the Apple App Store. In-Situ recommends the use of an Android operating system as that operating system will be fully supported going forward. This SOP contains instructions for both Android and iOS operating systems. WinSitu must be installed on a laptop or desktop computer and can be downloaded from the manufacturer's website². Be sure to install the latest version of the software available on the manufacturer's website.

² <https://in-situ.com/support/type/software/>

In general, prior to using the Smartroll in the field, a template must be set up that defines stabilization parameters, data required for input, well construction details, etc. The template will eliminate or reduce the amount of data needed to be recorded on handwritten worksheets; therefore, what was required on the handwritten worksheets must be included in the template prior to low flow sampling or entered via the “test notes” function during low flow sampling.

Templates must be set up in the office using WinSitu prior to use in the field. Any unknown information, such as the initial depth to water, may be entered during the sampling program. Once templates are set up prior to use the first time, they should need very little maintenance or updating and can be reused for each subsequent field event. A step-by-step description of how to set up templates for both Android and Apple tablets is provided in the *In-Situ Smartroll Equipment Set Up & Use* SOP in the SAP.

Note: When using the Smartroll, the low flow forms shall be transferred to the field lead’s laptop at a minimum of once per day, although twice per day is preferred: Once in the middle of the day and again at the end of the day to allow the field lead/quality assurance personnel to review the documentation prior to leaving the site or completing the field event.

EQUIPMENT/INSTRUMENT CALIBRATION

1. In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer’s instructions prior to the sampling event. This will ensure that the equipment/instruments are working properly before they are used in the field. The manufacturer’s instruction manuals for field equipment shall be on site during each sampling event.
2. If cold weather conditions exist that may impact successful calibration, consider indoor calibration/calibration checks at hotel/office/site trailer (if heated).
3. **All field instruments shall be successfully calibrated (including a successful calibration check) in the office prior to the sampling event (within one week) according to the Calibration SOP in the SAP to ensure that the equipment is working properly and meets the QA criteria. The calibration/calibration check shall be documented on the Calibration Log.**

IMPORTANT – Refer to the *Calibration of YSI, In-Situ and Hach Field Instruments* SOP in the SAP for specific calibration information and procedures

4. For this project, once the equipment is calibrated and checked prior to the sampling event, it is not necessary to recalibrate or check the calibration at the beginning of each sampling day. Instead, calibration checks, made in the run mode, shall be performed at the beginning of the first sampling day to ensure the equipment is in calibration and again at the end of the day of use to ensure that the instruments have remained in calibration throughout the day.
5. After the first day, calibration checks shall be performed at the end of each day of use, at a minimum, to ensure that the instruments have remained in calibration. However, if an instrument is not used for a day (for example: over the weekend) or if the field team leader

determines it's necessary, then the next sampling day would be considered the "first" sampling day again; where the calibration check is performed both at the beginning of that sampling day and at the end of that day; after which the schedule would revert back to checking the calibration at the end of the day only.

6. If one or more parameters are not within the appropriate range during the calibration check, only those parameters shall be calibrated using all the standards for that parameter and the calibration shall be checked again, to ensure the instrument was calibrated properly. See individual parameters in the SOP for specific instructions. If the calibration or calibration check is not successful, recalibrate using a new standard solution with a different lot number and recheck. Then, if the calibration or calibration check is still unsuccessful, replace the unit with a backup unit. The backup instrument(s) shall be calibrated (including a calibration check) and used in place of the inoperable unit(s).
7. In addition, should any erratic or illogical readings occur between calibrations/calibration checks, the instrument shall be recalibrated in order to ensure that representative measurements are obtained. All calibration and check values shall be documented on the calibration log maintained by each user.
8. If a calibration check at the end of the day is not within the acceptable range for a parameter, the data collected that day for that parameter shall be qualified in its use. This qualification shall be documented on the calibration log and the field sheets/logs for the appropriate sampling locations. For example: pH measurements are collected as part of the low flow sampling procedure. If the afternoon pH calibration check was not within the acceptable range that day, the pH data collected by that instrument on that day would be qualified as useful only for determining stabilization and not as representative pH measurements of the water being sampled. That qualification would then be documented on the calibration log and the sampling sheet for each of those locations and the applicable data summary table(s) in the report deliverable.
9. **Note:** during the day, if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), then this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs, the data from this instrument will need to be qualified or rejected, and the instrument must be recalibrated before further use.
10. Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., multi-parameter meter, turbidity meter) can result in faulty data being collected.

PRELIMINARY PROCEDURES INCLUDING WATER LEVEL MEASUREMENTS

1. Inspect the well for security (e.g., damage, evidence of tampering, missing lock) and record pertinent observations (include photographs as warranted). Note any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box or standpipe. If a lock is found to be damaged, replace with a new lock. Wells shall be locked at all times when not being sampled; this ensures the integrity of the well, any samples collected and the chain of custody.
2. Install and secure polyethylene sampling tubing if necessary. **NOTE:** The HWRB requires that a fiberglass measuring tape or other accurate measuring device be used when measuring and installing tubing. Great care must be taken during tubing installation and sampling to minimize the disturbance of particulates that can greatly extend the purge time by increasing turbidity. Each well will have dedicated sampling tubing, which will be left in the well for future rounds. The dedicated tubing intake within each well is located generally at the midpoint of the saturated well screen length based on the historical low groundwater, unless otherwise specified on **Table 4** in the SAP.

In general, keep the tubing intake at least 1 to 2 feet above the bottom of the well to minimize mobilization of particulates present in the bottom of the well. The exceptions to this include wells with 2-foot screen lengths and those wells that typically have less than 2 feet of saturated thickness and are not flowing under artesian conditions. For these wells, the intake needs to be at least ½-foot off the bottom of the well. If there is less than ½-foot of water, a sample will not be collected.

3. A synoptic water level measurement round is to be performed (in the shortest possible time, i.e., all in one day) before any purging and sampling activities begin. Refer to the Water Level Measurement SOP in the SAP. NHDES recommends that water levels (to 0.01 feet) be measured at least one day prior to well sampling activities, if possible, in order to allow for re-settlement of any particulates that were mixed into the water column by the measuring activity.
4. The depth to the bottom of the monitoring well shall be confirmed in each well included on **Table 4** in the SAP every five years, during the sampling event just prior to the Five Year Review, and as required. Refer to **Table 2** in the SAP to determine if depth measurements are required.

If a measurement of total well depth is required and cannot be made at least 24 hours in advance, it shall not be measured until after sampling of the well is complete.

5. Lay out a sheet of clean polyethylene to place the monitoring and sampling equipment upon, unless equipment is elevated above the ground (e.g., on a table or a bucket).

Note: When using peristaltic pumps, it is highly recommended that the pump be placed on a table, or other surface, as close to the height of the well casing as possible to eliminate or reduce the buildup of air bubbles in the sample line between the peristaltic pump and the top of the casing.

6. Check to determine if the well is under artesian conditions, if the water level is at, or below, the top of the screen, or if the well is flagged on SAP **Table 2** as having insufficient recharge.
7. Set up equipment according to the attached Low Flow Setup Diagram. Be sure to tilt the flow-through cell so that the outflow connection is facing upward, in order to eliminate and prevent air bubble entrapment in the flow-through cell. Be sure the pump head is set at 300 RPM, not 600 RPM.

Either size #16 (i.e., 1/8" ID x 1/4" OD x 1/16" Wall) or #14 (i.e., 1/16" ID x 3/16" OD x 1/16" Wall) silicon tubing shall be used through the pump head.

8. If available, check flow rate, silicon tubing size, drawdown and pump setting information from previous sampling events for each well. Duplicate from previous events, to the extent practicable, the silicon tubing size, the final settings and flow rates. For wells that are routinely sampled, refer to the prior **Low Flow Sampling Worksheets** to determine the initial settings to reach stabilization of the water level as quickly as possible. This is only a guide and the sampler will need to "fine tune" the operating conditions, because the recharge rate of groundwater in a given well may vary from event to event.

If a 50 ml/minute flow could not be reached or maintained with the #16 tubing, a section of #14 silicon tubing shall be connected to the end of the #16 tubing and the size #14 tubing shall be positioned into the pump head to reach a 50 ml/minute flow rate. The #14 tubing shall only be used where a 50 ml/minute flow rate cannot be maintained with the #16 tubing.

9. Be sure all sampling equipment is properly protected from the weather.
10. **If using the Smartroll, additional well-specific information not previously entered can be entered before purging and sampling begins.** This information includes:
 - a. Sampler's full name; not just initials.
 - b. Pump serial numbers/identification numbers.
 - c. Turbidity model and serial number.
 - d. Static water level from measuring point.
 - e. Total tubing length: This is the length of tubing inside the well (from Table 4 Well Construction) and the length of tubing outside the well, used to calculate the PVR. If not previously entered, this total length shall be added. Any previously entered measurement shall be confirmed prior to initiating the low flow test and adjusted as necessary.
 - f. Calculated purge volume requirement. Document the actual calculations on the worksheet to show how the total volume was determined. Refer to the next step (Step 11) for specific instructions.
 - g. Note: Check the inside diameter of the tubing to make sure the diameter on the Smartroll template is correct. If not, enter the correct diameter to the "test notes" on the tablet.

- h. Maximum allowable drawdown rate in the parameter stabilization criteria tab.

Note: If during the course of the test, this well-specific information gets lost (i.e., because of a cable disconnection) then wait until the end of the test (before you click “Complete”) to re-enter this well-specific information. If the cable disconnection happens more than once, then notify the field team leader. Use the backup equipment, if necessary.

11. Purge Volume Requirement

The procedure includes a purge volume requirement (PVR) to ensure that a minimum volume of water has been removed from the well before sampling begins. The PVR is calculated just before sampling begins.

The purge volume requirement is one tubing volume. In other words:

$$\text{PVR} = (\text{Total Tubing Length [ft.]} \times \text{Unit Tubing Capacity [gal/ft. or ml/ft.]})$$

Note: Include the length of tubing that is outside the well in the Total Tubing Length.

For convenience, the table below can be used to determine the appropriate volumes in gallons or milliliters. Refer to the *Purge Volume Calculations* section in this SOP for the formula used for determining the table values, if necessary.

Unit Tubing Capacity Values

Tubing Diameter (Inches)	1/4 (0.25) OD (0.17 ID)*	3/8 (0.375) OD (0.25 ID)*	1/2 (0.50) OD (0.375 ID)*	5/8 (0.625) OD (0.50 ID)*
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

* Calculations are based on the ID, not the OD.

Record the PVR and the calculations used to determine the PVR on the well sampling worksheet, or in the “test notes” section of the low-flow test on the tablet if using the Smartroll.

WELL PURGING AND SAMPLING PROCEDURE

1. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides.

If using a Smartroll, select the low-flow template for the monitoring well you are about to sample and record the initial depth-to-water. Enter any additional preliminary information not previously entered. If using the YSI, then record the measurement on the paper worksheet.

2. If the well is under artesian conditions or the water level is within the screen, refer to the “Modified Sampling Procedure” section for instruction on sampling the well. If the well is not under either of these conditions, then proceed to the next step.

3. Start the pump and allow the flow-through cell to fill.

If using the YSI, note pump start time on the worksheet. If using the Smartroll, add the pump start time to your field notes right away so that it can later be added to the test notes.

If using the Smartroll, click “start test” once your flow-through cell is completely full and water is discharging from the outlet. Well details may be edited during the test by selecting “Edit Properties”. *Note:* If using an Android, editing properties or otherwise navigating away from the test screen after a test has been started will restart the sample interval timer and the series of readings.

- a. Try to match the final pumping rate used during previous sampling events. If no previous information is available, start the pump at its lowest speed setting using the #16 silicon tubing and slowly increase the speed until discharge occurs.
- b. From the time the pump starts purging until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged.
- c. The water flow during purging and sampling needs to be a laminar flow without air bubbles.

If air bubbles are observed, they can usually be removed by elevating the affected section of tubing and/or the pump to allow the air to continue rising until discharged with the purge water.

Prevent sample tubing from crimping and avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This may cause the groundwater to degas, which can result in a loss of VOCs and dissolved gasses in the groundwater samples. All tubing needs to be maintained in an open condition.

- d. If excessive turbidity or floc is anticipated or encountered with the pump startup, divert the water through the three way stopcock, as if you were taking a turbidity sample, until it clears in order to minimize particulate buildup in the flow-through cell (this is a judgment call made by the sampler). Make sure that the discharge water is going into the graduated bucket so that it will be included in the determination of the final purge volume.
4. Measure and record the water level in the well after 5 minutes of pumping. Record the drawdown on the worksheet, if using the YSI. If using the Smartroll, drawdown is not entered into the tablet; the operator is required to make mental note of the drawdown and drawdown rate based on water level measurements and elapsed time.
 5. Assess the water level drawdown rate.
 6. Adjust pump rates until there is little or no water level drawdown.

Pumping rates shall, if needed, be reduced to the minimum capabilities of the pump and tubing size to avoid or minimize drawdown and to ensure stabilization of monitoring parameters. **However, pumping rates shall not be less than 50 ml/minute.**

Concentrate on the flow rate and drawdown rate stabilization for the first 15 minutes, or so, of the well purging effort (e.g., first 3 to 4 water level readings at 5 minute intervals). In general, the drawdown rate is expected to be stabilized within the first 15 to 20 minutes after the purge water exits the flow-through cell and enters the bucket.

The following drawdown rate limits are acceptable with a flow rate of no less than 50 ml/minute:

Maximum Allowable Drawdown Over One 5 Minute Period	
Inside Diameter of Inner Casing (Inches)	Drawdown Rate (Feet per 5 Minutes)
3 or less	0.02
3.5 - 5	0.01
6	No drawdown allowed

If using iSitu on your iOS device, the following drawdown rate limits are acceptable with a flow rate of no less than 50 ml/minute:

Maximum Allowable Drawdown Over One 5 Minute Period	
Inside Diameter of Inner Casing (Inches)	Drawdown Rate (Inches per 5 Minutes)
3 or less	0.24
3.5 - 5	0.12
6	No drawdown allowed

These maximum allowable drawdown rates enhance the potential for acquiring at least 90% (and greater for smaller diameter wells within the range) fresh aquifer water and no more than 10% stagnant well water in the flow-through cell and samples.

If the pump flow rate is greater than 50 ml/minute, the maximum allowable drawdown rate cannot be achieved and the pump cannot be adjusted to a slower rate using the #16 silicon tubing, then the #14 tubing must be used through the pump head. Use the following procedure to change the tubing:

- Stop the pump. Do not release the tubing from the pump head at this time, in order to maintain the vacuum that retains the water in the tubing.
- Add a length of #14 tubing to the end of the #16 tubing. The #14 tubing should be about the same length as the #16 tubing, 12-18 inches.
- Crimp the #16 silicon tubing on the influent side of the pump head with one hand so that the water does not flow back down the tubing and into the well.
- Release the pump head, move the #14 tubing into place and close the pump head.
- Release the crimp from the #16 tubing. The point here is to not let the water flow back into the well when moving the #14 tubing into the pump head housing, as this may increase the turbidity and prolong sample time. This procedure may require two people.

- f. Once the tubing is changed, start the pump again, adjust the rate until a flow rate of 50 ml/minute is achieved and maintained, and continue to assess drawdown rate (e.g., by collecting 3 to 4 water level readings at 5 minute intervals).

In general, recording of the indicator field parameters (i.e., pH, turbidity, specific conductance, temperature, DO and ORP), although useful, is not mandatory during this Initial Time Period (i.e., 15 to 20 minutes with the #16 tubing, or 40 minutes if the tubing was changed to #14) when attempts are being made to adjust the flow rate and stabilize the drawdown rate.

However, when using the Smartroll, most of the parameters are recorded automatically.

For parameters that require manual input into the tablet when using the Smartroll during low flow sampling (e.g., water level, purge rate, and turbidity), those cells will remain blank or the previously entered value will be automatically carried over until the data is manually entered. Water level and purge rate/flow data must be manually entered into the tablet during the initial drawdown period. Drawdown is not entered into the tablet; the operator is required to make mental note of the drawdown and drawdown rate based on water level measurements and elapsed time.

If the desired drawdown rate cannot be achieved by the end of the Initial Time Period, then begin collecting the indicator field parameters **at a minimum frequency of five-minute intervals**, if not already doing so. Make sure the purge water is still being collected in the graduated bucket as part of the total purge volume.

When using the YSI, if minimum fluctuation of the indicator field parameters is observed during the Initial Time Period, then go ahead and begin recording indicator field parameter data, as it may help reduce the time spent purging.

Make a notation on the field worksheet (when using the YSI) “NR” for “no reading” at times when only partial data is being collected (e.g., water level only) during the Initial Time Period while adjusting pump speed and stabilizing the drawdown rate.

7. Well Conditions

- A. The well will NOT be considered suitable for low flow sampling under the following conditions:
 - a. The initial water level was above the top of the screen prior to starting the pump but the water level falls below the top of the well screen during purging.
 - b. The well has insufficient recharge: The water level continues to drop at the 2-hour time limit at a rate that is greater than the maximum allowable drawdown rate in the chart above, with the pump setting at the lowest level (but not below 50 ml/min) using the #14 silicon tubing.

Under these conditions, sampling may occur immediately if the total purge volume is greater than one tubing volume, and enough water remains above the tubing intake to collect the samples, as follows:

- a. Collect one last set of field parameters before disconnecting the three-way stopcock and collecting the samples.

- b. To collect the samples, refer to the Sample Collection steps below.
- c. If the water level in the well drops to the tubing intake, discontinue sampling at that location and return once the well has sufficiently recharged to collect the remaining samples.

If the well has to recharge overnight, refer to the *Modified Sampling Procedure* section in this SOP for instruction on sampling the well. One tubing volume of water must be removed immediately before resumption of sample collection the next day.

Once the well has been determined to have insufficient recharge for two consecutive rounds, then the well will be designated on **Table 2** in the SAP for future sampling under the Modified Sampling Procedure.

- B. If the well is not under any of the conditions in Step A, then continue to the next step (Field Parameter Monitoring).

8. Field Parameter Monitoring

In addition to the water level, drawdown, pumping rate and any adjustments, and if not already doing so, now begin recording the indicator field parameters (pH, turbidity, specific conductance, temperature, DO and ORP) at a frequency of five-minute intervals (or greater if using the YSI; e.g., every ten minutes until the indicator field parameters start to stabilize, then every five minutes. Note: the Smartroll will automatically record readings every five minutes.) until stabilization or until the point at which two hours have elapsed since commencement of purging. **Readings shall not be less than five minutes apart.**

- a. When recording pH and DO data, round off data to one decimal place (i.e., nearest tenth). When DO is less than 0.5 mg/L, data should be recorded as “< 0.5” or “less than 0.5”. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers (round off to the nearest whole number). When turbidity data is less than 5 NTU, data should be recorded as “< 5” or “less than 5”. Please note, other than turbidity readings, rounding of data is not possible when using the Smartroll.
- b. Periodically check the monitoring probes and the top of the flow-through cell for air bubbles and eliminate any that are found. Be sure to tilt the flow-through cell with the outflow connection facing upward to minimize, if not eliminate and prevent air bubbles.
- c. Rinse the turbidity vial with DI water before collecting the first sample. Rinse with fresh purge water or DI water between readings to eliminate any sediment that may have collected on the bottom.
- d. Condensation (fogging) of Turbidity Vial: Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off of the sample cell before measurement. If fogging recurs, let the sample warm slightly at ambient temperature or immerse the sample cell in a container of ambient temperature water for a short period. After warming, wipe the

sample cell dry and gently invert the sample cell to thoroughly mix the contents before measurement.

- e. If the flow-through cell needs to be cleaned during purging operations, then continue pumping, while letting purge water discharge directly to the graduated bucket, and disconnect the flow-through cell for cleaning; reconnect after cleaning and continue monitoring activities. Record start and stop times for cleaning and document with a brief description of cleaning activities. If using the Smartroll do not stop the test. Make a note in the “test notes” section that the flow-through cell was being cleaned during the applicable time period to explain the erroneous readings.
 - f. The flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples. However, it may be necessary to reduce the flow rate to collect volatile samples (e.g., VOCs, methane, ethane, ethene, carbon dioxide, volatile fatty acids) in order to fill the sample containers by allowing the discharge to flow gently down the inside of the container with minimal turbulence.
9. Stabilization of indicator field parameters is considered to be achieved when three consecutive readings at **five-minute intervals** are within the limits listed below.

When using the Smartroll, the tablet display automatically highlights the parameters measured by the Smartroll (i.e., not turbidity, which is hand-entered) in green once they become stabilized.

- **Temperature: +/- 1 °C**
Values are to be rounded to the nearest whole number when recorded on the paper worksheet (e.g., 10.4 is rounded to 10; 10.5 is rounded to 11).
- **Specific Conductivity (µS/cm): +/-3%**
Values are to be rounded to the nearest whole number when recorded on the paper worksheet.
- **DO: +/-10% for values greater than 1 mg/l**
Values are to be rounded to one decimal place when recorded on the paper worksheet.
Values between 0.5 and 1.0 are considered stable within +/- 0.1 mg/l.
Values less than zero point five (0.5) are reported as “<0.5”.
If three consecutive DO values are less than 0.5 mg/l, consider the DO values stabilized.

Note: When using the Smartroll, the user will need to determine DO stability when the value is below 0.5 mg/l using the above criteria because the Smartroll can only be set to one criterion (i.e., 10%).
- **pH: +/- 0.1**
Values are to be rounded to one decimal place when recorded on the paper worksheet.

Note: The Smartroll rounds to the nearest hundredth (0.01) for pH, and then subtracts adjacent readings to calculate stability. As such, the meter may indicate that pH has fallen out of stability when the criteria for stability required by the SAP are actually still being met.

- **ORP: +/- 10 millivolts**

Values are to be rounded to the nearest whole number when recorded on the paper worksheet.

- **Turbidity: +/-10% for values greater than 10 NTU**

Values are to be rounded to the nearest whole number when recorded on the paper worksheet or the tablet.

Values between 5 and 10 are typically considered stable within +/- 1 NTU.

Values less than five (5) are typically reported as “<5”.

If three consecutive turbidity values are less than 5 NTU, consider the values stabilized.

Note: When using the Smartroll, the user will need to determine turbidity stability because the Smartroll doesn't determine stability on manually entered data.

10. Sampling Requirements:

- a. When the drawdown rate and indicator field parameters have stabilized, ensure that the PVR has been met before sample collection. On the worksheet or in the test notes of the Smartroll, record the total volume that was purged before sample collection begins and then compare that volume to the PVR. The PVR was calculated in the Preliminary Procedures and recorded on the worksheet, or in the “test notes” section of the low-flow test on the tablet if using the Smartroll.

If the PVR has not been met, continue purging the well (and recording stabilization parameters) until a minimum of one tubing volume of water (i.e., PVR) is discharged from the flow-through cell. Do not include the volume of water in the flow-through cell as part of the PVR.

- b. If all the indicator field parameters have not stabilized within 2 hours of commencing purging, proceed as in Step “a” above, ensuring that the PVR has been met before sample collection. Note: Additional information (i.e., parameters that did not stabilize and total purge volume) will be input in to the ‘Test Notes’ section during Post Sampling Activities. If not using the Smartroll, record the following information on the field worksheet: indicate that two-hour purge limit was reached, note which specific parameters did not stabilize, the final set of readings, and the total purge volume.

11. Smartroll “Finish Test”

When stabilization has been achieved or the 2 hour time limit has been reached, click the “Finish Test” button on the tablet. The app will confirm with the user that the test is indeed finished collecting parameters. The user will confirm that the test is finished. The test cannot be restarted once “Finish Test” is confirmed. More information will be added to the tablet after sample collection, including sample information.

12. Sample Collection.

- a. Samples for laboratory analyses must be collected before the flow-through cell and the three-way stopcock. This will be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.
- b. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
- c. See **Table 2** in the SAP for specific samples to be collected. The order in which samples should be collected from each well includes:
 - 1) Per- & Polyfluoroalkyl Substances (PFAS) samples, if required;
 - 2) SVOCs (acid/base/neutral extractables), then dissolved acid/base/neutral extractables, as required;
 - 3) VOCs (see special notes);
 - 4) Total manganese, and other metals, as required;
 - 5) Dissolved metals, as required;
 - 6) 1,4-Dioxane, as required (see special notes for Method 8260 SIM); and
 - 7) Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Method 8260 SIM), carbon dioxide, methane, ethane and ethene, refer to the *Special Notes* section at the end of this SOP.

- d. If dissolved (i.e., filtered) metals samples or other samples collected for dissolved analytes, such as dissolved organic carbon (DOC), are required, then attach a one-time-use-only, 0.45-micron, in-line filter (transparent housing preferred) to the end of the tubing. Make sure the filter is free of air bubbles before samples are collected. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used.
- e. Make sure that all sample containers are properly labeled. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.
- f. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples are collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, arsenic sample, arsenic duplicate sample). Duplicate samples are not intended to be blind duplicate samples. They are to be designated with a "DUP" after the well designation

as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general, most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., “Lab MS/MSD”) on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle(s) for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site-related MS/MSD samples.

- g. Place samples in re-sealable plastic bags and then into loose ice within the cooler. Metals samples, after acidification to a pH less than 2, do not need to be cooled.

13. Post Sampling Activities

- a. After sample collection, sample information including sample identification, analysis, sample collection time, and any QC samples if collected, will be entered by selecting “Add Sample” from the bottom of the screen. Move on to the test notes screen by selecting “next” but do not yet select “Complete”.
- b. Just prior to turning off the pump, measure and record the water level on the worksheet or in the “test notes” section of the low-flow test on the tablet if using the Smartroll, then turn off the pump. Disconnect the flow-through cell from the three-way stopcock and discharge the water from the flow-through cell into the graduated bucket.
- c. Record the total purged volume (contained in the graduated bucket) on the Low Flow Sampling Worksheet or “test notes” section of the low-flow test on the tablet. If using the Smartroll, the total volume purged during the test will be calculated for you. Manually delete this number so that the estimated value is not included in the Low Flow test report (do not replace with the measured volume purged) and **record the actual total volume purged in the test notes** section based on the volume in the graduated bucket. Make sure that the water in the flow-through cell has already been discharged into the bucket before recording the total volume in the bucket.
- d. Disconnect all other equipment as needed. Tubing should be secured to the inside of the well.
- e. Collect the well depth measurement, if required by **Table 2** in the SAP. Record the depth measurement on the Low Flow Sampling Worksheet, or in the “test notes” section of the low-flow test on the tablet. Also note variation in total depth of well compared to that previously documented.
- f. Additional Information required for the Smartroll:
 - 1) Information required for the Low Flow Test Report, if not previously entered, is as follows (i.e., The Smartroll Tip Sheet):

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler's full name or first initial and full last name (not just initials)
Pump serial number
Turbidity meter model and serial number (or similar unique designation; i.e., last four digits).
Static water level from measuring point
Total tubing length (inside and outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
Maximum allowable drawdown rate
Is #14 tubing used at this location?
The following information must be captured in the test notes:
Pump start time
Indicator parameters stable? If "no", which parameters were out?
Record total volume purged before sample collection to compare to PVR
Minimum PVR reached?
2-hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable.
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24 hour clock time)
All samples collected, including QC samples (i.e., DUPs, EQUIP BLANKS, FIELD BLANKS) recorded on the "Sample" page
Final water level
Total actual volume purged (recorded in test notes only) and delete "Estimated Purge Volume"
Measured well depth, if required. If measured, note variation in total depth of well compared to that previously documented.
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

Notes:

- a) The Smartroll Tip Sheet is also included as an attachment to this SOP so that it may be printed onto index cards and used as a reminder in the field to ensure that the required information is recorded.
- b) The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it isn't captured before a test is finished, it may be entered on the form by hand in the office from the field log book.

Also, it has been noted that if the Smartroll gets disconnected from the tablet at any time, the manually entered notes data is lost if not previously saved. If the information is in the logbook, it can be re-entered.

- c) **If the “back” button is selected from the test notes screen to return to the “Add Sample” screen, any test notes entered will be deleted and will need to be reentered.**
- 2) Once this information has been added to the “test notes” for each well, click **“Complete”**. **At this point, no additional revisions or additions of information can be made.**
 - 3) Saving the Low-Flow Test Report
 - a) If using an Android tablet, click on “Save to...” at the bottom of the screen and select the “VuSitu” folder.

After the report is saved, it may be dragged and dropped to a computer for storage once connected via USB or Bluetooth. The report may also be emailed from the tablet if Wi-Fi or cellular service is available. To email the report, select “Email” from the list of options. From here the user may email the files to the desired email address.
 - b) If using an Apple tablet, after selecting “next”, a copy of the low-flow report will be displayed. That file is automatically stored on your tablet.

If transferring to a computer, files may be found in the tablet by selecting the iSitu app within Apple's iTunes software on the computer.

To email the report, select the envelope icon at the bottom of the screen to send to the desired email address if Wi-Fi or cellular service is available.
 - 4) After transferring or saving the files, press the “Close” option at the bottom of the screen (if using an Android tablet) or press “Home” at the top of the screen (if using an Apple tablet). The app will return to the low-flow test screen where additional testing can begin.

- 5) The Power Pack will automatically shut off if idle for an extended period of time and the user may see a Java script error while setting up at the location. If this happens, simply turn on the Power Pack and close and restart the VuSitu App.
- g. Secure the well with the locking cap.
- h. All non-dedicated equipment (e.g., water level meter) must be decontaminated according to the Decontamination SOP in the SAP.
- i. If an equipment blank is required, refer to **Table 5** in the SAP for specific quality control sampling requirements and appropriate chain-of-custody notations required for samples.

MODIFIED SAMPLING PROCEDURE

This procedure is to be used if: (1) the well is under artesian conditions; (2) the water level is at, or below, the top of the screen; (3) the well has been identified on **Table 2** in the SAP as having insufficient recharge (minimal drawdown cannot be achieved according to the criteria listed in the standard procedure above); or (4) the well had to recharge overnight. Wells where this occurs may be considered for replacement in the future. This modified procedure includes the collection of one set of field parameters before collecting the samples.

Procedure

1. Set up equipment according to the attached Low Flow Setup Diagram. Be sure to tilt the flow-through cell so that the outflow connection is facing upward, in order to eliminate and prevent air bubble entrapment in the flow-through cell.

If using a Smartroll, select the low-flow template for the monitoring well you are about to sample. Enter any additional preliminary information that may be needed. This information includes: the operator's name, turbidity make and model, pump serial number, weather conditions, test notes, well material, the tubing length, and the PVR.

2. Measure the water level. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides. If using a Smartroll, record the initial depth-to-water as part of the preliminary information. If not using a Smartroll, then document the data on the field sampling worksheet.

3. Start the pump and allow the flow-through cell to fill.

If using the YSI, note pump start time on the worksheet. If using the Smartroll, add the pump start time to your field notes right away so that it can later be added to the test notes.

If using the Smartroll, click "start test" once your flow-through cell is completely full and water is discharging from the outlet. Well details may be edited during the test by selecting "Edit Properties". *Note:* If using an Android, editing properties or otherwise navigating away from the test screen after a test has been started will restart the sample interval timer and the series of readings.

- a. From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated beaker/cylinder/bucket to determine the total volume of groundwater purged.
- b. Start the pump at its lowest speed setting and slowly increase the speed until a flow rate of 50 ml/minute is reached. **Pumping rates shall not be less than 50 ml/minute.**
- c. If a 50 ml/minute flow rate cannot be achieved using the smallest size silicon tubing (#14), then set the pump at the lowest flow rate that the pump is cable of attaining (making sure the correct pump head and silicon tubing is being used and that the pump head is set at 300 RPM not 600 RPM).

4. Purge Volume Requirement

Ensure that the purge volume requirement (PVR) has been met before sample collection. On the worksheet or in the test notes of the Smartroll, record the total volume that was purged before sample collection begins and then compare that volume to the PVR. The PVR was calculated in the Preliminary Procedures and recorded on the worksheet, or in the “test notes” section of the low-flow test on the tablet if using the Smartroll.

Continue purging the well at 50 ml/minute, or lowest flow rate possible above that, until a minimum of one tubing volume of water (i.e., PVR) is discharged from the flow-through cell. Do not include the volume of water in the flow-through cell as part of the PVR.

5. Collect one set of parameter readings from the YSI or In-Situ instrument, and an aliquot of water through the three-way stop cock to analyze for turbidity using the Hach Turbidity meter. Record the YSI and turbidity readings on the sampling worksheet or, if using the Smartroll, record the turbidity readings in the turbidity column of the low-flow test.

When using the Smartroll, once one set of readings have been collected:

Click the “Finish Test” button. The app will confirm with the user that the test is indeed finished collecting parameters. The user will confirm that the test is finished. The test cannot be restarted once “Finish Test” is confirmed. More information will be added to the tablet after sample collection.

6. Sample Collection

- a. Samples for laboratory analyses must be collected before the flow-through cell and three-way stopcock. This will be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.
- b. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
- c. See **Table 2** in the SAP for specific samples to be collected. Begin collecting groundwater samples in the following order:
 - 1) Per- & Polyfluoroakyl Substances (PFAS) samples, if required;
 - 2) SVOCs (acid/base/neutral extractables), then dissolved acid/base/neutral extractables, as required;

- 3) VOCs (see special notes);
- 4) Total manganese, and other metals, as required;
- 5) Dissolved metals, as required;
- 6) 1,4-Dioxane, as required (see special notes for Method 8260 SIM); and
- 7) Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Method 8260 SIM), carbon dioxide, methane, ethane and ethene, refer to the *Special Notes* section at the end of this SOP.

- d. If dissolved (i.e., filtered) metals samples or other samples collected for dissolved analytes, such as dissolved organic carbon (DOC), are required, then attach a one-time-use-only, 0.45-micron, in-line filter to the end of the tubing. Make sure the filter is free of air bubbles before samples are collected. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used.
- e. Make sure that all sample containers are properly labeled. Fill all sample containers by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.
- f. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples are collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, arsenic sample, arsenic duplicate sample). Duplicate samples are not intended to be blind duplicate samples. They are to be designated with a “DUP” after the well designation as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general, most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., “Lab MS/MSD”) on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle(s) for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site-related MS/MSD samples.

- g. Place samples in re-sealable plastic bags and then into loose ice within the cooler. Metals samples, after acidification to a pH less than 2, do not need to be cooled.

7. Post Sampling Activities

- a. After completing the test, sample information including sample identification, analysis, sample collection time, and any QC samples if collected, will be entered by

selecting “Add Sample” from the bottom of the screen. Move on to the test notes screen by selecting “next” but do not yet select “Complete”.

- b. Just prior to turning off the pump, measure and record the water level on the worksheet or in the “test notes” section of the low-flow test on the tablet if using the Smartroll, then turn off the pump. Disconnect the flow-through cell from the three-way stopcock and discharge the water from the flow-through cell into the graduated bucket.
- c. Record the total purged volume (contained in the graduated bucket) on the Low Flow Sampling Worksheet or “test notes” section of the low-flow test on the tablet. If using the Smartroll, the total volume purged during the test will be calculated for you. Manually delete this number so that the estimated value is not included in the Low Flow test report (do not replace with the measured volume purged) and **record the actual total volume purged in the test notes** section based on the volume in the graduated bucket. Make sure that the water in the flow-through cell has already been discharged into the bucket before recording the total volume in the bucket.
- d. Disconnect equipment as needed. Tubing should be secured to the inside of the well.
- e. Collect the well depth measurement, if required by **Table 2** in the SAP. Record the depth measurement on the Low Flow Sampling Worksheet, or in the “test notes” section of the low-flow test on the tablet. Also note variation in total depth of well compared to that previously documented.
- f. Additional Information required for the Smartroll:
 - 1) Information required for the Low Flow Test Report, if not previously entered, is as follows (i.e., The Smartroll Tip Sheet):

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler’s full name or first initial and full last name (not just initials).
Pump serial number
Turbidity meter model and serial number (or similar unique designation, i.e., last four digits)
Static water level from measuring point
Total tubing length (inside & outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
Maximum allowable drawdown rate
Is #14 tubing used at this location?
The following information must be captured in the test notes:
Pump start time

Indicator parameters stable? If “no”, which parameters were out?
Record total purge volume before sample collection to compare to PVR
Minimum PVR reached?
2 hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
The following information must be captured in the test notes (continued):
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24 hour clock time)
All samples collected, including QC samples (i.e., DUPs, EQUIP BLANKS, FIELD BLANKs) recorded on the “Sample” page
Final water level
Total actual volume purged (recorded in test notes only) and delete “Estimated Purge Volume”
Measured well depth, if required. If measured, note variation in total depth of well compared to that previously documented.
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

Notes:

- a) If the sampler went directly to the Modified Sampling Procedure without starting the standard low flow procedure, then the information that is **bolded** in the table above will not be applicable.
- b) The Smartroll Tip Sheet is also included as an attachment to this SOP so that it may be printed onto index cards and used as a reminder in the field to ensure that the required information is recorded.
- c) The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it isn’t captured before a test is finished, it may be entered on the form by hand in the office from the field log book.

Also, it has been noted that if the Smartroll gets disconnected from the tablet at any time, the manually entered notes data is lost if not previously saved. If the information is in the logbook, it can be re-entered.

- d) **If the “back” button is selected from the test notes screen to return to the “Add Sample” screen, any test notes entered will be deleted and will need to be reentered.**

- 2) Once this information has been added to the “test notes” for each well, click **“Complete”**. **At this point, no additional revisions or additions of information can be made.**
 - 3) Saving the Low-Flow Test Report
 - a) If using an Android tablet, click on “Save to...” at the bottom of the screen and select the “VuSitu” folder.

After the report has been saved, it may be dragged and dropped to a computer for storage once connected via USB or Bluetooth. The report may also be emailed from the tablet if Wi-Fi or cellular service is available. To email the report, select “Email” from the list of options. From here the user may email the files to the desired email address.
 - b) If using an Apple tablet, after selecting “next”, a copy of the low-flow report will be displayed. The file is automatically saved on your tablet.

If transferring to a computer, files may be found in the tablet by selecting the iSitu app within Apple’s iTunes software. Refer to the operator’s manual for further information.

To email the report, select the envelope icon at the bottom of the screen to send to the desired email address if Wi-Fi or cellular service is available.
 - 4) After transferring or saving the files, press the “Close” option at the bottom of the screen (if using an Android tablet) or press “Home” at the top of the screen (if using an Apple tablet). The app will return to the low-flow test screen where additional testing can begin.
 - 5) The Power Pack will automatically shut off if idle for an extended period of time and the user may see a Java script error while setting up at the location. If this happens, simply turn on the Power Pack and close and restart the VuSitu App.
- g. Secure the well with the locking cap.
 - h. All non-dedicated equipment (e.g., water level meter) must be decontaminated following the Decontamination SOP in the SAP.
 - i. If an equipment blank is required, refer to **Table 5** in the SAP for specific quality control sampling requirements and appropriate chain-of-custody notations required for samples.

RECORDS AND DOCUMENTATION

A field log must be kept each time ground water monitoring activities are conducted in the field. The attached Low Flow Sampling Worksheet is the approved worksheet for use by field sampling staff when using the YSI meter. Fill out the worksheet completely. The field logs/sampling

worksheets shall be filled out in black ink.

When using the Smartroll, some of the documentation information will be populated on the well template, while other data will be entered at the well before purging, during purging, after sampling has been completed and finally after the end-of-day calibration. The information below has been divided into the appropriate categories for use with the Smartroll.

The sampling worksheets and/or the Smartroll tablet (Low-Flow Test Report) shall document (at a minimum) the following:

1. The following information will be added to the Smartroll template before the sampling event:
 - a. Site name
 - b. Well identification.
 - c. Type of pump used (**Note: Serial numbers/Identification numbers will be added before sampling begins, see below**).
 - d. Reference measuring point description (e.g., top of PVC, top of casing).
 - e. Well depth in reference to measuring point from **Table 4** in the SAP.
 - f. Well screen interval from measuring point.
 - g. Tubing intake depth from measuring point.
 - h. The inside diameter of the PVC (or inside well casing), in inches, for purge volume calculation or determination.
 - i. Inside diameter of the tubing for purge volume requirement. (**Note: The diameter will be checked in the field before sampling begins, see below.**)
2. The following information will be added to the Smartroll tablet prior to starting the low flow test (i.e., before purging begins):
 - a. Sampler's full name or first initial and full last name; not just initials. Please print full name on worksheets.
 - b. Pump serial numbers/identification numbers.
 - c. Turbidity meter model and serial number.
 - d. Static water level from measuring point.
 - e. Total tubing length: This is the length of tubing inside the well (from Table 4 Well Construction) and the length of tubing outside the well, used to calculate the PVR. If not previously entered, this total length shall be added. Any previously entered measurement should be confirmed prior to initiating the low flow test and adjusted as necessary.
 - f. **Note:** Check the inside diameter of the tubing to make sure the diameter on the Smartroll template is correct. If not, enter the correct diameter to the "test notes" on the tablet.

- g. Calculated PVR. Document the actual calculations on the worksheet to show how the total volume was determined.
 - h. Maximum allowable drawdown rate in the parameter stabilization criteria tab.
- 3. The following information will be added to the worksheet or Smartroll tablet during purging:
 - a. Pump start time.
 - b. Purge rate/flow in milliliters per minute.
 - c. Any adjustments made (including adjustments in flow rates, etc.).
 - d. All measurement readings of indicator parameters and water levels. Turbidity readings and water levels must be entered manually for the Smartroll. The Smartroll automatically records readings for temp, pH, specific conductivity, DO, and ORP.
 - e. Time of all measurements (applies to written worksheets only, automatically entered on Smartroll).
 - f. Drawdown, in feet (applies to written worksheets only). **Note:** If using the Smartroll, drawdown is not entered into the tablet; the operator is required to make mental note of the drawdown and drawdown rate based on water level measurements and elapsed time.
 - g. At the end of purging, record the amount purged and compare to the PVR to verify that the minimum purge has been met. Do not include the volume in the flow-through cell in the purge volume recorded.
- 4. The following information will be added to the worksheet or Smartroll tablet after samples have been collected:
 - a. Final water level.
 - b. Total actual purge volume in gallons or liters/milliliters, as appropriate. Record this information in the test notes section of the Smartroll only. Do not replace the estimated purge volume as it will still show as an “estimated” value.
 - c. Notation of reaching time limit, if applicable.
 - d. Notation of condition that triggered the switch to the Modified Sampling Procedure, if applicable.
 - e. Clock time for switch to Modified Sampling Procedure, if applicable.
 - f. Notation of parameter stabilization (or not) and which parameters did not stabilize after time limit was reached (if any).
 - g. Time at sample collection (as recorded on the bottle) and completion (24 hour clock time).
 - h. Samples collected, including QC samples.

- i. Comments or field observations during sampling event (e.g., condition of well, missing locks).
- j. Weather conditions, including approximate ambient air temperature.
- k. Measured well depth, if required. If measured, note variation in total depth of well from measuring point compared to previously documented depth.

Once all information has been entered into the tablet, press the **Complete** button. At this point, no additional revisions or additions of information can be made.

5. The following information will be **manually hand written** on the Smartroll Low-Flow Test Report after it has been printed, if appropriate:

(**Note:** If worksheets are used, the information will be written on the worksheet after the end of day calibration check has been performed, if appropriate.)

If a calibration check at the end of the day is not within the acceptable range for any parameter(s), the data collected that day for that parameter shall be qualified in its use. A note must be added to the worksheet to indicate the qualification and the values for that parameter highlighted. (Example note: “The afternoon calibration check for ORP was not within the acceptable range; therefore, these ORP values can only be used for determining stabilization and not as representative of actual ORP values of the water being sampled.”) Refer to the *Calibration of YSI, In-Situ and Hach Field Instruments* SOP in the SAP for more information on the calibration check.

Refer to the *Chain-of-Custody, Sample Handling and Shipment* SOP in the SAP for additional documentation requirements.

SPECIAL NOTES

Special Considerations for the Collection of Volatile Organic Compound Samples
Including 1,4-dioxane samples analyzed by Method 8260 SIM.

The proper collection of a sample for volatile organic compound analysis requires minimal disturbance of the sample to limit volatilization and therefore minimize loss of volatiles from the sample. The following VOC procedures shall be followed:

1. Open the vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples (duplicates and MS/MSD samples), collect them immediately following the original sample (e.g., VOC sample, VOC duplicate sample, then VOC MS/MSD sample).
2. Do not rinse the vial or excessively overflow it because it likely contains a specific volume of preservative that must not be diluted.
3. Do not collect the initial 10 ml (approximate) of sample in the discharge tubing, as the beginning of the sample has been in contact with air.

4. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.
5. There should be a convex meniscus on the top of the vial prior to capping the vial. The cap may be used to create the convex meniscus for VOC samples, if needed.

For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. These vials should be filled in the shortest time possible and capped immediately. Do not uncap these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort shall be made to collect the highest quality (e.g., bubble-free) sample possible.

6. Check that the cap has not been contaminated (e.g., splashed) and carefully cap the vial.
7. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.
8. Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.
9. Wipe the vial dry and immediately place the vial into a re-sealable plastic bag and then into loose ice in the cooler.

PURGE VOLUME REQUIREMENT CALCULATIONS

The following approach is used to determine the necessary PVR:

$$\text{PVR} = (\text{Total Tubing Length [ft.]} \times \text{Unit Tubing Capacity [gal/ft. or ml/ft.]})$$

One purge volume is equal to $h * 3.14 * (r/12)^2 * 7.48 \text{ gal/ft}^3$, where

h = length of tubing (feet)

r = internal radius of tubing (inches) = inside diameter/2

Or, in other words, one purge volume is equal to (h) * (f) where:

h = length of tubing (feet)

f = the unit volume per foot of water column (gal/ft.)

For convenience, the table below is provided in order to quickly determine the “f” factor. In order to more accurately measure the purge volume, the table can also be used to determine the purge volume in units of milliliters. It accounts for the gallons-to-milliliters conversion (1 gallon = 3,785 ml).

One unit purge volume (gal/ft. or ml/ft.) = one foot of tubing (ft.) x volume (gal or ml).

Unit Tubing Capacity Values

Tubing Diameter (inches)	1/4 (0.25) OD (0.17 ID)*	3/8 (0.375) OD (0.25 ID)*	1/2 (0.50) OD (0.375 ID)*	5/8 (0.625) OD (0.50 ID)*
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

* Calculations are based on the ID, not the OD.

REFERENCES

Low Flow Groundwater Purging and Sampling Procedure included in the current NHDES HWRB Master QAPP, EQA RFA #18008.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

ATTACHMENTS

Low Flow Setup Diagram – Peristaltic Pump

Low Flow Sampling Worksheet

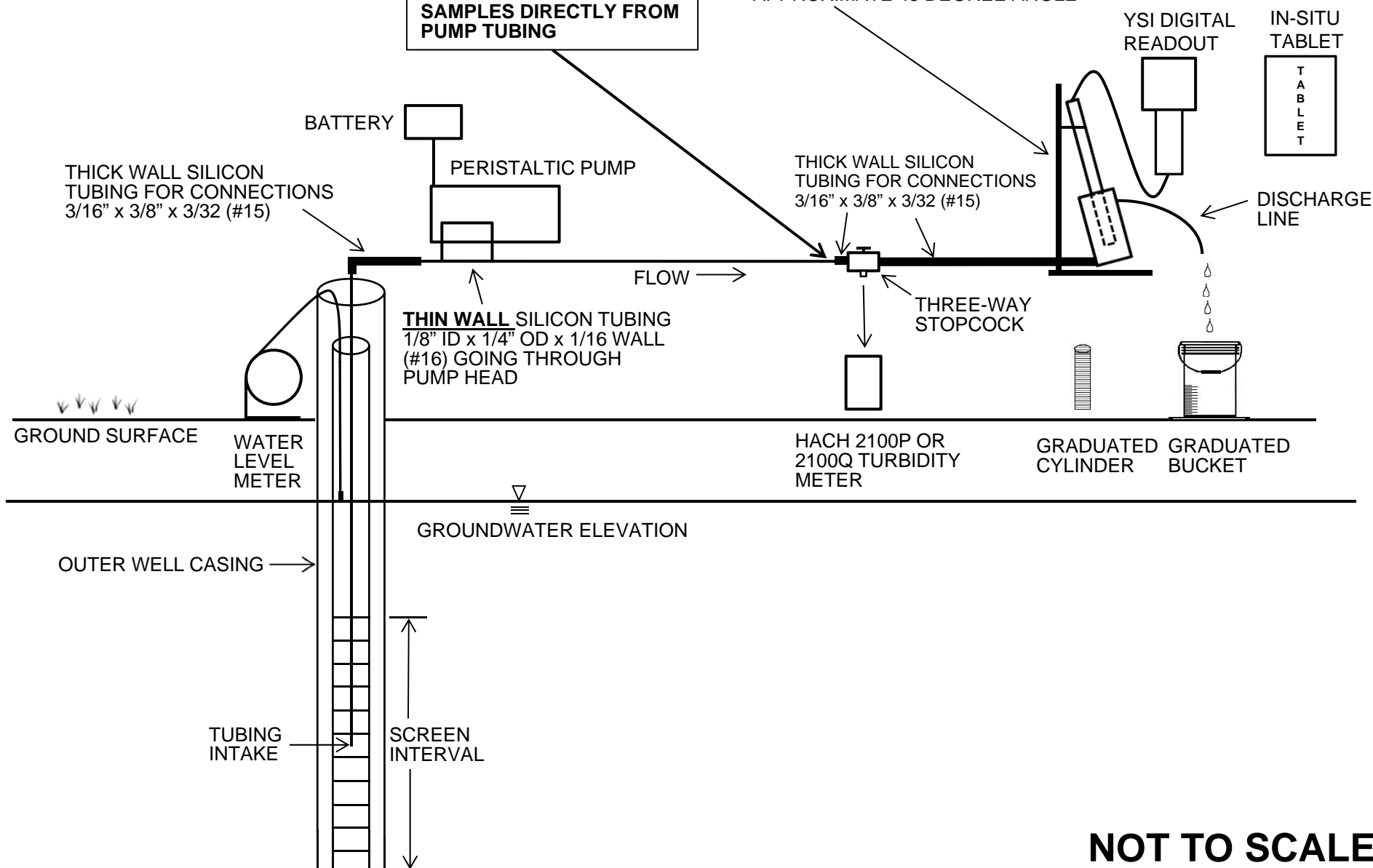
Smartroll Tip Sheet

-Low Flow Equipment Setup Diagram – Peristaltic Pump

LOW FLOW SETUP DIAGRAM USING A PERISTALTIC PUMP

MULTI-PARAMETER WATER QUALITY METER (YSI 600 XL/XLM OR IN-SITU SMARTROLL) WITH TRANSPARENT (250 ML OR LESS) FLOW-THROUGH CELL ON A STAND AT AN APPROXIMATE 45 DEGREE ANGLE

DISCONNECT THREE-WAY STOPCOCK AND COLLECT SAMPLES DIRECTLY FROM PUMP TUBING



-Low Flow Sampling Worksheet -- Peristaltic

Low Flow Sampling Worksheet - Peristaltic Pump
Troy Mills Landfill Superfund Site, Troy, New Hampshire

Page ____ of ____

Date : _____ Well ID : _____ Weather Conditions : _____ Sampler's Name (Print): _____ Purging Device & Serial # (pump type): _____ Reference Measuring Point (Top of PVC/Top of Casing): _____ Well Depth (ft., ref. to measuring point, from Table 4): _____ Screen Interval (ft., ref. to measuring point, Table 4): _____ Samples Collected: _____ Purging Start Time : _____ (24 hour cycle)	Initial Water Level (ft., ref. to measuring point): _____ Tubing Intake (ft., ref. to measuring point): _____ Actual Total Purge Volume (gallons, milliliters or liters): _____ PVC/Inner Well Casing ID (inches): _____ Tubing OD (inches): _____ Tubing ID (inches) _____ Two Hour Time Limit Reached ? yes OR no (circle one) Indicator Parameter Stabilization (all): yes OR no (circle one) Has a minimum of one tubing volume been removed before sampling? Yes OR no (circle one) Sample Time: _____ (24 hour cycle) Time at Sample Completion: _____ (24 hour cycle)
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Clock Time (24 HR)	Water Level (ft.)	Drawdown (ft.)	Purge Rate (ml/min)	Temp +/- 1 °C (°C)	Spec. Cond. +/- 3% (µS/cm)	DO +/- 10% if > 0.5 (mg/l)	pH +/- 0.1 units	ORP +/-10 (mV)	Turbidity +/- 10% if > 5 (NTU)	Comments/Adjustments
PVR =	Calculations: _____									

- Notes: 1. All depths in feet below the referenced measuring point, unless specified. 2. "NR" indicates no reading taken. 3. ID = Inside Diameter
4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers.
 When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l.
 When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are considered stable within +/- 1 NTU.
5. Tubing Factors - Milliliters to purge standing water in tubing: 1/2" ID: length in ft. x 38.6 = ml needed; 3/8" ID: length in ft. x 21.7 = ml needed; 1/4" ID: length in ft. x 9.7 = ml needed; 0.17" ID: length in ft. x 4.5 = ml needed.
6. Purge volume requirement (PVR) is a minimum of one tubing volume of water, so the PVR = Total Tubing Length x Unit Tubing Capacity. Note: Include the length of tubing that is outside the well in the Total Tubing Length.

-SmarTroll Tip Sheet

SmarTroll Tip Sheet

The following information is required for the “test notes” section of the low-flow test report when using the Smartroll multiparameter meter. The table of prompts may be printed onto index cards, laminated and used as a reminder in the field to ensure that the required information is recorded.

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler’s full name or first initial and full last name (not just initials)
Pump serial number
Turbidity meter model and serial number (or similar unique designation, i.e., last four digits).
Static water level from measuring point
Total tubing length (inside and outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
Maximum allowable drawdown rate
Is #14 tubing used at this location?
The following information must be captured in the test notes:
Pump start time
Indicator parameters stable? If “no”, which parameters were out?
Record total volume purged before sample collection to compare to PVR
Minimum PVR reached?
2-hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24 hour clock time)
All samples collected, including QC samples (i.e., VOCs, DUPs, FIELD BLANKs,) recorded on the “Sample” page
Final Water Level
Total Actual Volume Purged (recorded in test notes) and delete “Estimated Purge Volume”
Measured Well depth, if required. If measured, note variation in total depth of well compared to that previously documented.
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

Notes:

1. If the sampler went directly to the Modified Sampling Procedure without starting the standard low flow procedure, then the information that is **bolded** in the table above will not be applicable.

2. The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it isn't captured before a test is finished, it may be entered on the form by hand in the office from the field log book.

Also, it has been noted that if the Smartroll gets disconnected from the tablet at any time, the manually entered notes data is lost if not previously saved. If the information is in the logbook, it can be re-entered.

SOP B-6
Groundwater Well Sampling – Low Flow Using a Bladder Pump

GROUNDWATER WELL SAMPLING – LOW FLOW USING A BLADDER PUMP

SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) *Groundwater Sampling – Low flow Using A Bladder Pump*, provides a general framework for collecting groundwater samples at the Troy Mills Landfill Superfund Site (the “Site”) located in Troy, New Hampshire that are indicative of total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions with minimal physical and chemical alterations from sampling operations.

The intent of this SOP is to enhance the quality of the samples being measured and to help ensure that the project-specific data quality objectives (DQOs) are met when low flow conditions are required. In this procedure, the user is required to monitor the rate at which the water level in the well drops, generally referred to herein as the drawdown rate. The procedure includes a reference table based on calculations that improve the potential that at least 90% of the water being pumped out of the well (i.e., the discharge water) was in contact with the formation and that no more than 10% of the discharge water is influenced by the stagnant water in the well riser.

Total purge volume, stabilization of indicator field parameters [pH, turbidity, specific conductance, temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP)], and drawdown rate are used to indicate when conditions are suitable for sample collection. The SOP emphasizes the need to minimize hydraulic stress at the well and better enable collection of samples representative of the aquifer. This is accomplished by low pumping rates, negligible water level draw down rate and stabilization of water quality parameters. These requirements and parameters, upon meeting certain stability thresholds, indicate that the groundwater being pumped is reasonably representative of the formation interval in which the well is screened.

In low permeability formations or poorly installed monitoring wells it may not be possible to collect groundwater samples using the standard low flow procedure. Under such conditions a modified sampling procedure is employed. The conditions that will require moving from the standard low-flow procedure to the modified procedure are:

- a. The well is under artesian conditions.
- b. The water level is within the well screen interval.
- c. The well has been identified as having insufficient recharge on **Table 2** in the SAP for two consecutive rounds.
- d. The water level falls below the top of the well screen interval while purging.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with Environmental Protection Agency (EPA), documented in the field logbook

and presented in the final report.

This procedure is primarily designed for monitoring wells with an inside diameter that can accommodate a positive lift pump (1.5-inches or greater) with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval. Hereafter, the “screen or open interval” will be referred to only as “screen interval”.

The “Modified Sampling Procedure” will be used without further attempt to use the standard low flow procedure if the low flow procedure has been attempted unsuccessfully due to insufficient recharge at a well for two consecutive rounds. These wells will be identified on **Table 2** in the SAP.

PROCEDURE REQUIREMENTS

All measurements of field parameters must be obtained using a “flow-through cell”, except for turbidity. Turbidity must be collected at a point before the flow-through cell and measured with an instrument that is separate from the flow-through cell apparatus. A three-way stop cock (or “T” connection) attached to the tubing before the flow-through cell will be used to collect the turbidity samples. Transparent flow-through cells with a cell capacity of 250 milliliters or less are required. The transparency allows field personnel to watch for air bubbles and particulate build-up within the flow-through cell, which may affect indicator field parameter values measured within the cell. The flow-through cell must be designed and used in a way that prevents air bubble entrapment in the cell. Placing the flow-through cell at an approximate 45-degree (°) angle with the outlet port facing upward can help remove bubbles from the flow-through cell. The flow-through cell must remain free of any air bubbles at all times. Otherwise, the monitoring probes may act erratically. When the pump is turned off, water in the flow-through cell must not drain out. Monitoring probes must be submerged in water at all times during the collection of field parameter data. Refer to the attached Low Flow Setup Diagram.

A small volume flow-through cell (250 ml or less) facilitates rapid turnover of water in the cell between measurements of the indicator field parameters. The pump’s flow rate must be able to “turn over” at least one flow-through cell volume between measurements. For example: The monitoring frequency for a 250 mL flow-through cell with a flow rate of 50 ml/minute would be every five minutes. **Note: The indicator field parameters shall be measured at a minimum frequency of five-minute intervals.**

The YSI Models 600XL/XLM multiparameter meters that have previously been used with this low flow procedure are slowly being phased out by YSI; therefore, this SOP also includes instructions on using the In-Situ smarTROLL™ multiparameter meter (referred to as the Smartroll in this SOP) with a mobile tablet. The Smartroll was chosen because it appears to meet all of the NHDES Hazardous Waste Remediation Bureau (HWRB) requirements for field instrumentation and will eliminate or reduce the amount of data needed to be recorded on hand written worksheets. The HWRB requires that field personnel use a rugged field electronic tablet with the Smartroll to calibrate and record data in the field in order to view all data simultaneously and clearly; **it is not acceptable to use a smartphone, iPod, or equivalent due to screen-size**

limitations.

The tablet used with the Smartroll must be set up in advance. Refer to the *Smartroll Tablet Set Up* section in this SOP and the *In-Situ Smartroll Equipment Set Up & Use* SOP in the SAP.

USE OF TERMS

Battery Pack: The Battery Pack is used with the Smartroll, enables wireless (Bluetooth) communication between the Apple tablet and the multiparameter meter, and supplies power to the multiparameter meter. The Battery Pack also provides an ambient temperature measurement and a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements.

Drawdown Rate: The rate at which the water level in the well riser drops as the well is purged and sampled.

Equipment Blank: is a sample of deionized (analyte-free) water which has been poured around and through sample collection equipment to evaluate the equipment decontamination procedures and the potential for cross-contamination between sample locations. Refer to **Table 5** in the SAP for equipment blank requirements.

Field Duplicates: Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (e.g., volatile organic compound [VOC] original, VOC duplicate, metals original, metals duplicate).

Field Parameters: Field parameters (also referred to herein as “parameters” and “indicator parameters”) comprise those field analyses of water quality such as ORP, DO, pH, Specific Conductivity, temperature, and turbidity used as indicators of when purging operations are sufficient and sample collection may begin.

iOS: Refers to an Apple mobile operating system that powers Apple devices (i.e., iPad tablet).

iSitu: Refers to the Apple-based application (app) downloaded from iTunes and installed on your iPad tablet. The iSitu app is the user interface and control application for the Smartroll and enables collection of water quality field parameters.

Low-Flow Test: Reference to a low-flow test is specific to monitoring using an In-Situ Smartroll and implies the recording of a set of parameters during monitoring of a particular well.

Matrix Spike/Matrix Spike Duplicates (MS/MSD): Primarily used by the laboratory in its quality assurance program. Refer to **Table 3** in the SAP for the sample volume to be collected.

Potentiometric Surface: The level to which water rises in a well that is constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

Power Pack: The Power Pack is used with the Smartroll, enables wireless (Bluetooth) communication between the Android tablet and the multiparameter meter, and supplies power to the multiparameter meter. The Power Pack also provides an ambient temperature measurement and a barometric pressure measurement that is used to compensate depth and dissolved oxygen measurements.

RDO cap: This refers to the optical Rugged Dissolved Oxygen (RDO) sensor that is housed in a cap and used to measure dissolved oxygen with the Smartroll.

Smartroll: The Smartroll is a multiparameter meter that allows you to collect water quality parameter data on a mobile tablet and eliminates or reduces the amount of data needed to be recorded on hand written worksheets.

Stabilization: A condition that is achieved when the drawdown rate and all indicator field parameter measurements are sufficiently stable (as described in the “Well Purging and Sampling Procedure” section), thereby allowing sample collection to begin (as long as the minimum purge volume requirement is met).

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): A trip blank is a sample of analyte-free water taken to the sampling site along with the sample bottles, and returned to the laboratory for analysis (e.g., treated as a sample), to measure possible cross contamination of containers/samples during shipping to and from the site. Trip blanks must not contain any analytes at or above the quantitation limit of the test. One trip blank consists of two full volatile organic analysis (VOA) vials and is added to each sample cooler that contains VOC samples.

VuSitu: refers to the Android-based app downloaded from the Google Play Store and installed on your tablet. The VuSitu app is the Android-based user interface and control application for the Smartroll and enables collection of water quality field parameters.

Win-Situ: Refers to the Windows software downloaded from the In-Situ website¹ and installed on your laptop or desktop computer. Low-flow test templates used within iSitu and/or VuSitu are created in WinSitu and then transferred to the tablet.

BACKGROUND FOR IMPLEMENTATION

Prior to conducting the sampling event, information regarding well construction, development, screen length and water level records for each well to be sampled should be obtained and reviewed to determine the appropriate pump to be used, the location of the intake, and the potential groundwater recharge rate of the well. If this information is not available, a reconnaissance should be made prior to the actual sampling event to determine well depth, water

¹ <https://in-situ.com/support/type/software/>

level, etc., and possibly perform a pump test to determine the recharge rate of the well. Additionally, wells that have not been sampled in years should be redeveloped prior to conducting the actual sampling event, if possible.

It is expected that the monitoring well screen, or open interval, has been properly located (both laterally and vertically) to intercept existing contaminant plumes or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate at a given well remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake.

Significant chemical or permeability differences within the screen may require additional field work (e.g., interval sampling, borehole geophysics) to determine the optimum vertical location for the pump intake and an appropriate pumping rate for purging and sampling more localized target zones. Primary flow zones (e.g., higher permeability and/or higher chemical concentrations) shall be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help ensure that the low stress procedure will not underestimate contaminant concentrations. Refer to **Table 4** in the SAP for well construction details and intake depths.

A goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help minimize sampling variability.

Cold weather considerations must be factored into a low flow sampling plan. It is recommended that low flow sampling be conducted when the air temperature is above 32° Fahrenheit (F) or 0° Celsius (C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the DQOs, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be implemented. Ice formation in the flow-through cell may cause the monitoring probes to act erratically. A transparent flow-through cell is required to

observe whether ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

The use of dedicated sampling equipment is recommended, as it promotes consistency in the sampling, may reduce sampling bias by having the pump's intake at a constant depth, avoids cross contamination and can streamline sampling activities that significantly reduce the time needed to complete each sampling event, thereby reducing the overall field costs.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All appropriate personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples shall be handled with suitable protection to skin, eyes, etc.

PRECAUTIONS

Consider the following precautions when planning to collect groundwater samples if the conditions listed below are expected to occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethane, ethene, dissolved oxygen) and VOCs will need to be qualified. Some conditions that can promote degassing are changes in aperture along the sampling tubing and squeezing/pinching the pump's tubing (e.g., constricting the flow) which results in a pressure change. The observation of bubbles in the tubing is indicative of groundwater degassing.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in the groundwater. Having the pump's tubing completely filled prior to sampling will help avoid this problem.

Direct sunlight and hot ambient air temperatures may cause the groundwater in the tubing and flow-through cell to heat up. This may cause the groundwater to degas, which will result in loss of VOCs and dissolved gases. When sampling under these conditions, shade the equipment from the sunlight (e.g., umbrella, tent). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sunlight or ambient air heating up the groundwater in the tubing.

Condensation (fogging) of Turbidity Vial: Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at ambient temperature or immersing the sample cell in a container of ambient temperature water for a short period. After warming, gently invert the sample cell to thoroughly mix the contents before measurement.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water, which is denser than warm water, sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convection cell. “During low flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions” (Vroblesky 2007).

Interferences may result from using contaminated equipment, cleaning materials and sample containers, or from uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems caused by ambient air interferences can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely inspected to ensure that it is free from contaminants and equipment blanks also need to be collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site to determine whether the previous cleaning procedure removed the contaminants. If contaminants were detected, then a more rigorous or alternative cleaning procedure will be required.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. Federal regulations require the sampler to take the 40-hour OSHA health and safety training course and a yearly 8-hour refresher course prior to engaging in any field activities on Superfund Sites.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team must read, and be familiar with, the site Health and Safety Plan, the SAP, all relevant SOPs, and the current Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), including the most recent amendments, before going onsite for the sampling event. It is recommended that the field sampling leader attest to, and document that, they and their field team have read and understand these site documents.

EQUIPMENT AND MATERIALS

All equipment and materials must be identified and approved before use and must support site-specific DQOs.

- Appropriate health and safety gear.
- Informational materials to be brought to the site during the sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP, monitoring well construction data (e.g., well depth, inner casing diameter, screen interval), location maps, field data from prior sampling events, manuals for sampling, diagrams to show how the equipment is to be set up, and the monitoring instruments' operation and maintenance manuals.
- A tablet that has been prepared for site use according to the *In-Situ Smartroll Equipment Set Up & Use* SOP in the SAP, if using the Smartroll multiparameter meter.
- Site and well keys, spare locks, and bolt cutters.
- Electronic water level meter and/or oil/water interface probe of appropriate lengths (e.g., 100 feet, 200 feet, 300 feet) that measures in increments of 0.01 feet.
- Non-contact gas stainless steel bladder pump and operation manual, stainless steel / polyethylene bladders (e.g., QED Sample Pro, T1250, and T1300 with a minimum bladder sample capacity of 100 ml; bladder pump repair kits (for T1250 pumps) and replacement bladders for the Sample Pro.

The size, capacity of the pump, and placement in the well shall be selected to maximize the filling of the pump's bladder. For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence requirements must be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

For the collection of VOCs and dissolved gases: The bladder's capacity shall be a minimum of 100 ml (large enough to fill a VOA vial in one discharge).

The pump settings (refill and discharge rates) shall be set so that one pulse will deliver a water volume that is sufficient to fill a 40 ml VOA vial while allowing the discharge to flow gently down the inside of the container with minimal turbulence.

- QED bladder pump controller (Model MP-10) capable of adjusting flow to 50 ml/minute, with a manual control option and operation manual.
- Compressed gas source (Also see "Special Notes" section at end of this SOP): Compressed nitrogen stored in a tank with a gas regulator for 150/200 pounds per square inch (psi) to a maximum of 400 psi and the appropriate gas lines with quick disconnect fittings.

Acceptable alternative method: Compressor (minimum 100 psi) and marine battery, plus spare marine battery. **NHDES prefers that gasoline powered equipment is not used if at all possible.** If a gasoline-powered source (e.g., generator) is used, it must be located downwind and at a safe distance from the well (**at least 30 feet**) so that the exhaust fumes do not contaminate the samples.

- Polyethylene sample tubing (sized for bladder pump) – quantity enough to dedicate to each well and to accommodate connection from the well to the multi-parameter meter, and the three-way stop cock for collecting samples for the turbidity meter. **NOTE:** The HWRB requires that a fiberglass measuring tape or other accurate measuring device be used when measuring and installing tubing.
- Polyethylene air tubing (sized for bladder pump) - quantity enough to dedicate to each well and to accommodate connection from the bladder pump to the MP-10 controller and the compressed gas source.
- Silicon tubing (pharmaceutical or surgical grade only) for pump and connections (sized according to: ID" x OD" x Wall"). For sampling: Thin walled tubing size #16 (1/8" x 1/4" x 1/16") and/or thin walled tubing size #14 (1/16" x 3/16" x 1/16") if necessary to reduce flow to 50 ml/minute. For connections: thick walled tubing size #15 (3/16" x 3/8" x 3/32") and possibly size #17 (1/4 x 3/8 x 1/16). Silicon tubing shall be connected to the well tubing by placing the silicon tubing over the well tubing (not inside the well tubing). Various sizes of silicon tubing shall be connected together by placing the end of the large tubing over the end of the smaller tubing. Make sure that tubing being connected together are sized appropriately so that the connections are snug and air bubbles do not form at the connections.
- YSI 600XL/XLM or In-Situ Smartroll Multiparameter unit with built in barometer and a 250 ml or less transparent flow-through cell, capable of measuring pH; ORP, millivolts (mV); DO, milligrams per liter (mg/l), 100% saturation for calibration; specific conductance, microsiemens ($\mu\text{S}/\text{cm}$); and temperature, °C.
- Appropriate calibration solutions for the multiparameter meter including: 0 mg/l DO for DO; Zobell solution for ORP; two different specific conductance standards, one standard is used to calibrate and the other standard is used to check the calibration (e.g., 718 and 1,413 $\mu\text{S}/\text{cm}$); and pH 4, 7, & 10 buffering solution. A small wet sponge or paper towel for DO 100% saturation calibration. Extra DO membranes for the YSI or RDO caps for the Smartroll, in case of breakage.
- Hach 2100P or 2100Q Turbidity Meter.
- Calibration solutions for the Hach Turbidity meter: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) standards as appropriate for the selected meter.
- A three-way stopcock (recommended) or a "T" connector coupled with a clamp/valve is connected between the pump's tubing and flow-through cell to divert sample flow to collect turbidity samples (e.g., Nalgene three-way stopcock with a plug bore of 4 mm [or 0.157 inch]: NNI No. 6470-0004, VWR catalog No. 59097-080). If using an in-line "T" connector, attach a short piece of tubing and a clamp/valve to the center branch of the "T" connector to serve as a sampling port for the turbidity samples.
- One-time use, 0.45 micron, in-line filters (transparent housing preferred) for dissolved metals, if required.
- Plumbing fittings including clips for holding tubing and water level meter in place within the well casing and prevent pinching of tubing. Plumbing fittings for extending the well

sample and air tubing in the well must be either polyethylene or stainless steel. Crimping tool for the plumbing fittings.

- Flow measurement supplies: graduated cylinder sized according to the flow rate (250 ml max, measured in 10 ml increments), stop watch, and a large graduated bucket to record the total volume of water purged from the well, in gallons or liters (milliliters where appropriate).
- Logbook, pencil/pen/sharpies and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.
- Field-data sheets, sample labels, and chain-of-custody records.
- Sample containers and spare containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags and packing materials.
- Clear tape – Place clear tape over sample container labels before sampling in the event the labels are not water proof labels. Alternatively, use plastic water proof labels.
- On-site Tools to include at least: a sharp knife with locking blade (or a tubing cutter, or other safe means of cutting tubing to desired length), bolt cutters, screwdrivers, pliers, hacksaw, 25' measuring tape, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Decontamination equipment and supplies in accordance with the Decontamination SOP in the SAP, including appropriate size buckets and lids for containerization of liquids, if required.
- Trash bags to containerize solid waste.
- Laboratory grade deionized (DI) water.
- Flagging/spray paint as needed to demark well locations, if needed.
- Equipment to keep monitoring and sampling equipment off the ground (e.g., table, bucket or polyethylene sheeting).
- Equipment protection paraphernalia, including a tent/canopy, to:
 - Adequately shade equipment and tubing to prevent temperature variations in the readings, bubbles from forming in the tubing and the acid preservative in the sample containers from volatilizing.
 - Protect both personnel and equipment from other elements including rain, wind, etc.
 - Keep the sampling equipment from freezing in the winter.
- If using the Smartroll:
 1. A rugged Android or Apple tablet is required.

2. The following specific equipment **MUST** be requested from the vendor as they may not automatically be provided with the Smartroll:
 - a. The appropriate Bluetooth connection for the operating system of the tablet (no smartphones or iPods) you are using (i.e., the Power Pack for the Android or the Battery Pack for the Apple). The power pack or battery pack enables wireless communication between the corresponding tablet and the multiparameter meter and supplies power to the multiparameter meter; they are not interchangeable.
 - b. A ring stand and clamp.
 - c. A spare RDO cap.
 - d. The Smartroll MP Storage and Calibration Cup.

The Storage and Calibration Cup (referred to as the storage cup when discussing the Smartroll in this SOP) is a rugged alternative to the standard calibration cup. This storage cup is not provided with the Smartroll multiparameter meters from In-Situ. The vendor orders them separately from In-Situ and you must specifically request the storage cup from the vendor.

SMARTROLL TABLET SET UP

The Smartroll combines water quality sensors with the mobility of an Android or iOS (Apple) mobile device (i.e., a rugged tablet). The VuSitu app runs on an Android tablet and is available from the Google Play store, while the iSitu app runs on an iOS tablet and is available from the Apple App Store. In-Situ recommends the use of an Android operating system as that operating system will be fully supporting going forward. This SOP contains instructions for both Android and iOS operating systems. WinSitu must be installed on a laptop or desktop computer and can be downloaded from the manufacturer's website². Be sure to install the latest version of the software available on the manufacturer's website.

In general, prior to using the Smartroll in the field, a template must be set up that defines stabilization parameters, data required for input, well construction details, etc. The template will eliminate or reduce the amount of data needed to be recorded on handwritten worksheets; therefore, what was required on the handwritten worksheets must be included in the template prior to low flow sampling or entered via the "test notes" function during low flow sampling.

Templates must be set up in the office using WinSitu prior to use in the field. Any unknown information including initial depth to water, for example, may be entered during the sampling program. Once templates are set up prior to use the first time, they should need very little maintenance or updating and can be reused for each subsequent field event. A step-by-step description of how to set up templates for both Android and Apple tablets is provided in the *In-Situ Smartroll Equipment Set Up & Use* SOP in the SAP.

Note: When using the Smartroll, the low flow forms shall be transferred to the field lead's laptop at a minimum of twice a day: Once in the middle of the day and again at the end of the day

² <https://in-situ.com/support/type/software/>

to allow the field lead/quality assurance personnel to review the documentation prior to leaving the site or completing the field event.

EQUIPMENT/INSTRUMENT CALIBRATION

1. In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions prior to the sampling event. This will ensure that the equipment/instruments are working properly before they are used in the field. The manufacturers' instruction manuals for field equipment shall be on site during each sampling event.
2. If cold weather conditions exist that may impact successful calibration, consider indoor calibration/calibration checks at hotel/office/site trailer (if heated).
3. **All field instruments shall be successfully calibrated (including a successful calibration check) in the office prior to the sampling event (within one week) according to the Calibration SOP in the SAP to ensure that the equipment is working properly and meets the QA criteria. The calibration/calibration check shall be documented on the Calibration Log.**

IMPORTANT – Refer to the *Calibration of YSI, In-Situ and Hach Field Instruments* SOP in the SAP for specific calibration information and procedures.

4. For this project, once the equipment is calibrated and checked, prior to the sampling event, it is not necessary to recalibrate or check the calibration at the beginning of each sampling day. Instead, calibration checks, made in the run mode, shall be performed at the beginning of the first sampling day to ensure the equipment is in calibration and again at the end of the day of use to ensure that the instruments have remained in calibration throughout the day.
5. After the first day, calibration checks shall be performed at the end of each day of use, at a minimum, to ensure that the instruments have remained in calibration. However, if an instrument is not used for a day (for example: over the weekend) or if the field team leader determines it's necessary, then the next sampling day would be considered the "first" sampling day again; where the calibration check is performed both at the beginning of that sampling day and at the end of that day; after which the schedule would revert back to checking the calibration at the end of the day only.
6. If one or more parameters are not within the appropriate range during the calibration check, only those parameters shall be calibrated using all the standards for that parameter and the calibration shall be checked again, to ensure the instrument was calibrated properly. See individual parameters in the SOP for specific instructions. If the calibration or calibration check is not successful, recalibrate using a new standard solution with a different lot number and recheck the new calibration. Then, if the calibration or calibration check is still unsuccessful, replace the unit with a backup unit. The backup instrument(s) shall be calibrated (including a calibration check) and used in place of the inoperable unit(s).

7. In addition, should any erratic or illogical readings occur between calibrations/calibration checks, the instrument shall be recalibrated in order to ensure that representative measurements are obtained. All calibration and check values shall be documented on the calibration log maintained by each user.
8. If a calibration check at the end of the day is not within the acceptable range for a parameter, the data collected that day for that parameter shall be qualified in its use. This qualification shall be documented on the calibration log and the field sheets/logs for the appropriate sampling locations. For example: pH measurements are collected as part of the low flow sampling procedure. If the afternoon pH calibration check was not within the acceptable range that day, the pH data collected by that instrument on that day would be qualified as useful only for determining stabilization and not as representative pH measurements of the water being sampled. That qualification would then be documented on the calibration log and the sampling sheet for each of those locations and the applicable data summary table(s) in the report deliverable.
9. **Note:** during the day, if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), then this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs, the data from this instrument will need to be qualified or rejected, and the instrument must be recalibrated before use.
10. Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., multi-parameter meter) can result in faulty data being collected.

PRELIMINARY PROCEDURES INCLUDING WATER LEVEL MEASUREMENTS

1. The pump's bladder capacity must be optimized to ensure a VOC sample can be collected in one bladder cycle or in the "pause-hold-sample" mode of the MP-10. As a result, a minimum bladder capacity of 100 ml is required to ensure that 40 ml can be obtained to fill the VOC vial.

The dedicated bladder pump intake within each well is located generally at the midpoint of the saturated well screen length based on the historical low groundwater, unless otherwise specified on **Table 4** in the SAP.

The pump intake needs to be kept at least 1 to 2 feet above the bottom of the well to avoid disturbing any sediment on the bottom of the well. If there is less than two feet of water in the well, a sample will not be collected using this method.

Great care must be taken during pump installation and sampling to minimize the disturbance of particulates that can greatly extend the purge time by increasing turbidity.

2. Inspect the well for security (e.g., damage, evidence of tampering, missing lock) and record pertinent observations (include photographs as warranted). Note any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box or standpipe. If a lock is found to be damaged, replace with a new lock. Wells shall be

locked at all times when not being sampled; this ensures the integrity of the well, any samples collected and the chain of custody.

3. A synoptic water level measurement round is to be performed (in the shortest possible time, i.e., all in one day) before any purging and sampling activities begin. Refer to the Water Level Measurement SOP in the SAP. NHDES recommends that water levels (to 0.01 feet) be measured at least one day prior to well sampling activities, if possible, in order to allow for re-settlement of any particulates that were mixed into the water column by the measuring activity.
4. The depth to the bottom of the monitoring well shall be confirmed in each well included on **Table 4** in the SAP based on the following:
 - If a dedicated bladder pump has been installed in a monitoring well, the depth to the bottom of the monitoring well will be confirmed at such time when the bladder pump is removed for repairs or maintenance activities, or if a significant increasing trend in the turbidity values has been observed.
 - In monitoring wells where the bladder pump hasn't been installed yet, or where a non-dedicated portable bladder is used, the depth to the bottom of the monitoring well will be confirmed once every five years, during the sampling event just prior to the 5-year review.
 - If a measurement of total well depth is required and cannot be made at least 24 hours in advance, it shall not be measured until after sampling of the well is complete.
5. Lay out a sheet of clean polyethylene to place the monitoring and sampling equipment upon, unless equipment is elevated above the ground (e.g., on a table or a bucket).
6. Check to determine if the well is under artesian conditions, if the water level is at, or below, the top of the screen, or if the well is flagged on SAP **Table 4** as having insufficient recharge.
7. Set up equipment according to the attached Low Flow Setup Diagram. Be sure to tilt the flow-through cell so that the outflow connection is facing upward, in order to eliminate and prevent air bubble entrapment in the flow-through cell.
8. If available, check flow rates, drawdown and pump setting information from previous sampling events for each well. Duplicate, to the extent practicable, the PSI, refill and discharge settings (use final pump dial setting information) and flow rates from previous events. For wells that are routinely sampled, refer to the ***prior Low Flow Sampling Worksheets*** to determine the initial settings to reach stabilization of the water level as quickly as possible. This is only a guide and the sampler will need to “fine tune” the operating conditions because the recharge rate of groundwater may vary.
9. Be sure all sampling equipment is properly protected from the weather.
10. **If using the Smartroll, additional well-specific information not previously entered can be entered before purging and sampling begins.** This information includes:

- a) Sampler's full name; not just initials.
- b) Pump serial numbers/identification numbers.
- c) Turbidity model and serial number.
- d) Static water level from measuring point.
- e) Total tubing length: This is the length of tubing inside the well (from Table 4 Well Construction) and the length of tubing outside the well, used to calculate the PVR. If not previously entered, this total length shall be added. Any previously entered measurement shall be confirmed prior to initiating the low flow test and adjusted as necessary.
- f) Calculated purge volume requirement. Document the actual calculations on the worksheet to show how the total volume was determined. Refer to the next step (Step 11) for specific instructions.
- g) **Note:** Check the inside diameter of the tubing to make sure the diameter on the Smartroll template is correct. If not, enter the correct diameter to the "test notes" on the tablet.
- h) Maximum allowable drawdown rate in the parameter stabilization criteria tab.

Note: If during the course of the test, this well-specific information gets lost (i.e., because of a cable disconnection) then wait until the end of the test (before you click "Complete") to re-enter this well-specific information. If the cable disconnection happens more than once, then notify the field team leader. Use the backup equipment, if necessary.

11. Purge Volume Requirement

The procedure includes a purge volume requirement (PVR) to ensure that a minimum volume of water has been removed from the well before sampling begins. The PVR is calculated just before sampling begins.

The purge volume requirement is one tubing volume. In other words:

$$\text{PVR} = (\text{Total Tubing Length [ft.] x Unit Tubing Capacity [gal/ft. or ml/ft.]} + \text{The Bladder's Volume Capacity (gal or ml)})$$

Note: Include the length of tubing that is outside the well in the Total Tubing Length.

For convenience, the table below can be used to determine the appropriate volumes in gallons or milliliters. Refer to the *Purge Volume Calculations* section in this SOP for the formula used for determining the table values, if necessary.

Unit Tubing Capacity Values

Tubing Diameter (Inches)	1/4 (0.25) OD (0.17 ID)*	3/8 (0.375) OD (0.25 ID)*	1/2 (0.50) OD (0.375 ID)*	5/8 (0.625) OD (0.50 ID)*
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Converted to Volume (ml/foot)	4.5	9.7	21.7	38.6

* Calculations are based on the ID, not the OD.

Bladder Volumes

QED Bladder Pump Model	Volume Capacity (ml)
Sample Pro®	100
T1250	100
T1300	220

Record the PVR and the calculations used to determine the PVR on the well sampling worksheet, or in the “test notes” section of the low-flow test on the tablet if using the Smartroll.

WELL PURGING AND SAMPLING PROCEDURES

1. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides.

If using a Smartroll, select the low-flow template for the monitoring well you are about to sample and record the initial depth-to-water. Enter any additional preliminary information not previously entered. If using the YSI, then record the measurement on the paper worksheet.

2. If the well is under artesian conditions or the water level is within the screen, refer to the “Modified Sampling Procedure” section for instruction on sampling the well. If the well is not under either of these conditions, then proceed to the next step.
3. Activate the gas source, which activates the pneumatic controller (MP-10).
4. Start the pump and allow the flow-through cell to fill.

If using the YSI, note purge start time on the worksheet. If using the Smartroll, add the purge start time to your field notes right away so that it can later be added to the test notes.

If using the Smartroll, click “start test” once your flow-through cell is completely full and water is discharging from the outlet. Well details may be edited during the test by selecting “Edit Properties”. *Note:* If using an Android, editing properties or otherwise navigating away from the test screen after a test has been started will restart the sample interval timer and the series of readings.

- a. From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged.
- b. Select the appropriate pressure setting for the MP-10 controller. It should be based on previous information available. Otherwise, the pressure (measured in pounds per square inch, or psi) setting should be close to the pressure needed to lift water the depth of the pump intake, plus 10-20 feet, to maximize the discharge

volume from the bladder. However, be careful not to set the pressure too high; this may result in a high-velocity sample stream discharging from the tubing during sampling and/or damage to the bladder. Once the final pressure selection is made, lock the flow throttle in place. Record the pressure on the attached worksheet.

- c. Use a cycle setting of one cycle per minute. Do not change this setting.
- d. Start with a discharge setting of 20 seconds and a refill setting of 40 seconds unless otherwise indicated on the historical flow sheets. Check water level. The purge rate should be close to the well recharge rate so that the water level in the well doesn't decrease during purging. **Purging rates shall not be below 50 milliliters per minute.** Record the settings and adjustments.
- e. On the next cycle use the "pause-hold-sample" function of the QED MP-10 controller to flush out any stagnant water and completely evacuate the bladder, then return the pump to normal function.
- f. The water flow out of the bladder pump during sampling must be a laminar flow without air bubbles. If air bubbles are observed, they can usually be removed by elevating the discharge tube to allow the air to continue rising until discharged with the water. In the event that it is difficult to remove the captured air bubbles in the sample tubing, use the "pause-hold-sample" mode to flush the air bubbles out of the sample tubing.

Prevent sample and air tubing from crimping and avoid the use of constriction devices on the tubing to decrease the water flow rate because the constrictor will cause a pressure difference in the water column. This may cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples. All tubing needs to be maintained in an open condition.

- g. If excessive turbidity or floc is anticipated or encountered with the pump startup, divert the water through the three-way stopcock, as if you were taking a turbidity sample, until it clears in order to minimize particulate buildup in the flow-through cell (this is a judgment call made by the sampler). Make sure that the discharge water is going into the graduated bucket so that it will be included in the determination of the final purge volume.
5. Measure and record the water level in the well after 5 minutes of pumping. Record the drawdown on the worksheet, if using the YSI. If using the Smartroll, drawdown is not entered into the tablet; the operator is required to make mental note of the drawdown and drawdown rate based on water level measurements and elapsed time.
6. Assess the water level drawdown rate.
7. Adjust pump discharge and refill rates (followed by pressure, if required) until there is little or no water level drawdown.

Keep the refill setting higher than the discharge setting and make sure that the refill setting is greater than 10 seconds. Try to reserve adjustment of the pressure setting only

to keep the flow of discharge water laminar. As adjustments are being made, continue to check the water level. Once final pressure selection is made, lock flow throttle in place.

Pumping rates shall, if needed, be reduced to the minimum capabilities of the pump and tubing size to avoid drawdown and to ensure stabilization of monitoring parameters. **However, pumping rates shall not be less than 50 ml/minute.**

Concentrate on the flow rate and drawdown rate stabilization for the first 15 minutes, or so, of the well purging effort (e.g., first 3 to 4 water level readings at 5-minute intervals). In general, the drawdown rate is expected to be stabilized within the first 15 to 20 minutes after the purge water exits the flow-through cell and enters the bucket.

The following drawdown rate limits are acceptable with a flow rate of no less than 50 ml/minute:

Maximum Allowable Drawdown Over One 5 Minute Period	
Inside Diameter of Inner Casing (in.)	Drawdown Rate (Feet per 5 Minutes)
3 or less	0.02
3.5 - 5	0.01
6	No drawdown allowed

If using iSitu on your iOS device, the following drawdown rate limits are acceptable with a flow rate of no less than 50 ml/minute:

Maximum Allowable Drawdown Over One 5 Minute Period	
Inside Diameter of Inner Casing (Inches)	Drawdown Rate (Inches per 5 Minutes)
3 or less	0.24
3.5 - 5	0.12
6	No drawdown allowed

These maximum allowable drawdown rates enhance the potential for acquiring at least 90% (and greater for smaller diameter wells within the range) fresh aquifer water and no more than 10% stagnant well water in the flow-through cell and samples.

In general, recording of the indicator field parameters (i.e., pH, turbidity, specific conductance, temperature, DO and ORP), although useful, is not mandatory during this Initial Time Period (i.e., 15 to 20 minutes) when attempts are being made to adjust the flow rate and stabilize the drawdown rate.

However, when using the Smartroll, most of the parameters are recorded automatically.

For parameters that require manual input into the tablet when using the Smartroll during low flow sampling (e.g., water level, purge rate/flow and turbidity), those cells will remain blank or the previously entered value will be automatically be carried over until the data is manually entered. Water level and purge rate/flow data must be manually entered into the tablet during the initial drawdown period. Drawdown is not entered into the tablet; the operator is required to make mental note of the drawdown and drawdown rate based on water level measurements and elapsed time.

If the desired drawdown rate cannot be achieved by the end of the Initial Time Period, then begin collecting the indicator field parameters **at a minimum frequency of five-minute intervals**, if not already doing so. Make sure the purge water is still being collected in the graduated bucket as part of the total purge volume.

When using the YSI, if minimum fluctuation of the indicator field parameters is observed during the Initial Time Period, then go ahead and begin recording indicator field parameter data, as it may help reduce the time spent purging.

Make a notation on the field worksheet (when using the YSI) “NR” for “no reading” at times when only partial data is being collected (e.g., water level only) during the Initial Time Period while adjusting pump speed and stabilizing the drawdown rate.

8. Well Conditions

A. The well will NOT be considered suitable for low flow sampling under the following conditions:

- 1) The initial water level was above the top of the screen prior to starting the pump but the water level falls below the top of the well screen during purging.
- 2) The well has insufficient recharge: The water level continues to drop at the 2-hour time limit at a rate that is greater than the maximum allowable drawdown rate in the chart above, with the MP-10 controller settings at one cycle per minute and a discharge setting of one second.

Under these conditions, sampling may occur immediately if the total purge volume is greater than one tubing volume plus the bladder’s volume capacity, and enough water remains above the bladder pump intake to collect the samples, as follows:

- 1) Collect one last set of field parameters before disconnecting the three-way stopcock and collecting the samples.
- 2) To collect the samples, refer to the sampling collection steps below.
- 3) If the water level in the well drops to, or below the pump intake, discontinue sampling at that location and return once the well has sufficiently recharged to collect the remaining samples.

If the well has to recharge overnight, refer to the “*Modified Sampling Procedure*” section for instruction on sampling the well. One tubing volume of water must be removed immediately before resumption of sample collection the next day.

Once the well has been determined to have insufficient recharge for two consecutive rounds, then the well will be designated on **Table 4** in the SAP for future sampling under the Modified Sampling Procedure.

B. If the well is not under any of the conditions in Step A, then continue to the next step.

9. After the drawdown rate criteria is met, if the normal discharge volume from a pump cycle is less than 70 ml, place the controller in the “pause-hold-sample mode” to confirm that a discharge volume of 70 ml or greater can be collected. The “pause-hold-sample mode” will empty the bladder. Note that if the discharge volume is 70 ml or greater, there is no need to perform this check as you will be sampling directly from the pump cycle.

In the event the “pause-hold-sample mode” volume is less than 70 ml, attempt to change operating conditions to increase the “pause sample mode” volume. If attempts are unsuccessful, call the project manager to discuss the issue. (Note: the need to fill the VOA vials with one discharge volume of water is a NHDES requirement and an EPA recommendation.)

10. Field Parameter Monitoring

In addition to the water level, drawdown, pumping rate and any adjustments, and if not already doing so, now begin recording the indicator field parameters (pH, turbidity, specific conductance, temperature, DO and ORP) at a frequency of five-minute intervals (or greater if using the YSI; e.g., every ten minutes until the indicator field parameters start to stabilize, then every five minutes. Note: the Smartroll will automatically record readings every five minutes.) until stabilization or until the point at which two hours have elapsed since commencement of purging. **Readings shall not be less than five minutes apart.**

- a. When recording pH and DO data, round off data to one decimal place (nearest tenth). When DO is less than 0.5 mg/L, data should be recorded as “< 0.5” or “less than 0.5”. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers (round off to the nearest whole number). When turbidity data is less than 5 NTU, data should be recorded as “< 5” or “less than 5”. Please note, other than turbidity readings, rounding of data is not possible when using the Smartroll.
- b. Periodically check the probes and the top of the flow-through cell for air bubbles and eliminate any that are found. Be sure to tilt the flow-through cell with the outflow connection facing upward to eliminate and prevent air bubbles.
- c. Rinse the turbidity vial with DI water before collecting the first sample. Rinse with fresh purge water or DI water between readings to eliminate any sediment that may have collected on the bottom.
- d. Condensation (fogging) of Turbidity Vial: Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be

thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly at ambient temperature or immerse the sample cell in a container of ambient temperature water for a short period. After warming, wipe the sample cell dry and gently invert the sample cell to thoroughly mix the contents before measurement.

- e. If the flow-through cell needs to be cleaned during purging operations, then continue pumping, while letting purge water discharge to the graduated bucket, and disconnect the flow-through cell for cleaning; reconnect after cleaning and continue monitoring activities. Record start and stop times for cleaning and document with a brief description of cleaning activities. If using the Smartroll do not stop the test. Make a note in the “test notes” section that the flow-through cell was being cleaned during the applicable time period to explain the erroneous readings.
- f. The flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples. It may be necessary to reduce the flow rate to collect volatile samples (e.g., VOCs, methane, ethane, ethene, carbon dioxide, volatile fatty acids, etc.) in order to fill the sample containers by allowing the discharge to flow gently down the inside of the container with minimal turbulence.
- g. In the event that flow from the bladder pump appears to be a water/air mixture during purging/sampling operations, pull the bladder pump to check the tubing and fitting connections, and to tighten them, if necessary. If the flow from the bladder pump still appears to be a water/air mixture, pumping should be discontinued without taking a sample. This may signal that turbulent flow is occurring, the water level in the well is at the pump intake level, or the bladder has been damaged.

If possible, lower the pump further into the water so the pump unit is fully submerged (if it is not fully submerged) and continue field-parameter stabilization operations. If the pump is lowered, the sampler needs to record the reason for lowering the pump and the new pump's depth on the worksheet(s). This new depth should be maintained as the fixed pumping depth for all subsequent monitoring events. If using the Smartroll do not stop the test. Make a note in the “test notes” section that the pump was lowered and record the reason for lowering the pump and the new pump's depth.

11. Stabilization of indicator field parameters is considered to be achieved when three consecutive readings at **five-minute intervals** are within the following limits:
 - **Temperature: +/- 1 °C**
Values are to be rounded to the nearest whole number when recorded on the paper worksheet (e.g., 10.4 is rounded to 10; 10.5 is rounded to 11).
 - **Specific Conductivity (µS/cm): +/-3%**
Values are to be rounded to the nearest whole number when recorded on the paper worksheet.

- **DO: +/-10% for values greater than 1 mg/l**

Values are to be rounded to one decimal place when recorded on the paper worksheet. Values between 0.5 and 1.0 are considered stable within +/- 0.1 mg/l.

Values less than zero point five (0.5) are reported as “<0.5”.

If three consecutive DO values are less than 0.5 mg/l, consider the DO values stabilized.

Note: When using the Smartroll, the user will need to determine DO stability when the value is below 0.5 mg/l using the above criteria because the Smartroll can only be set to one criterion (i.e., 10%).

- **pH: +/- 0.1**

Values are to be rounded to one decimal place when recorded on the paper worksheet.

Note: The Smartroll rounds to the nearest hundredth (0.01) for pH, and then subtracts adjacent readings to calculate stability. As such, the meter may indicate that pH has fallen out of stability when the criteria for stability required by the SAP are actually still being met.

- **ORP: +/- 10 millivolts**

Values are to be rounded to the nearest whole number when recorded on the paper worksheet.

- **Turbidity: +/-10% for values greater than 10 NTU**

Values are to be rounded to the nearest whole number when recorded on the paper worksheet or the tablet.

Values between 5 and 10 are typically considered stable within +/- 1 NTU.

Values less than five (5) are typically reported as “<5”.

If three consecutive turbidity values are less than 5 NTU, consider the values stabilized.

Note: When using the Smartroll, the user will need to determine turbidity stability because the Smartroll doesn't determine stability on manually entered data.

Note: Due to the typical bladder discharge and refill setting, there is a period of time where temperature and other field parameters may begin to fluctuate during the 40 second refill period (the time where groundwater is not continuously flowing through the flow-through cell). When using the Smartroll, the user will need to make visual assessments of the “live readings” to ensure field parameter stabilizations have not significantly drifted from their respective limits during this time.

12. Sample Requirements:

- a) When the drawdown rate and indicator field parameters have stabilized, ensure that the PVR has been met before sample collection. On the worksheet or in the test notes of the Smartroll, record the total volume that was purged before sample collection begins and then compare that volume to the PVR. The PVR was calculated in the Preliminary Procedures and recorded on the worksheet, or in the “test notes” section of the low-flow test on the tablet if using the Smartroll.

If the PVR has not been met, continue purging the well (and recording stabilization parameters) until a minimum of one tubing volume of water (i.e., PVR) is discharged from the flow-through cell. Do not include the volume of water in the flow-through cell as part of the PVR.

- b) If all the indicator field parameters have not stabilized within 2 hours of commencing purging, proceed as in Step “a” above, ensuring that the PVR has been met before sample collection. Note: Additional information (i.e., parameters that did not stabilize and total purge volume) will be input in to the ‘Test Notes’ section during Post Sampling Activities. If not using the Smartroll, record the following information on the field worksheet: indicate that two-hour purge limit was reached, note which specific parameters did not stabilize, the final set of readings, and the total purge volume.

13. Smartroll “Finish Test”

When stabilization has been achieved or the 2 hour time limit has been reached, click the “Finish Test” button on the tablet. The app will confirm with the user that the test is indeed finished collecting parameters. The test cannot be restarted once “Finish Test” is confirmed. More information will be added to the tablet after sample collection, including sample information.

14. Sample Collection.

- a. Samples for laboratory analyses must be collected before the flow-through cell and the three-way stopcock. This will be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.
- b. When collecting VOCs, if the discharge water volume is 70 ml per discharge or greater, the sampler may sample directly from the pump discharge. In the event the discharge water volume is less than 70 ml per discharge, the water samples will need to be collected through the “pause-hold-sample” function of the QED MP-10 controller.
- c. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
- d. See **Table 2** in the SAP for specific samples to be collected. Begin collecting groundwater samples in the following order:
 - 1) Per- & Polyfluoroalkyl Substances (PFAS) samples, if required;
 - 2) SVOCs (acid/base/neutral extractables), then dissolved acid/base/neutral extractables, as required;
 - 3) VOCs (see special notes);
 - 4) Total manganese, and other metals, as required;
 - 5) Dissolved metals, as required;

- 6) 1,4-Dioxane, as required (see special notes for Method 8260 SIM); and
- 7) Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Methods 8260 SIM), carbon dioxide, methane, ethane and ethene, refer to the Special Notes section at the end of this SOP.

- e. If dissolved (i.e., filtered) metals samples or other samples collected for dissolved analytes, such as dissolved organic carbon (DOC), are required, then attach a onetime-use-only, 0.45-micron, in-line filter to the end of the tubing. Make sure the filter is free of air bubbles before samples are collected. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used.
- f. Make sure that all sample containers are properly labeled. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.
- g. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples are collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, 1,4-dioxane sample, 1,4-dioxane duplicate sample and/or 1,4-dioxane MS/MSD sample). Duplicate samples are not intended to be blind duplicate samples. They are to be designated with a “DUP” after the well designation as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general, most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., “Lab MS/MSD”) on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site-related MS/MSD samples.

- h. Place samples in re-sealable plastic bags and then into loose ice within the cooler. Metal samples, after acidification to a pH less than 2, do not need to be cooled.

15. Post Sampling Activities

- a. After sample collection, sample information including sample identification, analysis, sample collection time, and any QC samples if collected, will be entered by selecting ‘Add Sample’ from the bottom of the screen. To move on to the test notes screen by selecting “next” but do not yet select “Complete”.
- b. Just prior to turning off the pump, measure and record the water level on the worksheet or in the “test notes” section of the low-flow test on the tablet if using the

Smartroll, then turn off the pump. Disconnect the flow-through cell from the three-way stopcock and discharge the water from the flow-through cell into the graduated bucket.

- c. Record the total purged volume (contained in the graduated bucket) on the Low Flow Sampling Worksheet or “test notes” section of the low-flow test on the tablet. If using the Smartroll, the total volume purged during the test will be calculated for you. Manually delete this number so that the estimated value is not included in the Low Flow test report (do not replace with the measured volume purged) and **record the actual volume purged in the test notes** section based on the volume in the graduated bucket. Make sure that the water in the flow-through cell has already been discharged into the bucket before recording the total volume in the bucket.
- d. Deactivate the gas source and disconnect equipment as needed. Tubing should be secured to the inside of the well.
- e. Collect the well depth measurement if required by **Table 2** in the SAP. Record the depth measurement on the Low Flow Sampling Worksheet, or in the “test notes” section of the low-flow test on the tablet. Also note variation in total depth of well compared to that previously documented.
- f. Additional Information required for the Smartroll:
 - 1) Information required for the “test notes” section of the low-flow test is as follows (i.e., The Smartroll Tip Sheet):

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler’s full name or first initial and full last name (not just initials)
Pump serial number
Bladder pumps: add pump type; add pump serial number if not dedicated. Add MP-10 serial number
Turbidity meter model and serial number (or similar unique designation (i.e., last four digits).
Static water level from measuring point
Total tubing length (inside & outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
Maximum allowable drawdown rate
The following information must be captured in the test notes:
Pump start time
Indicator parameters stable? If “no”, which parameters were out?

Record total volume purged before sample collection to compare to PVR
Minimum PVR reached?
2-hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24-hour clock time)
All samples collected, including QC samples (i.e., VOCs, DUPs, FIELD BLANKs) recorded on the “Sample” page
Final water level
Total volume purged (recorded in test notes only) and delete “Estimated Purge Volume”
Final Pressure setting and fill/discharge cycle and rate for bladder pumps
Measured Well depth, if required. If measured, note variation in total depth of well compared to that previously documented.
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

Notes:

- a) The Smartroll Tip Sheet is also included as an attachment to this SOP so that it may be printed onto index cards and used as a reminder in the field to ensure that the required information is recorded.
 - b) The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it isn’t captured before a test is finished, it may be entered on the form by hand in the office from the field log book.
 - c) **If the “back” button is selected from the test notes screen to return to the “Add Sample” screen, any test notes entered will be deleted and will need to be reentered.**
- 2) Once this information has been added to the “test notes” for each well, click **“Complete”**. **At this point, no additional revisions or additions of information can be made.**
 - 3) Saving the Low-Flow Test Report
 - a) If using an Android tablet, click on “Save to...” at the bottom of the screen and select the “VuSitu” folder.

After the report is saved, it may be dragged and dropped to a computer for storage once connected via USB or Bluetooth. The report may also be emailed from the tablet if Wi-Fi or cellular service is available. To email the report, select “Email” from the list of options. From here the user may email the files to the desired email address.

- b) If using an Apple tablet, after selecting “next”, a copy of the low-flow report will be displayed. That file is automatically stored on your tablet.

If transferring to a computer, files may be found in the tablet by selecting the iSitu app within Apple’s iTunes software on the computer.

To email the report, select the envelope icon at the bottom of the screen to send to the desired email address if Wi-Fi or cellular service is available.

- 4) After transferring or saving the files, press the “Close” option at the bottom of the screen (if using an Android tablet) or press “Home” at the top of the screen (if using an Apple tablet). The app will return to the low-flow test screen where additional testing can begin.
- 5) The Power Pack will automatically shut off if idle for an extended period of time and the user may see a Java script error while setting up at the location. If this happens simply turn on the Power Pack and close and restart the VuSitu App.

- g. Secure the well with the locking cap.
- h. All non-dedicated equipment (e.g., water level meter, Sample Pro bladder pump) must be decontaminated following the Decontamination SOP in the SAP.
- i. If an equipment blank is required for a bladder pump setup, decontaminate the bladder pump in accordance with the procedures included in the Decontamination SOP. Fill the PVC chamber (a 4-foot PVC pipe with end cap to simulate a well scenario for pump) with DI water. Lower pump setup including pump and tubing into the PVC chamber. Activate bladder pump and purge one tubing volume of water through the setup. Collect an equipment blank sample by filling the appropriate bottles from the pump tubing. Refer to **Table 5** in the SAP for specific quality control sampling requirements and appropriate chain-of-custody notations required for samples. Continuously add DI water to the PVC chamber until all the bottles have been filled.

MODIFIED SAMPLING PROCEDURE

This procedure is to be used when: (1) the well is under artesian conditions; (2) the water level is at, or below, the top of the screen; or (3) the well has been identified on **Table 2** in the SAP as having insufficient recharge (minimal drawdown cannot be achieved according to the criteria listed in the standard procedure above); or (4) the well had to recharge overnight. Wells where this occurs may be considered for replacement in the future. This modified procedure includes

the collection of one set of field parameters before collecting the samples.

Procedure

1. Set up equipment according to the attached Low Flow Setup Diagram. Be sure to tilt the flow-through cell so that the outflow connection is facing upward, in order to eliminate and prevent air bubble entrapment in the flow-through cell.

If using a Smartroll, select the low-flow template for the monitoring well you are about to sample. Enter any additional preliminary information that may be needed. This information includes: the operator's name, turbidity make and model, pump serial number, weather conditions, test notes, well material, the tubing length, and the PVR.

2. Measure the water level. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides. If using a Smartroll, record the initial depth-to-water as part of the preliminary information. If not using a Smartroll, then document the data on the field sampling worksheet.
3. Start the pump and allow the flow-through cell to fill.

If using the Smartroll, click "start test" once your flow-through cell is completely full and water is discharging from the outlet. Well details may be edited during the test by selecting "Edit Properties". *Note:* If using an Android, editing properties or otherwise navigating away from the test screen after a test has been started will restart the sample interval timer and the series of readings.

- a. From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated beaker/cylinder/bucket to determine the total volume of groundwater purged.
- b. If not already done, select the appropriate pressure setting for the MP-10 controller. It should be based on previous information available. Otherwise, the pressure (measured in pounds per square inch, or psi) setting should be close to the pressure needed to lift water the depth of the pump intake, plus 10-20 feet, to maximize the discharge volume from the bladder. However, be careful not to set the pressure too high; this may result in a high-velocity sample stream discharging from the tubing during sampling and/or damage to the bladder. Once the final pressure selection is made, lock the flow throttle in place. Record the pressure on the attached worksheet or in the "test notes" section of the low-flow test on the Smartroll tablet.
- c. Use a cycle setting of one cycle per minute. Do not change this setting.
- d. Start with a discharge setting of 10 seconds and a refill setting of 50 seconds unless otherwise indicated on the historical flow sheets. Check water level. The purge rate should be close to the well recharge rate so that the water level in the

well doesn't decrease during purging. **Purging rates shall not be below 50 mL/minute.** Record the settings and adjustments.

- e. On the next cycle use the “pause-hold-sample” function of the QED MP-10 controller to flush out any stagnant water and completely evacuate the bladder, then return the pump to normal function.
 - f. The water flow out of the bladder pump during sampling must be a laminar flow without air bubbles. If air bubbles are observed, they can usually be removed by elevating the discharge tube to allow the air to continue rising until discharged with the water.
 - g. Adjust pump discharge and refill rates (followed by pressure if required) until there is little or no water level drawdown.
4. Purge Volume Requirement

The purge volume requirement (PVR) must be calculated to ensure that a minimum volume of water has been removed from the well before sampling begins.

The following approach is used to determine the necessary PVR:

$$\text{PVR} = (\text{Total Tubing Length [ft.]} \times \text{Unit Tubing Capacity [gal/ft. or ml/ft.]} + \text{The Bladder's Volume Capacity (gal or ml)})$$

To calculate the volume in the tubing: $h * 3.14 * (r/12)^2 * 7.48 \text{ gal/ft}^3$, where

h = length of tubing (feet)

r = internal radius of tubing (inches) = inside diameter/2

Or, in other words, one tubing volume is equal to (h) * (f) where:

h = length of tubing (feet)

f = the volume per foot of water column (gal/ft.)

For convenience, the table below is provided in order to quickly determine the “f” factor. In order to more accurately measure the purge volume, the table can also be used to determine the purge volume in units of milliliters. It accounts for the gallons-to-milliliters conversion (1 gallon = 3,785 mL).

One unit tubing volume (gal/ft. or ml/ft.) = one foot of tubing (ft.) x volume (gal or ml).

Unit Tubing Capacity Values

Tubing Diameter (inches)	¼ - inch (0.25) OD (0.17 in ID)*	3/8 - inch (0.375) OD (0.25 in ID)*	1/2 - inch (0.50) OD (0.375 in ID)*	5/8 - inch (0.625) OD (0.50 in ID)*
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

Now use the following table to determine the bladder's volume capacity:

Bladder Volumes

QED Bladder Pump Model	Volume Capacity (ml)
Sample Pro	100
T1250	100
T1300	220

On the worksheet or in the test notes of the Smartroll, record the total volume that was purged before sample collection begins and then compare that volume to the PVR. Record the PVR and the calculations used to determine the purge volume required on the well sampling worksheet, or in the “test notes” section of the low-flow test on the tablet if using the Smartroll.

Continue purging the well at 50 ml/minute, or lowest flow rate possible above that, until a minimum of one tubing volume of water plus the bladder volume (i.e., PVR) is discharged from the flow-through cell. Do not include the volume of water (approximately 250 ml) in the flow-through cell as part of the PVR.

5. Collect one set of parameter readings from the YSI or In-Situ instrument, and an aliquot of water through the three-way stop cock to analyze for turbidity using the Hach Turbidity meter. Record the YSI and turbidity readings on the sampling worksheet or, if using the Smartroll, record the turbidity readings in the turbidity column of the low-flow test.

When using the Smartroll, once one set of readings have been collected:

Click the “Finish Test” button. The app will confirm with the user that the test is indeed finished collecting parameters. The test cannot be restarted once “Finish Test” is confirmed. More information will be added to the tablet after sample collection.

6. Sample Collection
 - a. Samples for laboratory analyses must be collected before the flow-through cell and three-way stop cock. This will be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.
 - b. The water samples for VOCs or gases will need to be collected through the “pause-hold-sample” function of the QED MP-10 controller.
 - c. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
 - d. See **Table 2** in the SAP for specific samples to be collected. Begin collecting groundwater samples in the following order:
 - 1) Per- & Polyfluoroalkyl Substances (PFAS) samples, if required;
 - 2) SVOCs (acid/base/neutral extractables), then dissolved acid/base/neutral extractables, as required;
 - 3) VOCs (see special notes);
 - 4) Total manganese, and other metals, as required;

- 5) Dissolved metals, as required;
- 6) 1,4-Dioxane, as required (see special notes for Method 8260 SIM); and
- 7) Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Methods 8260 SIM), carbon dioxide, methane, ethane and ethene, refer to the Special Notes section at the end of this SOP.

- e. If dissolved (i.e., filtered) metals samples or other samples collected for dissolved analytes, such as dissolved organic carbon (DOC), are required, then attach a onetime-use-only, 0.45-micron, in-line filter to the end of the tubing. Make sure the filter is free of air bubbles before samples are collected. Hold the filter upright until the purge water exits the top to allow the water to completely fill the filter. Allow a volume of purge water, roughly equivalent to the volume of the filter, to discharge into the bucket to rinse the filter before collecting the sample. Discard the filter after use. When collecting a duplicate sample, a new filter must be used.
- f. Make sure that all sample containers are properly labeled. Fill all sample containers by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.
- g. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples are collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., VOC sample, VOC duplicate sample, 1,4-dioxane sample, 1,4-dioxane duplicate sample and/or 1,4-dioxane MS/MSD sample). Duplicate samples are not intended to be blind duplicate samples. They are to be designated with a “DUP” after the well designation as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general, most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., “Lab MS/MSD”) on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site-related MS/MSD samples.

- h. Place samples in re-sealable plastic bags and then into loose ice within the cooler. Metal samples, after acidification to a pH less than 2, do not need to be cooled.

7. Post Sampling Activities

- a. After completing the test, sample information including sample identification, analysis, sample collection time, and any QC samples if collected, will be entered by selecting ‘Add Sample’ from the bottom of the screen. To move on to the test notes screen by selecting “next” but do not yet select “Complete”.

- b. Just prior to turning off the pump, measure and record the water level on the worksheet or in the “test notes” section of the low-flow test on the tablet if using the Smartroll, then turn off the pump. Disconnect the flow-through cell from the three-way stopcock and discharge the water from the flow-through cell into the graduated bucket.
- c. Record the total purged volume (contained in the graduated bucket) on the Low Flow Sampling Worksheet or “test notes” section of the low-flow test on the tablet. If using the Smartroll, the total volume purged during the test will be calculated for you. Manually delete this number so that it is not included in the Low Flow test report (do not replace with the measured volume purged) and **record the actual volume purged in the test notes** section based on the volume in the graduated bucket. Make sure that the water in the flow-through cell has already been discharged into the bucket before recording the total volume in the bucket.
- d. Deactivate the gas source and disconnect equipment as needed. Tubing should be secured to the inside of the well.
- e. Collect the well depth measurement if required. Refer to **Table 2** in the SAP. Record the depth measurement on the Low Flow Sampling Worksheet, or in the “test notes” section of the low-flow test on the tablet. Also note variation in total depth of well compared to that previously recorded.
- f. Additional Information required for the Smartroll:
 - 1) Information required for the “test notes” section of the low-flow test is as follows (i.e., The Smartroll Tip Sheet):

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler’s full name or first initial and full last name (not just initials)
Pump serial number
Bladder pumps: add pump type; add pump serial number if not dedicated. Add MP-10 serial number
Turbidity meter model and serial number (or similar unique designation (i.e., last four digits).
Static water level from measuring point
Total tubing length (inside & outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
Maximum allowable drawdown rate
The following information must be captured in the test notes:

Pump start time
Indicator parameters stable? If “no”, which parameters were out?
Record total volume purged before sample collection to compare to PVR
Minimum PVR reached?
2-hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24-hour clock time)
All samples collected, including QC samples (i.e., VOCs, DUPs, FIELD BLANKs) recorded on the “Sample” page
Final water level
Total volume purged (recorded in test notes only) and delete “Estimated Purge Volume”
Final Pressure setting and fill/discharge cycle and rate for bladder pumps
Measured Well depth, if required. If measured, note variation in total depth of well compared to that previously documented.
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

Notes:

- a) If the sampler went directly to the Modified Sampling Procedure without starting the standard low flow procedure, then the information that is **bolded** in the table above will not be applicable.
- b) The Smartroll Tip Sheet is also included as an attachment to this SOP so that it may be printed onto index cards and used as a reminder in the field to ensure that the required information is recorded.
- c) The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it isn’t captured before a test is finished, it may be entered on the form by hand in the office from the field log book.

Also, it has been noted that if the Smartroll gets disconnected from the tablet at any time, the manually entered notes data is lost if not previously saved. If the information is in the logbook, it can be re-entered.

- d) **If the “back” button is selected from the test notes screen to return to the “Add Sample” screen, any test notes entered will be deleted and will need to be reentered.**
 - 2) Once this information has been added to the “test notes” for each well, click **“Complete”**. **At this point, no additional revisions or additions of information can be made.**
 - 3) Saving the Low-Flow Test Report
 - a) If using an Android tablet, click on “Save to...” at the bottom of the screen and select the “VuSitu” folder.

After the report has been saved, it may be dragged and dropped to a computer for storage once connected via USB or Bluetooth. The report may also be emailed from the tablet if Wi-Fi or cellular service is available. To email the report, select “Email” from the list of options. From here the user may email the files to the desired email address.
 - b) If using an Apple tablet, after selecting “next”, a copy of the low-flow report will be displayed. The file is automatically saved on your tablet.

If transferring to a computer, files may be found in the tablet by selecting the iSitu app within Apple’s iTunes software. Refer to the operator’s manual for further information.

To email the report, select the envelope icon at the bottom of the screen to send to the desired email address if Wi-Fi or cellular service is available.
 - 4) After transferring or saving the files, press the “Close” option at the bottom of the screen (if using an Android tablet) or press “Home” at the top of the screen (if using an Apple tablet). The app will return to the low-flow test screen where additional testing can begin.
 - 5) The Power Pack will automatically shut off if idle for an extended period of time and the user may see a Java script error while setting up at the location. If this happens simply turn on the Power Pack and close and restart the VuSitu App.
- g. Secure the well with the locking cap.
 - h. All non-dedicated equipment (e.g., water level meter, Sample Pro bladder pump) must be decontaminated following the Decontamination SOP in the SAP.
 - i. If an equipment blank is required for a bladder pump setup, decontaminate the bladder pump in accordance with the procedures included in the Decontamination SOP. Fill the PVC chamber (a 4-foot PVC pipe with end cap to simulate a well scenario for pump) with DI water. Lower pump setup including pump and tubing into the PVC chamber. Activate bladder pump and purge one tubing volume of water through the setup. Collect an equipment blank sample by filling the

appropriate bottles from the pump tubing. Refer to **Table 5** in the SAP for specific quality control sampling requirements and appropriate chain-of-custody notations required for samples. Continuously add DI water to the PVC chamber until all the bottles have been filled.

RECORDS AND DOCUMENTATION

A field log must be kept each time ground water monitoring activities are conducted in the field. The attached Low Flow Sampling Worksheet is the approved worksheet for use by field sampling staff when using the YSI meter. Fill out the worksheet completely. The field logs/sampling worksheets shall be filled out in black ink.

When using the Smartroll, some of the documentation information will be populated on the well template, while other data will be entered at the well before purging, during purging, after sampling has been completed and finally after the end-of-day calibration. The information below has been divided into the appropriate categories for use with the Smartroll.

The sampling worksheets and/or the Smartroll tablet (Low-Flow Test Report) shall document (at a minimum) the following:

1. The following information will be added to the Smartroll template before the sampling event:
 - a. Site name
 - b. Well identification.
 - c. Type of pump used (**Note: Serial numbers/Identification numbers will be added before sampling begins, see below**).
 - d. Reference measuring point description (e.g., top of PVC, top of casing).
 - e. Well depth in reference to measuring point from **Table 4** in the SAP.
 - f. Well screen interval from measuring point.
 - g. Tubing intake depth from measuring point.
 - h. The inside diameter of the PVC (or inside well casing), in inches, for purge volume calculation or determination.
 - i. Inside diameter of the tubing for purge volume requirement. (**Note: The diameter will be checked in the field before sampling begins, see below.**)
2. The following information will be added to the Smartroll tablet prior to starting the low flow test (i.e., before purging begins):
 - a. Sampler's full name or first initial and full last name; not just initials. Please print full name on worksheets.
 - b. Pump serial numbers/identification numbers.
 - c. Turbidity meter model and serial number.
 - d. Static water level from measuring point.

- e. Total tubing length: This is the length of tubing inside the well (from Table 4 Well Construction) and the length of tubing outside the well, used to calculate the PVR. If not previously entered, this total length shall be added. Any previously entered measurement should be confirmed prior to initiating the low flow test and adjusted as necessary.
 - f. **Note:** Check the inside diameter of the tubing to make sure the diameter on the Smartroll template is correct. If not, enter the correct diameter to the “test notes” on the tablet.
 - g. Calculated PVR. Document the actual calculations on the worksheet to show how the total volume was determined.
 - h. Maximum allowable drawdown rate in the parameter stabilization criteria tab.
3. The following information will be added to the Smartroll tablet during purging:
- a. Pump start time.
 - b. Purge rate/flow in milliliters per minute.
 - c. Any adjustments made (including adjustments in flow rates, etc.).
 - d. All measurement readings of indicator parameters and water levels. Turbidity readings and water levels must be entered manually for the Smartroll. The Smartroll automatically records readings for temp, pH, specific conductivity, DO, and ORP.
 - e. Time of all measurements (applies to written worksheets only, automatically entered on Smartroll).
 - f. Drawdown, in feet (applies to written worksheets only). **Note:** If using the Smartroll, drawdown is not entered into the tablet; the operator is required to make mental note of the drawdown and drawdown rate based on water level measurements and elapsed time.
 - g. At the end of purging, record the amount purged and compare to the PVR to verify that the minimum purge has been met. Do not include the volume in the flow-through cell in the purge volume recorded.
4. The following information will be added to the Smartroll tablet after sampling has been collected:
- a. Final water level.
 - b. Total actual purge volume in gallons or liters/milliliters, as appropriate. Record this information in the test notes section of the Smartroll only. Do not replace the estimated purge volume as it will still show as an “estimated” value.
 - c. Notation of reaching time limit, if applicable.
 - d. Notation of condition that triggered the switch to the Modified Sampling Procedure, if applicable.

- e. Clock time for switch to Modified Sampling Procedure, if applicable.
 - f. Notation of parameter stabilization (or not) and which parameters did not stabilize after time limit was reached (if any).
 - g. Time at sample collection (as recorded on the bottle) and completion (24-hour clock time).
 - h. Samples collected, including QC samples.
 - i. Comments or field observations during sampling event (e.g., condition of well, missing locks).
 - j. Weather conditions, including approximate ambient air temperature.
 - k. Measured well depth, if required. If measured, note variation in total depth of well from measuring point compared to previously documented depth.
5. The following information will be **manually hand written** on the Smartroll Low-Flow Test Report after it has been printed, if appropriate:

(**Note:** If worksheets are used, the information will be written on the worksheet after the end of day calibration check has been performed, if appropriate).

If a calibration check at the end of the day is not within the acceptable range for any parameter(s), the data collected that day for that parameter shall be qualified in its use. A note must be added to the worksheet to indicate the qualification and the values for that parameter highlighted. (Example note: “The afternoon calibration check for ORP was not within the acceptable range; therefore, these ORP values can only be used for determining stabilization and not as representative of actual ORP values of the water being sampled.”)

Refer to the *Calibration of YSI, In-Situ and Hach Field Instruments* SOP in the SAP for more information on the calibration check.

Refer to the *Chain-of-Custody, Sample Handling and Shipment* SOP in the SAP for additional documentation requirements.

SPECIAL NOTES

When using compressed gas as the compressed air source, be sure to transport tanks upright and properly secured. Always remove the regulator and install the protective cover over the cylinder valve to prevent damage to the valve, which could result in rapid pressure release, when transporting tanks or moving a tank to a new sampling location. Connect the regulator valve and shut the regulator valve off, then open the tank valve all the way and then close the tank valve (this seats the regulator properly). The regulator valve shall use a pressure gauge that reads in psi with a range of 150 psi (minimum) to 400 psi (maximum).

Special Considerations for the Collection of Volatile Organic Compound Samples

Including 1,4-dioxane samples analyzed by Methods 8260 SIM and EPA EIASOP-VOADIOX4.

The proper collection of a sample for volatile organic compound analysis requires minimal disturbance of the sample to limit volatilization and therefore minimize loss of volatiles from the sample. The following VOC procedures shall be followed:

1. Open the vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples (duplicates and MS/MSD samples), collect them immediately following the original sample (e.g., VOC sample, VOC duplicate sample, then VOC MS/MSD sample).
2. Do not rinse the vial or excessively overflow it because it likely contains a specific volume of preservative that must not be diluted.
3. Do not collect the initial 10 ml (approximate) of sample in the discharge tubing, as the beginning of the sample has been in contact with air.
4. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.
5. There should be a convex meniscus on the top of the vial prior to capping the vial. The cap may be used to create the convex meniscus for VOC samples, if needed.

For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. These vials should be filled in the shortest time possible and capped immediately. Do not uncap these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort shall be made to collect the highest quality (e.g., bubble free) sample possible.

6. Check that the cap has not been contaminated (splashed) and carefully cap the vial.
7. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.
8. Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.
9. Wipe the vial dry and immediately place the vial in a re-sealable plastic bag and then in loose ice in the cooler.

PURGE VOLUME REQUIREMENT CALCULATIONS

The following approach is used to determine the necessary PVR:

$$\text{PVR} = (\text{Total Tubing Length [ft.]} \times \text{Unit Tubing Capacity [gal/ft. or ml/ft.]})$$

One purge volume is equal to $h * 3.14 * (r/12)^2 * 7.48 \text{ gal/ft}^3$, where

h = length of tubing (feet)

r = internal radius of tubing (inches) = inside diameter/2

Or, in other words, one purge volume is equal to (h) * (f) where:

h = length of tubing (feet)

f = the unit volume per foot of water column (gal/ft.)

For convenience, the table below is provided in order to quickly determine the “f” factor. In order to more accurately measure the purge volume, the table can also be used to determine the purge volume in units of milliliters. It accounts for the gallons-to-milliliters conversion (1 gallon = 3,785 ml).

One unit purge volume (gal/ft. or ml/ft.) = one foot of tubing (ft.) x volume (gal or ml).

Unit Tubing Capacity Values

Tubing Diameter (inches)	1/4 (0.25) OD (0.17 ID)*	3/8 (0.375) OD (0.25 ID)*	1/2 (0.50) OD (0.375 ID)*	5/8 (0.625) OD (0.50 ID)*
Volume (gal/foot)	0.0012	0.0026	0.0057	0.0102
Volume (ml/foot)	4.5	9.7	21.7	38.6

* Calculations are based on the ID, not the OD.

REFERENCES

Low Flow Groundwater Purging and Sampling Procedure included in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA #13027.

Vroblesky, Don A., Clifton C. Casey, and Mark A. Lowery, Summer 2007, Influence of Dissolved Oxygen Convection on Well Sampling, *Ground Water Monitoring & Remediation* 27, no. 3: 49-58.

ATTACHMENTS

Low Flow Setup Diagram – Bladder Pump

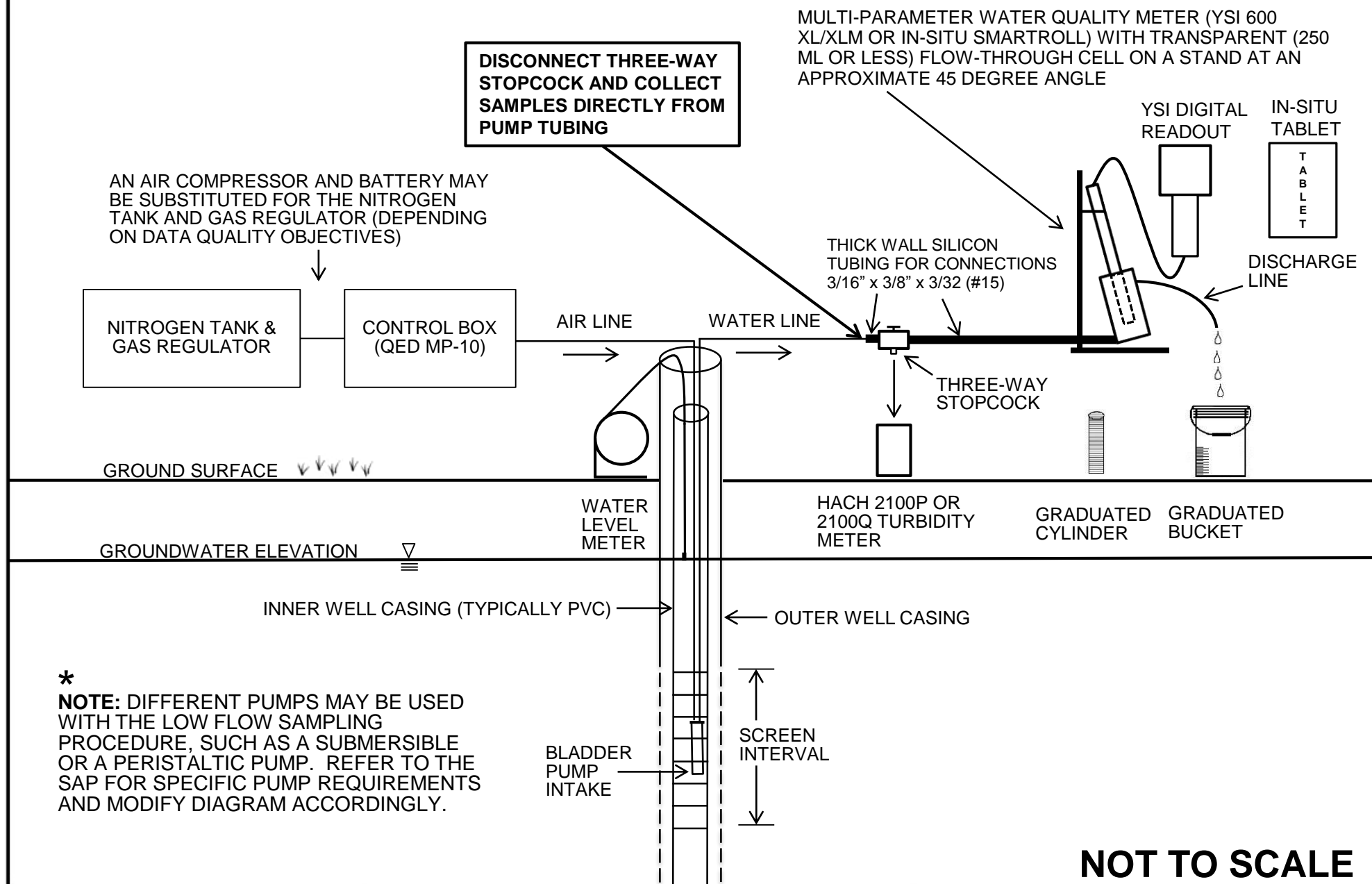
Low Flow Sampling Worksheet – Bladder Pump

Smartroll Tip Sheet

-Low Flow Equipment Setup Diagram – Bladder Pump

LOW FLOW SETUP DIAGRAM

THIS DIAGRAM SHOWS THE BLADDER PUMP SETUP FOR LOW FLOW SAMPLING*



-Low Flow Sampling Worksheet – Bladder

Low Flow Sampling Worksheet - Bladder Pump

Troy Mills Landfill Superfund Site, Troy, New Hampshire

Date : _____ Well ID : _____						Initial Water Level (ft., ref. to measuring point): _____								
Weather Conditions : _____						Pump Intake (ft., ref. to measuring point): _____								
Sampler's Name (Print) _____						Head Above Pump Intake (ft., ref. measuring point): _____								
Purging Device & Serial # (pump type): _____ Bladder Volume (ml): _____						Actual Total Purge Volume (gallons, milliliters or liters) _____								
Reference Measuring Point (Top of PVC/Top of Casing): _____						Indicator Parameter Stabilization: yes OR no (circle one)								
Well Depth (ft., ref. to measuring point) from Table 4: _____						Two Hour Time Limit Reached ? yes OR no (circle one)								
Screen Interval (ft., ref. to measuring point), Table 4: _____														
PVC/Inner Well Casing ID (inches): _____ Tubing ID (inches): _____						Samples Collected: _____								
Purging Start Time : _____ (24 hour cycle) Sample Time: _____ (24 hour cycle)						Time at Sample Completion: _____ (24 hour cycle)								
Bladder Pump Control Box Cycle Setting should be set to "1"														
Clock Time	Water Level	Drawdown	Cumulative Drawdown	Bladder Refill Time	Bladder Discharge Time	Pressure	Purge Rate	Temp. +/- 1 °C	Spec. Cond. +/- 3%	DO +/- 10% if > 0.5	pH +/- 0.1	ORP +/-10	Turbidity +/- 10% if > 5	Comments/Adjustments
(24 HR.)	(ft.)	(ft.)	(ft.)	setting	setting	(psi)	(ml/min)	(°C)	(µS/cm)	(mg/l)	units	(mV)	(NTU)	
PVR =	Calculations:													

Notes: 1. All depths in feet below the referenced measuring point, unless specified. 2. "NR" indicates no reading taken. 3. ID = Inside Diameter

4. When recording pH and dissolved oxygen data, only use one decimal place. When recording specific conductance, temperature, turbidity, and ORP data, record only whole numbers. When DO data is less than 0.5 mg/l, data should be recorded as "<0.5" or "less than 0.5". DO values between 0.5 and 1.0 are typically considered stable within +/- 0.1 mg/l. When turbidity data is less than 5 NTU, data should be recorded as "< 5" or "less than 5". Turbidity values between 5 and 10 are typically considered stable within +/- 1 NTU.

Sampler's Signature

-SmarTroll Tip Sheet

Smartroll Tip Sheet

The following information is required for the “test notes” section of the low-flow test report when using the Smartroll multiparameter meter. The table of prompts may be printed onto index cards, laminated and used as a reminder in the field to ensure that the required information is recorded.

The following information should have been entered <u>PRIOR</u> to starting the low flow test:
Sampler’s full name or first initial and full last name (not just initials)
Pump serial number
Bladder pumps: add pump type; add pump serial number if not dedicated. Add MP-10 serial number
Turbidity meter model and serial number (or similar unique designation, i.e., last four digits)
Static water level from measuring point
Total tubing length (inside & outside of well)
Check tubing inside diameter shown on template, if not correct, enter correct inside diameter here
PVR (including the calculations)
Maximum allowable drawdown rate
The following information must be captured in the test notes:
Pump start time
Indicator parameters stable? If “no”, which parameters were out?
Record total volume purged before sample collection to compare to PVR
Minimum PVR reached?
2-hour time limit reached?
Clock time for switch to Modified Sampling Procedure, if applicable
Condition that triggered the switch to the Modified Sampling Procedure, if applicable
Any adjustments made (including adjustments in flow rates, tubing, etc.)
Time at sample collection (as recorded on the bottle) and completion (24-hour clock time)
All samples collected, including QC samples (i.e., VOCs, DUPs, FIELD BLANKs,) recorded on the “Sample” page
Final Water Level
Total Actual Volume Purged (recorded in test notes) and delete “Estimated Purge Volume”
Final Pressure setting and fill/discharge cycle and rate for bladder pumps
Measured Well depth, if required. If measured, note variation in total depth of well compared to that previously documented
Comments or field observations during sampling event (e.g., condition of well, missing locks, weather)

Notes:

1. If the sampler went directly to the Modified Sampling Procedure without starting the standard low flow procedure, then the information that is **bolded** in the table above will not be applicable.
2. The HWRB recommends that each sampler maintain a field logbook with this information recorded for each low-flow test (i.e., each well) so that if it isn't captured before a test is finished, it may be entered on the form by hand in the office from the field log book.

Also, it has been noted that if the Smartroll gets disconnected from the tablet at any time, the manually entered notes data is lost if not previously saved. If the information is in the logbook, it can be re-entered.

SOP B-7
Groundwater Well Sampling – Using a Bailer

GROUNDWATER WELL SAMPLING – USING A BAILER

PURPOSE

This Standard Operating Procedure (SOP) *Groundwater Well Sampling – Using a Bailer*, is designed to provide general reference information on purging and sampling of groundwater wells (other than using low flow techniques).

At the Troy Mills Landfill Superfund Site, wells which contain little water may be sampled using a stainless steel or Teflon, bottom filling/bottom dispensing bailer. The bailer is equipped with a check with valve at the bottom of the bailer, which allows water to enter from the bottom as the bailer is lowered, and then prevents its release as the bailer is raised. The bailer will be decontaminated prior to use in accordance with Decontamination SOP in the SAP.

This SOP is primarily concerned with the collection of samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of groundwater being sampled. These procedures are designed to be used in conjunction with analyses for the most common types of groundwater contaminants (e.g., volatile and semivolatile organic compounds, and metals).

This sampling procedure does not require that the well be purged prior to sampling. The groundwater sample will be collected without purging, utilizing a “bottom discharge” type bailer. The procedures discussed herein may be varied or changed as required, dependent upon site conditions or equipment limitations.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material commonly used for the collection of groundwater samples:

- Appropriate health and safety gear.
- Informational materials for sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP, monitoring well construction data (e.g., well depth, inner casing diameter, screen interval), location maps, field data from prior sampling events, manuals for sampling, diagrams to show how the equipment is to be set up, and the monitoring instrument’s operation and maintenance manuals, should be brought to the site.
- Site and well keys, spare locks, and bolt cutters.

- Electronic water level meter and/or Oil Water Interface Probe of appropriate lengths (e.g., 100 ft., 200 ft., and 300 ft., and measures in increments of 0.01 feet).
- Clean, portable or dedicated, bottom filling/bottom dispensing bailer of appropriate size and construction material (e.g., stainless steel or Teflon) with a sample dispensing device (e.g., slow dispensing VOC tip).
- Bailing twine made of appropriate material (e.g., nylon).
- Logbook, pencil/pen/sharpeners and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpeners can bleed through pages and smudge, making the documentation hard to read.
- Field-data sheets, sample labels and chain-of-custody records.
- Sample containers and spare containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags and packing materials.
- Clear tape – Place clear tape over sample container labels before sampling in the event the labels are not water proof labels. Alternative - use plastic water proof labels.
- Onsite Tools to include at least: a sharp knife with locking blade, bolt cutters, screwdrivers, pliers, hacksaw, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Plastic sheeting.
- Laboratory grade deionized (DI) water.
- Decontamination equipment and supplies in accordance with the Decontamination SOP in the SAP, including appropriate size buckets and lids for containerization of liquids, if required.
- Flagging/spray paint as needed to demark well locations, if needed.

PRELIMINARY PROCEDURES INCLUDING WATER LEVEL MEASUREMENTS

1. Decontaminate bailer before use and between uses at different wells in accordance with the Decontamination SOP in the SAP.
2. Inspect well for security (e.g., damage, evidence of tampering, missing lock) and record pertinent observations (include photograph as warranted). Note any physical changes to well condition, such as erosion or cracks in protective concrete pad, road box or standpipe. If a lock is found to be damaged, replace with a new lock. Wells shall be locked at all times when not being sampled, to ensure the integrity of the well, any samples collected and the chain of custody.

3. A synoptic water level measurement round should be performed (in the shortest possible time, i.e., all in one day) before any purging and sampling activities begin. Refer to the Water Level Measurement SOP in the SAP. It is recommended that water levels (to 0.01 feet) be measured at least one day prior to well sampling activities, if possible, in order to allow for re-settlement of any particulates that were mixed into the water column by the measuring activity.
4. The depth to the bottom of the monitoring well shall be confirmed in each well included on **Table 4** in the SAP every five years, during the sampling event just prior to the 5-year review, and as required. Refer to **Table 2** in the SAP to determine if depth measurements are required.
5. Lay out sheet of clean polyethylene to place the sampling equipment on.
6. If possible, and when applicable, using non-dedicated equipment (e.g., bailer and water level meter), sample the least contaminated wells first and proceed to those wells that are most contaminated, to prevent cross contamination. If the degree of contamination is unknown, sample the upgradient wells first and the downgradient wells last.

WELL SAMPLING PROCEDURE

1. Carefully lower a water level indicator to the top of groundwater. Measure and record the water level (to 0.01 feet) before any disturbance to the well. Care shall be taken to minimize suspension of any particulates attached to the sides.
2. Using the water level and well construction information included on the attached **Table 4** of the SAP, determine the mid point of the saturated screen (sample location) and record on the worksheet or in the logbook.
3. Attach a pre-cleaned bailer to a dedicated unused line for lowering.
4. Prior to sampling, the bailer shall be rinsed with a small amount of water from the well to be sampled.

Note: In the event that there is an insufficient volume of water in the well to fill all sample bottles, do not rinse the bailer prior to sampling.

To obtain rinse water:

- a. During the rinse procedure the bailer does not need to be fully submerged, nor should it be submerged beyond the sample location calculated in #3 above (middle of the saturated screen).
- b. Slowly lower the bailer, being careful not to drop the bailer into the water, causing turbulence and possible loss of volatile organic compounds (VOCs).
- c. Allow the bailer to fill and then slowly and gently retrieve the bailer from the well avoiding contact with the casing, so as not to knock flakes of rust or other foreign materials into the bailer. When pulling the bailer out, ensure that the line either falls onto a clean area of plastic sheeting or never touches the ground.

- d. Tip bailer enough so that the entire inside of the bailer has been rinsed with groundwater, and pour/dispense out the top.
 - e. Discharge the rinse water collected from the bailer to the ground. The bailer is then considered “rinsed” and is ready to be used for sample collection.
5. To collect a groundwater sample:
- a. Remove the cap from the appropriate sample container and place it on the plastic sheet or in a location where it won't become contaminated.
 - b. Slowly lower and retrieve the bailer as described above.
 - c. Attach the sample dispensing device to the bottom of the bailer.
 - d. Begin slowly discharging the groundwater from the bottom of the bailer, using the dispensing device, into the appropriate sample containers.
 - e. See **Table 2** for specific samples to be collected. The order in which samples should be collected from each well includes:
 - 1) SVOCs (acid/base/neutral extractables), then dissolved acid/base/neutral extractables, as required
 - 2) VOCs (see special notes)
 - 3) Total manganese and other metals, as required (then dissolved metals, as required)
 - 4) 1,4 Dioxane, as required (see special notes for Methods 8260 SIM or EPA EIASOP-VOADIOX4)
 - 5) Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Methods 8260 SIM or EPA EIASOP-VOADIOX4), carbon dioxide, methane, ethane and ethene, refer to the Special Notes section at the end of this SOP.

- f. All sample containers shall be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.
- g. Continue to remove water from the well until sufficient volume has been obtained to fill all sample containers according to the priority order identified above.
- h. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g. SVOC sample, SVOC duplicate sample and/or SVOC MS/MSD sample, VOC sample, VOC duplicate sample).

Duplicate samples are not intended to be blind duplicate samples. They should be designated with a “DUP” after the well designation as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., “Lab MS/MSD”) on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site related MS/MSD samples.

- i. Place samples in re-sealable plastic bags and then into loose ice within the cooler. Metal samples, after acidification to a pH less than 2, do not need to be cooled.
6. If the bailer is dedicated and will remain in the well, it should be suspended as close to the top of the well as possible and above the water column if possible.
7. Replace the well cap and secure the well.
8. Log all samples in the field book and ensure all samples are appropriately labeled.
9. Package samples and complete necessary paperwork.
10. The bailer and water level meter (and all other non-dedicated equipment) must be decontaminated following the Decontamination SOP in the SAP.
11. If an equipment blank is required for the bailer, decontaminate the bailer. Fill the bailer with DI water and rinse the bailer once. Once rinsed, collect an equipment blank sample by filling the bailer with DI water and then slowly discharging the rinsate from the bottom of the bailer using the release device for the bailer. Refill the bailer with DI water as needed to fill all the appropriate containers. Refer to **Table 5** included in the SAP for specific quality control sampling requirements and appropriate chain-of-custody notations required for samples.

RECORDS AND DOCUMENTATION

Refer to the *Chain-of-Custody, Sample Packaging and Shipment Procedures* SOP for documentation requirements.

SPECIAL NOTES

Special Considerations for the Collection of Volatile Organic Compound Samples

Including 1,4-dioxane samples analyzed by Methods 8260 SIM and EPA EIASOP-VOADIOX4.

The proper collection of a sample for volatile organic compound analysis requires minimal disturbance of the sample to limit volatilization and therefore minimize loss of volatiles from the sample. The following VOC procedures shall be followed:

1. Open the vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples (duplicates and MS/MSD samples), collect them immediately following the original sample (e.g., VOC sample, VOC duplicate sample, then VOC MS/MSD sample).
2. Do not rinse the vial or excessively overflow it because it likely contains a specific volume of preservative that must not be diluted.
3. Do not collect the initial 10 ml (approximate) of sample in the discharge tubing, as the beginning of the sample has been in contact with air.
4. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.
5. There should be a convex meniscus on the top of the vial prior to capping the vial. The cap may be used to create the convex meniscus for VOC samples, if needed.

For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. These vials should be filled in the shortest time possible and capped immediately. Do not uncapped these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort shall be made to collect the highest quality (e.g., bubble free) sample possible.

6. Check that the cap has not been contaminated (splashed) and carefully cap the vial.
7. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.
8. Invert the vial and tap gently. If an air bubble appears, uncapped and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.
9. Wipe the vial dry and immediately place the vial in a re-sealable plastic bag and then in loose ice in the cooler.

REFERENCES

Bailer Sampling Procedure included in current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA #13027

ATTACHMENT

Bailer Sampling Worksheet

-Bailer Sampling Worksheet

Bailer Sampling Worksheet

Troy Mills Landfill Superfund Site, Troy, New Hampshire

Sampler Name

Date:

	Well ID	
Measuring Point (Top of PVC/Inner Casing, Top of Casing)		
PVC/Inner Well Casing Inside Diameter (inches)		
Well Depth (from top of measuring point, feet, to 0.01')		
Static Water Level (from top of measuring point, feet, to 0.01')		
Water Column Length = Well Depth Minus Depth to Water Level (feet to 0.01')		
Midpoint of Saturated Screen = Sample Location (feet to 0.01')		
Sample Collection Time (24 hour time)		
Lab Analyses Collected:		
Quality Control Samples:		

Notes:

[illegible]

Sampler Signature

SOP B-8
Leachate Sampling Procedure

LEACHATE SAMPLING PROCEDURE

PURPOSE

This Standard Operating Procedure (SOP) *Leachate Sampling Procedure* is to obtain leachate samples for analyses that are representative of environmental conditions at the location sampled at the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

EQUIPMENT AND MATERIALS

- Appropriate health and safety gear.
- Informational materials for sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP, location map(s), field data from prior sampling events, manuals for sampling, and the monitoring instrument's operation and maintenance manuals, should be brought to the site.
- Waders as needed.
- New wide-mouth glass sample containers (jars) for each sampling location, plus extra, to use as intermediary containers to fill pre-preserved sampling containers; pre-cleaned by laboratory.
- Pole and strapping, as necessary, to collect samples from locations with limited access.
- Logbook, pencil/pen/sharpies and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.
- Field data sheets, sample labels and chain of custody forms.
- Sample containers and spare containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags and packing materials.
- Polyethylene sheeting.
- Onsite Tools to include at least: a sharp knife with locking blade, bolt cutters, screwdrivers, pliers, 25' measuring tape, hacksaw, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Digital camera.

PROCEDURE

Field sampling of leachate will include the collection of leachate samples from the discharge area of the culvert west of the site access road (TRY_SW-LEACHATE) and at the discharge area immediately upgradient of the old beaver dam (TRY_SW-LEACH-B), as illustrated on **Figure 1** included in the SAP. In addition, should flow be observed on the east (uphill) side of the access road at the entrance of the culvert, a second leachate sample will be collected (TRY_SW-LEACH-A). The leachate sampling locations are permanently marked in the field so that sampling points are consistent for each round.

These areas continue to be the only ongoing leachate seeps observed since 2006. Should additional seeps be identified in the future, GZA will consult with NHDES and EPA as to whether or not they should be incorporated into the sampling program.

The following methodology will be utilized to collect leachate samples where minimum sample agitation is required and the sampling depth is typically 1 foot or less:

1. Digital photographs shall be taken at each sampling location from the same position(s). Consistency should be maintained between sampling rounds. Note in log book the photo number and directional information for each photo.
2. Prepare sampling equipment and bottles on a clean sheet of polyethylene near the sample location.
3. For the TRY_SW-LEACHATE sample, the sample should be collected from the shore inside the boom for safety. If no safe access is available, attach the sample collection container to a pole with strapping or tape and collect the samples.
4. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
5. Clear surface floc on the leachate location to allow collection of a sample with minimal floc.
6. Use extreme care in lowering the container into the water being careful not to disturb sediments or floc. Using the sample container, fill the sample containers based on the following priority order:
 - a. SVOCs (acid/base/neutral extractables)
 - b. VOCs (see special notes)
 - c. Total manganese, hardness, and other metals as required (then dissolved metals, as required)
 - d. Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Methods 8260 SIM or EPA EIASOP-VOADIOX4), carbon dioxide, methane, ethane and ethene, refer to the Special Notes section at the end of this SOP.

7. All sample containers shall be filled by allowing the discharge to flow gently down the inside of the container with minimal turbulence. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry.
8. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g. SVOC sample, SVOC duplicate sample and/or SVOC MS/MSD sample, VOC sample, VOC duplicate sample).

Duplicate samples are not intended to be blind duplicate samples. They should be designated with a "DUP" after the well designation as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., "Lab MS/MSD") on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site related MS/MSD samples.

9. Place samples in re-sealable plastic bags and then into loose ice within the cooler. Metal samples, after acidification to a pH less than 2, do not need to be cooled.

SPECIAL NOTES

Special Considerations for the Collection of Volatile Organic Compound Samples

Including 1,4-dioxane samples analyzed by Methods 8260 SIM and EPA EIASOP-VOADIOX4.

The proper collection of a sample for volatile organic compound analysis requires minimal disturbance of the sample to limit volatilization and therefore minimize loss of volatiles from the sample. The following VOC procedures shall be followed:

1. Open the vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples (duplicates and MS/MSD samples), collect them immediately following the original sample (e.g., VOC sample, VOC duplicate sample, then VOC MS/MSD sample).
2. Do not rinse the vial or excessively overflow it because it likely contains a specific volume of preservative that must not be diluted.
3. Do not collect the initial 10 ml (approximate) of sample in the discharge tubing, as the beginning of the sample has been in contact with air.

4. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.
5. There should be a convex meniscus on the top of the vial prior to capping the vial. The cap may be used to create the convex meniscus for VOC samples, if needed.

For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. These vials should be filled in the shortest time possible and capped immediately. Do not uncap these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort shall be made to collect the highest quality (e.g., bubble free) sample possible.

6. Check that the cap has not been contaminated (splashed) and carefully cap the vial.
7. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.
8. Invert the vial and tap gently. If an air bubble appears, uncap and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.
9. Wipe the vial dry and immediately place the vial in a re-sealable plastic bag and then in loose ice in the cooler.

RECORDS AND DOCUMENTATION

All data and sampling information will be recorded as specified in the Sampling and Analysis Plan.

SOP B-9
Surface Water & Stream Sediment Sampling Procedure

SURFACE WATER AND STREAM SEDIMENT SAMPLING PROCEDURE

The purpose of this standard operating procedure (SOP) *Surface Water and Stream Sediment Sampling Procedure* is to obtain surface water and sediment samples for analyses that are representative of environmental conditions at the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

The collection of these samples using the following sampling procedures will be carried out at the locations identified in **Table 2** and on **Figure 1** in the SAP. Refer to **Table 3** in the SAP for specific information on containers, preservatives and hold times.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

It is assumed that sampling can be conducted either from the shore, by a sampler standing in the water wearing boots/waders or from a small boat/inflatable raft.

SAFETY

This sampling procedure requires two field personnel.

It is assumed that sampling can be conducted either from the shore, by a sampler standing in the water wearing boots or waders or from a small boat/inflatable raft.

If a sample cannot be obtained safely, the sample should not be taken at all and the conditions documented in the sampler's field book. Potential dangers include, but are not limited to: strong water currents, uneven terrain, slippery substrate, roots, thick brush, or sharp objects beneath the water's surface that may cause a fall or other personal injury. All necessary precautionary measures should be heeded when performing these sampling techniques.

GENERAL INFORMATION

1. Each of the regular sampling locations is permanently marked in the field so that sampling points are consistent for each round. All surface water and sediment samples shall be located using a global positioning system (GPS) unit.
2. When both surface water and sediment samples are to be collected at the same location, the surface water samples are collected first, then the sediment samples.
3. A surface water depth measurement shall be collected from the permanently mounted stream gage located midstream, just downstream of the SW-4 location, to track changes in the water levels along the stream.
4. Digital photographs shall be taken at each sampling location, upstream and downstream from the same position. Consistency should be maintained between sampling rounds.

5. Surface water and sediment sampling will occur congruent to the groundwater sampling event, unless otherwise specified. Based on weather reports, the sampling team will select the driest period during the Site sampling events to collect the samples, unless otherwise directed by the project manager.
6. Additional information to be recorded on the Surface Water Sediment Worksheet includes the following:
 - Past 7 days of local meteorological data showing a minimum of daily precipitation totals and barometric pressure
 - General physical description of the samples and sampling locations
 - Descriptions/ID's of digital photographs

PART I – SURFACE WATER

PURPOSE

The purpose is to obtain surface water samples for analyses that are representative of the current environmental conditions.

EQUIPMENT AND MATERIALS

- Appropriate health and safety gear.
- Informational materials for sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP, location maps, field data from prior sampling events, manuals for sampling, diagrams to show how the equipment should be set up (as appropriate), and the monitoring instrument's operation and maintenance manuals for the instruments and equipment, should be brought to the site.
- Waders.
- Pre-decontaminated glass jar or stainless-steel container to use as an intermediary container to fill pre-preserved sample containers. Include a minimum of one spare if using glass.
- Pole and strapping, as necessary, to collect samples from locations with limited access.
- Sample containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags to protect and store samples.
- A multiparameter meter (e.g., YSI 600XL/XLM or In-Situ smarTROLL™ Multiparameter meter, referred to as the Smartroll in this document) with a built in barometer, a transparent 250 ml or less flow-through cell and a ring stand, capable of measuring pH (units); oxidation reduction potential (ORP), mV; dissolved oxygen (DO), milligrams per liter (mg/l), 100% saturation for calibration; specific conductance, $\mu\text{S}/\text{cm}$;

and temperature, degrees Celsius (°C); the same make and model as used for the site groundwater sampling.

- A tablet that has been prepared for site use according to the In-Situ Smartroll Equipment Set Up & Use SOP in the HWRB Master QAPP, if using the Smartroll multiparameter meter.
- Appropriate calibration solutions for the multiparameter meter, if water quality parameters are collected, including: a small wet sponge or paper towel for DO 100% saturation calibration, “Zero” (0) mg/L DO check standard; Zobell Solution for ORP; two different specific conductance standards, one standard is used to calibrate and the other standard is used to check the calibration (e.g., 718 $\mu\text{S}/\text{cm}$ and 1,413 $\mu\text{S}/\text{cm}$); 4, 7, & 10 units pH buffering solution; and extra DO membranes for the YSI or RDO caps for the Smartroll, in case of breakage..
- A probe guard for the multiparameter meter to take in-situ parameter readings.
- A Turbidity Meter (e.g., Hach 2100P or 2100Q); the same make and model as used for groundwater sampling, if applicable.
- Calibration solutions for the Hach Turbidity meter: <0.1, 10, 20, 100, 800 Nephelometric Turbidity Units (NTUs) standards as appropriate for the selected meter.
- Field-data sheets, sample labels and chain-of-custody forms.
- Logbook, pencil/pen/sharpies, calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.
- Laboratory grade deionized (DI) water.
- Paper towels.
- Onsite Tools to include at least: a sharp knife with locking blade, bolt cutters, screwdrivers, pliers, 25’ measuring tape, hacksaw, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Camera to take digital pictures.

PRELIMINARY PROCEDURES

1. Each of the regular sampling locations is permanently marked in the field so that sampling points are consistent for each round. All surface water samples shall be located using a global positioning system (GPS) unit.
2. In general, all instrumentation necessary for field monitoring and health and safety purposes shall be maintained, tested, and inspected according to the manufacturer's instructions. The manufacturer's instruction manuals for field equipment shall be kept on-site with the equipment.

3. All instruments will be successfully calibrated once by the sampling team prior to the sampling event. Instruments will be calibrated and checked according to the Calibration SOP in the SAP.
4. An initial brook stage measurement (height of water column in the brook from a permanent location at TRY_SW-4) shall be collected from the permanently mounted stream gage located midstream, just downstream of the SW-4 location during the synoptic water level worksheet (refer to SOP B-1). Transfer the data from the Water Level Measurement Worksheet to Surface Water Worksheet.

Two additional brook stage measurements at TRY_SW-4 stream gage station shall be collected including: (1) just prior to the sampling the TRY_MW-104 cluster well, and (2) just prior to the sampling of surface water at TRY_SW-4. The stage measurement should be taken to the nearest one one-hundredth of a foot. Record this information on the attached Surface Water Worksheet. If significant changes in flow conditions are observed by the field team, discuss with the Senior Project Manager if surface water sampling should be completed.

SAMPLING PROCEDURE

Each of the regular sampling locations are permanently marked in the field so that sampling points are consistent for each round. The following procedures shall be used to collect a surface water sample from each location:

1. Prepare sampling equipment and bottles on shore.
2. Laboratory samples are collected first, followed by in-situ field screening parameters using the multi-parameter meter and turbidity using the Hach turbidity meter. If there is a co-located sediment location (TRY_SW-3 and TRY_SED-3), surface water samples are collected first, then in-situ field screening parameters, followed lastly by the sediment sample (Part II below).
3. Sampling occurs sequentially from downstream (TRY_SW-100) to upstream (TRY_SW-1). Each sampling location is entered from the downgradient side. Sampling locations are identified on **Table 2** in the SAP.
4. Sample Collection
 - a. Surface water will be collected using the dipping technique, using a clean wide-mouth glass bottle (without preservatives) attached to a pole with strapping or tape, if necessary. **Note:** Due to ground conditions around TRY_SW-1 and TRY_SW-4 at various times of the year, samples may be collected from either side of the stream. Sample from whichever side has appropriate flow and can be accessed most safely. A new dedicated, glass (laboratory pre-cleaned), wide-mouth sampling container will be used at each sample location.

- b. Rinse the sample container downstream of the sampling location once. While facing upstream, collect the sample by slowly lowering the jar one to two inches below the surface of the water. Make sure that the sample is free of floating debris and/or surface skim. Refer to **Table 2** in the SAP for specific analysis.
- c. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
- d. Surface water will be transferred to the appropriate containers by gently pouring water down the inside of the container with minimal turbulence, in the following order:
 - 1) SVOCs (acid/base/neutral extractables)
 - 2) VOCs (see special notes)
 - 3) Total manganese, hardness, and other metals as required
 - 4) 1,4-Dioxane, as required (see special notes for Methods 8260 SIM or EPA EIASOP-VOADIOX4)
 - 5) Other parameters, as required

For collection of VOC samples, including 1,4-dioxane (for analytical Methods 8260 SIM or EPA EIASOP-VOADIOX4), carbon dioxide, methane, ethane and ethene, refer to the Special Notes section at the end of this SOP.

- e. Cap sample containers securely after filling each bottle. Sample containers must be wiped dry. Make sure that all sample containers are properly labeled.
- f. Field duplicate and matrix spike/matrix spike duplicate (MS/MSD) samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., SVOC sample, SVOC duplicate sample and/or SVOC MS/MSD sample, VOC sample, VOC duplicate sample). Duplicate samples are not intended to be blind duplicate samples. They should be designated with a "DUP" after the well designation as indicated in the SAP. Refer to **Table 5** in the SAP for specific QA sampling requirements.

In general, most MS/MSD samples will be requested by the laboratory as part of their QA requirements. If that is the case, add a note to the comment section on the chain-of-custody (e.g., "Lab MS/MSD") on the same line used for the regular samples at that location. The number of sample containers will also change to accommodate the extra bottle for the MS/MSD sample. MS/MSD samples should not be on a separate line on the chain-of-custody. Refer to the Chain of Custody SOP in the SAP for information on collected Site related MS/MSD samples.

- g. Place samples in re-sealable plastic bags and then in loose ice within the cooler. Metal samples, after acidification to a pH less than 2, do not need to be cooled.
5. Record sample information (e.g., sample ID, location, time, comments) on the attached surface water sample sheets.

6. Collection of Field Parameters

- a. With the probe guard on the multiparameter meter, rinse the probes in the brook downstream of the sampling location.
- b. Immerse the probes into the water, immediately upstream of any disturbance caused by accessing the sample location, making sure it is deep enough to cover the probes and probe guard. It is important that there are no air bubbles on/in the electrode. To dislodge any bubbles, gently move the electrode through the water before recording the measurement. If the sample location is not accessible, a pole and strapping may be used to hold the probes in place for stabilization and readings.
- c. Allow a minimum of two minutes for the readings to stabilize.
- d. Once the readings have stabilized, record the pH, specific conductivity ($\mu\text{S}/\text{cm}$), temperature ($^{\circ}\text{C}$), ORP (millivolts) and DO (mg/l) on the worksheet.
- e. Rinse out a turbidity vial downstream of the sampling location.
- f. Collect an aliquot of water for the Hach and analyze the sample for turbidity. Record the NTU value on the surface water sampling sheet.

Condensation (fogging) of Turbidity Vial: Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly at ambient temperature or immerse the sample cell in a container of ambient temperature water for a short period. After warming, wipe the sample cell dry and gently invert the sample cell to thoroughly mix the contents before measurement.

7. Take digital photographs at each location upstream and downstream unless collecting sediment samples, in which case the photographs would be taken after the sediment samples have been collected.

SPECIAL NOTES

Special Considerations for the Collection of Volatile Organic Compound Samples

Including 1,4-dioxane samples analyzed by Methods 8260 SIM and EPA EIASOP-VOADIOX4.

The proper collection of a sample for volatile organic compound analysis requires minimal disturbance of the sample to limit volatilization and therefore minimize loss of volatiles from the sample. The following VOC procedures shall be followed:

1. Open the vial, set cap in a protected place, and collect the sample by allowing the water to flow gently down the inside wall of the container with minimal turbulence. When collecting quality control samples (duplicates and MS/MSD samples), collect them immediately following the original sample (e.g., VOC sample, VOC duplicate sample, then VOC MS/MSD sample).

2. Do not rinse the vial or excessively overflow it because it likely contains a specific volume of preservative that must not be diluted.
3. Do not collect the initial 10 ml (approximate) of sample in the discharge tubing, as the beginning of the sample has been in contact with air.
4. Be sure the sample flow is laminar and there are no air bubbles in the sample flow.
5. There should be a convex meniscus on the top of the vial prior to capping the vial. The cap may be used to create the convex meniscus for VOC samples, if needed.

For methane/ethane/ethene and carbon dioxide, the laboratory typically requests that the sample bottle cap is not used to top off the sample vials. These vials should be filled in the shortest time possible and capped immediately. Do not uncapped these vials and add more water. Small bubbles are considered normal for these pre-preserved containers; however, every effort shall be made to collect the highest quality (e.g., bubble free) sample possible.

6. Check that the cap has not been contaminated (splashed) and carefully cap the vial.
7. Place the cap directly over the top and screw down firmly. Do not over-tighten and break the cap.
8. Invert the vial and tap gently. If an air bubble appears, uncapped and attempt to add a small volume of sample to achieve the convex meniscus without excessively overfilling the vial. If this has to be repeated more than twice, discard the sample and begin again with a new container and preservative. It is imperative that no entrapped air is in the sample vial.
9. Wipe the vial dry and immediately place the vial in a re-sealable plastic bag and then in loose ice in the cooler.

PART II – STREAM SEDIMENT SAMPLES

PURPOSE

To obtain sediment samples underlying water bodies to describe the physical characteristics and to investigate contamination in the sediments.

If a sediment sample is to be collected at the same location as a surface water sample, the sediment sample should be collected after collection of the surface water sample.

In general, sediment samples will be collected from the designated location to a depth of approximately 2 to 4 inches. Sediment samples, in shallow water, may be collected with stainless steel scoops, bowls, spoons, hand augers, or coring tubes that are hand held or attached to a coring tool. In deeper waters a Ponar dredge should be used, unless otherwise specified. All non-dedicated sampling equipment shall be decontaminated prior to use and between samples.

NOTE: The collection of samples for volatile organic compound (VOC) analysis shall follow the guidelines written for soils in the New Hampshire Department of Environmental Services (NHDES) “Final Policy Preservation of VOCs in Soil Samples” dated March 2000 included in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP).

MATERIALS AND EQUIPMENT

- Appropriate health and safety gear.
- Informational materials for sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP, location maps, field data from prior sampling events, manuals for sampling, diagrams to show how the equipment should be set up (as appropriate), and the monitoring instrument's operation and maintenance manuals, should be brought to the site.
- Waders.
- A small boat/inflatable raft may be necessary to reach the sediment sampling location if the water level is very high in the stream.
- Sample containers and spare containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags and packing materials.
- Cut off disposable syringes (along with a stainless spoon if necessary), to collect the VOC samples.
- Disposable syringes, for siphoning surface water off top of sediment sample.
- Pre-decontaminated Petite (6 inches by 6 inches) Ponar Dredge, if required.
- A tripod stand to hold the Ponar dredge while excess water is being removed, if the Ponar dredge is used.
- Two (2) foot PVC corers, marked at 4-inch depth, and spares, as required.
- Sharp knife to cut the PVC corer to collect the VOC sample, as required.
- Hand augers, as appropriate.
- Stainless steel hand tools or utensils (spoons, spatulas, scoops).
- Stainless steel mixing bowls/spoons.
- Stream staff/gage or similar measuring device.
- Logbook, pencil/pen/sharpies and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.

- Laboratory grade deionized (DI) water.
- Paper towels.
- Onsite Tools to include at least: a sharp knife with locking blade (or a tubing cutter, or other safe means of cutting tubing to desired length), bolt cutters, screwdrivers, pliers, 25' measuring tape, hacksaw, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Decontamination supplies as described in the Decontamination SOP included in the SAP.
- Digital camera

GENERAL SEDIMENT SAMPLE COLLECTION PROCEDURE

The following procedure is applicable for surface sediment sample collection.

1. Using a stream staff/gage or similar measuring device, measure the depth of water from the bottom of the streambed to the surface of the water in feet, directly downstream of the sampling location in order not to disturb the sediment where the sample is collected. Record the measurement on the Sediment Sampling Worksheet.
2. If possible, carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location, taking care not to greatly disturb fine sediments.
3. Using a stainless-steel scoop, dredge, or other sampling device, slowly scoop or otherwise collect and retrieve the surface sediment from the bottom of the upstream location.
4. Remove any leaves, twigs, rocks or other gross debris that may have been collected.
5. Collect VOC samples directly from the sampling device according to the **NHDES "Final Policy Preservation of VOCs in Soil Samples" dated March 2000**. Using the disposable syringe, the proper volume of sediment is added to the methanol preserved volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. A separate container for dry weight calculation is not required as long as an unpreserved container is being collected for some other parameter. If collecting VOCS only, an additional unpreserved sample must be collected to allow for a determination of moisture.

Using the syringe method to extract the VOC sample assumes that the water content does not prevent sample collection. If the water content and/or sediment characteristics are such that a sample can't be obtained using a syringe, a stainless-steel spoon will be used to transfer sediment from the sampling device to the VOC sample vial.

6. Transfer the remaining sediment to a pre-decontaminated stainless-steel mixing bowl. Continue to collect additional sediment from areas adjacent to the original sample location to ensure staying within the required depth. Continue this procedure until the appropriate volume of sediment is obtained, and carefully decant excess liquid from the bowl.
7. When collecting duplicates, collect enough sample material in the stainless-steel mixing bowl for both the sample and the duplicate.

8. Thoroughly mix sediment to obtain a homogeneous sample by quartering the sample, mixing each quarter and mixing all quarters together as described under sample mixing at the end of this document.
9. Record a general physical description of the sample such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. on the Sediment Sampling Worksheet.
10. Following VOCs sample collection, the sample containers should be filled in the following priority order:
 - SVOCs (acid/base/neutral extractables) and percent solids
 - Total metals
 - Total Organic Carbon
 - Grain Size
11. Fill and cap the sampling containers and clean the exteriors of the containers to remove any potential residue. Place samples in re-sealable bags. VOC and other samples requiring cooling shall be placed within **loose** ice in a cooler.
12. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., SVOC sample, SVOC duplicate sample; metals sample, metals duplicate sample). **Note** that the VOC sample and duplicate shall be collected directly from the dredge, prior to sample mixing. Duplicate samples are not intended to be blind duplicate samples. They should be designated with a “DUP” after the well designation as indicated in the SAP (e.g., TRY_SED-3 DUP). Refer to **Table 5** in the SAP for specific quality control (QC) sampling requirements.
13. If not previously done, use a GPS unit to permanently mark the sample location for future reference. In addition, use flagging to visually mark the location if possible.
14. Take digital photographs at each sampling location, upstream and downstream from the same position so that consistency can be maintained between sampling rounds.
15. Decontaminate the equipment according to the Decontamination SOP in the SAP.
16. Equipment blanks are required for sediment sampling equipment. Following sample collection and after equipment decontamination, gently pour DI water over the equipment used to collect the sediment samples (e.g., Ponar dredge, stainless steel tools, bowl, and mixing spoon). Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to **Table 5** in the SAP for specific QC sampling requirements and analysis.

PONAR DREDGE PROCEDURE FOR COLLECTING SURFACE SEDIMENT

Due to high water levels in the stream, it may be necessary to use a small boat/inflatable raft (craft) to collect the sediment sample. In this case the craft would be positioned in the safest

location to collect the sample, preferably with one person securing the craft against the shore while the other person slowly lowers the Ponar dredge into the water from the other end of the craft to collect the sample as described below.

1. Pre-decontaminate the Ponar dredge in accordance with the Decontamination SOP in the SAP.
2. Set up the tripod to hold the dredge once is full.
3. Attach a dedicated nylon rope to the hook provided on top of the dredge.
4. Arrange the Ponar dredge sampler in the open position, setting the trip bar so the sampler remains open when lifted from the top.
5. Carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location, taking care not to greatly disturb fine sediments.
6. Slowly lower the sampler to a point just above the sediment (about 2 inches)
7. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the trip bar and closing the dredge.
8. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. Be careful to retain fine sediments.
9. Suspend the dredge on the tripod.
10. Open the dredge and using a syringe, siphon off, to the extent possible while minimizing the disturbance of any fines, any existing standing water in the Ponar dredge.
11. Collect VOC samples directly from the sampling device (using the methanol preserved VOA vials and disposable syringe) according to the **NHDES “Final Policy Preservation of VOCs in Soil Samples” dated March 2000**. Using the disposable syringe, the proper volume of sediment is added to the methanol preserved volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. A separate dry weight sample will not be necessary as long as the dry weight analysis is added to the analysis for the SVOC container.

Using the syringe method to extract the VOC sample assumes that the water content does not prevent sample collection. If the water content and/or sediment characteristics are such that a sample can't be obtained using a syringe, a stainless-steel spoon will be used to transfer sediment from the Ponar dredge to the VOC sample vial.

12. Transfer the remaining sediment to a pre-decontaminated stainless-steel mixing bowl. Continue to collect additional sediment from areas adjacent to the original sample location until sufficient material has been gained to fill the remaining sample containers in the priority listed below. When collecting duplicates, collect enough sample material in the stainless-steel mixing bowl for both the sample and the duplicate.
13. Thoroughly mix sediment to obtain a homogeneous sample by quartering the sample, mixing each quarter and mixing all quarters together as described under sample mixing at the end of this document and then transfer to the appropriate sample containers.

14. Following VOCs sample collection, the sample containers should be filled in the following priority order:
 - SVOCs (acid/base/neutral extractables) and percent solids
 - Total metals
 - Total Organic Carbon
 - Grain Size
15. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., SVOC sample, SVOC duplicate sample; metals sample, metals duplicate sample). Note that the VOC sample and duplicate shall be collected directly from the dredge, prior to sample mixing. Duplicate samples are not intended to be blind duplicate samples. They should be designated with a “DUP” after the well designation as indicated in the SAP (e.g., TRY_SED-3 DUP). Refer to **Table 5** in the SAP for specific quality control (QC) sampling requirements.
16. Once samples are collected, digital photographs shall be taken at each sampling location, upstream and downstream.
17. Decontaminate any non-dedicated equipment between each sampling location in accordance with the Decontamination SOP in the SAP.
18. Equipment blanks are required for sediment sampling equipment. Following sample collection and after equipment decontamination, gently pour DI water over the equipment used to collect the sediment samples (e.g., Ponar dredge, stainless steel tools, bowl, and mixing spoon). Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to **Table 5** in the SAP for specific QC sampling requirements and analysis.

SAMPLE COLLECTION PROCEDURE USING A PVC CORE

1. Pre-decontaminate the coring device according to the Decontamination SOP in the SAP.
2. If possible, carefully clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the sampling location, taking care not to greatly disturb fine sediments.
3. Rinse the pre-decontaminated core in the surface water downstream of the sampling location three times.
4. Advance the coring device into the sediment to a marked depth of no more than 4 inches. A gentle rotation of the coring tube may aid penetration. The final sample should consist of the top 4 inches of sediment.
5. Cap the top of the tube to provide a vacuum for sample retention during retrieval.
6. Pull the sampler from the sediment and quickly cap the bottom to secure the sample.
7. Holding the bottom securely, remove the top cap and slowly and carefully decant excess water from the surface of the sample.

8. Place the core over the stainless-steel bowl.
9. Carefully cut the tube and collect VOC samples directly from the sampling device (using the methanol preserved VOA vials and disposable syringe) according to the **NHDES “Final Policy Preservation of VOCs in Soil Samples” dated March 2000**. Using the disposable syringe, the proper volume of sediment is added to the methanol preserved volatile organic analysis (VOA) vial until the volume in the VOA vial reaches the pre-marked line established by the laboratory. A separate dry weight sample will not be necessary as long as the dry weight analysis is added to the analysis for the SVOC container.

Using the syringe method to extract the VOC sample assumes that the water content does not prevent sample collection. If the water content and/or sediment characteristics are such that a sample can't be obtained using a syringe, a stainless-steel spoon will be used to transfer sediment from the sampling device to the VOC sample vial.

10. Place the remaining sample into the bowl. If more sediment is needed, collect additional sediment next to the original sampling location to ensure staying within the required depth. Continue this procedure until the appropriate volume of sediment is obtained. When collecting duplicates, collect enough sample material in the stainless-steel mixing bowl for both the sample and the duplicate.
11. Gently decant any supernatant.
12. Remove any leaves, twigs, rocks or other gross debris that may have been collected.
13. Thoroughly mix sediment to obtain a homogeneous sample by quartering the sample, mixing each quarter and mixing all quarters together as described under sample mixing at the end of this document.

Record a general physical description of the sample such as color; basic makeup (sand, silt or clay); whether or not there is a high degree of organic material or high water content, etc. on the Sediment Sampling Worksheet.

14. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated.
15. Following VOCs sample collection, the sample containers should be filled in the following priority order:
 - SVOCs (acid/base/neutral extractables) and percent solids
 - Total metals
 - Total Organic Carbon
 - Grain Size
16. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., SVOC sample, SVOC duplicate sample; metals sample, metals duplicate sample). Note that the VOC sample shall be collected directly from the device, prior to sample mixing. Duplicate samples are not intended to be blind duplicate samples. They should be designated with a

“DUP” after the well designation as indicated in the SAP (e.g., TRY_SED-3 DUP). Refer to **Table 5** in the SAP for specific quality control (QC) sampling requirements.

17. Once samples are collected, digital photographs shall be taken at each sampling location, upstream and downstream.
18. Decontaminate any non-dedicated equipment between each sampling location in accordance with the Decontamination SOP in the SAP.
19. Equipment blanks are required for sediment sampling equipment. Following sample collection and after equipment decontamination, gently pour DI water over the equipment used to collect the sediment samples (e.g., stainless steel tools, bowl, and mixing spoon). Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to **Table 5** in the SAP for specific QC sampling requirements and analysis.

SAMPLE MIXING

With the exception of VOC samples, it is important that the sediment samples be mixed as thoroughly as possible to ensure that the sample is representative of the sample interval. A common method of mixing is referred to as quartering. The sediment in the pre-decontaminated sample pan is divided into quarters. Each quarter is mixed, and then all quarters are mixed into the center of the pan. This procedure is followed several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion and occasionally turning the material.

Note: If samples are predominantly moist and clayey, extra effort may be necessary to produce a homogeneous mixture.

QUALITY ASSURANCE

Refer to **Table 5** in the SAP for specific QC sampling requirements and analysis.

At least one duplicate sample should be collected. Collect enough sample material in the stainless-steel mixing bowl for both the sample and the duplicate. Thoroughly mix the sediment to obtain a homogeneous sample, remove any leaves, twigs, rocks or other gross debris that may have been collected and fill a separate container for each analysis immediately following the actual field sample collection. Cap the containers for both the sample and duplicate sample. Note that the VOC sample and duplicate shall be collected directly from the sampling device, prior to sample mixing.

Equipment blanks are collected to ensure that the equipment is clean and the decontamination procedure is adequate.

To collect an equipment blank after decontamination: Gently pour DI water over the equipment (e.g., Ponar dredge or other sampling device, stainless steel bowl, and mixing spoon) used to collect the sediment sample. Collect the rinsate that flows off the equipment into the appropriate sample containers.

RECORDS AND DOCUMENTATION

All data and sampling information will be recorded as specified in the SAP.

REFERENCES

Surface Water and Sediment Sampling SOPs in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA #13027

“Preservation of VOCs in Soil Samples”, included in the current HWRB Master QAPP, EPA RFA#13027

ATTACHMENTS

Surface Water Sediment Worksheet

-Surface Water Sediment Worksheet

Surface Water / Sediment Worksheet
Troy Mills Landfill Superfund Site, Troy, New Hampshire

Date:

Time:

Field Personnel:

WEATHER CONDITIONS									
CURRENT		Weather Station Location Used For Historical data:							
Barometric Pressure (in mm/hg)		PAST 7 DAYS							
Storm (heavy rain): circle one	Yes or No	Date							
Rain (Steady Rain): circle one	Yes or No	Barometric Pressure (in mm/hg)							
Intermittent Showers: circle one	Yes or No	Estimated Rainfall (in)							
Cloud Cover (%)		Comments							
Clear/Sunny: circle one	Yes or No								
Comments									
STREAM / SAMPLING LOCATION CHARACTERIZATION									
Provide physical description of sampling locations at the time of sampling. Provide a physical description of sediment samples if collected.	Sample Location: _____								

	Photograph #, date & time _____								
	Sample Location: _____								

	Photograph #, date & time _____								
	Sample Location: _____								

	Photograph #, date & time _____								
	Sample Location: _____								

	Photograph #, date & time _____								
IN SITU SURFACE WATER QUALITY DATA									
Minimum 2 minute parameter stabilization period met (Y/N)?									
Sample Location ID	Temperature (°C)	Specific Conductivity (µS/cm)	pH units	ORP/Eh (mV)	DO (mg/L)	Turbidity (NTU)	Sample Time	Comments	
TRY_SW-1									
TRY_SW-3									
TRY_SW-4									
TRY_SW-4 STREAM-STAGE MEASUREMENT (FT)									
Initial Synoptic Stream-Stage (from Water Level Measurement Form)	Date:		Depth of Water (ft):			Comments:			
Stream-stage when sampling TRY_MW-104S/D cluster	Date:		Depth of Water (ft):			Comments:			
Stream-stage when sampling surface water TRY_SW-4	Date:		Depth of Water (ft):			Comments:			

Notes: 1. Surface Water Quality Parameters are collected using the multiparameter meter and Hach 2100P/2100Q units. Both units are calibrated in accordance with the calibration SOP in the SAP.

SOP B-10
Wetland Soil Sampling Procedure

WETLAND SOIL SAMPLING PROCEDURE

PURPOSE

The purpose of this standard operating procedure (SOP) *Wetland Soil Sampling Procedure* is to surface soil samples for analyses to determine the physical characteristics of the material or levels of contamination in near-saturated or saturated wetland soils at the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

The collection of these samples using the following sampling procedures will be carried out at the locations identified in **Table 2** and on **Figure 1** in the SAP. Refer to **Table 3** in the SAP for specific information on containers, preservatives and hold times.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

EQUIPMENT AND MATERIALS

- Appropriate health and safety gear.
- Informational materials for sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, HWRB Master QAPP, location map(s), field data from prior sampling events, manuals for sampling, diagram(s) to show how the equipment should be set up (as appropriate), and the monitoring instrument's operation and maintenance manuals, shall be brought to the site.
- Sample containers and spare containers, preserved as necessary, provided by the laboratory.
- Loose ice and a sample cooler/shipping container.
- Re-sealable plastic bags and packing materials.
- T-handle auger.
- Stainless bowl(s).
- Stainless steel trowel.
- Stainless steel shovel.
- Disposable syringes.
- Field data sheets, sample labels and chain of custody forms.
- Logbook, pencil/pen/sharpies and a calculator. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.

- Laboratory grade deionized (DI) water.
- Paper towels.
- Decontamination supplies as described in the Decontamination SOP included in the SAP.
- Onsite Tools to include at least: sharp knife (locking blade), bolt cutters, screwdrivers, pliers, 25' measuring tape hacksaw, duct tape, hammer, flashlight, adjustable wrench and a socket set.
- Digital camera.

PROCEDURES

This methodology will be utilized to collect surface / shallow soil samples at designated wetland soil locations to a maximum depth of 6-inches deep. Refer to **Table 2** in the SAP for specific sample locations and analysis. The sample locations are in areas where the soils are saturated but there is no standing water above the soil and are permanently marked in the field so that sampling points are consistent for each round. Areas where there is a dense pine mat will be avoided.

The following procedures shall be used to collect a wetland soil sample:

1. Clear away all surface debris (leaves, twigs, etc.) for a 1-foot radius around the planned sampling location.

Note that the physical sample location should be located within a five-foot radius of the permanently marked sample location. This will allow the field sampler flexibility in case debris, ponded water, or other condition exists at the permanent sample marker.

If there is standing water, refer to the notes below.
2. Using a pre-decontaminated auger, auger a hole to the desired sampling depth of 6 inches. Carefully withdraw the auger to prevent cave-in of the borehole sidewalls. A pre-decontaminated stainless-steel shovel may also be used when appropriate.
3. Transfer soil to a pre-decontaminated stainless-steel mixing bowl. Continue to collect additional soil until sufficient material has been gained to fill the remaining sample containers. If additional soil is needed, collect the additional soil from a location next to the original sampling location so the soil at the desired depth of 6 inches can be collected. Thoroughly mix soil to obtain a homogeneous sample, and then transfer to the appropriate sample containers using a pre-decontaminated steel soil trowel.
4. The sample containers should be filled in the following priority order:
 - SVOCs (acid/base/neutral extractables) and percent solids
 - Total metals
 - Total Organic Carbon

5. Field duplicate samples should be collected by filling a separate container for each analysis immediately following the actual field sample collection (e.g., SVOC sample, SVOC duplicate sample; metals sample, metals duplicate sample). Duplicate samples are not intended to be blind duplicate samples. They should be designated with a “DUP” after the sample designation (e.g., TRY_WES-01 DUP) as indicated in the SAP. Refer to **Table 5** in the SAP for specific quality control (QC) sampling requirements.
6. Decontaminate the hand auger and/or stainless-steel shovel, stainless steel bowl and mixing spoons in accordance with the Decontamination SOP in the SAP.
7. If an equipment blank is required for soil sampling equipment, following sample collection and after equipment decontamination, gently pour DI water over the auger, stainless steel bowl, and mixing spoon used to collect the soil sample. Collect the rinsate that flows off the equipment into the appropriate sample containers. Refer to **Table 5** in the SAP for specific QC sampling requirements.
8. Digital photographs shall be taken at each sampling location from different positions and recorded in the field log book. Consistency should be maintained between sampling rounds.

Standing Water

If the sample location(s) are identified at the time of the sampling event to have standing water (1 foot or less) above the wetland soil locations, the following procedure is to be followed:

1. Using a pre-decontaminated auger, auger a hole to the desired sampling depth of 6 inches. Carefully withdraw the auger to prevent cave-in of the borehole sidewalls.
2. Surface water should be decanted from the sample prior to transfer using a syringe; care should be taken to retain the fine sediment fraction during this procedure.
3. Follow the steps above to collect the soil samples.

If the depth of standing water above the sample location(s) is greater than 1 foot, the sample will not be collected.

RECORDS AND DOCUMENTATION

All data and sampling information will be recorded as specified in the SAP.

APPLICABLE STANDARDS AND REFERENCES

Soil Sampling SOP in the current NHDES Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA #13027

SOP B-11
Sampling Equipment Decontamination Procedure

SAMPLING EQUIPMENT DECONTAMINATION PROCEDURE

PURPOSE

This Standard Operating Procedure (SOP) *Sampling Equipment Decontamination Procedure* is designed to provide a procedure for preventing, minimizing, or limiting cross-contamination of environmental samples at the Troy Mills Landfill Superfund Site in Troy, New Hampshire. This SOP focuses on small equipment decontamination (e.g., split spoons, hand augers, water level meters, sediment sampling tools, etc.) which combines both physical and chemical removal steps. Removing or neutralizing contaminants from equipment not only minimizes the likelihood of sample cross contamination, it reduces or eliminates transfer of contaminants to clean areas and prevents the mixing of incompatible substances.

Gross contamination can be removed by physical decontamination procedures. These abrasive and non-abrasive methods typically include the use of brushes and high and low pressure water cleaning. The first step, a soap and water wash, removes all visible particulate matter and residual oils and grease. The second step involves a distilled/deionized water rinse to remove the detergent.

A small number of wells require a more stringent decontamination which includes a pesticide-grade hexane rinse/wipe for trace semi-volatile organics removal followed by a pesticide-grade isopropanol rinse to remove trace volatile organics and any remaining hexane. Isopropanol must evaporate completely prior to a final distilled/deionized water rinse.

Refer to **Table 2** in the SAP for specific locations where the equipment used there requires the more stringent decontamination.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the United States Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material commonly used for decontamination:

- Appropriate personal protective equipment (e.g., safety glasses appropriate gloves, boots).
- Informational materials for sampling event: A copy of the current approved site-specific Health and Safety Plan, site-specific SAP, the current HWRB Master QAPP.
- Logbook and pen. **Note: Only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books).** Sharpies can bleed through pages and smudge, making the documentation hard to read.
- Non-phosphate detergent (Alconox).

****Note: Some non-phosphate detergents may contain 1,4-dioxane. See special notes below.**

- Selected solvent rinses (pesticide-grade isopropanol and pesticide-grade hexane) with spray bottles.
- Distilled or laboratory-grade deionized (DI) water.
- Brushes.
- Spray bottles Drop cloth/plastic sheeting.
- Paper towels.
- Plastic or galvanized tubs or buckets.
- Aluminum foil.
- Re-sealable plastic bags.

DECONTAMINATION PROCEDURES

Refer to Table 2 in the SAP for specific locations where more stringent decontamination is required.

The primary decontamination procedure is summarized as follows:

1. Physical removal - non-phosphate detergent wash. Remove gross contamination from the equipment by brushing, where appropriate, and then rinsing with distilled water.
2. Flush the equipment with distilled water. If equipment includes pumps, make sure that rinse water is mechanically run through the pump system (see special notes). If equipment includes pore water samplers, a large amount of water is needed for the flush.
3. Air dry equipment.
4. Secure clean equipment.

The secondary, more stringent decontamination procedure is summarized as follows:

1. Physical removal - non-phosphate detergent wash.
2. Distilled/deionized water rinse.
3. Solvent rinse bath (pesticide-grade hexanes).
4. Solvent wipe (pesticide-grade hexanes).
5. Solvent rinse (pesticide-grade isopropanol).
6. Air dry to evaporate any remaining isopropanol.
7. DI water rinse.
8. Air dry

9. Secure clean equipment.

Physical Removal

Fill a wash basin or a large bucket with non-phosphate detergent and tap water. Scrub equipment with soap and water using bottle and/or bristle brushes. For such equipment as bailers, ensure that the interior space is scrubbed with bottle brushes. Wash soap off of equipment with distilled/deionized water from a low-pressure sprayer. Repeat as many times as necessary.

Sensitive equipment which is not waterproof should be wiped down with a damp cloth.

Solvent Bath/Wipe - Hexanes

Rinse sampling equipment by thoroughly submerging contaminated equipment in fresh hexane contained in a 5-gallon bucket or other appropriate container (solvent bath). Be sure to replace the hexane in the container for each piece of equipment to be decontaminated. Next, carefully wipe the equipment down (inside/outside, as appropriate) with a paper towel saturated with hexane (solvent wipe). Allow hexane to evaporate.

Solvent Sprayer - Isopropanol

Rinse sampling equipment with pesticide-grade isopropanol. Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket.

DI Water Rinse

Rinse sampling equipment with DI water with a low-pressure sprayer.

Clean Equipment Drop

Lay clean equipment on plastic sheeting. Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material.

SPECIAL NOTES

All field activities must be carried out in accordance with a site-specific Health and Safety Plan.

Water level indicator and oil/interface probes shall be decontaminated after each monitoring well and, at a minimum, the length of tape used in that well in accordance with the above-described methods.

1,4-Dioxane and Non-Phosphate Detergents

Some non-phosphate detergents may contain 1,4-dioxane. Seek a non-phosphate detergent that does not contain 1,4-dioxane, even though 1,4-dioxane is not a contaminant of interest at the Site. In addition, an equipment blank would be collected and analyzed for 1,4-dioxane to ensure that the revised decontamination procedure was adequate and that there was no 1,4-dioxane residue. If 1,4-dioxane was found in the equipment blank, the sampling data would have to be qualified.

Sensitive equipment which is not waterproof should be wiped down with a damp cloth.

If decontaminating a pump other than the QED Sample Pro Bladder Pump: Fill a PVC chamber (4-foot PVC riser with end cap to provide well scenario for pump) with water. Lower pump setup including pump and appropriate tubing into the PVC chamber. Activate the pump and purge three pump volumes of water through the setup. Following this, empty the chamber and replace with distilled water. Repeat the step to rinse the pump.

If decontaminating a QED Sample Pro Bladder Pump: the pump is disassembled after each sample is collected and the disposable one-time use only internal components (polyethylene or Teflon bladder, the metal screen and top plate, and the o-rings) are discarded. Using a bottle brush, scrub the external and internal body of the pump with distilled water and a non-phosphate detergent and then rinse with distilled water. Replace the internal components including the bladder, the metal screen and top plate, and the o-rings that come in new pre-packaged, sealed replacement bladder kits.

Solid Waste – Place all solid waste materials generated (i.e., gloves and plastic sheeting, etc.) in an approved container.

Liquid Waste – Place used chemical wastes into 5-gallon plastic containers or the original glass jars as appropriate and store with lid on. GZA will arrange for appropriate disposal of wastes and unused decontamination chemicals (hexane and isopropanol), as appropriate, from the Site on behalf of NHDES.

It is anticipated that the levels of contamination of the contaminated rinse liquids (i.e., distilled and deionized water scrubs and rinses) are sufficiently low and containerizing and disposal at a hazardous waste facility is not necessary. Based on this, liquid wastes generated, other than chemical wastes, shall be discharged to the ground surface.

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

To ensure that decontamination procedures are meeting the expectations/requirements (e.g., removing detectable levels of contamination) equipment blanks may be collected and analyzed as stated in the site-specific SAP. See **Table 5** for QC requirements.

If an equipment blank is analyzed and found to contain a contaminant, possible sources of error will have to be investigated to determine whether or not the decontamination procedures were properly followed. Possible sources of error include: inadequate scrubbing/ washing/ rinsing of equipment, inadequate choice of chemical rinses, use of contaminated detergents or rinse waters, contact with contaminants after decontamination but prior to sampling, and/or lab error.

Pump equipment blank samples will be collected following the submergence and operation of the pumps and tubing in DI water. The water, pump and tubing will be containerized within a minimum 6-inch diameter PVC pipe for the submersible pump and a 2-inch-diameter PVC pipe

for the bladder pump. The PVC pipe will be sealed at the bottom with a slip cap. The pumps will be operated within the PVC pipe such that water re-circulates through the pump, tubing and PVC pipe. A grab sample of the water will be collected directly from the pump and submitted for analysis.

RECORDS AND DOCUMENTATION

General decontamination procedures should be documented in the field log book. Safety Data Sheets (SDS) are required to be on site when using decontamination acid and/or solvent solutions.

REFERENCES

The Equipment Decontamination Procedure in the current Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EPA RFA#13027.

SOP B-12
Chain-of-Custody, Sample Handling and Shipping Procedures

CHAIN-OF-CUSTODY, SAMPLE HANDLING AND SHIPPING PROCEDURES

PURPOSE

This Standard Operating Procedure (SOP) *Chain-of-Custody, Sample Packaging and Shipment Procedures* has been established to provide for sample integrity in addition to proper sample labeling and completion of Chain-Of-Custody (COC) forms; and proper sample packaging and shipment for the Troy Mills Landfill Superfund Site in Troy, New Hampshire.

Any modifications to this SOP shall be approved in advance by the New Hampshire Department of Environmental Services (NHDES) Project Manager and Quality Assurance (QA) Coordinator, in consultation with the United States Environmental Protection Agency (EPA), documented in the field logbook, and presented in the final report.

A COC is a legal document designed to track persons who are responsible for the preparation of the sample container, sample collection, delivery, storage, and analysis. The field sampler is personally responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible should handle the samples. A sample, including empty sample containers, samples and coolers, are under a person's custody if it meets the following requirements:

- It is in the person's possession;
- It is in the person's view, after being in the person's possession;
- It was in the person's possession and it was placed in a secured location; or
- It is in a designated secure area.

Never leave samples, including un-used sample containers, unattended. All samples and un-used sample containers must be in the person's possession or placed in a locked location at all times.

All samples submitted to a laboratory shall be accompanied by a properly completed COC form, be packaged and shipped as appropriate. Always check with the selected laboratory-specific requirements regarding COCs.

Failure to maintain possession in the ways outlined in this SOP would constitute a break in sample custody and would likely discredit this sample as use of evidence in court proceedings. The sampler must assume that all samples collected will someday be used as evidence in court and treat the task of sample custody accordingly.

For this project, GZA will be responsible for delivering/shipping all samples to the appropriate laboratories. Refer to **Table 3** in the Sampling and Analysis Plan (SAP) for specific information on laboratories, analysis, containers, preservatives, and hold times. A copy of each laboratory COC is attached.

- Samples going to the Absolute Resources Associates (ARA) laboratory in Portsmouth, New Hampshire will be transported using the attached ARA COC.
- Samples for PFAS going to the Alpha Analytical (Alpha) laboratory in Westborough, Massachusetts will be transported using the attached Alpha COC.

The GZA Project Manager or Field Operations Lead will coordinate sample delivery arrangements directly with each lab. Refer to the organizational chart in **Appendix A** in the Sampling and Analysis Plan (SAP) for contact information. The laboratory Turn-Around-Time (TAT) requested for all samples will be the standard 10 to 15 business day TAT.

Each lab will provide their own sample containers, trip blanks as necessary, and coolers.

EQUIPMENT AND MATERIALS

The following is a list of equipment and material commonly used for labeling, packaging and shipping samples:

- COC forms/seals
- Bubble wrap or air cushions and packing
- Re-sealable plastic bags
- Permanent waterproof ink marker;
- Black ink pen. Note: Only ball point pens with black ink shall be used to record field data (e.g., COCs, log books). Sharpies can bleed through pages and smudge, making the documentation hard to read
- Shipping coolers
- Loose ice
- Sample labels, and packing tape

CUSTODY PROCEDURES

1. The field sampler will review the SAP provided by the project manager for specific COC record-keeping requirements. Note the following key COC related items:
 - Quality Assurance/Quality Control (QA/QC) data package requirements for project-specific data validation needs.
 - Laboratory reporting options, including preliminary results or electronic deliverables.
 - Standard or rush turn-around-time required.
 - Special laboratory requirements including lower detection limits; short hold times; and sample volume issues.
2. The field sampler will label all sample bottles, using waterproof ink, with the following information at a minimum:

- Sample ID
- Site name/location
- Sampler name
- Date and time sample was collected
- Laboratory analysis and test method requested
- Preservative used
- GZA project number.

Note: If soil volatile organic compound (VOC) samples are collected, no additional labels or tape shall be applied to the sample container, as these are pre-weighed by the laboratory.

3. The unique laboratory COCs will be prepared by either one of the field samplers collecting the samples or the on-site QA officer and include the following information at a minimum:
 - a. The site/project name
 - b. Town the site is in
 - c. NHDES site number
 - d. Unique sample IDs
 - e. Time and date of collection
 - f. Matrix type
 - g. Laboratory analysis and method requested
 - h. Number of containers
 - i. Preservatives
 - j. Name and phone numbers of all samplers and staff involved in filling out the COC forms
 - k. Name and phone number of the project contact person
 - l. The street addresses corresponding to residential samples shall be included in the comment section for each sample.
 - m. Specific requirements such as specific reporting detection limits (RDLs)
 - n. Any special notes or requirements such as the lab account number, OneStop Project ID, etc.
 - o. All quality assurance/quality control (QA/QC) samples and associated information, such as:

1) **Trip Blanks:**

When a number of trip blanks are given in advance along with the containers from the specified labs above, the trip blanks will be maintained with the empty containers. VOC trip blanks consist of two volatile organic analysis [VOA] vials.

Note: PFAS samples require a different trip blank. Refer to the **Table 3** in the SAP for the specific trip blank requirements for each lab.

Before placing the trip blank in a re-sealable plastic bag, record the date and time on the labels. The trip blank must be placed in the cooler within the loose ice prior to the collection of the first VOC or PFAS sample.

The trip blank should be designated as “TRIP BLANK” in capital letters on the COC without any other designation and should be recorded on the first line along with the date and time.

Only one trip blank per sample matrix per COC, per cooler is acceptable.

2) **Duplicates:**

Sample duplicates are identified by adding “DUP” (in capital letters) to the end of the station ID (example “OGS_T-12 DUP”). The duplicate samples should appear on the next line of the COC after the regular samples.

3) **Matrix Spike (MS) Matrix Spike Duplicate (MSD) samples:**

MS/MSD samples are typically collected together at one sampling location. Refer to **Table 5** for specific MS/MSD requirements. Refer to **Table 3** for the number of bottles and analysis required. There are generally two types of MS/MSD samples:

a) **Lab QC MS/MSD Samples:**

A laboratory may require the collection of extra sample bottles for their internal lab QC. If so, indicate that in the comments section on the COC (e.g., “Lab MS/MSD” or “Lab MS/MSD-1,4-Dioxane” specifying the analysis). The lab typically does not report these results. The number of samples containers will also change to indicate the extra bottle(s). These lab QC samples should not be on a separate line on the COC. The NHDPHS lab typically requires extra sample bottles for their internal QC for 1,4-dioxane analysis. Refer to the specific lab and the site-specific SAP for MS/MSD requirements.

b) **Site MS/MSD Samples:**

A site-specific SAP may require MS/MSD samples to be collected at a specific location, and require the lab to report those results, as part of a site-specific sampling program if matrix interference is suspected. If so, indicate that in the comment section on the COC (e.g., “MS/MSD Report Results” or “MS/MSD-1,4-Dioxane Report Results” specifying the analysis if it is not required for each analysis). The number of

sample containers will also change to indicate the extra bottle(s) for the MS/MSD sample. These MS/MSD samples may be on a separate line on the COC. Refer to the specific lab and the site-specific SAP for MS/MSD requirements.

4) Equipment Blank Samples:

Equipment blank samples will be designated as “EQUIP BLANK” in capital letters on the COC without any other designation. Add a note to the comment section of the COC indicating what the equipment blank is for (e.g., water level meter). Refer to **Table 5**.

5) Field Blank Samples:

Field blank samples must be designated “FIELD BLANK” in capital letters on the COC without any other designation. Note that a comment is required on the chain-of-custody indicating the name of the person who collected the sample (i.e., S. Perkins).

6) Temperature Blanks:

A temperature blank will be included with each shipment cooler to verify that samples have been kept at the required temperature during shipping. Check off the box on the COC to indicate that there is a temperature blank in the cooler. If there is no box, indicate the temperature blank’s presence in the comment section of the COC.

4. Prior to leaving the site and before the samples are delivered to the lab, the field sampler or Field Operations Lead will check for errors on the sample label and COC form and verify that all pertinent data is present and correct.
5. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.

Only one of the field samplers signs the first “relinquished by” line. The person who receives the samples at the laboratory signs the COC last in the “received by” line. In case there are additional steps in the process requiring another person or persons to take custody of the sample, the form has additional lines for signatures. All signatures must be in ballpoint pen and are followed by a date and time that the COC was signed. The last line of the lab-specific COC is provided for personnel from the laboratory to sign for receiving the sample. The line at the bottom of the page “Data Reviewed By” is for Lab use only. If the samples are taken to the specified lab via courier the sampler may relinquish the samples to “[Specific Laboratory Name] Laboratory via courier”, as appropriate.

Note: Any errors must be lined out, initialed, dated and the correction written in.

6. If the samples are shipped by public courier (i.e., Federal Express, UPS, etc.) the airbill generally serves as the chain-of-custody record for that portion of the trip and will be retained by the field sampler and provided to the project manager as part of the permanent documentation.
7. The Field Operations Lead, QA Officer or Project Manager will review the COC to evaluate completeness; holding time or sample volume issues that may impact the validity of the results.

SAMPLE PACKAGING PROCEDURES

After collection, all samples shall be transported to the laboratory in such a manner as to prevent breakage and preserve sample integrity. Sample containers are generally packaged in insulated coolers for shipment or pickup by the laboratory courier. Appropriate packing materials include bubble wrap and air cushions. Sample containers are packed tightly to minimize movement during shipment that may cause breakage.

1. To eliminate the chance of breakage during shipment, approximately one inch of inert cushion material should be placed in the bottom of the cooler.
2. Include a temperature bank and any necessary trip blanks in loose ice in each cooler prior to sample collection.
3. Place each sample container, or set of sample containers (e.g., 2 to 4 VOCs vials; refer to **Table 3**), inside a re-sealable plastic bag as a precaution against cross-contamination due to leakage or breakage.
4. Place all containers in an upright position into the loose ice in the cooler and place all glass containers in such a way that they do not come into contact with each other during shipment.
5. After samples have been packed, loose ice will be added to the cooler to ensure target preservation temperature is achieved (i.e., 4 +/-2 degrees Celsius).
6. Place a completed COC in a re-sealable plastic bag within each cooler. Only one COC per cooler is acceptable. COCs may contain more than one page.
7. Coolers being shipped (not couriered) will be secured with strapping tape in at least two locations for shipment to the laboratory and include a custody seal.
8. Prior to any cooler being shipped that contains environmental samples, the Field Operations Lead, QA Officer or Project Manager is required to evaluate if the samples/sample containers being shipped are considered hazardous. Consult appropriate trained personnel for proper packaging and labeling requirements.

SAMPLE PICKUP/SHIPPING PROCEDURES

Samples shall be properly packaged for shipment to maintain sample integrity and delivered to the analytical laboratory with a separate signed COC form enclosed in each sample cooler. Samples

must be delivered in a manner consistent with the requirements of the analytical laboratory with respect for preservation, temperature, and holding times for the particular analytes to be tested.

In general, and whenever possible, all samples will be checked into the laboratory performing the analyses on the same day the samples are collected, unless other arrangements have been made. If it is impossible to check in samples at the laboratory the same day, the field team will be responsible for proper secure storage of samples following appropriate protocol for sample preservation (such as cooling to 4 +/- 2°C) until the samples are delivered to the laboratory or handed over to a courier.

Samples will be delivered to the specified labs listed above either every other day, or on Wednesday and Friday of each week, unless holding times require daily delivery, or other prior arrangements were made with the lab. Refer to **Table 3** in the SAP for all holding time requirements. If possible, no samples should be held over the weekend.

Sample Pickup/Delivery

Samples are either delivered directly to the laboratory by the field team or the laboratory provides a courier to transport them. Custody seals shall be used when the cooler is sent to the laboratory by independent courier, unless otherwise specified in the site-specific SAP.

Samples being delivered to these laboratories should arrive before 4 pm unless other arrangements have been made.

Shipping Samples to the Laboratory

Samples requiring shipment (e.g., Microseeps) shall be sent next-day delivery by Federal Express or an equivalent overnight carrier. Field personnel will coordinate directly with the appropriate laboratory in advance for delivery times and requirements and will notify the laboratory no later than 48 hours prior to sample shipment. Coolers will be secured with strapping tape in at least two locations for shipment and include a custody seal. If the sample is considered hazardous, consult appropriate trained personnel for proper packaging and labeling. The airbill generally serves as the chain-of-custody record for that portion of the trip and will be retained by the field sampler and provided to the Project Manager as part of the permanent documentation.

Refer to the organizational chart in **Appendix A** in the SAP for the contact information for each lab.

If Friday sampling is unavoidable and delivery to the lab late Friday or on Saturday is not possible, samples shall be properly stored (custody and sample preservation must be maintained) over the weekend in the office sample refrigerator. If prompt shipping and laboratory receipt of samples cannot be guaranteed, the field team will be responsible for proper storage of samples until adequate transportation arrangements can be made or sample collection schedules can be modified by the Project Manager. If holding times would be exceeded by storing the samples,

alternative arrangements must be made by the Project Manager for sample collection and shipment or pickup.

DOCUMENTATION

The original COC record will accompany the cooler and a copy will be retained by the sampler for return to the project manager.

REFERENCES

The Chain of Custody Sample Handling and Shipping found in the current version of the Hazardous Waste Remediation Bureau Master Quality Assurance Project Plan (HWRB Master QAPP), EQA RFA# 18008.

ATTACHMENTS

ARA COC
ARA PFAS COC

-ARA Laboratory Chain-of-Custody



124 Heritage Avenue #16
Portsmouth, NH 03801
603-436-2001
solutesourceassociates.com

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

ANALYSIS REQUEST

Company Name:	Project Name:
Dept. of Environmental Services, State of New Hampshire	Troy Mills Landfill Superfund Site
Company Address:	Project #:
29 Hazen Drive, P.O. Box 95	DES #198405082
Report To:	Project Location: NH MA ME VT NY Other
Michael Summerlin, P.E.	Protocol: RCRA SDWA NPDES MCP NHDES OTHER
Phone #:	Reporting Limits:
(603) 271-3649	QAPP GW-1 S-1 EPA DW Other SAP
Invoice to Email: michael.summerlinjr@des.nh.gov	Quote # _____ <input type="checkbox"/> NH Reimbursement Pricing
<input type="checkbox"/> Hard Copy Invoice Required	PO # Contract No. 1051314 (2589-00 T)

Lab Sample ID (Lab Use Only)	Field ID	# CONTAINERS	Matrix			Preservation Method					Sampling			ANALYSIS																			
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TAT REQUESTED Priority (24 hr)* <input type="checkbox"/> Expedited (48 hr)* <input type="checkbox"/> Standard (10 Business Days) <input checked="" type="checkbox"/>		See absoluteresourceassociates.com for sample acceptance policy and current accreditation lists.		SPECIAL INSTRUCTIONS Please contact Tanya Justham at (603) 493-1548 for sample questions and Michael Summerlin for all others.	
*Date Needed _____		REPORTING INSTRUCTIONS <input checked="" type="checkbox"/> PDF (e-mail address) _____ and Excel; Please send results to michael.summerlinjr@des.nh.gov and tanya.justham@gza.com		RECEIVED ON ICE <input type="checkbox"/> YES <input type="checkbox"/> NO	
		<input type="checkbox"/> HARD COPY REQUIRED <input type="checkbox"/> FAX (FAX#) _____		TEMPERATURE _____ °C	

CUSTODY RECORD <small>QSD-01 Revision 10/14/15</small>	Relinquished by Sampler:	Date	Time	Received by:	Date	Time
	Relinquished by:	Date	Time	Received by:	Date	Time
	Relinquished by:	Date	Time	Received by Laboratory:	Date	Time



124 Heritage Avenue #16
Portsmouth, NH 03801
603-436-2001
solutesourceassociates.com

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

ANALYSIS REQUEST

Company Name:	Project Name:
Dept. of Environmental Services, State of New Hampshire	Troy Mills Landfill Superfund Site
Company Address:	Project #:
29 Hazen Drive, P.O. Box 95	DES #198405082
Report To:	Project Location: NH MA ME VT NY Other
Michael Summerlin, P.E.	Protocol: RCRA SDWA NPDES MCP NHDES OTHER
Phone #:	Reporting GW-1 S-1 Limits: EPA DW Other SAP
(603) 271-3649	
Invoice to Email: michael.summerlinjr@des.nh.gov	Quote # <input type="checkbox"/> NH Reimbursement Pricing
<input type="checkbox"/> Hard Copy Invoice Required	PO # Contract No. 1051314 (2589-00 T)

Lab Sample ID (Lab Use Only)	Field ID	# CONTAINERS	Matrix			Preservation Method					Sampling			ANALYSIS																	
			WATER	SOLID	OTHER	HCl	HNO ₃	H ₂ SO ₄	NaOH	MeOH	DATE	TIME	SAMPLER	<input type="checkbox"/> VOC 8260 <input checked="" type="checkbox"/> VOC 8270 <input type="checkbox"/> VOC 8280 <input type="checkbox"/> VOC 8290 <input type="checkbox"/> VOC 8300 <input type="checkbox"/> VOC 8310 <input type="checkbox"/> VOC 8320 <input type="checkbox"/> VOC 8330 <input type="checkbox"/> VOC 8340 <input type="checkbox"/> VOC 8350 <input type="checkbox"/> VOC 8360 <input type="checkbox"/> VOC 8370 <input type="checkbox"/> VOC 8380 <input type="checkbox"/> VOC 8390 <input type="checkbox"/> VOC 8400 <input type="checkbox"/> VOC 8410 <input type="checkbox"/> VOC 8420 <input type="checkbox"/> VOC 8430 <input type="checkbox"/> VOC 8440 <input type="checkbox"/> VOC 8450 <input type="checkbox"/> VOC 8460 <input type="checkbox"/> VOC 8470 <input type="checkbox"/> VOC 8480 <input type="checkbox"/> VOC 8490 <input type="checkbox"/> VOC 8500 <input type="checkbox"/> VOC 8510 <input type="checkbox"/> VOC 8520 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TAT REQUESTED Priority (24 hr)* <input type="checkbox"/> Expedited (48 hr)* <input type="checkbox"/> Standard (10 Business Days) <input checked="" type="checkbox"/>	See absoluteresourceassociates.com for sample acceptance policy and current accreditation lists.	SPECIAL INSTRUCTIONS Please contact Tanya Justham at (603) 493-1548 for sample questions and Michael Summerlin for all others.	
	REPORTING INSTRUCTIONS <input checked="" type="checkbox"/> PDF (e-mail address) <u>and Excel; Please send results to michael.summerlinjr@des.nh.gov and tanya.justham@gza.com</u>		RECEIVED ON ICE <input type="checkbox"/> YES <input type="checkbox"/> NO TEMPERATURE _____ °C
*Date Needed _____	<input type="checkbox"/> HARD COPY REQUIRED <input type="checkbox"/> FAX (FAX#)		

CUSTODY RECORD <small>QSD-01 Revision 10/14/15</small>	Relinquished by Sampler:	Date	Time	Received by:	Date	Time
	Relinquished by:	Date	Time	Received by:	Date	Time
	Relinquished by:	Date	Time	Received by Laboratory:	Date	Time

-ARA Laboratory Chain-of-Custody for PFAS



124 Heritage Avenue #16
Portsmouth, NH 03801
603-436-2001
solutesourceassociates.com

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

ANALYSIS REQUEST

Company Name:	Project Name:
Dept. of Environmental Services, State of New Hampshire	Troy Mills Landfill Superfund Site
Company Address:	Project #:
29 Hazen Drive, P.O. Box 95	DES #198405082
Report To:	Project Location: NH MA ME VT NY Other
Michael Summerlin, P.E.	Protocol: RCRA SDWA NPDES MCP NHDES OTHER
Phone #:	Reporting Limits: QAPP GW-1 S-1 EPA DW Other SAP
(603) 271-3649	
Invoice to Email: michael.summerlinjr@des.nh.gov	Quote # <input type="checkbox"/> NH Reimbursement Pricing
<input type="checkbox"/> Hard Copy Invoice Required	PO # Contract No. 1051314 (2589-00 T)

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TAT REQUESTED Priority (24 hr)* <input type="checkbox"/> Expedited (48 hr)* <input type="checkbox"/> Standard (10 Business Days) <input checked="" type="checkbox"/> *Date Needed _____		See absoluteresourceassociates.com for sample acceptance policy and current accreditation lists.		SPECIAL INSTRUCTIONS Please contact Tanya Justham at (603) 493-1548 for sample questions and Michael Summerlin for all others.	
		REPORTING INSTRUCTIONS <input checked="" type="checkbox"/> PDF (e-mail address) _____ and Excel; Please send results to michael.summerlinjr@des.nh.gov and tanya.justham@gza.com		RECEIVED ON ICE <input type="checkbox"/> YES <input type="checkbox"/> NO TEMPERATURE _____ °C	
<input type="checkbox"/> HARD COPY REQUIRED <input type="checkbox"/> FAX (FAX#) _____					

CUSTODY RECORD <small>QSD-01 Revision 10/14/15</small>	Relinquished by Sampler:	Date	Time	Received by:	Date	Time
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SOP B-13
Sampling for Per- & Poly-Fluorinated Alkyl Substances

SAMPLING FOR PER- & POLY-FLUORINATED ALKYL SUBSTANCES

PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for collecting samples for per- and poly-fluorinated alkyl substances (PFAS) analysis at the Troy Mills Landfill Superfund Site (the “Site”) located in Troy, New Hampshire. *Please note that PFAS are emerging contaminants; therefore, this SOP will be modified as new information becomes available.*

Because of the potential presence of PFAS in common consumer products and in equipment typically used to collect groundwater samples and the low detection limits associated with laboratory PFAS analysis, special handling and care must be taken when collecting samples for PFAS analysis.

This SOP outlines general practices for collecting PFAS samples and provides a summary of non-acceptable field and sampling materials (likely to contain PFAS) and acceptable alternatives.

The initial site evaluation shall assess potential groundwater quality impacts by sampling existing monitoring wells to determine if PFAS are present at the site at concentrations which exceed AGQS. Sampling of additional media (e.g., soil, surface water, drinking water) may be required in future monitoring events if elevated concentrations in groundwater are detected, taking into consideration the potential release mechanism and proximity of the site to sensitive receptors.

The New Hampshire Department of Environmental Services (NHDES) currently requires that, at a minimum, representative samples shall be collected from the source area and downgradient compliance monitoring points (e.g., at the extent of the GMZ) that were previously impacted by other COCs and that would evaluate potential impact to receptors and off-site supply wells.

Other considerations include previous and current uses of the site, and proximity to sensitive receptors or other known releases. Further sampling and analysis may be required to ensure that the sampling completed is representative.

Any modifications to this SOP shall be approved in advance by the NHDES Project Manager and Quality Assurance (QA) Coordinator, in consultation with the United States Environmental Protection Agency (EPA), documented in the field logbook and presented in the final report.

BACKGROUND

Based on USEPA guidance, “per- and polyfluoroalkyl substances (PFAS)” is the preferred term to refer to this class of chemicals, although the general public and others may also refer to them as “perfluorinated chemicals (PFCs)” or “perfluorinated compounds (PFCs).” For further information, see: : <https://www.epa.gov/pfas/what-are-pfcs-and-how-do-they-relate-and-polyfluoroalkyl-substances-pfass>.

PFAS are a family of man-made compounds that do not naturally occur in the environment. They have a large number of industrial uses and are found in many commercial products because of their properties to resist heat, oil, grease and water. Once released to the environment, PFAS are persistent and do not readily biodegrade or break down. New Hampshire and several other northeast states are dealing with several sites where there have been widespread PFAS impacts to drinking water supplies.

The USEPA issued drinking water lifetime health advisories for two PFAS, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), on May 19, 2016. After a review of USEPA's information, NHDES filed an emergency rule to establish the health advisories as Ambient Groundwater Quality Standards (AGQS) on May 31, 2016. NHDES set three groundwater standards: 70 parts per trillion (ppt) for PFOA, 70 ppt for PFOS and 70 ppt for PFOA and PFOS combined, where the chemicals are found together. After completing the regular rulemaking process, these rules became permanent on October 22, 2016.

Frequently asked questions, fact sheets and additional information concerning PFAS can be found on the NHDES website¹ and on the New Hampshire Department of Health and Human Services (NHDHHS) website.²

GENERAL GUIDANCE

Personal Protective Equipment

Disposable nitrile gloves must be worn at all times. Further, a new pair of nitrile gloves shall be donned prior to the following activities at each sample location:

1. Decontamination of re-usable sampling equipment.
2. Contact with sample bottles or water containers.
3. Insertion of anything into the well (e.g., tubing, pump, bailer).
4. Insertion of silicon tubing into the peristaltic pump.
5. Sample collection, at completion of monitoring well purging.
6. Handling of any quality assurance/quality control samples including field blanks and equipment blanks.

New gloves shall also be donned after the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.

The use of a different colored glove (e.g., bright orange) for the collection of PFAS samples can help provide a visual reminder to prevent cross-contamination.

¹ <http://www.des.nh.gov/organization/commissioner/pfoa.htm>

² <http://www.dhhs.nh.gov/dphs/pfcs/documents/pfc-faqs-gen.pdf>

Sample Collection Method/Sequence

1. Samples for laboratory analyses must be collected before the flow-through cell and the three-way stopcock. This will be done by disconnecting the three-way stopcock from the pump discharge tubing so that the samples are collected directly from the pump tubing.
2. Using new nitrile gloves, collect the sample for PFAS *first*, prior to collecting samples for any other parameters into any other containers; this avoids contact with any other type of sample container, bottles or package materials that may have PFAS-related content.
3. **Do not place the sample bottle cap on any surface when collecting the sample and avoid all contact with the inside of the sample bottle or its cap.**
4. Once the sample is collected, capped and labeled, place the sample in an individual re-sealable plastic bag and then into loose ice within the cooler (preferably from a verifiable PFAS-free source).

Decontamination

When feasible, use dedicated, single-use or disposable polyethylene or silicone materials (tubing, bailers, etc.) for monitoring well purging and sampling equipment.

All non-dedicated equipment (i.e., water levels) shall be decontaminated according to the *Equipment Decontamination* SOP in the SAP using PFAS-free deionized water. Equipment blanks shall be collected according to **Table 5** in the SAP.

Decontamination fluids have been seen as a possible source of equipment cross contamination. Therefore, more frequent changes of decontamination liquids are warranted. Refer to the Equipment and Materials Table below for prohibited and acceptable decontamination liquids.

Laboratory Analysis

A New Hampshire accreditation program for PFAS analysis is under development but is not yet in place. In the meantime, *NHDES requires that a lab with DOD and/or NELAP certification be used for PFAS analysis.*

Analysis by a method that uses isotope dilution techniques is required. Both linear and branched isomers shall be reported, consistent with USEPA's September 2016 Technical Advisory: <https://www.epa.gov/sites/production/files/2016-09/documents/pfoa-technical-advisory.pdf>

As of the date of this document, there is no standardized isotope dilution method for PFAS analysis. Therefore, individual laboratories have developed their own methods using the USEPA Method 537 as a basis. USEPA is developing a standardized method for analysis of samples from groundwater and other media.

Samples shall be submitted for analysis of the longer list of PFAS compounds in the table below to support the understanding of potential PFAS impacts at the Site. **Note:** The longer list may vary slightly between labs (i.e., the lab may analyze 23 to 25 compounds); however, the 9 highlighted compounds must be analyzed.

Refer to **Table 1** in the SAP for the complete list of PFAS compounds to be analyzed, along with their reporting limits. *The analytical reporting detection limit (RDL) of analyses for each contaminant shall be no greater than 5 nanograms per liter (ng/l, equivalent to ppt) for aqueous samples;* however, available RDL from some laboratories for compounds other than PFOA and PFOS may be slightly higher (e.g., 10 ng/l).

Compound Name	CAS #
Perfluorononanoic acid (PFNA)	375-95-1
Perfluorooctanoic acid (PFOA)	335-67-1
Perfluoroheptanoic acid (PFHpA)	375-85-9
Perfluorohexanoic acid (PFHxA)	307-24-4
Perfluoropentanoic acid (PFPeA)	2706-90-3
Perfluorobutanoic acid (PFBA)	375-22-4
Perfluorooctanesulfonic acid (PFOS)	1763-23-1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4
Perfluorobutanesulfonic acid (PFBS)	375-73-5
Perfluorodecane sulfonate (PFDS)	335-77-3
Perfluorodecanoic acid (PFDA)	335-76-2
Perfluorododecanoic acid (PFDoA)	307-55-1
Perfluoroheptane sulfonate (PFHpS)	375-92-8
Perfluorotetradecanoic acid (PFTeDA)	376-06-7
Perfluoro-n-tridecanoic acid (PFTrDA)	72629-94-8
Perfluorooctanesulfonamide (FOSA)	754-91-6
Perfluoroundecanoic acid (PFUnA)	2058-94-8
2-(N-ethylperfluoro-a-octanesulfonamido)-ethanol (N-EtFOSE)	1691-99-2
2-(N-methylperfluoro-a-octanesulfonamido)-ethanol (N-MeFOSE)	24448-09-7
6:2 Fluorotelomersulfonate (6:2 FTS)	17619-97-2
8:2 Fluorotelomersulfonate (8:2 FTS)	39108-34-4
Ethylperfluoro-1-octanesulfonamide (N-EtFOSA)	4151-50-2
Methylperfluoro-1-octanesulfonamide (N-MeFOSA)	31506-32-8
2,3,3,3-tetrafluoro-2- (heptafluoropropoxy)propanoic acid (HFPO-DA)	13252-13-6

The laboratory report must show the RDLs for each compound and the lab must report the results to the RDL. In order to be consistent with other Site analysis results, only the RDLs shall be reported. Method detection limits (MDLs) are not required and shall not be included in the report.

Some analytical laboratories report slightly different forms of sulfonic acids, such as PFOS (i.e., perfluorooctanesulfonic acid vs. perfluorooctane sulfonate), which vary slightly from one another in molecular weight, resulting in slight differences in reported concentrations. **Confirm with the analytical laboratory that the form of sulfonic acids being analyzed and reported correspond to the appropriate CAS Number.** If the lab analyzes for one form and reports the other form, the lab must show the conversion calculations in the report.

QUALITY ASSURANCE QUALITY CONTROL (QA/QC)

Many clothing items and types of field equipment may contain PFAS, which increases the potential for inadvertent contamination of the samples. Refer to **Table 5** in the SAP for all QA/QC samples.

In order to evaluate the potential impact these, as well as laboratory-provided materials, might have on our PFAS samples, the following QA/QC samples shall be collected:

- Trip Blanks
 - Trip blanks for PFAS samples shall be prepared by the laboratory prior to the sampling event using PFAS-free water.
 - Only one PFAS trip blank per chain-of-custody, per cooler is acceptable.
 - Refer to **Table 3** in the SAP for the preservation requirements.
- Field Duplicates
 - Duplicate samples shall be collected by filling a separate container for each analysis immediately following the collection of the primary sample (e.g., PFAS sample, PFAS duplicate sample; VOC sample, VOC duplicate sample).
 - Duplicate samples shall be collected at a frequency of one duplicate sample per twenty field samples (1:20) with a minimum of one duplicate.
 - Refer to **Table 5** in the SAP for the specific numbers and locations.
- Equipment Blanks - for all non-dedicated equipment used to collect samples
 - Equipment blanks shall be prepared using PFAS-free laboratory grade deionized (DI) water provided by the laboratory.
 - Equipment blanks consist of a sample of PFAS-free laboratory grade deionized (DI) water which has been poured around and through sample collection equipment to evaluate the equipment decontamination procedures and the potential for cross-contamination between sample locations.
 - One equipment blank per type of non-dedicated equipment shall be collected per sampling event (e.g., water level meter, submersible pump).
 - Refer to **Table 5** in the SAP for the specific numbers and locations.

- Field Blanks

- Collect a field blank from the PFAS-free water provided by the laboratory while in the field by pouring an aliquot of the water into the appropriate PFAS sample container immediately following the collection of the first PFAS sample by each sampler.
- At a minimum, field blanks must be collected by each person collecting PFAS samples.
- Refer to **Table 5** in the SAP for the specific numbers and locations.

The site QC Manager will be responsible for conducting field audits during PFAS sampling activities. During these audits, the QC Manager will ensure that field crew is adhering to the HWRB Master Quality Assurance Project Plan (HWRB Master QAPP) and procedures provided herein and in the site-specific SAP, including, but not limited to, sampling techniques, field documentation, decontamination, sample packaging, chain of custody sample handling and shipping documentation procedures, and equipment calibration. Refer to the *Chain of Custody Sample Handling & Shipment SOP* and the *Calibration of YSI, In-Situ and Hach Field Instruments SOP* in the SAP.

EQUIPMENT AND MATERIALS

The following table provides a summary of items that are likely to contain PFAS (i.e., prohibited items) and that are not to be used by the sampling team at the site, along with acceptable alternatives. This list may change as new information becomes available.

Category	Prohibited Items	Allowable Items
Sample Storage and Preservation	LDPE or glass bottles, PTFE-or Teflon-lined caps, chemical ice packs ²	Laboratory-provided sample container - <i>preferred</i> ; or, HDPE or polypropylene bottles with an unlined plastic screw cap, as specified by the laboratory doing the analysis, loose ice (preferably from a known PFAS-free source)
Decontamination	Decon 90	Alconox® or Liquinox® ¹ , potable water followed by laboratory “PFAS-free” deionized water rinse.
Category	Prohibited Items	Allowable Items
Field Equipment Including: • Pumps • Tubing • Bailers	Teflon and other fluoropolymer containing materials (e.g., Teflon tubing, bailers, tape, Teflon-containing plumbing paste, or other Teflon materials)	High-density polyethylene (HDPE) – <i>preferred</i> , low density polyethylene (LDPE) or silicone tubing HDPE/LDPE or stainless steel bailers Peristaltic pumps Stainless steel submersible pumps

	<p>Note: The Grundfos Redi-Flow Submersible Pump is a submersible pump which, as of this revision, has a Teflon impeller and is not recommended for collecting PFAS samples.</p>	<p>(e.g., ProActive stainless steel pumps with PVC (polyvinyl chloride) leads and Geotech Stainless Steel Geosub pumps)</p> <p>Equipment with Viton components needs to be evaluated on a case by case basis. Viton contains PTFE, but may be acceptable if used in gaskets or O-rings that are sealed away and will not come into contact with sample or sampling equipment.)</p>
Field Documentation	Waterproof/treated paper or field books, plastic clipboards, non-Sharpie markers, Post-It® and other adhesive paper products	Plain Paper, metal clipboard, Sharpies ³ , pens
Clothing/laundrying	<p>Clothing or boots made of or with Gore-Tex™ or other synthetic water proof/ resistant and/or stain resistant materials, coated Tyvek® material that may contain PFAS;</p> <p>fabric softener</p>	<p>Synthetic or cotton material, previously laundered clothing (preferably previously washed greater than six times) without the use of fabric softeners.</p> <p>Polyurethane and wax coated materials.</p> <p>Boots made with polyurethane and PVC, well-worn or untreated leather boots</p> <p>Tyvek material that is PFAS free (e.g., uncoated)</p>
Category	Prohibited Items	Allowable Items
Personal Care Products (for day of sample collection)	Cosmetics, moisturizers, hand cream and other related products	<p>Sunscreens:</p> <p>Alba Organics Natural</p> <p>Yes to Cucumbers</p> <p>Aubrey Organics</p> <p>Jason Natural Sun Block</p> <p>Kiss My Face</p> <p>Baby-safe sunscreens (‘free’ or ‘natural’)</p> <p>Insect Repellents:</p> <p>Jason Natural Quit Bugging Me</p> <p>Repel Lemon Eucalyptus</p> <p>Herbal Armor</p> <p>California Baby Natural Bug Spray</p> <p>BabyGanics</p> <p>Sunscreen and Insect Repellents:</p> <p>Avon Skin So Soft Bug Guard-SPF 30</p>

Food and Beverage	Pre-packaged food, fast food wrappers or containers	Bottled water or hydration drinks (i.e., Gatorade® and Powerade®)
Shelter	The use of a canopy/gazebo/tent, which can be erected over the sample location to provide shelter, may be considered. Note that the canopy is likely to have a treated surface and must be handled with care. Gloves must be worn when setting up and moving the tent and then changed immediately afterwards. Further contact with the tent must be avoided until all PFAS samples have been collected and properly stored.	

Notes

- ^{1.} While Alconox and Liquinox soap is acceptable for use for PFAS decontamination, they may contain 1,4-dioxane, which is a site contaminant of interest. If Alconox® and Liquinox® soap is used, then equipment blanks analyzed for 1,4-dioxane shall be required.
- ^{2.} The HWRB Master QAPP requires that all samples requiring cooling must be placed in loose ice within a cooler; the use of bagged ice, block ice and ice packs is not acceptable.
- ^{3.} Sharpies may be used if necessary on the labels; however, only ball point pens with black ink shall be used to record field data (e.g., calibration logs, worksheets, log books). Sharpies can bleed through pages and smudge, making the documentation hard to read.

REFERENCES

Sampling for Per- & Poly-Fluorinated Alkyl Substances SOP included in the current HWRB Master QAPP, EQA RFA #18008.

Appendix C – EPA’s Record of Decision Groundwater and Leachate Cleanup Levels

Record of Decision
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Table L-1

Interim Groundwater Cleanup Levels

Carcinogenic Chemical of Concern	Cancer Classification	Interim Cleanup Level (ug/L)	Basis	RME Risk
1,4-Dioxane	B2	3	GW-1	1E-06
Benzene	A	5	MCL	7E-06
Tetrachloroethene	not available*	5	MCL	7E-05
Trichloroethene	B1*	5	MCL	6E-05
Vinyl Chloride	A	2	MCL	2E-04
Benzo(a)pyrene	B2	0.2	MCL	3E-05
Benzo(b)fluoranthene	B2	0.05	AGQS	6E-07
bis(2-Ethylhexyl)phthalate	B2	6	MCL	3E-06
Dibenzo(a,h)anthracene	B2	0.01	PQL	1E-06
Pentachlorophenol	B2	1	MCL	2E-06
Arsenic	A	10	MCL	3E-04
Non-Carcinogenic Chemical of Concern	Target Endpoint	Interim Cleanup Level (ug/L)	Basis	RME Hazard Quotient
1,2,4-Trimethylbenzene	General Toxicity/ Liver/Kidney	50	AGQS	1
1,3,5-Trimethylbenzene	General Toxicity/ Liver/Kidney	50	AGQS	1
2-Butanone	Developmental	170	AGQS	0.03
4-Isopropyltoluene	Kidney	50	AGQS	0.1
Benzene	Immune System	5	MCL	0.2
cis-1,2-Dichloroethene	Blood	70	MCL	0.7
n-Butylbenzene	Blood	50	AGQS	5
n-Propylbenzene	Blood	50	AGQS	4
Tetrachloroethene	Liver	5	MCL	0.07
Tetrahydrofuran	not available	154	AGQS	Not available
Toluene	Liver/Kidney	1,000	MCL	1
Trichloroethene	Liver	5	MCL	0.02
Vinyl Chloride	Liver	2	MCL	0.07
bis(2-Ethylhexyl)phthalate	Liver	6	MCL	0.06
Naphthalene	General Toxicity	20	AGQS	0.8
Pentachlorophenol	Liver/Kidney	1	MCL	0.003
Arsenic	Skin	10	MCL	3
Boron	Developmental	620	AGQS	0.3
Manganese	CNS	300	Advisory	1

Key

AGQS – New Hampshire Ambient Groundwater Quality Standards - 2/24/99.

ug/L = micrograms per liter (equivalent to parts per billion).

* = The cancer classifications for tetrachloroethene and trichloroethene are under review by EPA.

GW-1 = New Hampshire Department of Environmental Services Method 1 Groundwater Standards (RCMP, 3/31/05). Note that recent updates have been made to the NHDES GW-1 standards. It is anticipated that the AGQS concentrations presented will be made equivalent to the GW-1 standards. However, GW-1 standards have only been selected as the PRG when there is no AGQS available.

The AGQS for dibenzo(a,h)anthracene is 0.005 ug/L; however the interim groundwater cleanup levels has been set at 0.01 ug/L based on the practical quantification limit (PQL) for this chemical. During five-year reviews, the PQL for this chemical will be revisited to determine if analytical detection limits in the range of the AGQS are achievable. If so, the interim groundwater cleanup level for this chemical will be revised to match the AGQS.

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Table L-1

Interim Groundwater Cleanup Levels

Tetrahydrofuran was included on the above table as it was found in groundwater at levels that exceed an AGQS. However, as an RfD was not available, an RME hazard quotient could not be calculated.

MCL = Maximum Contaminant Level.

MCLG = Maximum Contaminant Level Goal

Advisory = Health Advisory on Manganese (EPA-822-R-04-003; January 2004).

CNS = Central Nervous System.

PQL = Practical Quantification Limit.

As noted above, at the time that Interim Groundwater Cleanup Levels identified in the ROD, newly promulgated ARARs, and modified ARARs, which require higher standards for the remedy to remain protective have been achieved, a risk assessment shall be performed on the residual groundwater contamination to determine whether the remedy is protective at the points of compliance. This risk assessment of the residual groundwater contamination shall follow EPA procedures and will assess the cumulative carcinogenic and non-carcinogenic risks posed by ingestion and dermal absorption of groundwater and inhalation of VOCs from domestic water usage. At this Site, Interim Cleanup Levels must be met throughout the contaminated groundwater plume that extends from the former drum disposal area west-northwest into the adjacent Rockwood Brook wetland area. Compliance will be demonstrated by attainment of interim cleanup levels, or alternative protective levels as determined above, in all monitoring wells and area supply wells currently associated with the Site plume. EPA has estimated that the Interim Groundwater Cleanup Levels will be reached within 30 years after completion of the source control component.

Leachate Cleanup Levels

Without the maintenance of the LNAPL interceptor trenches at the Site, leachate migrating from the Site contains levels of contaminants that pose a potential future risk to young child and/or adult recreational users at the Site. Leachate PRGs based on RME human health risks were established. Risk estimates were calculated based on existing data and exposure parameters contained in the RI, FS, and risk assessment reports. Cleanup levels for chemicals of concern in leachate exhibiting an unacceptable cancer risk and/or hazard index have been established such that they are protective of human health. Leachate cleanup levels for known and suspect carcinogenic chemicals of concern (Classes A, B, and C compounds) have been set at a 10⁻⁶ excess cancer risk level considering exposures via dermal contact. Cleanup levels for chemicals of concern in leachate having non-carcinogenic effects were derived for the same exposure pathway(s) and correspond to an acceptable exposure level to which the human population (including sensitive subgroups) may be exposed without adverse affect during a lifetime or part of a lifetime, incorporating an adequate margin of safety (hazard quotient = 1).

Table L-2 summarizes the cleanup levels for carcinogenic and non-carcinogenic chemicals of concern in LNAPL-contaminated leachate protective of direct contact.

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Table L-2 Leachate Cleanup Levels for the Protection of Recreational Dermal Contact Exposures				
Carcinogenic Chemical of Concern	Cancer Classification	Interim Cleanup Level (ug/L)	Basis	RME Risk
bis(2-Ethylhexyl)phthalate	B2	40	Risk	1E-06
Non-Carcinogenic Chemical of Concern	Target Endpoint	Interim Cleanup Level (u/L)	Basis	RME Hazard Quotient
bis(2-Ethylhexyl)phthalate	Liver	40	Risk	0.01
Key HQ = Hazard Quotient. ug/L = micrograms per liter (equivalent to parts per billion).				

These leachate cleanup levels must be met at the completion of the remedial action at the point of compliance generally described as where leachate enters the adjacent Rockwood Brook wetlands. In addition, the leachate levels must be met without the maintenance of the LNAPL interceptor trenches. If the trenches must be maintained in order for cleanup levels to be met, this will not be considered compliance. The cleanup levels are consistent with ARARs for the leachate, attain EPA's risk management goals for remedial action, and are protective of human health.

M. STATUTORY DETERMINATIONS

The remedial action selected for implementation at the Troy Mills Landfill Site is consistent with CERCLA and, to the extent practicable, the NCP. The selected remedy is protective of human health and the environment, will comply with ARARs and is cost effective. In addition, the selected remedy utilizes permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable.

Based on the recent completion of a drum removal action by EPA's Removal Program, which eliminated the primary source of Site contamination; the remote location of the Site; the lack of current human health risks; and the relatively low levels of remaining contamination present, EPA concluded that it was impracticable to remove and treat the chemicals of concern in a cost-effective manner at the Site. Thus, the selected remedy does not satisfy the statutory preference for treatment as a principal element of the remedy.

1. The Selected Remedy is Protective of Human Health and the Environment

The remedy at this Site will adequately protect human health and the environment by eliminating, reducing or controlling exposures to human and environmental receptors through treatment, engineering controls and institutional controls. More specifically, the remedy will:

- 1) restore groundwater to drinking water standards through monitored natural attenuation;



GZA GeoEnvironmental, Inc.