SAMPLING AND ANALYSIS PLAN

Former LO-58 NIKE Missile Battery Launch Site, Caribou, Maine
FUDS Project No. D01ME007702
NAE Project No. 108313
Contract No. W912WJ19C0019
DTN: V-3002-092019-D




VERINA Consulting Group, LLC

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September 30, 2019

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CERTIFICATION

We hereby certify that the enclosed Sampling and Analysis Plan (SAP), shown and marked in this submittal, is that proposed to be incorporated into the US Army Corps of Engineers, New England District Contract Number W912WJ19C0019, Task Number 3.2. This plan has been prepared in accordance with the Performance Work Statement (PWS), dated April 3, 2019, for the Remedial Action and Long-Term Monitoring at former LO-58 NIKE Missile Battery Launch Site, Caribou, Maine, and is hereby submitted for Government Approval. This SAP will be updated, as appropriate, if any new information is found that would affect portions of this Plan. Changes to the SAP will be coordinated with CENAE for their concurrence.

Prepared By:

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ACRONYMS AND ABBREVIATIONS

AFNS	Acid Fueling/ Neutralization Station
AHA	Activity Hazard Analyses
AMAC	Adult Multiple Alternative Center
AMSL	Above Mean Sea Level
APH	Air-phase Petroleum Hydrocarbons
APP	Accident Prevention Plan
ARAR	Applicable or Relevant and Appropriate Requirements
AST	Above-ground Storage Tank
CENAE	Corps of Engineers, New England District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminants of Concern
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
CVOC	Chlorinated Volatile Organic Compound
DERP	Defense Environmental Restoration Program
DOD	Department of Defense
DRO	Diesel Range Organics
DUP	Duplicate
EB	Equipment Blank
EPA	Environmental Protection Agency
FS	Feasibility Study
ft	Feet
FUDS	Formerly Used Defense Site
GPR	Ground Penetrating Radar
GRO	Gasoline Range Organics
LTM	Long Term Monitoring
LTMP	Long Term Monitoring Program
MCLs	Maximum Contaminant Levels
MEDEP	Maine Department of Environmental Protection
MEFUDS	Maine Formerly Used Defense Site
MEG	Maximum Exposure Guidelines
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MW	Monitoring Well
NOBIS	Nobis Group
ORP	Oxidation Reduction Potential
PCBs	Polychlorinated Biphenyls
PID	Photoionization detector
POET	Point-of-Entry Treatment
PP	Priority Pollutant
PRG	Preliminary Remediation Goal
PSI	Preliminary Site Investigation
PWS	Performance Work Statement
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan

RI	Remedial Investigation
ROE	Rights of Entry
SAP	Sampling and Analysis Plan
SI	Site Investigations
SIM	Selective Ion Monitoring
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
SSHO	Site Health and Safety Officer
TB	Trip Blank
TCE	Trichloroethylene
TPH	Total Petroleum Hydrocarbons
UFP	Unified Federal Program
USACE	U.S. Army Corps of Engineers
USACE EM	U.S. Army Corps of Engineers Engineering Manual
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank
VERINA	Verina Consulting Group, LLC
VFW	Veterans of Foreign Wars
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbon

1.0 - BACKGROUND INFORMATION

1.1 - Project Background

This Sampling and Analysis Plan (SAP) summarizes the procedures and methods that will be used in the collection of field measurements and samples at the former LO-58 NIKE Missile Battery Launch Site located in Caribou, Maine (the LO-58 Site). This SAP has been prepared for the U.S. Army Corps of Engineers, North Atlantic Division, New England District (CENAE) under Contract Number W912WJ19C0019, Task Number 3.2 and was prepared in accordance with the April 3, 2019 CENAE Performance Work Statement (PWS). The work proposed in this SAP will be conducted pursuant to the Defense Environmental Restoration Program (DERP) - Formerly Used Defense Site (FUDS) Program.

The LO-58 Site is a 17-acre parcel of land located in Caribou, Maine. The property was acquired from the Town of Caribou in 1955 by the U.S. Government for the construction of a Nike missile launching facility. The LO-58 Site was deactivated by the Department of Defense (DOD) in 1966. Following its decommissioning as a military facility in 1969, the LO-58 Site was conveyed to the City of Caribou and used for storage of municipal property. In 1970, the property was purchased by the current owner, the Lister- Knowlton Veterans of Foreign Wars (VFW) Post 9389.

Based on the results of previous environmental investigations, the contaminants of concern (COCs) attributable to releases from the LO-58 Site are volatile organic compounds (VOCs) associated with fuels formerly used and stored at the LO-58 Site and chlorinated solvents associated with missile maintenance as well as manganese.

1.2 - Site Description

The former LO-58 Site is a 17-acre parcel of land located at 253 Van Buren Road (Route 1) in Caribou, Maine. The LO-58 Site is owned by the Lister-Knowlton Post #9389 VFW and is identified by the City of Caribou Assessor’s Office as Map 14/Lot 50. The entrance to the LO-58 Site from Van Buren Road is located at latitude 46º 52′ 55″ North and longitude 68º 0′ 38″ West. A Site location map is presented as Figure 1.

The LO-58 Site is located on a topographic high, east of Van Buren Road. Elevations at the LO-58 Site vary by approximately 60 ft, from approximately 540 ft above mean sea level (AMSL) at the former Barracks Building, which is located at the bottom of the hill near Van Buren Road, to approximately 600 ft above mean sea level (AMSL) at the former Launcher Area, which is situated at the topographic high for the property (Weston 2007).

Stormwater and snowmelt on the LO-58 Site either infiltrates the subsurface in unpaved portions or flows overland into catch basins and drainage swales. Following the topography at the LO-58 Site, surface water runoff flows generally north and northwest except from the former Barracks Building area where runoff flows downslope and eastward to a drainage swale behind the building. Catch basins and drainage swales direct surface water runoff from the LO-58 Site to a natural valley located between the former Barracks Building and the base of the hill below the former Test Building and Launcher Area, which directs surface water off of the property to the north (Weston 2007).

Unpaved areas of the LO-58 Site consist of grassland and shrub-scrub habitat, as early forest succession takes place in formerly mowed areas. There are no surface water bodies or wetlands present on the LO-58 Site (USFWS 2008). The nearest wetlands are located 0.18 mile to the northeast, within the floodplain of Hardwood Brook (USFWS 2008). Information from MEDEP and on-site observations do not indicate the presence of Significant Wildlife Habitat on the LO-58 Site or in its vicinity (MEDEP 2007). According to the Critical Natural Resources Map for the City of Caribou, Maine, there are no critical natural resource areas on the LO-58 Site. Note that such natural resource areas are reported along Hardwood Brook located approximately 0.5 miles north of the LO-58 Site (City of Caribou, Undated). Based on these results, it was concluded that there are no ecological receptors of particular significance on the LO-58 Site. However, there may be ecological receptors of particular significance in areas downgradient of the LO-58 Site (Weston 2011).

The LO-58 Site consists of the former NIKE missile launcher area, the former Engine, Generator, & Frequency Changer Building (Generator Building), the former Missile Assembly & Test Building (Test Building), the Acid Fueling/Neutralization Station (AFNS) and the former Barracks Building. The former Warhead Building was present at the LO-58 Site until the summer of 2006 when it was destroyed by fire. The former Generator Building has been expanded and is used by the Adult Multiple Alternative Center (AMAC) for an adult learning center. Aside from the former sentry station, the only other building that remains standing is the former Missile Assembly and Test Building. An abandoned 500-gallon fuel oil above ground storage tank (AST) is located behind the former Test Building. A concrete block building was demolished and a new storage building for AMAC was constructed west of the Test Building.

Municipal water supply and sanitary sewer are not available to the properties in the immediate vicinity of the LO-58 Site, municipal water supply in the area terminates at the Cary Medical Center, approximately 2,300 feet to the south along US Route 1. All properties in the area of the LO-58 Site are served by private drinking water wells and private septic systems. There are two drinking water supply wells on the LO-58 Site: DW-01 services the AMAC building and DW-02R services the VFW Building. DW-02R was recently installed as a replacement well for DW-02 and has yet to be sampled. The nearest off-site drinking water well is located at the Morin's Auto Detailing property, which abuts the LO-58 Site to the southwest. The drinking water well for this property is located approximately 750 ft west of the former Launcher Area (Weston 2007).

1.3 - Site Inspections and Cleanup Activities

According to available documents for the LO-58 Site, at least three site visits were performed between the mid-1980s and 1993 for the purpose of identifying environmental hazards associated with the former defense Site. Plans for the LO-58 Site indicated that three fuel storage tanks were originally at the facility and included:

- A 2,000-gallon underground storage tank (UST) associated with the former Barracks Building;
- A 500-gallon fuel oil above-ground storage tank (AST) located outside the former Missile Assembly Building; and,
- A 4,000-gallon fuel UST located adjacent to the southwest corner of the former Generator Building.

Records indicated that the 2,000-gallon UST had been removed. The 500-gallon AST had been utilized by a previous tenant at the property, and therefore was not eligible for removal under the DERP program. Also, there was no indication that the 4,000-gallon UST was still present at the property and was assumed to have been removed. Inspections also noted that the acid neutralization pit and refueling area were still in place but indicated that they posed no threat to the environment as hazardous materials and petroleum products are no longer present and required no further action.

The three missile silos at the LO-58 Site were closed by Mason and Maine Environmental Engineering Co. between August 1994 and October 1994. The closure of each missile silo included: the sampling of infiltrated water in the three silos and the laboratory analysis for polychlorinated biphenyls (PCBs) and flashpoint; removal and disposal of the water within the silos; removal and disposal of hydraulic systems; and capping the three silos with concrete planks. Topside silo closure demolition work consisted of removing several vent pipes, manholes, and bulkhead doors (Weston 2007).

CENAE has conducted a series of site investigations (SIs) at LO-58 Site to characterize soil and groundwater impacts. The narrative below describes the history of investigations subsequent to closure activities, including lists of the investigation reports and work plans related to these investigations.

In the fall of 1996, MEDEP responded to a complaint made by the current owner concerning odors in the water from the well serving the AMAC. Two rounds of groundwater sampling and analysis, using US Environmental Protection Agency (EPA) Method 8260, of well DW-01 by MEDEP documented and confirmed the presence of trichloroethylene (TCE). Thereafter, MEDEP immediately installed a point of entry treatment (POET) system (i.e., where the waterlines would enter the building) consisting of a dual granular activated carbon filtering system to remove organic contaminants in the drinking water and initiated a quarterly monitoring program. CENAE took over the maintenance and monitoring of the POET system at the AMAC Building in 2009.

During a site visit on May 21, 1998, MEDEP staff investigated an area located southwest of the former Generator Building (AMAC), where a 4,000-gallon UST was previously located during the time the LO-58 Site was in operation by the government. Although this tank had reportedly been removed, a magnetometer survey of the area detected a significant anomaly located approximately 3 ft east and 9 ft south of the southwest corner of the building. This magnetometer “hit” suggested that a large metallic object may still exist in this portion of the property. The results of a June 1999 ground-penetrating radar (GPR) survey indicated that the metallic response observed during the magnetometer survey by representatives of the MEDEP was not due to the presence of a UST.

Following the May 21, 1998 site visit, the drinking water well located adjacent to the VFW Post headquarters building (DW-02) was added to the ongoing quarterly monitoring program. Because this well is located topographically downhill from the area of known TCE contamination, it was added to the program as a precautionary measure. During the summer of 1998, a drinking water sample was collected from the VFW water supply well and analyzed for VOCs by EPA Method 8260. Analytical results of the sample indicated all analyzed compounds were not detectable at laboratory reporting limits.

In October 1998, representatives of Weston and MEDEP performed a walkover at the LO-58 Site to identify potential areas of concern regarding the release of process-related substances to the subsurface. During the LO-58 Site walk, several areas were identified as potential sources of contamination, including the former Launcher Area, the former AFNS, and the former Test Building. A Preliminary Site Investigation (PSI) was performed at the property in the summer of 1999 to evaluate subsurface conditions at the LO-58 Site. GPR and passive soil-gas surveys, as well as a Geoprobe® soil boring and soil sampling programs were conducted. The objective was to assess if the source of the TCE contamination detected in the on-site bedrock water supply well servicing the AMAC facility was due to former Department of Defense (DOD) activities during its operation of the property, and to assess if additional investigations are warranted. A passive soil-gas survey was initiated at the LO-58 Site on June 22, 1999. A total of 75 EMFLUX® soil-gas probes were installed on the LO-58 Site.

In October 1999, a Geoprobe® soil boring and soil sampling investigation was performed to characterize the LO-58 Site soils, determine the depth of the overburden groundwater table (if present), explore the depth to bedrock at the property, and sample potentially contaminated soil zones identified by the passive soil-gas survey. A total of 40 soil borings were advanced in the overburden at the LO-58 Site.

A supplemental SI was conducted between October 2000 and May 2001, to supplement the information obtained during the PSI. In addition to the information obtained during the PSI, MEDEP performed an investigation at the property in the spring of 2000 that indicated the presence of fuel-impacted soils in the vicinity of a former UST, which was reportedly removed in 1994. The objectives of the supplemental SI activities were to further evaluate the source of TCE in the on-site drinking water well, to obtain further information regarding hydrogeologic conditions in bedrock, and to fill data gaps caused by the premature removal of soil-gas probes by third parties during the PSI. The additional SI activities included: a Geoprobe® soil boring and soil sampling program; the installation of five bedrock groundwater monitoring wells; and the collection of soil, groundwater, and drinking water samples for laboratory analysis of VOCs, total petroleum hydrocarbons (TPH)-diesel-related organics (DRO), and TPH-gasoline-related organics (GRO).

Following these SIs, a long-term monitoring program (LTMP) for the Maine Formerly Used Defense Site (MEFUDS) program was developed. This monitoring program included not only the LO-58 Site but also the four additional MEFUDS locations. For the LO-58 Site, the LTMP included monitoring the two drinking water supply wells as well as five bedrock monitoring wells on a semi-annual basis for a period of at least 2 years to investigate whether a remedial action was required in accordance with MEDEP regulations. The MEDEP LTMP was conducted from 2002 to 2010.

Geologic, geophysical, and hydrophysical investigations were conducted at the LO-58 Site in May 2008. The purpose of the investigation was to gather additional site-specific hydrogeologic information to further refine the conceptual site model (CSM) related to groundwater flow (COLOG 2009).

A CERCLA compliant RI/FS was performed from 2012-2016 with the following findings:

- Soil, groundwater, soil gas, and indoor air have been impacted by releases of petroleum hydrocarbons and chlorinated solvents related to the historical operations of the LO-58 Site;

- Low levels of these contaminants have been identified in soil samples collected from across the LO-58 Site;

- Petroleum contamination in groundwater has been identified in MW-05, but differences in sampling methods (peristaltic pumping performed previously, and bladder pumps performed as part of the RI) does not allow for a direct comparison of results over time;

- The presence of petroleum contamination in the area near MW-05 may be promoting enhanced biological activity in the groundwater samples, thus contributing to elevated manganese concentrations reported in the well;

- No widespread source of soil contamination by chlorinated volatile organic compounds (CVOCs) has been identified by extensive soil sampling across the LO-58 Site;

- Two localized sources of CVOC contamination in soil have been identified at the LO-58 Site;

- Petroleum compounds and CVOCs have been detected in soil gas beneath the AMAC Building and in indoor air in the AMAC Building;

- Complete exposure pathways to human receptors exist for CVOCs in indoor air at the AMAC Building;

- Based on the observed concentrations of CVOC in groundwater and in indoor air at the AMAC Building, it did not appear likely that CVOCs present in indoor air originate in groundwater beneath the building but may be related to soils above the water table adjacent to the building;

- CVOCs and petroleum hydrocarbons have been detected in pre-treatment samples collected from the AMAC Building drinking water supply well (DW-01);

- Depth profiling of groundwater entering DW-01 indicates petroleum hydrocarbons and CVOCs infiltrate into the well at multiple depths through fractures observed in the well boring; and

- No evidence of site-specific contamination has been identified in the three other sampled drinking water supply wells that are located on downgradient abutting properties (DW-02 at the former Barracks Building, and 271 and 241 Van Buren Road.)

A decision document was issued for the Site in February of 2019. The decision document presented the selected remedial alternatives for the Site. For site groundwater the selected remedy included continued point of entry treatment for DW-01, institutional controls, monitored natural attenuation and long-term monitoring. For vapor intrusion the selected remedy includes active sub-slab vapor mitigation, institutional controls, and long-term monitoring. Efforts are currently in progress to implement the selected remedial alternatives as presented in the decision document and are detailed in Section 3 below.

2.0 - PROJECT ORGANIZATION AND RESPONSIBILITIES

The responsibilities of key individuals involved in the execution of the SAP are summarized in Table 2-1:

Table 2-1 – Key Project Personnel and Responsibilities

Project Personnel	Project Positions	Responsibilities
Julia Rupp	CENAE Project Manager (PM)	Project Manager for CENAE
Paul Young	CENAE Geologist	Supervises field activities
Katherine Miller	CENAE Chemist	Supervises laboratory analyses and data
Cynthia Auld	CENAE Risk Assessor	Risk oversight
Naji Alkadiss	MEDEP Project Manager	State regulatory oversight
Robert Gan	VERINA Program Manager and QA/QC Officer	QA/QC oversight of project execution.
Michael Hansen	VERINA Project Manager	Project and task Management.
Ryan Wheeler	VERINA Field Operations Leads and Site Safety and Health Officer (SSHO)	Field activities preparation and implementation, including health and safety aspects
Erik Hall	NOBIS Senior Engineer and Technical Lead	Work plan preparation and resources coordination.
Gary Glennon	NOBIS Chemist	Supervision of laboratory analyses and data management activities.
Gregory Lull	Katahdin Project Manager	Coordination of laboratory analytical services and analytical data management for the water samples.
Chris Anderson	Alpha Analytical Project Manager	Coordination of laboratory analytical services and analytical data management for the air samples.

3.0 - PROJECT SCOPE AND OBJECTIVES

3.1- Task Description

The following tasks summarized below will be conducted in order to collect necessary information in support of the development of the long-term monitoring plan for the LO-58 Site. These tasks include:

- Assessment of the condition of six (6) existing, on-site monitoring wells including one (1) overburden well and five (5) bedrock wells.
- Collection of one round of water level measurements from the six (6) on-site monitoring wells.
- Redevelopment of the five (5) bedrock monitoring wells.
- Collection of groundwater samples from five (5) bedrock wells via low-flow purging and sampling procedures to determine baseline conditions.
- Collection of drinking water samples from up to four (4) drinking water wells. Three samples will be collected from one drinking water well (DW-01): before the POET system, between the treatment vessels, and after the POET system (at the tap). Two samples will be collected from one drinking water well (DW-02R): before the POET system and after the POET system (at the tap). One sample will be collected from two off-site residential/business drinking water wells (DW-03 and DW-04) from the tap. Currently, access to wells DW-03 and DW-04 is pending approval.
- Installation of two new sub-slab sampling points, includes geophysical survey within the AMAC building to locate subsurface utilities prior to installation of sub-slab sampling points.
- Collection of vapor intrusion (VI) samples from the interior of the AMAC building, including three sub-slab samples, two indoor air samples, and one ambient air/background sample.

These tasks include mobilization and demobilization of personnel, equipment, and supplies.

Quality Assurance (QA)/Quality Control (QC) procedures are discussed in detail in the Quality Assurance Project Plan (QAPP) (VERINA 2019a) for the LO-58 Site.

Field activities will be conducted in order to complete the remedy/long term monitoring (LTM) phase of the project as detailed in the LO-58 Decision Document (USACE 2019).

3.2 - Applicable Regulations and Standards

Section 2.0 and Table 2-1 of the LO-58 Final Decision Document present the chemical, location, and action-specific Applicable or Relevant and Appropriate Requirements (ARARs) and Preliminary Remediation Goals (PRGs) for the LO-58 Site (USACE 2019). The ARARs and the PRGs are summarized as follows in Table 3-1 below.

Table 3-1 – Summary of ARARs and PRGs

Authority	Medium	Requirement	Status	Synopsis of Requirement	Actions to be Taken to Attain Requirement
Federal	Groundwater	National Primary Drinking Water Regulations (40 C.F.R. Part 141.616)	Relevant & Appropriate	These regulations establish Maximum Contaminant Levels (MCLs) for common organic and inorganic contaminants applicable to public drinking water supplies. MCLs are relevant and appropriate cleanup standards for aquifers and surface water bodies that are current or potential drinking water sources. Chemical of Concern included for this ARAR is TCE.	The selected groundwater remedy will comply with the ARAR by preventing current and future exposure to contaminants above MCLs.
Federal	Air	2019 Decision Document	Relevant & Appropriate	The Decision Document established risk based preliminary remediation goals (PRGs) for Site indoor air. These PRGs are relevant and appropriate as they have been established specifically for the Site Chemicals of Concern included for this ARAR are chloroform, naphthalene and TCE	The selected vapor intrusion remedy will comply with the ARAR by preventing current and future exposure to contaminants above PRGs.

Groundwater PRGs were established for TCE at 5 micrograms per liter (µg/L). The source for this PRG is the MCL.

Indoor Air PRGs were established for chloroform at 1.1 microgram per cubic meter (µg/m^3), naphthalene at 0.7 µg/m^3, and TCE at 2.0 µg/m^3. The source for these PRGs is risk-based.

3.3 - Project Schedule

The project schedule is presented in Appendix A.

4.0 - FIELD ACTIVITIES

Field activities will be conducted including the following:

- Mobilization and demobilization of personnel, equipment, and supplies;
- Assessment of the condition of 6 existing, on-site monitoring wells including one overburden well and five 5 bedrock wells;
- Collection of one round of water level measurements from the 6 on-site monitoring wells;
- Redevelopment of the 5 bedrock monitoring wells;
- Collection of baseline groundwater samples from the 5 bedrock monitoring wells via low-flow purging and sampling procedures;
- Collection of drinking water samples from 4 drinking water wells. Three samples will be collected from one drinking water well DW-01: before the POET system, between the treatment vessels, and after the POET system, two samples will be collected from one drinking water well DW-02R before and after the POET system, and one sample each will be collected from drinking water wells DW-03 and DW-04 at the tap;
- Installation of two new sub-slab sampling points, and a geophysical survey of the interior of the AMAC building to locate utilities prior to sub-slab sample point installation;
- Collection of vapor intrusion (VI) samples from the interior of the AMAC building, including three sub-slab soil vapor samples, two indoor air samples, and one ambient air/background sample.

4.1 - Mobilization/Demobilization

Prior to initiating field work, site personnel will review the LO-58 Site QAPP (VERINA 2019a) as well as the Accident Prevention Plan (APP) (VERINA 2019b) which includes the LO-58 Site Safety and Health Plan (SSHP) and Activity Hazard Analyses (AHA). A field team orientation meeting will be held prior to initiating investigation activities to familiarize field personnel with the scope of field activities and to draw attention to any potential health and safety hazards.

Prior to initiating field investigations, the sub-slab sampling locations will be pre-marked and DigSafe will be notified to identify underground utilities in the vicinity of the LO-58 Site. In addition, a private utility locator will provide additional on-site utility clearance in the area of the two new sub-slab monitoring locations. Equipment mobilization may include, but is not limited to, transporting and setting up the following:

- Health and safety equipment;
- Sample collection equipment;
- Sample shipping supplies;
- Decontamination equipment; and

- Subcontractor equipment.

Additionally, prior to any site activities including work such as reconnaissance, surveying, drilling, sampling existing wells, etc. permission shall be granted by the property owner(s) or designated representative. The signed Rights of Entry (ROE) by VFW was received in August 2019 (Expires August 2024). The ROE to the off-site residential/business properties will be acquired by the U.S. Army Corps of Engineers (USACE).

The following sections discuss the groundwater, drinking water, soil vapor, and air sampling to be performed at the LO-58 Site.

4.2 -Sampling Summary

Several types of samples will be collected at the LO-58 Site as part of the field activities, including groundwater, drinking water, indoor air and soil vapor samples. A sample will not be collected from sub-slab sample point SV-01. Table 4-1 presents a summary of the samples to be collected from the LO-58 Site.

Table 4-1 – Summary of Sample Collection

Sample ID	Matrix	Type	Analyte/ Analytical Group	Sampling SOP
AA-01-SeasonYYYY	Ambient Air	Air Canister	VOC Air	ENV-029
DW-01-TAP-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-01-TAP-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-01-TAP-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-01-AC-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-01-AC-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-01-AC-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-01-BC-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-01-BC-SeasonYYYY-MS	Drinking Water	MS/MSD	Metals	SA-012
DW-01-BC-SeasonYYYY-MSD	Drinking Water	MS/MSD	Metals	SA-012
DW-01-BC-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-01-BC-SeasonYYYY-MS	Drinking Water	MS/MSD	VOC	SA-012
DW-01-BC-SeasonYYYY-MSD	Drinking Water	MS/MSD	VOC	SA-012
DW-01-BC-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-01-BC-SeasonYYYY-MS	Drinking Water	MS/MSD	VPH	SA-012
DW-01-BC-SeasonYYYY-MSD	Drinking Water	MS/MSD	VPH	SA-012
DW-02R-EF-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-02R-EF-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-02R-EF-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-02R-IN-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-02R-IN-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-02R-IN-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-03-TAP-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-03-TAP-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-03-TAP-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-04-TAP-SeasonYYYY	Drinking Water	Grab	Metals	SA-012
DW-04-TAP-SeasonYYYY	Drinking Water	Grab	VOC	SA-012
DW-04-TAP-SeasonYYYY	Drinking Water	Grab	VPH	SA-012
DW-FD-SeasonYYYY	Drinking Water	Field Duplicate	VOC	SA-012
IA-01-SeasonYYYY	Indoor Air	Air Canister	VOC Air	ENV-029
IA-02-SeasonYYYY	Indoor Air	Air Canister	VOC Air	ENV-029
IA-FD-SeasonYYYY	Indoor Air	Field Duplicate	VOC Air	ENV-029

Sample ID	Matrix	Type	Analyte/ Analytical Group	Sampling SOP
MW-01-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	Metals	SA-003
MW-01-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VOC	SA-003
MW-01-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VPH	SA-003
MW-01-SeasonYYYY-MS	Groundwater	MS/MSD	Metals	SA-003
MW-01-SeasonYYYY-MS	Groundwater	MS/MSD	VOC	SA-003
MW-01-SeasonYYYY-MS	Groundwater	MS/MSD	VPH	SA-003
MW-01-SeasonYYYY-MSD	Groundwater	MS/MSD	Metals	SA-003
MW-01-SeasonYYYY-MSD	Groundwater	MS/MSD	VOC	SA-003
MW-01-SeasonYYYY-MSD	Groundwater	MS/MSD	VPH	SA-003
MW-02-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	Metals	SA-003
MW-02-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VOC	SA-003
MW-02-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VPH	SA-003
MW-03-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	Metals	SA-003
MW-03-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VOC	SA-003
MW-03-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VPH	SA-003
MW-04-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	Metals	SA-003
MW-04-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VOC	SA-003
MW-04-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VPH	SA-003
MW-05-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	Metals	SA-003

Sample ID	Matrix	Type	Analyte/ Analytical Group	Sampling SOP
MW-05-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VOC	SA-003
MW-05-SeasonYYYY	Groundwater	Low-Flow (Slow Purge) Groundwater Pumping	VPH	SA-003
MW-FD-SeasonYYYY	Groundwater	Field Duplicate	Metals	SA-003
MW-FD-SeasonYYYY	Groundwater	Field Duplicate	VOC	SA-003
MW-FD-SeasonYYYY	Groundwater	Field Duplicate	VPH	SA-003
SV-02-SeasonYYYY	Sub-slab Vapor	Air Canister	VOC Air	SV-001
SV-03-SeasonYYYY	Sub-slab Vapor	Air Canister	VOC Air	SV-001
SV-04-SeasonYYYY	Sub-slab Vapor	Air Canister	VOC Air	SV-001
SV-FD-SeasonYYYY	Sub-slab Vapor	Field Duplicate	VOC Air	SV-001

Notes:

IN indicates Influent, **EFF** indicates effluent, **BC** indicates before carbon treatment, **AC** indicates after carbon treatment, **MS** indicates matrix spike, **MSD** indicates matrix spike duplicate, **FD** indicates field duplicate.

4.3 - Groundwater

The five existing on-site bedrock monitoring wells will be redeveloped prior to well gauging and sampling activities. A static water level measurement will be conducted at the six existing on-site monitoring wells and groundwater sampling will be conducted on the five existing on-site bedrock monitoring wells. The following sections provide additional detail on the rationale and methods used in the groundwater investigations at the LO-58 Site.

4.3.1 - Rationale/Design

The results of the groundwater sampling will support the development of the LTM program at the LO-58 Site. The development of the LTM program may include the installation of up to four additional bedrock monitoring wells. Data collected from the existing five Site bedrock monitoring wells and the four supply wells will support the decision-making process as to the installation locations and depths of the additional bedrock wells. The collected data will also be used to develop sampling frequency and locations for the LTM program. The goal of the LTM program is to monitor the effectiveness of the POET systems and to monitor changes in groundwater chemistry and contaminant concentrations.

4.3.2 - Groundwater Sampling Locations

The initial assessment will determine the feasibility of sampling each monitoring well. If the well assessment indicates issues with the existing monitoring wells (cracking, displacement, etc.), recommendations for repair or abandonment will be provided by VERINA and plans will be made for well replacement, if required. With the discretion of the initial assessment, groundwater samples will be collected from the five existing on-site bedrock groundwater monitoring wells MW-01 through MW-05. The groundwater monitoring wells to be sampled are shown on Figure 2. Table 4-2 presents basic monitoring well information for the bedrock monitoring wells.

Table 4-2 – Summary of Bedrock Monitoring Well Information

Monitoring Well ID	Top of Casing Elevation (ft amsl)	Well Total Depth, measured (ft bmp)	Screened Interval Elevation (ft amsl)	Depth to Water, measured (ft bmp)	Groundwater Elevation (ft amsl)
MW-01	578.96	144.07	435.69 – 445.69	42.12	536.84
MW-02	590.13	61.93	527.76 – 537.76	45.41	544.72
MW-03	571.07	48.99	521.78 – 531.78	33.78	537.29
MW-04	605.84	83.11	522.75 – 532.75	53.57	552.27
MW-05	575.88	78.80	497.92 – 507.92	38.81	537.07

Notes:
1. Monitoring wells MW-01 through MW-05 were surveyed in May 2001 by Blackstone Land Surveying of Caribou, Maine.
2. The groundwater measurements were obtained on August 7, 2019.
3. ft bmp = feet below measuring point (top of casing)
4. ft amsl = feet above mean sea level

4.3.3 - Monitoring Well Development

Prior to sampling, the five existing on-site bedrock monitoring wells (MW-01 through MW-05) will be redeveloped using an inertial lift pump with a surge block. Well redevelopment will be performed in general accordance with USACE EM 1110-1-4000 by surging and pumping each well (SOP HYD-004; Appendix B). Depth to water and depth to bottom measurements will be collected from each monitoring well. The data will be used to plan well development activities. During well redevelopment geochemical parameters including temperature, specific conductivity, pH, dissolved oxygen, oxidation reduction potential (ORP), and turbidity will be recorded at a rate of once per five gallons of water purged form the well. The data will be used to determine when the well has been sufficiently developed. Generally, the well will be deemed sufficiently developed once two of the monitored geochemical parameters stabilize, and the turbidity is less than 5 NTUs or five standing well volumes have been purged, whichever occurs first.

4.3.4 - Groundwater Sample Collection and Laboratory Analysis

Groundwater samples will be collected in accordance with low flow sampling procedures outlined in USEPA Document Low Stress (Low Flow) Purging and Sampling Procedures and as presented in SOP SA-003 included in Appendix B). Groundwater samples will be submitted for laboratory analysis for VOCs by 8260, Volatile Petroleum Hydrocarbons (VPH [including target C9-C10 aromatics]), and 13 Priority Pollutant (PP) Metals plus manganese.

Analytical methods, quality control requirements, sample container details, and similar sampling details are included in the LO-58 Site QAPP (VERINA 2019a) (worksheets 1, 12, 18, 19 and 30, 20, 23, 24, 26, 27 and 28).

4.4 - Drinking Water Sampling

The following sections discuss the drinking water sampling activities to be performed at the LO-58 Site.

4.4.1 - Rationale/Design

In order to evaluate protectiveness of the selected remedy and the possible presence of site contamination in nearby residential water supply wells, drinking water samples will be collected from four drinking water wells at preexisting sample taps. Drinking water well covers will not be opened nor will the submersible pumps be removed. No instruments will be put inside the wells.

Three samples will be collected from DW-01: before the POET system, between the treatment vessels, and after the POET system. Two samples will be collected from DW-02R before and after the POET system. One sample will be collected from two drinking water wells at the tap, DW-03 and DW-04.

The locations of the drinking water wells are shown on Figure 2.

4.4.2 - Drinking Water Sampling Locations

Four drinking water supply wells will be sampled during the LO-58 Site investigations. DW-01 and DW-02R, located on-site, and DW-03 and DW-04, located off-site, will be sampled. DW-03 is located at a property southwest of the LO-58 Site and DW-04 is located at a property north of the LO-58 Site. Currently, access agreements for the sampling of DW-03 and DW-04 are still pending. Figure 2 shows the approximate locations of the drinking water wells.

4.4.3 - Sample Collection and Laboratory Analysis

Drinking water samples will be collected in accordance with the procedures outlined in SOP SA-012 included in Appendix B and locations will be purged for 20 minutes prior to sample collection. Samples collected from locations with POET systems will be sampled in reverse order of system flow (i.e. the samples at DW-01 would be collected in the following order: Tap, AC, BC) to reduce the potential for cross contamination as specified in SOP SA-012 included in Appendix B. Drinking water samples will be submitted for laboratory analysis for VOCs by 524.2, VPH (including target C9-C10 aromatics), and 13 PP Metals plus Manganese. Drinking water samples will be collected from the existing system sample ports and/or the tap, with no modifications of the drinking water system infrastructure to made to accomplish the sampling.

Analytical methods, quality control requirements, sample container details, and similar sampling details are included in the LO-58 Site QAPP (VERINA 2019a) (worksheets 1, 12, 18, 19 and 30, 20, 23, 24, 26, 27 and 28).

4.5 - Indoor Air and Sub-Slab Soil Vapor Sampling

The following sections discuss the indoor air and sub-slab vapor sampling investigation to be performed at the LO-58 Site.

4.5.1 - Rationale/Design

A summary of the indoor and sub-slab vapor samples to be collected at the LO-58 Site is presented in Table 4-1 above and on Figure 3. Indoor air and sub-slab soil vapor samples will be collected to establish baseline conditions to support the design of a sub-slab depressurization system to mitigate concentrations of COCs in the indoor air of the AMAC building. The sampling design includes sampling one existing vapor point (SV-02) and installation of two new sub-slab soil vapor sampling points (SV-03 and SV-04) located within the AMAC Building. The two additional sub-slab soil vapor samples will be located to provide acceptable geospatial coverage of the sub-slab environment. SV-03 is proposed to be installed in the men’s room and SV-04 is proposed to be installed in the kitchen/dining room, pending subsurface utility clearance. Two indoor air samples will be collected within the AMAC building, one will be collected in the OT room (IA-01), one will be collected in the living room (IA-02). Additionally, an ambient air sample (AA-01) will be collected from outside the AMAC building just north of the northwest corner.

Soil vapor samples will not be collected from beneath the “front room” (shown on Figure 3) of the AMAC Building due to the construction of a second wooden floor above the original building floor. The AMAC building is the result of several additions to the former generator building, the “front room” is part of the original generator building footprint, due to the original designed use of this part of the building a pipe trench may exist in this area. Because there is no information on the nature of the subfloor it would be difficult to interpret the results of sub-slab sampling in this area.

A soil vapor sample will not be collected from sub-slab vapor point SV-01. SV-01 is located in the northwest corner of the building close to the exterior walls, results from this location may not be representative of sub-slab conditions closer to the center of the building. A sample collected from SV-01 will not provide data suitable for the future design of a sub-slab vapor mitigation system. Additionally, SV-01 is not easily accessed currently due to the location of furnishings in the room.

4.5.2 - Indoor Air and Sub-Slab Vapor Sampling Locations

The proposed indoor air, ambient air, and sub-slab soil vapor sampling point locations are presented on Figure 3.

At each soil vapor sampling location, a permanent sub-slab soil vapor sample point will be installed by using a hammer drill to create a hole through the building slab and installing a Vapor Pin® within the hole.

4.5.3 - Sample Collection and Laboratory Analysis

Samples will be collected using Summa canisters in accordance with SOP ENV-029, included in Appendix B. Ambient air, indoor air and sub-slab soil vapor samples will be submitted for laboratory analysis for VOCs in air by TO-15 Selective Ion Monitoring (SIM). Batch certified Summa canisters equipped with calibrated regulators will be utilized to collect the samples. 6-liter canisters calibrated for a 8-hour sampling period will be used to collect the sub-slab soil vapor, indoor air and ambient air samples. A field duplicate soil vapor sample will be collected using a “T” splitter to connect two Summa canisters to a single soil vapor sampling point. This will permit simultaneous collection of two soil vapor samples from the same vapor sample point. The field duplicate for the indoor air samples will be collected from two unconnected canisters located next to each other. The field duplicate location will be selected based on PID screening readings collected from sub-slab vapor points, the location with the highest PID reading will be selected as the field duplicate. If PID readings are not conclusive SV-03 will be the field duplicate location. All air sampling will occur concurrently on the same day.

Prior to sub-slab vapor sampling, the integrity of the seal between the building slab and each of the Vapor Pin® sample points will be tested using an inert helium gas tracer test, during which time at least one soil vapor sample volume will be purged from each sampling point in accordance with the Sub-Slab Sampling SOP (SOP SV-001) included in Appendix B. Once the integrity of the seal is confirmed at a given sampling location, the soil vapor point will be screened using a PID able to read parts per billion by volume, this screening activity will also confirm the seal and direct the selection of the field duplicate location. Once the PID screening is complete the soil vapor sample will be collected.

To the extent feasible with minimal disturbance to facility flooring materials , the AMAC building will be inspected for possible sub-slab vapor preferential flow pathways. These will include utility penetrations of the slab (e.g., plumbing, electrical, etc.), cracks in the floor, seams, subfloor patching, etc.

At least 24 hours prior to initiating air sampling all materials that may contain compounds that may interfere with the indoor air sampling (i.e. cleaning products, correction fluids, medical products, etc.) will be removed. This material will be temporarily stored in the AMAC garage (located across the driveway from the AMAC building) for the duration of the air sampling events. The removed products will be cataloged. Additionally, the air purifier located in the living room area will be turned off at least 24 hours prior to the initiation of air sampling. It is anticipated that the indoor air sampling will be in October. The heating system will be operated during regular weekdays when the building is occupied or will be activated to maintain the temperature in the AMAC building at a normal level if the building is not occupied. Over the 8-hour sample collection period the heating system will be operated to create the same conditions as when the building is occupied if the sampling period occurs when the building is unoccupied.

Analytical methods, quality control requirements, sample container details, and similar sampling details are included in the LO-58 QAPP (VERINA 2019a) (worksheets 1, 12, 18, 19 and 30, 20, 23, 24, 26, 27 and 28).

4.6 - Sampling Equipment Decontamination

Decontamination is the process of removing contaminants that have accumulated on field and sampling equipment. Proper decontamination is essential in minimizing the transfer of harmful materials into clean areas, in the prevention of cross-contamination between samples due to the use of improperly decontaminated field sampling equipment, and in protecting workers from hazardous substances. Sampling equipment that may require decontamination includes but is not limited to the following: sub-slab sampling equipment and groundwater sampling equipment (pumps, meters, etc.) that is in contact with sample media. Equipment blanks are not anticipated to be collected due to the selected sampling methods using dedicated disposable materials to facilitate sample collection. Sampling equipment decontamination procedures are presented in SOP FS-004 in Appendix B. Dedicated and single use disposable equipment will not require decontamination, this includes but is not limited to sample tubing, soil vapor probes, inertial lift foot valves, and surge blocks.

5.0 - QUALITY ASSURANCE PROJECT PLAN

The Optimized Unified Federal Program (UFP) QAPP was prepared for the use of CENAE under Contract No. W912WJ19C0019, Task 3.3. The LO-58 QAPP was prepared in accordance with the March 2012 Intergovernmental Data Quality Task Force Uniform Federal Policy for Quality Assurance Project Plans; Optimized UFP-QAPP Worksheets Guidance. The optimized worksheets are presented in the LO-58 QAPP (VERINA 2019a) in numerical order beginning with Worksheet 1. A list of worksheets of the LO-58 QAPP (VERINA 2019a) as follows:

- Worksheets 1 and 2 – Title and Approval Page
- Worksheets 3 and 5 – Project Organization
- Worksheets 4, 7, and 8 – Personnel Qualifications and Sign-Off
- Worksheet 6 – Communication Pathways
- Worksheet 9 – Project Planning Session Summary
- Worksheet 10 – Conceptual Site Model/Project Goals
- Worksheet 11 – Project/Data Quality Objectives
- Worksheet 12 – Measurement Performance Criteria
- Worksheet 13 – Secondary Data Uses and Limitations
- Worksheets 14 and 16 – Sample Collection and Analysis Projects Tasks and Schedule
- Worksheet 15 – Project Action Limits and Lab-Specific Detection/Quantitation Limits
- Worksheet 17 – Sampling Design and Rationale
- Worksheet 18 – Sampling Locations and Methods
- Worksheets 19 and 30 – Fixed Lab Sample Containers, Preservation, and Hold Times
- Worksheet 20 – Field Sample and QC Sample Summary
- Worksheet 21 – Field Standard Operating Procedures
- Worksheet 22 – Field Equipment Calibration, Maintenance, Testing, and Inspection
- Worksheet 23 – Analytical SOP References
- Worksheet 24 – Analytical Instrument Calibration
- Worksheet 25 – Analytical Instrument and Equipment, Maintenance, Testing and Inspection
- Worksheets 26 and 27 – Sample Handling, Custody, and Disposal
- Worksheet 28 – Analytical Quality Control Samples and Corrective Actions
- Worksheet 29 – Project Documentation and Records
- Worksheets 31, 32, and 33 – Project Assessments and Corrective Actions
- Worksheet 34 – Data Verification and Validations Inputs
- Worksheet 35 – Data Verification Procedures
- Worksheet 36 – Data Validation Procedures
- Worksheet 37 – Data Usability Assessment

6.0 - FIELD OPERATIONS DOCUMENTATION

The following sections outline the procedures and methods that will be used to document field activities.

6.1 - Field Logbook, Sample Field Sheets and Daily Reports

A field logbook will be maintained by site personnel during all field activities. The logbook for field activities will be a bound book with consecutively-numbered, water-repellent pages. The front of each field logbook will contain the project name, project number, and date(s) of use. The logbook will contain a diary of all field activities performed at the LO-58 Site including but not limited to the following information:

- Date and time of personnel entries on site;
- Weather conditions and temperature;
- List of start/stop times of all subcontractors hired for activities such as surveying, drilling, geophysical surveys, etc.;
- List of the personnel present on site during each sampling day to include all personnel, subcontractors, and visitors;
- Documentation of the daily health and safety meeting;
- Results of inspections;
- Results of field testing;
- List of the equipment decontaminated along with a reference to the procedure used;
- List of any changes from standard operating procedures, decisions made in the field, and other pertinent information;
- QC samples associated with the samples collected, and QC sample collection procedures;
- Equipment and/or instrument identification numbers (if available) for those used;
- Sample preservation techniques performed;
- Air monitoring information gathered (e.g., PID readings, etc.);
- Samples collected using the same equipment as, and immediately after, equipment blank (if needed);
- Documentation of conversations with outside parties or case team members;
- Other logs/paperwork used to document activities;

- Instrument calibration information including the instruments calibrated during the day and the individual who performed the calibration (note: Instrument calibration information should be documented in the field logbook as well as on the instrument calibration log kept with each instrument and serving to document instrument response over time);

- List of the samples collected by media (i.e., soil, water, etc.); and

- Comments relative to any problem areas that occurred during the day's activities, their final resolution, and any anticipated impact on the outcome of the field investigation.

Any strikeouts will consist of one line through the word/phrase which will be initialed and dated. The data recorded in the field log books and on field sample sheets will be used to generate a daily report. A copy of a blank daily report is included as Appendix C.

6.2 - Photographic Records

The field team will photo document various on-site conditions and field activities as deemed necessary for the Task Order. Examples of items that may require photographic documentation include:

- General site topography;

- Physical location and appearance of environmental samples;

- Changes in site conditions; and

- Documentation of work procedures.

6.3 - Sample Documentation

Appropriate sample tracking and documentation procedures promote sample authenticity and defensibility. Sample tracking involves the designation of a unique sample number for each sample location that is carried through the shipping, analytical, and data reporting processes, so that analytical results can be attributed to a specific location with confidence. Custody procedures maintain sample integrity and the defensibility of the tracking system. All samples will be assigned a unique sample number.

6.3.1 - Sample Numbering System

Each sample collected will be assigned a unique sample tracking number, which will consist of three to four alphanumeric code segments, each separated by hyphens. The sample tracking number will identify the LO-58 Site, sample type or medium, location, sample depth (soil samples), or sampling date. QC sample designations will be added, as appropriate, following the nomenclature presented below. Other pertinent information regarding sample identification will be recorded in the field logbooks or on sample log sheets.

The sample tracking number format will be as follows:

Location - Season (Spring, Summer, Fall, Winter) Year (YYYY)

Examples of the sample tracking numbers for the various sample types are provided below:

- For groundwater and drinking water samples, the season and four-digit year will be used. For example, a groundwater sample collected from location MW-01 on October 1, 2019 would be designated as MW-01-Fall2019.

- For indoor air, ambient air and sub-slab vapor samples, the season and four-digit year will be used. For example, a subs-lab vapor sample collected from SV-02 on October 1, 2019 would be designated as SV-02-Fall2019; an indoor air sample collected from IA-01 on October 1, 2019 would be designated as IA-01-Fall2019; and, an ambient air vapor sample collected from AA-01 on October 1, 2019 would be designated as AA-01-Fall2019.

For QA/QC samples, the following codes will be applied:

- FD = Field Duplicate
- EB = Equipment Blank (If collected)
- TB = Trip Blank
- MS = Matrix Spike
- MSD = Matrix Spike Duplicate

For example, the first duplicate groundwater sample will be identified as: MW-FD-Fall2019.

The duplicate source will be recorded in the field data sheet. All pertinent descriptions to define each sample (measurements of sample locations and observations) will be noted on the sample log sheet and/or the logbook.

6.3.2 - Sample Labels

Sample labels will be completed in the field during sample collection. Sample labels will include the following information:

- Project name;
- Project number;
- Sample identification as specified in Section 6.3.1;
- Sample date;
- Sample time;
- Required laboratory analysis;
- Preservative information; and
- Field personnel initials.

6.3.3 - Chain-of-Custody Records

Chains-of-custody will be generated in FUDSChem. Chain-of-custody records will document the possession, handling, and location of samples, and data from sample collection through reporting.

6.4 - Documentation Procedures/Data Management and Retention

All written documentation must be recorded in permanent ink. Each logbook page will be initialed and dated at the end of the day. Empty space on each page will be struck out prior to initialing. Corrections to errors in documentation or recorded calculations will be made by first striking out the error with a single line so as not to obliterate the original entry. Then the replacement entry or value will be inserted where appropriate. The person originating the change will initial and date each separate change.

7.0 - SAMPLE PACKAGING AND SHIPPING REQUIREMENTS

Field samples and QC samples are to be placed in sample containers, preserved, and shall meet holding times required by the analytical method and specified in the QAPP. Table 7-1 summarizes the sample containers, preservation, and holding time for each analyte or analytical group.

Table 7-1 – Sample Containers, Preservation, and Hold Times

Analyte/Analytical Group	Matrix	Method/SOP	Container(s) (number, size, and type per sample)	Preservation	Analytical Holding Time
Metals	Water	SW6020 (A)/SA-003	1x 600 mL PTFE, plastic	HNO_3 to pH < 2	180 Days
VOC Air	Air	TO15 (A)/ENV-029 and SV-001	1x Leak-free stainless-steel pressure vessels, with valve and specially prepared interior surfaces	None	30 Days
Volatile Organic Compounds	Water	E524.2 (A)/SA-012	3x 40 mL Vials with PTFE lined Septum Caps	Cool to 4 ± 2 ºC.	14 Days
Volatile Organic Compounds	Water	SW8260C (A)/SA-003	3x 40 mL Vials with PTFE lined Septum Caps	HCL to pH < 2, Cool to 4ºC ± 2 ºC	14 Days
Volatile Petroleum Hydrocarbons	Water	MADEPVP (A)/SA-003	1x 2X40-mL vials w/Teflon lined septa screw caps	Add 3 to 4 drops of 1:1 HCL to pH < 2, Cool to 4ºC ± 2 ºC	14 Days

Sample packaging, shipping, and chain-of-custody are to follow included SOP SH-001 and the guidelines as listed in DoD Environmental Field Sampling Handbook, April 2013. Samples will be packaged and shipped in general accordance with the following guidelines:

- Samples will be placed on ice in appropriate containers immediately following collection;
- Shipping coolers will be made of appropriate material, non-damaged coolers;
- Empty spaces in coolers will be filled with inert packing material;
- Any bottles will be placed in clean plastic bags;
- Appropriate labels and or tags will be taped to the sample jars;
- Precautions will be taken to avoid breaking of any glass bottles including packaging technique and the use of bubble wrap or packing paper materials;
- Sealed bags of ice will be placed in coolers where needed;
- The cooler drain will be sealed;

- Summa canisters will be prepared for shipment to the off-site laboratory by closing the sample valve, removing all regulators and enclosing the canisters in a rigid shipping container;
- Chain-of-custody and other required documentation will be placed in a plastic bag and taped to the inside lid of the shipping container;
- If high concentrations are suspected, this information will be included on the chain-of-custody for the laboratory; and
- Appropriate shipping documentation, labels and warning stickers will be attached to the outside of the shipping container.

The samples taken for this project are to be considered low-level or environmental samples for packaging and shipping purposes.

The water samples will be shipped to Katahdin Analytical Services laboratory in Scarborough, Maine via sample courier or dropped off at the lab by field personnel, and the air samples will be shipped to Alpha Analytical Inc. in Westborough Massachusetts via sample courier or FedEx.

8.0 - INVESTIGATION DERIVED WASTE MANAGEMENT

The water produced during well redevelopment and groundwater sampling will be initially contained for observation and if, as expected, there is no visual or olfactory evidence of impacts the water will be returned to the ground in the vicinity of the well from which it was removed. If contamination is observed (i.e. sheen, odor, product, high PID readings) the purge water will be containerized until proper waste disposal characterization can be performed. PID readings will be monitored in the breathing zone during well development activities, if elevated readings are sustained over the action limit established in the APP work will cease until engineering controls are enacted or a PPE upgrade is performed. Eye protection should be worn at all times during well development and groundwater sampling activities. Caution should be used around the high lift pump during well development to limit the risk of potential injury caused by moving pump arm.

Other IDW likely to be generated includes discarded PPE. Unless impacted by gross contamination the PPE can be disposed of as municipal solid waste.

9.0 - REFERENCES

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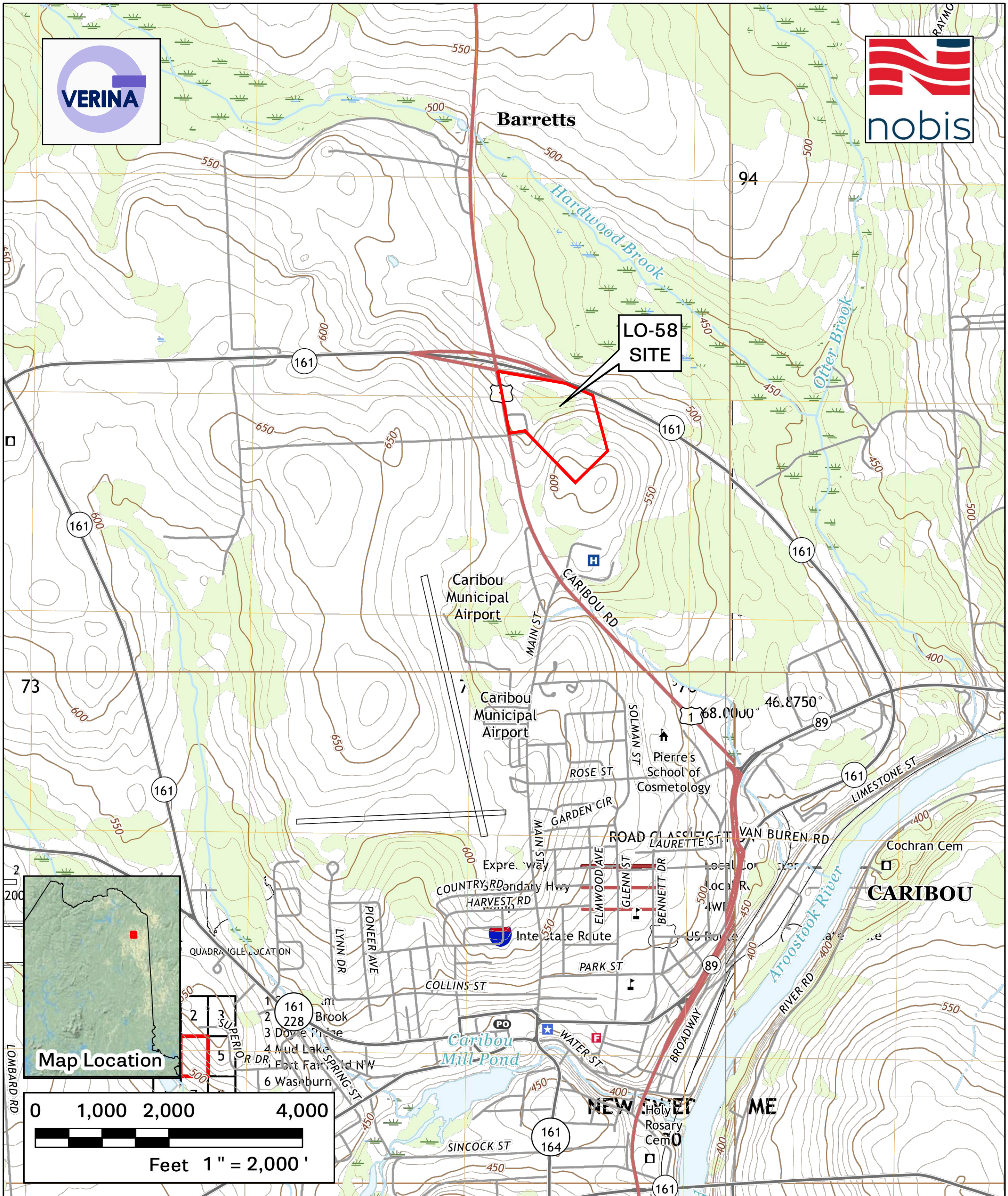
Figures



USGS TOPOGRAPHIC MAP
NEW SWEDEN, ME
1983 REVISED 2017

N

US Army Corps of Engineers
New England District

FIGURE 1

SITE LOCUS
FORMER LO-58
NIKE BATTERY LAUNCH SITE
CARIBOU, MAINE

PREPARED BY: CMS	CHECKED BY: RPW
PROJECT NO.: 2102.0100	DATE: OCTOBER 3, 2019

\\server01\Shared\JOBFILES\2102-ACOE-NE District\2102.0100 - Caribou, ME - W912WJ19C0019\CAD\2102.0100-RLM-00.dwg LAYOUT: RLM SAVED: 10/3/2019 2:33 PM BY: CLAUDIO STABILE

Notes:

1. Site Plan was developed from a Corps of Engineer's Survey dated May 2006, and observations made by Nobis. Aerial Photography from Maine Geolibrary (photo date 2003).

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- Overburden Well
- Bedrock Well
- Drinking Water Supply Well
- Site Boundary

VERINA
nobis

0 75 150 300
Feet
1 inch = 150 feet

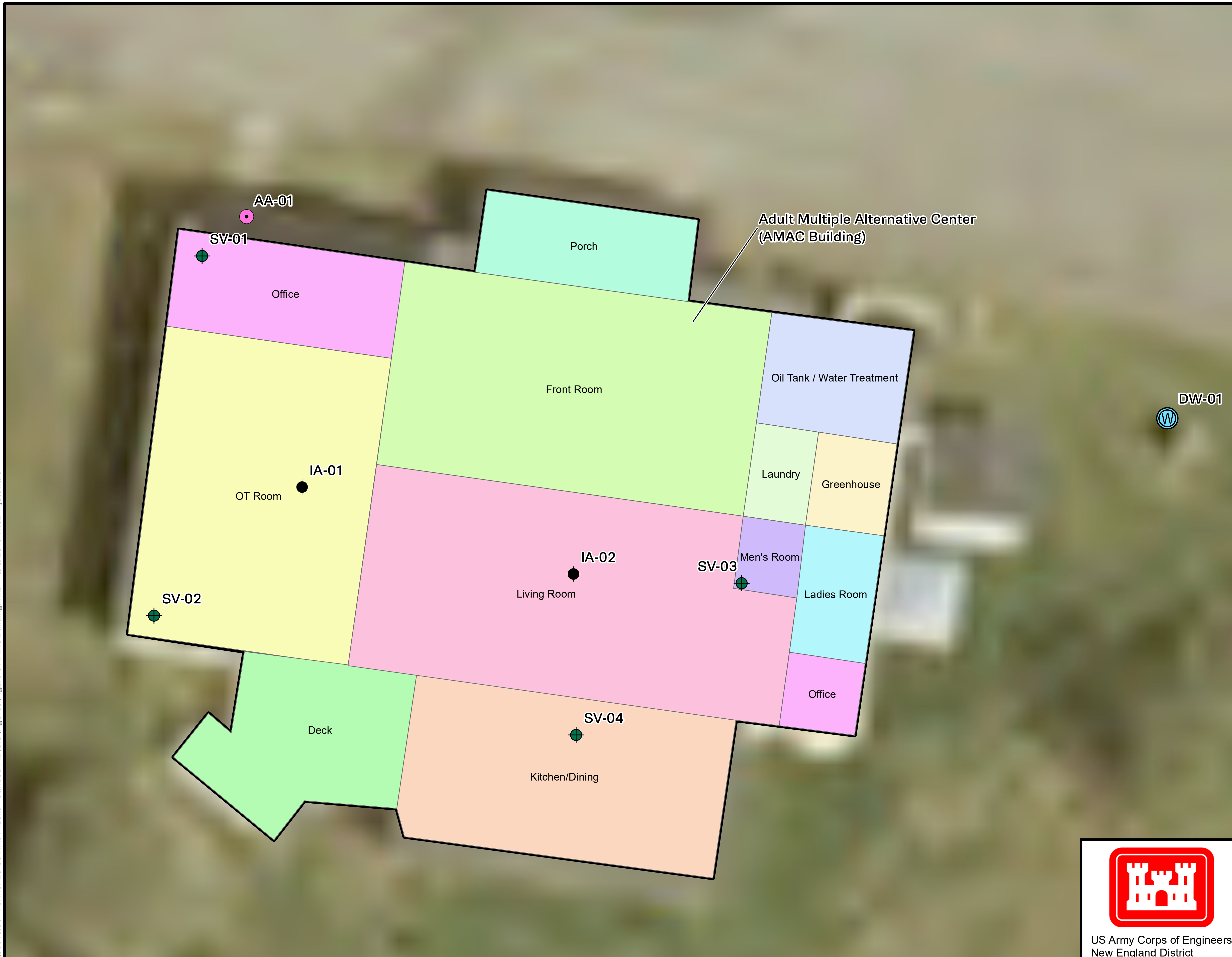
N

US Army Corps of Engineers
New England District

FIGURE 2
SITE PLAN
FORMER LO-58
NIKE BATTERY LAUNCH SITE
CARIBOU, MAINE

PREPARED BY: JRS	CHECKED BY: EH
PROJECT NO. 96010.00	DATE: JULY 2019

J:\96010.00 - Former LO-58 Nike Missile - Caribou ME\GIS\Figures\Figure 2 Site Sketch.mxd 8/8/2019 11:58 jstewart



Notes:

1. Site Plan was developed from a Corps of Engineer's Survey dated May 2006, and observations made by Nobis. Aerial Photography from Maine Geolibrary (photo date 2003).

2. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- Ambient Air Sample Location
- Indoor Air Sample Location
- Sub-Slab Vapor Sample Location
- Drinking Water Supply Well
- Deck
- Front Room
- Greenhouse
- Kitchen/Dining
- Ladies Room
- Laundry
- Living Room
- Men's Room
- OT Room
- Office
- Oil Tank / Water Treatment
- Porch

VERINA

nobis

0 5 10 20

Feet

1 inch = 10 feet

N

US Army Corps of Engineers
New England District

FIGURE 3

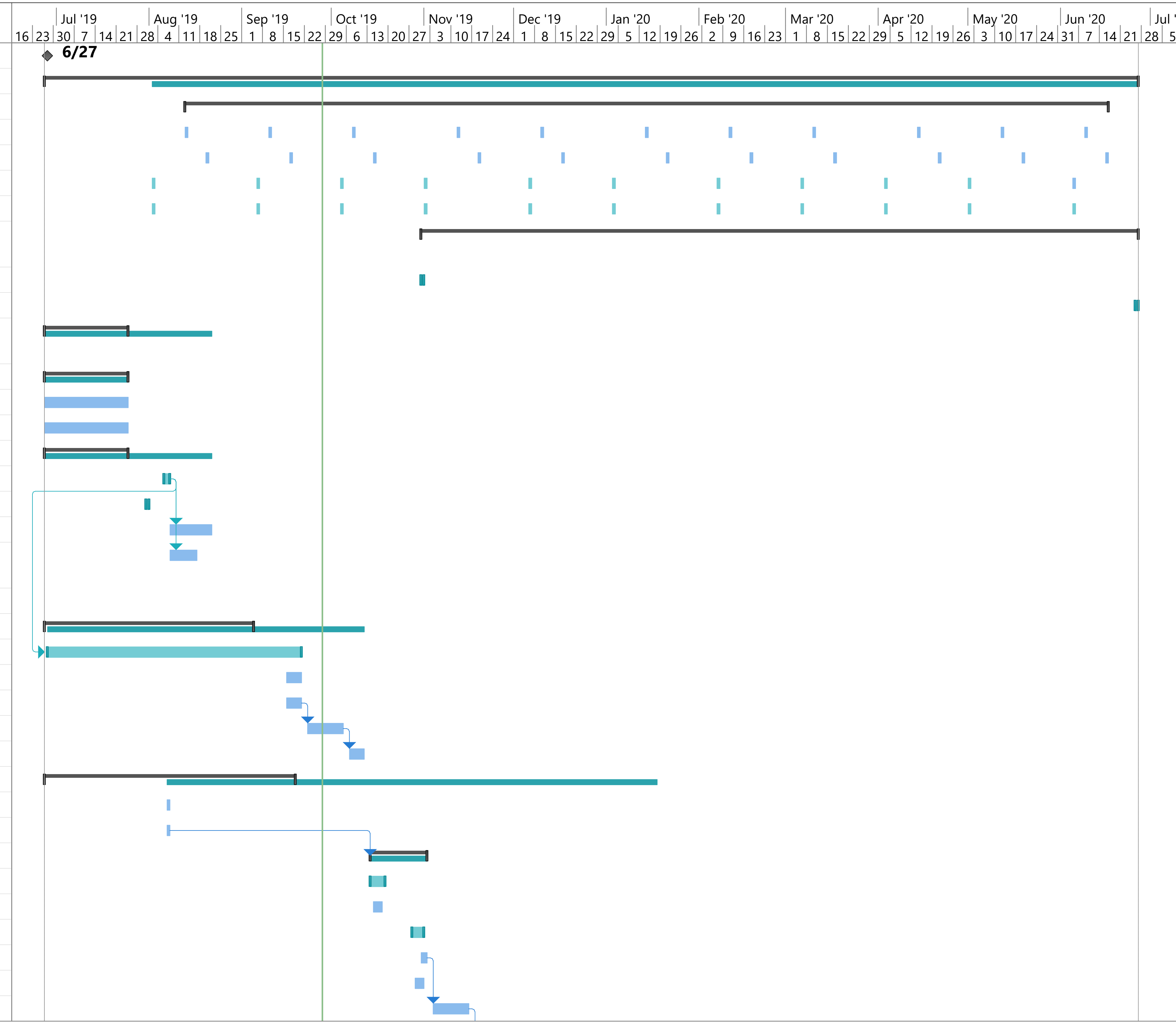
AMAC BUILDING
FORMER LO-58
NIKE BATTERY LAUNCH SITE
CARIBOU, MAINE

PREPARED BY: JRS	CHECKED BY: EH
PROJECT NO. 96010.00	DATE: AUGUST 2019

J:\96010.00 - Former LO-58 Nike Missile - Caribou ME\GIS\Figures\Figure 3 AMAC Building.mxd 8/8/2019 11:52 jstewart

Appendix A

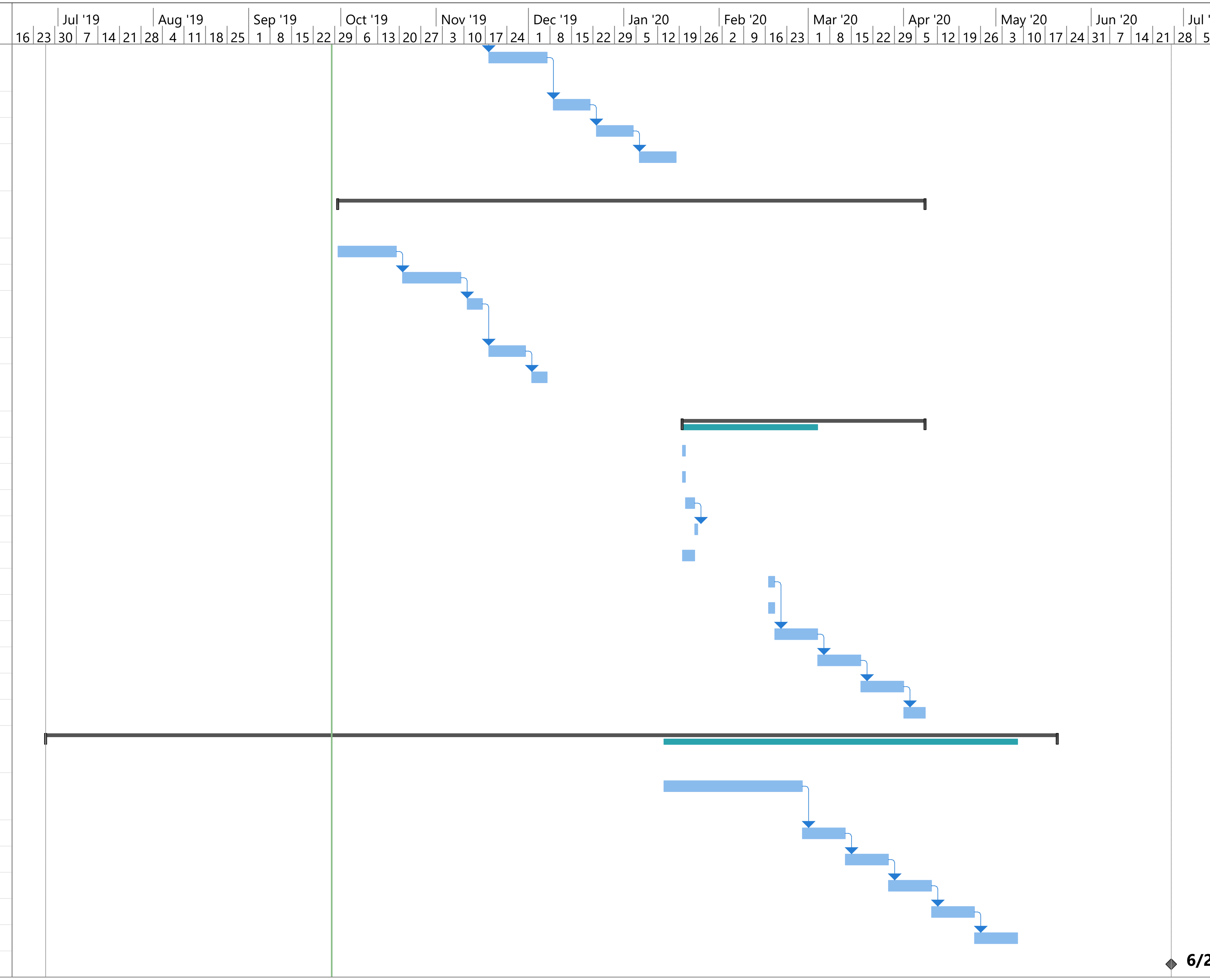
ID	Task Name	Duration	Start	Finish
1	Notice to Proceed	1 day	Thu 6/27/19	Thu 6/27/19
2	**Project and Financial Management**	**52.8 wks**	**Thu 6/27/19**	**Fri 6/26/20**
3	**Project Teleconferences and Meeting**	**223 days**	**Tue 8/13/19**	**Tue 6/16/20**
4	**Meeting/Call Agenda**	**218 days**	**Tue 8/13/19**	**Tue 6/9/20**
16	**Meeting Minutes**	**218 days**	**Tue 8/20/19**	**Tue 6/16/20**
28	**Progress Invoice**	**223 days**	**Fri 8/2/19**	**Fri 6/5/20**
40	**Monthly Status Report**	**223 days**	**Fri 8/2/19**	**Fri 6/5/20**
52	**Contractor Manpower Reporting Application (CMRA)**	**172 days**	**Thu 10/31/19**	**Fri 6/26/20**
53	CMRA #1	1 day	Thu 10/31/19	Thu 10/31/19
54	CMRA #2	1 day	Fri 6/26/20	Fri 6/26/20
55	**Review of Existing Project Files, Project Kick-off Meeting and Site Visit**	**4 wks?**	**Thu 6/27/19**	**Wed 7/24/19**
56	**Review Existing Data**	**4 wks**	**Thu 6/27/19**	**Wed 7/24/19**
57	E-Copies from USACE	4 wks	Thu 6/27/19	Wed 7/24/19
58	Hard Copies from USACE	4 wks	Thu 6/27/19	Wed 7/24/19
59	**Project Coordination Meeting**	**4 wks?**	**Thu 6/27/19**	**Wed 7/24/19**
60	Held At Site	2 days	Tue 8/6/19	Wed 8/7/19
61	Prepare Materials and Agenda	1 day	Wed 7/31/19	Wed 7/31/19
62	Develop Daily Field Checklist	2 wks	Thu 8/8/19	Wed 8/21/19
63	Meeting Minutes/Site Walk Observation Summary	7 days	Thu 8/8/19	Fri 8/16/19
64	(3) Additional Meetings on Site Issue			
65	**Develop Project Plans**	**10 wks**	**Thu 6/27/19**	**Wed 9/4/19**
66	Combined Health and Safety Plan (HAS	12.6 wks	Thu 6/27/19	Fri 9/20/19
67	Sampling and Analysis Plan	1 wk	Mon 9/16/19	Fri 9/20/19
68	Quality Assurance Project Plan	1 wk	Mon 9/16/19	Fri 9/20/19
69	Awaiting USACE Review	2 wks	Mon 9/23/19	Fri 10/4/19
70	Finalization	1 wk	Mon 10/7/19	Fri 10/11/19
71	**Well Assessment and Baseline Sampling**	**12.4 wks**	**Thu 6/27/19**	**Wed 9/18/19**
72	Assessment	1 day	Wed 8/7/19	Wed 8/7/19
73	Water Level Readings	1 day	Wed 8/7/19	Wed 8/7/19
74	**Baseline Sampling**	**3 wks**	**Mon 10/14/19**	**Fri 11/1/19**
75	Redevelopment (If Necessary)	1 wk	Mon 10/14/19	Fri 10/18/19
76	**Daily Field Checklists**	**5 days**	**Mon 10/14/19**	**Fri 10/18/19**
80	Bedrock Well Sampling	4 days	Mon 10/28/19	Thu 10/31/19
81	Drinking Water Well Sampling	2 days	Thu 10/31/19	Fri 11/1/19
82	**Daily Field Checklists**	**5 days**	**Mon 10/28/19**	**Fri 11/1/19**
86	Laboratory Analysis	2 wks	Mon 11/4/19	Fri 11/15/19



Project: LO-58 Project Schedule
Date: Sat 9/28/19

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

ID	Task Name	Duration	Start	Finish
87	Well Assessment and Baseline Sampling Report	3 wks	Mon 11/18/19	Fri 12/6/19
88	Await USACE Comments	2 wks	Mon 12/9/19	Fri 12/20/19
89	Response to USACE Comments	2 wks	Mon 12/23/19	Fri 1/3/20
90	Finalize Well Assessment and Baseline Sampling Report	2 wks	Mon 1/6/20	Fri 1/17/20
91	**Sub-Slab Vapor Mitigation System Installation**	**137 days**	**Mon 9/30/19**	**Tue 4/7/20**
92	Remedial Action Work Plan	15 days	Mon 9/30/19	Fri 10/18/19
93	Await USACE Comments	3 wks	Mon 10/21/19	Fri 11/8/19
94	Response to USACE Comments / Final Draft Submittal to USACE and MEDEP	1 wk	Mon 11/11/19	Fri 11/15/19
95	USACE / MEDEP Review	2 wks	Mon 11/18/19	Fri 11/29/19
96	Finalize and Submit Remedial Action Work Plan	1 wk	Mon 12/2/19	Fri 12/6/19
97	**System Installation**	**57 days**	**Mon 1/20/20**	**Tue 4/7/20**
98	Geophysical Survey	1 day	Mon 1/20/20	Mon 1/20/20
99	Baseline VI Sampling	1 day	Mon 1/20/20	Mon 1/20/20
100	Installation	3 days	Tue 1/21/20	Thu 1/23/20
101	System Startup	1 day	Fri 1/24/20	Fri 1/24/20
102	**Daily Field Checklists**	**5 days**	**Mon 1/20/20**	**Fri 1/24/20**
107	Performance Monitoring Sampling	2 days	Mon 2/17/20	Tue 2/18/20
108	**Daily Field Checklists**	**2 days**	**Mon 2/17/20**	**Tue 2/18/20**
111	Laboratory Analysis	2 wks	Wed 2/19/20	Tue 3/3/20
112	Vapor Mitigation Installation Report	2 wks	Wed 3/4/20	Tue 3/17/20
113	Await USACE Comments	2 wks	Wed 3/18/20	Tue 3/31/20
114	Final Vapor Mitigation Installation Repo	1 wk	Wed 4/1/20	Tue 4/7/20
115	**Long Term Monitoring Plan and Associated Tasks**	**47.4 wks**	**Thu 6/27/19**	**Wed 5/20/20**
116	Long Term Monitoring Plan Draft to USACE	6.6 wks	Tue 1/14/20	Thu 2/27/20
117	Await USACE Comments	2 wks	Fri 2/28/20	Thu 3/12/20
118	RTC	2 wks	Fri 3/13/20	Thu 3/26/20
119	Complete Final Draft	2 wks	Fri 3/27/20	Thu 4/9/20
120	Stakeholder Review	2 wks	Fri 4/10/20	Thu 4/23/20
121	Final Long Term Monitoring Plan	2 wks	Fri 4/24/20	Thu 5/7/20
122	Project Completion	1 day	Fri 6/26/20	Fri 6/26/20



Project: LO-58 Project Schedule
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Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
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Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

Appendix B

1.0 SCOPE, APPLICATION, AND LIMITATIONS

This Standard Operating Procedure (SOP) establishes a methodology for the collection of volatile organic compound (VOC) samples from ambient air, soil gas, or other atmospheres. The method is based on samples collected as whole air samples in Summa® passivated stainless steel canisters. The samples are subsequently separated by gas chromatography and measured by mass-selective detector or multidetector techniques. This method presents procedures for sampling into canisters at final pressures below atmospheric pressure (referred to as sub-atmospheric pressure sampling).

This method is applicable to specific VOCs that have been tested and determined stable when stored in sub-atmospheric conditions. These compounds are measured at the parts per billion by volume level. Applicable analytical methods (TO-14A and TO-15) for VOCs will be specified in the project Work Plan, Site Specific Quality Assurance Plan, etc.

2.0 INTRODUCTION

The sub-atmospheric pressure sampling mode uses an initially-evacuated canister. This mode may also use a flow controller such as a critical orifice, capillary, or adjustable micrometering valve to regulate flow. With this configuration, a sample of ambient air, soil gas, or other atmosphere is drawn through a sampling train comprised of components that regulate the rate and duration of sampling into a pre-evacuated passivated Summa canister.

There are two common types of sampling: grab sampling and time-integrated sampling. When collecting a grab sample, the canister valve is opened and the vacuum inside the canister draws in a sample in as little as a few seconds. The collection of time-integrated samples requires an additional piece of equipment calibrated by the laboratory (typically a critical orifice). The critical orifice assembly will be placed in-line to the canister and will have been selected for a flow rate that will result in a user-defined sample collection period of up to 24 hours without allowing the pressure in the canister to equilibrate to the ambient air pressure (i.e., the canister remains under vacuum at end of the sample collection period).

The size of the Summa canisters to be used will be determined based on the project-specific data quality objectives. Common sizes for Summa canisters range from 0.4 Liter or 6 Liter volumes. For samples of ambient air, communicate to the laboratory what the sampling period will be. For samples of soil gas, the laboratory will need to know the required project-specific flow rate (typically between 100 and 200 milliliters per minute [mL/min], and not exceeding 200 mL/min).

At very low flow rates, an in-line filter may be used to prevent blockage of the critical orifice by dust or other debris. The laboratory will typically determine the need for, and provide, the filter assembly.

3.0 DEFINITIONS

EPA	Environmental Protection Agency
FOL	Field Operations Leader
HASP	Health and Safety Plan
OSHA	Occupation Safety and Health Administration
PM	project manager
PPE	personal protective equipment
PSI	pounds per square inch
SOP	standard operating procedure
VOC	volatile organic compound

4.0 CAUTIONS

When working with potentially hazardous materials, follow U.S. Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA), and the safety practices as outlined in the site-specific health and safety plan (HASP).

Canisters are under vacuum pressure, and should not be dented or punctured in order to maintain sample integrity. They should be stored in a cool, dry place. Canisters should always be transported or stored in the shipping boxes provided by the laboratory.

5.0 PERSONNEL QUALIFICATIONS

Personnel collecting samples using this method should be familiar with this SOP and the particular equipment to be used to facilitate sampling and troubleshooting equipment problems more efficiently. Because equipment can vary between laboratories, refer to the laboratory's canister handling instructions for product-specific details.

All field samplers are required to take the 40-hour OSHA health and safety training and annual 8-hour refresher courses prior to engaging in any field collection activities.

6.0 EQUIPMENT AND SUPPLIES

- Summa Canister
- Flow controller assembly
- Filter assembly
- Gauge Assembly
- Tubing, typically ¼-inch outside diameter, PTFE (a.k.a. Teflon®)
- Adjustable wrenches

- Extra ferrules
- Field log book
- Field data sheet
- Personal Protective Equipment (PPE), as specified in the site-specific HASP

7.0 PROCEDURES

7.1 Office Preparation and Mobilization

Contamination may occur in the sampling system if canisters are not properly cleaned before use. Additionally, all other equipment with which the sample stream will come into contact (i.e., flow controllers, gauge assemblies, etc.) should be thoroughly cleaned. All cleaning should be completed by a qualified laboratory. Based on project-specific needs, the laboratory can be requested to complete either a certified cleaning of each individual canister or a batch-certified cleaning. The cleaning certification needs will be based on Data Quality Objectives that are typically specified in the project Work Plan, Site Specific Quality Assurance Project Plan, etc.

Summa canister sampling components are shipped in a disassembled state from the laboratory. Canister sampling components will be assembled at the office or at the site prior to sample collection activities.

7.2 Field Procedures

- Sub-atmospheric Sampling

  1) Prior to sample collection; complete the appropriate information on the field data sheet included as Attachment 1. Enter the sample designation and all other appropriate information on the canister tag/label.

  2) The Summa canister may be used to collect grab samples (i.e., 10-20 seconds or 10 minutes) or time-integrated samples (i.e., 8, 12, or 24 hours). Sampling duration depends upon the degree to which the flow is restricted.

  3) Install the flow controller and gauge assemblies onto the canister, which is evacuated to 28-30 inches of mercury at sea level and open the canister valve to the atmosphere to be sampled. Record the start time and the gauge reading immediately before and after opening the valve. In general, for time integrated samples, no movement of the indicator needle on the pressure gauge should be evident. If the needle moves fast enough that movement can be seen, there may be a problem with the flow controller.

  4) When the sample collection period is complete, record the time and final vacuum on the field data sheet included in Attachment 1 and close the canister valve. During time-integrated sampling it is advisable to perform periodic inspections of the remaining negative pressure in the canister to ensure that the canister does not approach neutral prematurely. Also, record the gauge reading after closing the canister valve. In some cases, it may be necessary to shorten the sampling period slightly to ensure that there is negative pressure remaining in the Summa canister. The canister should not be allowed to equilibrate to atmospheric pressure during the sampling period.

5) If there is no measureable vacuum remaining in the canister, the canister may have equilibrated to the ambient air. This has the potential for sample loss. However, the gauge provided by the laboratory for use in the field is generally considered to be less accurate than the pressure gauges used by the laboratory. In some cases, it may be necessary to instruct the laboratory to analyze the sample only if a vacuum remains in the canister. In these instances, it may be appropriate to request that the laboratory report the vacuum pressure remaining in the canister.

- Ambient Air Sampling

1) Prior to locating a sampling location, determine the prevailing wind direction using a wind sock or ribbon (surveyor's flag is sufficient). Using this information, identify the location(s) for sample collection.

2) Construct a protective cover for the Summa canister and inlet. The cover should protect the sampling apparatus from excessive solar, wind, and precipitation effects that may have the potential to influence the sample collection and results. An umbrella or portable canopy can be used. The Summa canister should be placed on the ground surface or on a stable platform to avoid tipping or other physical disturbances.

3) Install a rod in the ground or attach the rod to an existing object such as a utility pole, fence post, monitoring well standpipe, etc. as a support for sample collection tubing. Tubing size will vary depending on the dimensions of the regulator; however, it is typical for the regulators to come with ¼ inch NPT threaded connections. Check that all connections are tight and that air cannot enter or escape from the unions. Teflon thread sealant should be used to ensure a tight fit at threaded connections; barbed and push-to-lock fittings can also be used, as appropriate. Use sufficient tubing to extend from the ground surface (or the surface that the Summa canister is placed on) to the desired elevation for sample collection. This elevation is typically within the breathing zone of approximately five to six feet above the ground surface. Refer to the attached Figure 1 for a diagram of the sampling assembly.

4) Once the sampling apparatus is configured follow the procedures for sub-atmospheric sampling outlined above.

- Process Vapor Sampling

1) Process vapor sampling pertains to collection of vapor/air samples from a treatment system (e.g., soil vapor extraction, dual-phase extraction, air-stripping, etc.).

2) Identify the sampling points and assign an identifier (if not already completed). Ensure that the sampling point is sealed properly. Sampling points will often be installed by drilling into PVC piping that carries the vapor/air, tapping the drilled hole, and threading a valved-fitting into the pipe. These threaded connections should have Teflon® thread sealant.

3) Identify the nearest valves before and following the sampling point, relative to the direction of air flow in the treatment system. Isolate the sampling point by closing each of the identified valves simultaneously to trap a "core" of air/vapor to be sampled. Perform

appropriate shut-down procedures on the treatment system and lock-out/tag-out, as necessary.

4) In cases where the treatment system, under vacuum, cannot be shutdown or isolating the process line is not practical, the sample may be collected first into a tedlar bag using a high vacuum double diaphragm pump (KnF brand or equilvalent) with Teflon or Viton® seals due to the potential corrosive nature of the process vapors. The Summa canister is then filled from the tedlar bag.

5) Tedlar bags should be dedicated to individual sample locations where possible and flushed with 1 volume of ambient or zero air and 1 volume of process air prior to collecting the process sample. Teflon or Teflon-ined tubing is preferred. Silicone tubing is acceptable but should be changed out frequently due to the potential of attack from corrosive process vapors.

6) A photo-ionization detector/flame ionization detector (PID/FID) reading of the process vapor should be obtained immediately before or after filling the Summa canister for correlation to the laboratory analytical results. In addition, the PID/FID reading should be noted on the chain-of custody (COC).

7) Connect the Summa canister regulator to the sampling point using the appropriately sized tubing. Check that all connections are tight and prevent air from entering and/or escaping from the connections.

8) Follow the sub-atmospheric sampling procedure described above.

7.3 Data and Records Management

The Summa Canister Sampling Log Sheet (included as Attachment 1) will be completed for every sampling event. Record of the sampling event(s) will also be documented in the site log book by the sampler or FOL.

Completed Field Log Sheets will be transmitted to the PM, and maintained as part of the project file.

7.4 Communication and Technical Direction

Any problems or issues encountered during the sampling event(s) shall be discussed with the PM in order to determine an appropriate solution. Any changes in scope or deviation will be confirmed with and approved by the PM.

7.5 Demobilization

Following the completion of sample collection activities, Summa canisters will be disassembled and shipped under chain-of-custody controls to a pre-determined laboratory for analysis. Sample holding times (when established) will not be exceeded.

8.0 QUALITY CONTROL/QUALITY ASSURANCE

The following general quality assurance procedures apply:

- All data must be documented on standard chain of custody forms, field data sheets, and within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the laboratory or manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

9.0 REFERENCES

U.S. Environmental Protection Agency; Compendium of ERT Air Sampling Procedures, PB92-963406, May 1992.

U.S. Environmental Protection Agency. Summa Canister Sampling. SOP #1704, Revision 0.1, July 27, 1995.

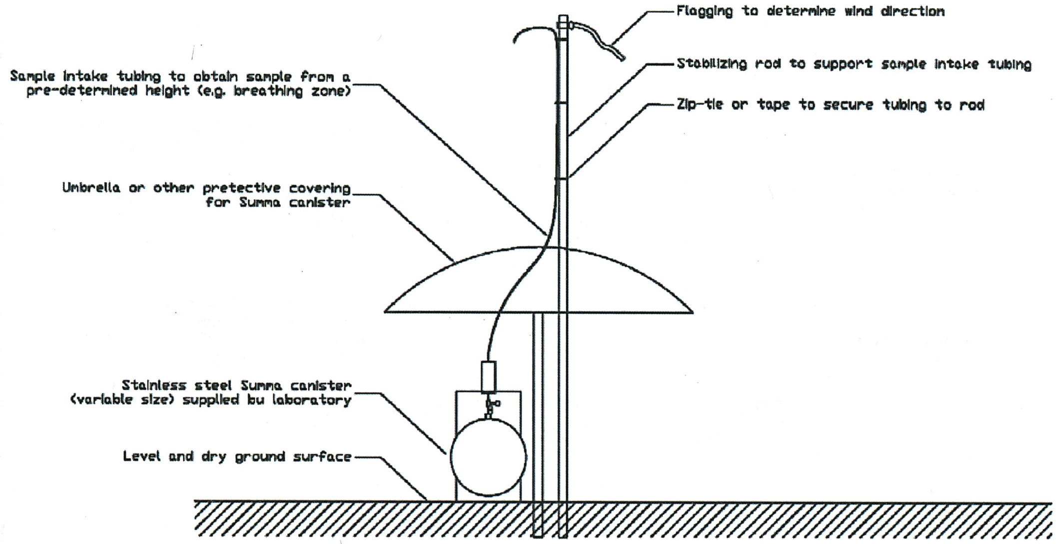

FIGURE 1

AMBIENT AIR SUMMA CANISTER SET-UP DETAIL

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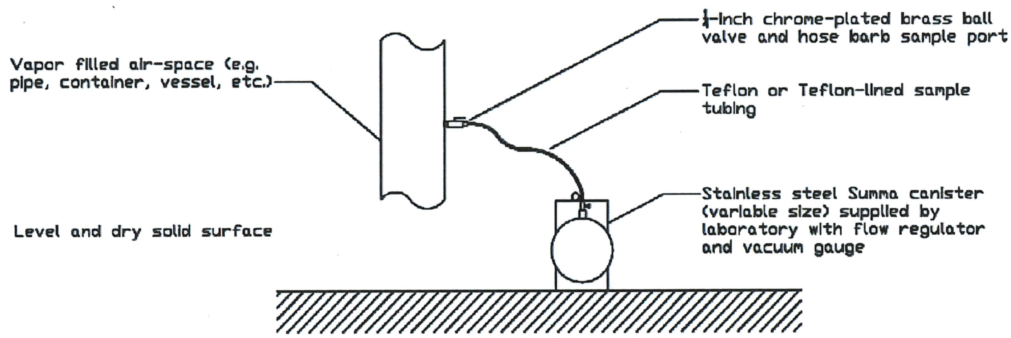

FIGURE 2

PROCESS VAPOR SUMMA CANISTER SET-UP DETAIL

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Attachment 1
Summa Canister Field Log Sheet

Nobis Engineering, Inc.	SUMMA® CANISTER SAMPLING LOG SHEET	SOP No: ENV-029 Page: of Date: Apr. 2009 Rev.: 01 Prepared by: Approved by:

Site Name: ______________________ Temperature Range: __________

Project Number/Task: ______________________ Precipitation: __________

Personnel: ______________________ Wind Speed/Direction: __________

EQUIPMENT INFORMATION

Type of Monitoring Equipment (circle): PID / FID / Other

Make & Model: ______________________ Latest Calibration Date: __________

Serial No.: ______________________ Nobis No.: __________

FIELD DATA

Sample #				
Location				
Canister ID - S/N				
Canister Size (Liters)				
Can Cleaning Certification: Batch or Individual				
Gauge S/N				
Orifice Used - S/N				
Analysis/Method				
Gauge reading before valve opened				
Date/Time (Start)				
Gauge reading immediately after valve opened				
Gauge reading before valve closed				
Date/Time (Stop)				
Gauge reading after valved closed				
Total Time				

COMMENTS:

Signature: ______________________

1.0 SCOPE, APPLICATION, AND LIMITATIONS

This procedure sets forth protocols for decontamination of environmental sampling equipment, which may include at a minimum: drilling sampling equipment (e.g., split spoons and direct-push tooling), hand augers, scoops, bowls, sample tubing, pumps, and bailers. Specific contaminants or conditions may require a more-refined or aggressive approach to equipment decontamination.

2.0 INTRODUCTION

This Standard Operating Procedure (SOP) has been prepared by Nobis Engineering, Inc. (Nobis) to provide a framework for decontaminating environmental sampling equipment.

3.0 DEFINITIONS

(IDW) – Investigation Derived Waste is waste that needs to be sampled and sent to a laboratory in order to be characterized for appropriate disposal off-site.

(MSDS) – Material Safety Data Sheets include important information and characteristics about chemicals and compounds and are helpful when human contact with the material occurs, or creates a dangerous situation.

(FOL) – Field Operation Lead ensures compliance with the Site work, regulatory compliance, quality, and the safety of employees working on the Site.

(QA/QC Officer) – The Quality Control and Quality Assurance officer ensures that SOPs are followed, and addresses issues with equipment anomalies or malfunctions.

4.0 CAUTIONS

The Nobis personnel should be equipped with appropriate personal protective equipment (PPE), including protective eyewear and/or face shield, nitrile gloves, tyvek suit (only as Site specified). The site-specific health and safety plan (HASP) will document the PPE required for the Site and activity.

Avoid inhalation, skin contact, eye contact, or ingestion of hazardous materials and contaminants. If skin contact occurs, remove the contaminated clothing immediately. Wash the affected areas thoroughly with large amounts of water. If inhalation, eye contact, or ingestion occurs, consult the MSDS for prompt action, and in all cases seek medical attention immediately

5.0 PERSONNEL QUALIFICATIONS

Nobis personnel should be trained on decontamination procedures by experienced Nobis personnel.

6.0 EQUIPMENT AND SUPPLIES

- Detergent soap (Alconox)
- Deionized Water
- Solvent (e.g., isopropanol, methanol, hexane)
- Nitric acid solution
- Potable water
- Drip pans/buckets
- Brushes
- Polyethylene sheeting
- Spray bottles
- Pump sprayers
- Paper towels
- Temporary storage container for the decontamination liquid (IDW)

7.0 PROCEDURES

7.1 OFFICE PREPARATION AND MOBILIZATION

Prior to field work, ensure that appropriate equipment and supplies are acquired prior to leaving for the Site.

7.2 FIELD PROCEDURES

- Table 1 provides a basic description of common decontamination fluids and their respective uses. Whenever site-specific contamination is known, a specialized decontamination procedure may be developed.
- Prior to completion of sampling, gross contamination of the sampling equipment should be removed at the sample collection site, and managed appropriately.
- Contaminated sample collection equipment to be decontaminated should be brought to a centralized decontamination station or pad, which should be lined with plastic sheeting to prevent decontamination solutions and/or contamination from contacting the ground surface. If possible, the station or pad should contain drip pans or buckets at each stage of the process to collect dripping decontamination fluids. For larger pads, the pad should be sloped such that water drains to a sump area for removal and containerization.

Table 1
Decontamination Fluids and Their Applications

FLUIDS	TYPICALLY USED	APPLICATIONS
Potable Water	Tap water	All-purpose rinse
Distilled/Deionized Water	deionized/distilled/ contaminant free water	All-purpose rinse
Low-phosphate detergent	10% solution	All-purpose cleaning
Sodium Carbonate	10% solution	Neutralize acids and bases
Trisodium Phosphate	10% solution	Organic compounds (including PCBs)

Calcium Hypochlorite	10% solution	"Disinfectant, oxidizes pesticides, fungicides, chlorinated phenols, dioxins, cyanides, ammonia, and other non-acidic inorganic wastes."
Hydrochloric, Nitric acids	10% solution	Heavy metals
Citric, tantaric, oxalic acid/salts	5% solution	Inorganic bases, alkali and caustic wastes
Organic Solvents	Concentrated	Organic compounds with poor solubility (e.g., oil and grease)

Notes: Adapted from ASTM D5088-02 Table 1 Applications of Various Solutions for Decontamination of Field Equipment

- A typical decontamination station and procedure for decontaminating soil or other solid-matrix sample collection equipment includes the following steps:
  - Wash and scrub using detergent, potable water, and brushes as necessary.
  - When using a pump sprayer and potable water, rinse the soap and gross contamination from the equipment.
  - Using a pesticide-grade isopropanol solution in a spray bottle, rinse the equipment thoroughly, with drippings collected in a drip pan or bucket.
  - A 10% nitric acid solution may be utilized if sampling is to consist of trace metals analysis. It should be noted that nitric acid on stainless-steel may cause inadvertent leaching of the steel into the acid.
  - If organic contamination (such as oils/greases, polychlorinated biphenyls, or other extractable organic compounds) is suspected, the use of an additional solvent in accordance with Table 1 should be considered.
  - Rinse the equipment with deionized water
  - Allow sampling equipment to air dry to the extent possible
  - Wrap the equipment with aluminum foil for storage

- A typical decontamination station and procedure for decontaminating monitoring well sample collection equipment includes the following steps:
  - To the extent possible purge water should be removed from the equipment prior to decontamination.
  - Scrub the exterior of the equipment using brushes, potable water, and soap.
  - Immerse the pump into a container of soapy water, and pump a sufficient amount of water through the pump to completely flush the equipment (and tubing if needed).
  - Remove the equipment from the soap and water, and immerse it into a container of tap water. Operate the pump for a sufficient length of time to remove all soap and water from the system (i.e., until clear).
  - Rinse the equipment with pesticide-grade isopropanol.
  - Immerse the equipment into a container of deionized water and flush the system until all solvent and residual soap is removed.
  - Allow all components to dry.
  - Wrap the equipment with aluminum foil and/or plastic storage bag.

- Equipment utilized during the collection of groundwater samples, but not actually involved in the collection of the sample (such as a water level meter, water quality meter sonde/flow-through cell) should be rinsed with soapy water, followed by a deionized water rinse and wipe-down.

All used decontamination solutions should be handled in accordance with project planning documents. In general, these fluids are contained as investigation-derived wastes (IDW), and transported/disposed of in accordance with applicable Local, State, and Federal regulations. This is particularly important when decontamination IDW includes solvents such as acids, methanol, acetone, and/or hexane.

At the end of equipment use, rinse and decontaminate all components and store in its case. If there are any issues with the piece of the equipment, leave a note regarding the problem with the unit to alert the rental company upon return.

7.3 DATA RECORDS AND MANAGEMENT

Not applicable to this SOP.

7.4 COMMUNICATION AND TECHNICAL DIRECTION

If any problems, health and safety issues concerns, or incidents occur, the Field Operations Leader (FOL) and Health and Safety Officer must be contacted. Follow up will occur in adherence to the HASP. If deviations from this SOP or site-specific quality assurance project plan (QAPP) are made in the equipment decontamination process, documentation of these deviations must be made in the field log and communicated to the Project Manager and Lead Chemist.

8.0 QUALITY CONTROL / QUALITY ASSURANCE

After completing decontamination activities on field equipment, a visual evaluation shall be completed to assess the overall effectiveness of the procedure in removing gross-level contamination (i.e., remnants of soil or other obvious indication of possible contamination).

Another commonly-applied practice is the collection of equipment rinse blanks. These samples are collected using a variety of methods, but all involve the use of high-purity water that is rinsed through/over the decontaminated field equipment in an effort to determine the overall effectiveness of the decontamination procedures. These samples should not be used in lieu of the visual inspection due to the fact the results of these samples may not be available for several days, if not weeks. Often, by that time, the field effort is completed, and no improvements on decontamination procedures can be made. The need for and method for collecting these samples should be included in project planning documents.

9.0 REFERENCES

- USEPA Environmental Response Team, 2004, USEPA Sampling Equipment Decontamination, SOP 006.

- U.S.EPA Region 9 Laboratory, Richmond, California, 1999. Field Sampling Guidance Document #1230 Sampling Equipment Decontamination.

1.0 SCOPE, APPLICATION, AND LIMITATIONS

This Standard Operating Procedure (SOP) has been prepared by Nobis Engineering, Inc. (Nobis) to specify the means and methods required to perform development of boreholes, newly-installed monitoring wells, or monitoring wells that require redevelopment after long periods of inactivity. This procedure includes the minimum required steps and quality checks that employees and subcontractors are to follow when using this technique.

The objective of well development is to enhance the hydraulic connection between the well screen and the natural formation or fill by removing fine soil material or drill cuttings within or adjacent to the well and subsequently rearranging the natural or artificial sand filter pack around the well. Well development is also necessary in order to remove fluids introduced during drilling or installation of the monitoring well. Well development may increase the hydraulic conductivity in the vicinity of the well screen. Appropriate mechanical rearrangement of the sand or gravel pack will allow the ground water to move through the sand pack more easily and reduce the amount of fines that enter the well. Reduction of groundwater turbidity will thereby reduce the chance of chemical alteration of groundwater samples caused by suspended sediments.

Care should be taken not to overdevelop the monitoring wells. Overdevelopment can potentially damage the well or cause well screens to become plugged with fine soil material.

2.0 INTRODUCTION

Two development techniques have been identified for use at the discretion of the Nobis Project Manager and technical lead. The methods are as follows:

- mechanical surging with a rubber surge block; and
- over-pumping using a submersible pump.

Mechanical surging is a technique that involves the use of a tool called a surge block. The device first forces water within the well through the well screen and out into the formation, and then pulls water back through the screen into the well along with fine soil and rock particles.

Over-pumping with a submersible pump involves pumping at a faster rate than the well would normally be pumped or purged for sample collection. The intent of over-pumping is to increase the hydraulic gradient near the well by drawing the water level down to as low a level as possible. The steepened hydraulic gradient increases the velocity of the groundwater moving through the screen into the well. The increased velocity will move residual fine soil or rock particles into the well and clear the well screen of this material.

While not generally encouraged, bailing can be used to develop monitoring wells if mechanical surging or over-pumping methods are not available or impracticable.

3.0 DEFINITIONS

EPA - U.S. Environmental Protection Agency

HASP - health and safety plan

HAZWOPER - hazardous waste operations and emergency response

OSHA - Occupational Safety and Health Administration

PM - Project Manager

PPE - personal protective equipment

SOP - standard operating procedure

4.0 CAUTIONS

When working with potentially hazardous materials, follow EPA, OSHA, and the safety practices as outlined in the site-specific HASP.

Each of the well development techniques described above has drawbacks that should be noted and avoided whenever possible. They are listed below:

- Mechanical Surging
  - Vigorous surging may cause damage to non-metallic well screens;
  - May cause the formation around the screen to become clogged by pushing fines back into the formation, reducing flow into the well;
  - If the surge block fits too tightly in the well casing, the surge block can damage the well screen; and
  - May remove sufficient formation material outside and above the well screen causing the seal to collapse, resulting in infiltration of overlying aquifer material.
- Over-pumping
  - If the permeability is quite high or quite variable, only a limited section of the screened zone may actually be developed, especially in wells with long screens;
  - Over-pumping may compact finer sediments around borehole and screen, restricting groundwater flow into the screen. If this happens it may be difficult to correct;
  - May result in an unstable formation around the well screen (i.e. bridging of fines may allow formation of voids around coarser-grained materials); and
  - At contaminated sites, over-pumping may produce a large volume of contaminated purge water that must be disposed of as a hazardous waste.
- Bailing
  - This method is slow, and not effective in adequately removing suspended sediments.

5.0 PERSONNEL QUALIFICATIONS

Personnel using this method should be familiar with this SOP and the particular equipment to be used to facilitate troubleshooting equipment problems more efficiently.

All field personnel at waste sites are required to receive 40 hours of basic hazardous waste operations and emergency response (HAZWOPER) training as prescribed by OSHA. This training must be refreshed annually with an 8-hour refresher course.

6.0 EQUIPMENT AND SUPPLIES

- Surge block or submersible pump (depending on method being used)
- Tubing
- Water level meter
- Graduated container to collect and measure purge water (e.g., 55-gallon drum or adequately sized tank)
- Multi-parameter or individual parameter water quality monitoring instruments to collect at a minimum pH, temperature, and specific conductivity.
- Turbidimeter or graduated Imhoff cones
- Field book
- Watch or stopwatch
- Field data sheets
- Personal protective equipment (PPE), as specified in the site-specific HASP

7.0 PROCEDURES

7.1 Office Preparation and Mobilization

All equipment that will be placed in the monitoring well must be decontaminated prior to beginning development activities. Decontamination of equipment will also occur between every monitoring well, when multiple wells are being developed.

7.2 Field Procedures

Prior to beginning development, the well will be sounded for total depth and static water level. Total depth will be compared to as built details to determine potential depth of sediment within the well or blockage of well screen. All development will begin gradually by gently surging or pumping from the top of the water column and gradually increasing in intensity while advancing through the water column and down the length of the well screen until the bottom of the well is reached. If mechanical surging is employed, fine material mobilized from the formation should be removed by pumping or bailing the well at a frequency determined by the technical lead.

For each well, development will include, if possible, removal of all of the water lost during installation. During the development of the wells, conductivity, pH, temperature will be monitored using a multi-parameter water quality monitoring instrument (or alternately individual parameter gauges/probes) an appropriate frequency as determined by the technical lead . If practical, the well development procedure will be continued until two of these parameters stabilize, or until at least five

(5) times the well volume has been removed. Stabilization is considered to be achieved after three consecutive readings are within 10 percent. Turbidity will also be monitored at an appropriate frequency as determined by the technical lead using either a turbidimeter or graduated Imhoff cone until stabilized values below 5 NTUs are recorded.

In the event that stabilization cannot be achieved after the removal of five well volumes, the technical lead should be notified and asked to provide direction regarding the appropriate completion of development.

During the well development, the purge rate and recharge rate should be estimated using a watch, a graduated vessel (e.g. 55-gallon drum, and a water level meter).

7.3 Data and Records Management

Field notes documenting the development activities will be recorded in a site field book and transferred to field data sheets as appropriate. All measured field data will be recorded using the Well Development Field Data Sheet (Attachment 1). Field books and data sheets will be transmitted to the Project Manager (PM) and maintained as part of the project file.

7.4 Communication and Technical Direction

Any problems or issues encountered while in the field shall be discussed with the PM or designated technical lead in order to derive an appropriate solution. Any changes in scope or deviation from procedure will be confirmed with and approved by the PM.

7.5 Demobilization

Purge water will be stored and disposed of in accordance with applicable Federal, state, and local regulations. In many instances, removed groundwater can be emptied on site. This determination will be made on a case-by-case basis.

All equipment will be decontaminated following the cessation of well development activities and prior to removal from the Site. Decontamination will be performed in accordance with the Nobis "Standard Operating Procedure FS-004, Field Sampling Equipment Decontamination."

8.0 QUALITY CONTROL/QUALITY ASSURANCE

The following general quality assurance procedures apply:

- All data must be documented in site field books and then can be transferred to field data sheets, as appropriate.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to operation, and they must be documented.

9.0 REFERENCES

American Society of Testing Materials, Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers, D 5092-04e1 (reapproved in 2004 with edits) or most recent version.

Massachusetts Department of Environmental Protection. Standard References for Monitoring Wells. Publication No. WSC-310-91. April 1991.

Attachment 1
Well Development Field Data Sheet

WELL DEVELOPMENT FIELD DATA SHEET

Project: ____________

Start Date/Time: ________ End Date/Time: ________

Well I.D.: ________ Method: ________ Identify Measuring Point: ________

Well Diameter: ________ Total Well Depth: (at start) ________ ft bmp Screen Length: ________ ft

(at finish) ________ ft bmp

Initial Level: ________ ft bmp Water Volume: ________ gallons Well headspace: ________

Water Volume Lost During Drilling: ________ gallons Approximate Sediment Thickness: ________ ft

Equipment: ________ Recharge Rate: ________ gpm Volume Removed: ________ gallons

Water Parameter Measurements

Time	Volume Purged (gallons)	Total Gallons	pH (SU)	Temp. (°C)	Specific Conductivity (mS/cm)	Turbidity (NTU) or (mL/L sediment[4])	Other (specify w/ units)	
Completion Criteria			(10%) [3]	(10%) [3]	(10%) [3]	(10% [3],<5 NTU)		

Development Notes: ____________

Signature:

Notes:
1. bmp = below measuring point
2. gpm = gallons per minute
3. 10% completion criteria refers to three consecutive measurements within 10% of each other.
4. mL/L is measured using an Imhoff Cone. The completion criteria for the Imhoff Cone method should be confirmed with the technical lead.

SOP HYD-004 Attachment A Well Development Field Data Sheet.xls Updated April 2009

1.0 SCOPE, APPLICATION, AND LIMITATIONS

This Standard Operating Procedure (SOP) establishes methodologies for low-flow / low-stress groundwater sample collection. This procedure includes the minimum required steps and quality checks that project samplers are to follow when sampling groundwater using this technique. This SOP addresses the technical requirements and required documentation to be completed during low-flow groundwater sampling.

Nobis Engineering Inc. (Nobis) follows the U.S. Environmental Protection Agency (EPA) Region I *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*, Revision 3, January 19, 2010. Therefore, for additional detail regarding the Scope and Application of this procedure, please refer to this EPA document.

Some project parameters and/or requirements may not be fully addressed by this SOP. Under some circumstances, the project work plans (e.g., Quality Assurance Project Plan (QAPP), Sampling and Analysis Plan (SAP), Field Sampling Plan (FSP), etc.) may be needed to clarify, expand, or modify the SOP. Project requirements written in such documents supersede this SOP, as project specific practices and procedures outlined in project specific work plans are approved by the governing body (EPA, state agency, U.S. Army Corps of Engineers (USACE), etc).

The EPA low flow method is intended for wells that can accommodate a positive lift pump (1.5-inch inside diameter or greater), have a screen (open) interval of 10 feet or less, and have a static water level above the top of the screen interval (i.e., fully saturated screen). Method modifications may be required on a project or well-specific basis if well conditions vary from these.

2.0 INTRODUCTION

This method of groundwater sample collection involves the minimal disturbance of the aquifer matrix to obtain a “representative” sample of groundwater containing mobile organic and inorganic constituents (including dissolved and mobile particulate organic and inorganic chemicals) and reduce or eliminate the inclusion of non-mobile particulates.

The method requires pumping of groundwater at a sufficiently low rate to minimally influence the water level and limit migration of fines from the aquifer matrix into the water sample. Groundwater indicator field parameters recommended to be measured include: turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation-reduction potential. These indicator parameters are used to determine when stabilization has been reached and sample collection can begin.

3.0 DEFINITIONS

DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FID	Flame Ionization Detector
FOL	Field Operations Leader
FSP	Field Sampling Plan

HASP	Health and Safety Plan
low-flow	Purge rates (usually less than 1 liter per minute) that stress the aquifer only minimally and minimize drawdown (ideally 0.3 feet or less once stabilized) so that samples can be collected with minimal alterations of the groundwater chemistry.
mg/L	milligrams per liter
mL	milliliter
mL/min	milliliters per minute
mV	millivolts
NTU	Nephelometric Turbidity Units
ORP	Oxidation-Reduction Potential
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PID	Photo Ionization Detector
QAPP	Quality Assurance Project Plan
QC	Quality Control
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SVOCs	Semi-Volatile Organic Compounds
USACE	United States Army Corps of Engineers
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds
YSI	Yellow Springs Instrument (multi-parameter meter)

4.0 CAUTIONS

Collecting groundwater samples using this method is generally not physically hazardous. Care should be taken to minimize slip/trip/fall hazards due to the presence of a large amount of equipment required for low flow sampling. Personal protective equipment (PPE), including the appropriate gloves specified in the site Health and Safety Plan (HASP) and eye protection, should be worn, as well as any other PPE specified in the HASP.

Sample preservatives commonly include strong acids and bases. Care should be taken to prevent contact with these chemicals. Acids and bases should be stored separate from each other.

When vapor hazards may be present, the HASP may require that a headspace reading be taken immediately upon opening the monitoring well. Refer to the site HASP for details regarding action levels, response actions, and other site-specific health and safety requirements.

5.0 PERSONNEL QUALIFICATIONS

Field personnel will be fully trained in low-flow techniques prior to the field event, including at a minimum: equipment calibration, pump operation, troubleshooting, sample collection, and documentation. While it is assumed that the qualified technician is generally familiar with low flow methods and equipment, project planning should include sufficient preparation time prior to mobilization for field personnel to become familiar with the specific methods, equipment, and instruments to be used at the specific site. Additionally, the timeframe of the project should be sufficient for the qualified field personnel to fully complete the tasks required.

Personnel collecting samples using this method must be familiar with this SOP and the particular equipment to be used to facilitate sampling and troubleshooting equipment problems more efficiently. Consult the user's manual for each meter and the EPA SOP, as required.

All field samplers at hazardous waste sites are required to complete the 40-hour Occupational Safety and Health Administration (OSHA) health and safety training and annual 8-hour refresher courses prior to engaging in any field collection activities.

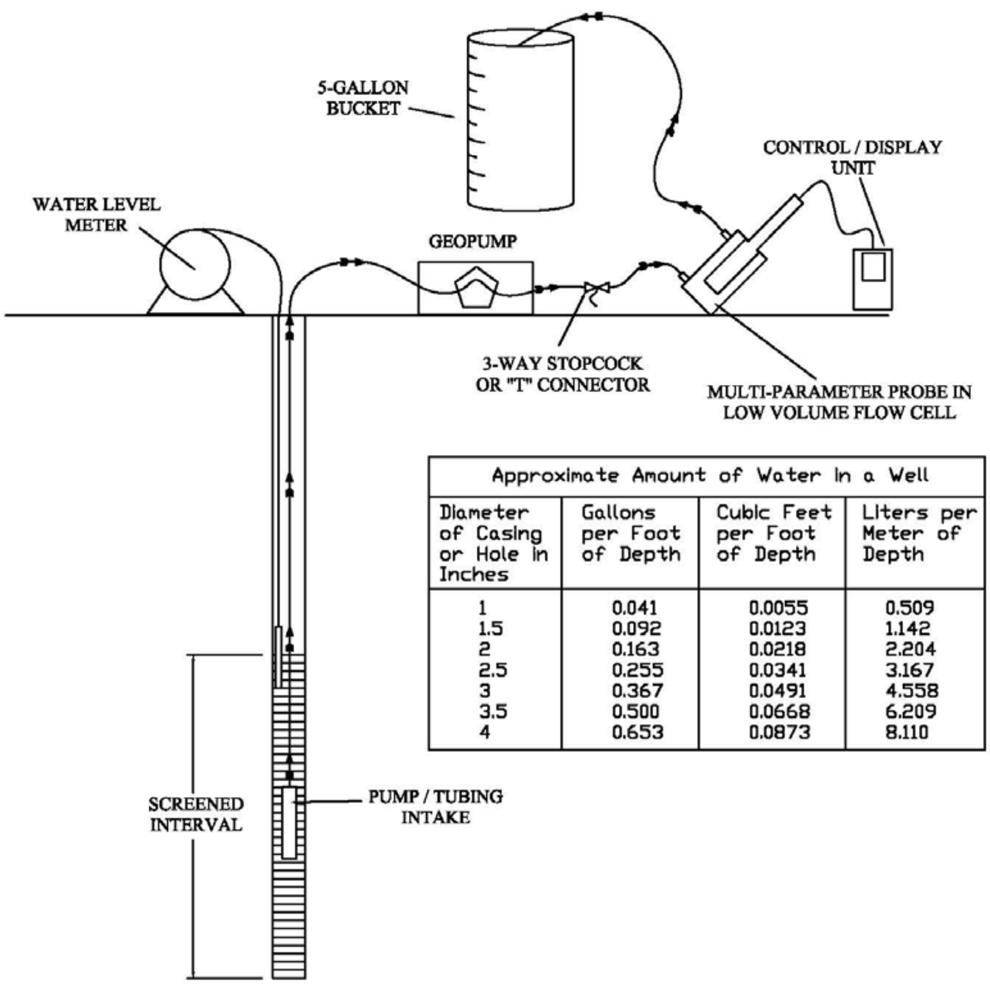
6.0 EQUIPMENT AND SUPPLIES

The following are recommended for low flow sample collection:

- Pump (bladder pumps and centrifugal pumps are preferred) constructed of stainless-steel. In some cases, dedicated plastic bladder pumps may be used. Non-dedicated bladder pumps need to have the bladder and other non-inert parts replaced between locations. Peristaltic pumps may be utilized with caution. When used, the inside diameter of the rotor head (usually silicon) tubing needs to match the inside diameter of the tubing installed in the monitoring well – rotor head tubing may be used for connections also.
- Tubing will be dedicated to the well and be selected based on the type of contaminants that may be present. Teflon® or Teflon®-lined tubing is preferred when samples will be analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and inorganic constituents. However, polyethylene tubing and silicone tubing may also be used in some cases when Teflon tubing is unavailable. The recommended inside diameter of the tubing is 1/4 inch or 3/8 inch
- 3-Way stopcock or "T" connector and clamp appropriately sized for the tubing in use
- Water level meter
- Power source (e.g., generator that is stationed at least 30-feet downwind of the well being sampled, compressed gas, battery, etc.)
- Multiple parameter instrument (e.g., Yellow Springs Instrument [YSI]) with a clear flow-through cell (250 mL flow-through cell is preferred) – manual must accompany the instrument in the field. Documentation of vendor calibration should be requested at the time the instrument is ordered.
- Turbidity meter (separate from the multiple parameter instrument) – manual must accompany the instrument in the field. Documentation of vendor calibration should be requested at the time the instrument is ordered.
- Graduated cylinder(s) of appropriate volume
- Stopwatch or other watch with display in seconds
- 5-Gallon buckets with 1/2 gallon graduations marked
- Utility spring-clamps for tubing

- Calibration standards or reagents
- Decontamination supplies
- Logbooks or tablets
- Well parameter data logs (sheets) (Attachment A)
- Site plan with well locations
- Project work plans (i.e., QAPP, SAP, FSP, etc.) and additional project documentation, as appropriate
- *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*, prepared by the U.S. EPA Region 1 Quality Assurance Unit in North Chelmsford, Massachusetts, January 19, 2010.
- Sample containers; pre-preserved is preferred when appropriate
- Labels
- Well keys
- Miscellaneous hand tools (minimum recommended: utility knife, standard and Phillips screwdrivers, slip-joint pliers, small and medium adjustable wrenches) – a tubing cutter is preferred over a utility knife for cutting rigid tubing in order to maintain tubing shape and avoid crimping
- Safety cord when using submersible pumps
- Vapor screening instruments (e.g., photo-ionization detector [PID], flame-ionization detector [FID] as required by HASP and/or project work plans [i.e., QAPP, SAP, FSP, etc.])
- Radios and/or cell phones, as appropriate
- Folding canopies or other appropriate shelter from sun or precipitation
- Extra buckets for equipment transport
- Appropriate protective gloves (see HASP)
- Resealable plastic bags
- Paper towels
- Camp chair
- Sample-holding cooler with loose ice for each sampler or team
- Extra coolers for on-site interim storage / ice and sample management
- Extra Batteries (e.g., 9V, C, and/or AA)
- Paint pens for marking wells (generally available where welding supplies are sold)

Refer to Figure 1 for a generalized description of the generic arrangement of equipment for low flow sampling.



Approximate Amount of Water in a Well			
Diameter of Casing or Hole in Inches	Gallons per Foot of Depth	Cubic Feet per Foot of Depth	Liters per Meter of Depth
1	0.041	0.0055	0.509
1.5	0.092	0.0123	1.142
2	0.163	0.0218	2.204
2.5	0.255	0.0341	3.167
3	0.367	0.0491	4.558
3.5	0.500	0.0668	6.209
4	0.653	0.0873	8.110

FIGURE 1

GENERALALIZED LOW–FLOW ARRANGEMENT

7.0 PROCEDURES

7.1 Office Preparation and Mobilizations

All field personnel should be familiar with the project work plans (i.e., QAPP, SAP, FSP, etc.) and have the opportunity to ask questions prior to beginning mobilization activities. All field equipment will be inspected by the Field Operations Leader (FOL) or designee prior to mobilization. When instruments requiring calibration are obtained from a vendor, documentation of calibration prior to delivery should be requested when the instruments are ordered. If documentation of pre-delivery calibration is provided, calibration prior to mobilization is considered to be completed. **This does not supersede QAPP/SAP requirements for field calibration on site prior to daily use.** If documentation of calibration by the vendor is not provided, field personnel should complete and document one full calibration of all instruments and equipment requiring calibration prior to mobilization for projects that require initial daily calibration to be performed prior to use. The data quality objectives for some projects may forgo re-calibration for single day field efforts if initial calibration is documented by the instrument vendor. Field technicians should refer to the project scope or consult with the project manager for clarification of the data quality objectives for projects that do not utilize other planning documents such as a QAPP/SAP. Reference Nobis SOP Nos. FS-005 and FS-006 for YSI and turbidity meter calibration procedures, respectively. Personnel should confirm that field instruments are complete and in working order prior to mobilization.

The project manager or FOL should provide the field personnel with a list of required and suggested equipment including any tools or personal items not being provided by the project or listed in this SOP. The field personnel should be fully informed of the work site conditions including availability of shelter, climate controls, food, potable water, and project expectations (e.g., anticipated work day length, weather-related decisions, and other reasonably foreseeable conditions) so they can make appropriate decisions on personal gear.

The FOL or designee is responsible for ensuring that all required equipment is organized, staged, and ready to mobilize. To the extent possible, all authorization, permission, and access issues should be resolved prior to mobilization. If samples are to be shipped, a shipper or parcel drop should be identified prior to mobilization and hours of operation confirmed. If expendable items such as gases are required, potential local sources should be researched prior to mobilization. Sample shipping and other SOPs should be referenced for further information.

7.2 Field Procedures

7.2.1. For most large-scale sampling efforts, a synoptic water level round where static water levels and total depths are measured and recorded for all locations is completed prior to initiating the low flow effort. The intent of the synoptic round is to measure water levels across all measuring points to obtain a “snapshot” of conditions at a given point in time. During the synoptic water level round, the condition of the wells should be noted as well as the presence and condition of tubing, dedicated pumps (where present), and other factors that may later impact purging and sample collection. This is also the appropriate time to verify well identity and add or refresh well markings to ensure correct identification during the subsequent sample collection efforts and in the future. Reference Nobis SOP No. HYD-003 for further information on measuring the groundwater level in wells. When the tubing, pump, or other equipment is to be installed or removed, it should be done after the static water level is measured during the synoptic round. If tubing is to be installed, repositioned, or replaced, water levels and turbidity should be allowed to stabilize prior to purging. Refer to the project work plan for other project-specific factors.

7.2.2. Equipment including the multiple parameter meter, turbidity meter, and pump (as necessary) shall be calibrated at the start of each sample day per the manufacturer's specifications and/or Nobis SOP Nos. FS-005 and FS-006. Manufacturer's literature for each piece of equipment will be included in planning documents and will accompany the instruments in the field. Documentation of equipment calibration will be made on an equipment calibration log as required by the project work plan.

7.2.3. If required for the project, remove the well cap and immediately screen for VOCs in the monitoring well headspace using a calibrated PID/FID and record the results. Record the readings on a project-specific field form (Attachment A). Note the presence of positive or negative pressure, if any, as the wellhead compression plug is released.

7.2.4. If required by the HASP, monitor the breathing zone air with the PID/FID. If below action levels, proceed with the sampling. If above action levels, allow VOCs to dissipate before proceeding.

7.2.5. Measure and record the initial depth to water; the total depth should have been measured and the well identification verified during the synoptic water level round (Section 7.2.1). If the total depth of the well was not measured during the synoptic water level round, it should be measured after completing the purge and collection process so as not to influence turbidity. The total depth should only be measured during the setup for purging if the well identification was not confirmed during the synoptic round and documentation such as site figures are unclear regarding the well identification.

7.2.6. Refer to the project work plans for specific instructions on pump or tubing intake depth based on screen interval or other site-specific factors. Pumps or pump tubing should be installed at the specified depth or in the center of the screened or open interval if no depth is provided. Dedicated tubing will be marked to facilitate correct placement with minimal disturbance to the water column. If dedicated tubing is not being used, the tubing should be measured as it is placed; using the bottom of the well as a reference point for setting the intake depth will disturb the water column and influence turbidity and should be avoided.

7.2.7. If not completed during the synoptic gauging round, install the pump (for non-dedicated submersible pumps) or pump tubing with as little disturbance to the water column as possible. Allow the groundwater level to return to static conditions prior to beginning of the purge process. When a peristaltic pump is used, the length of the rotor head tubing should be limited to one foot, to minimize vibrations that may aerate the sample. Limit the length of tubing outside the well to the extent possible while retaining enough tubing to allow for adjustments to the intake depth. The low-flow set-up, including tubing, should be protected from direct sunlight and precipitation to minimize changes in temperature.

7.2.8. Install a 3-way stopcock or "T" connector and clamp to the pump tubing and flow-through cell (as shown in Figure 1). Attach tubing to the bottom port of the flow-through cell so water flows up to and exits the upper port. Angle the flow through cell to approximately 45 degrees with tubing ports facing up to reduce the possibility of air bubbles becoming trapped in the cell and/or sticking to the DO probe. Water exiting the cell is to be collected in a graduated bucket.

7.2.9. Set the 3-way stopcock or "T" so that the flow from the well is directed out to the 5-gallon graduated bucket and not through the flow-through cell.

7.2.10. Turn on the pump and record the start time. Start purging the well using the lowest pump setting and gradually increase the speed until discharge occurs. Monitor the water level in the well and adjust the pump rate to minimize drawdown. Drawdown is considered stable when the water table drop is limited to 0.3 feet or less.

a. Stable drawdown of less than 0.3 feet, while desirable, is not always feasible. Continued drawdown may require additional purging to remove head and allow the well recharge rate to increase to match the pumping rate. The drawdown should never reach the screened interval. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected. The volume of drawdown should be less than the volume of water purged when parameter stability indicates adequate conditions for sample collection. When these conditions cannot be met, the actions taken should be fully documented and the FOL and/or quality control officer for the project should be consulted before collecting samples and submitting them for analysis. Continue with the following steps during drawdown to monitor purge water parameters and pumping conditions. When problematic wells are identified, establishing a well-specific procedure in the project planning is recommended.

b. If the water level cannot be stabilized, set the pump to the lowest setting and continue to record water levels in efforts to overcome drawdown issues. Estimate the drawdown rate and consult with the FOL or project manager for instructions. Be sure not to allow water to be drawn down into the screened interval of the well. If the water level approaches the screened interval, stop pump and allow the well to recharge while consulting the FOL and/or quality control officer for the project before collecting samples and submitting them for analysis. When problematic wells are identified, establishing a well-specific procedure in the project planning is recommended.

7.2.11. Measure the flow rate with a graduated cylinder and a stopwatch to calculate the purge rate in milliliters per minute (mL/min). Typical purge rates range between 100 mL/min to 400 mL/min but are dependent on the aquifer matrix composition. Historical flow rates are a good starting point; however, aquifer conditions can change seasonally and over time. Attempt to achieve historical purging flow rates if previously established; however, establish a new flow rate if those rates cause excessive drawdown. When using a bladder pump, the discharge rate should be capable of filling a 40 mL volatile organic analysis (VOA) vial with a single discharge while maintaining a smooth flow at a pressure that will not result in aeration of the sample.

7.2.12. If turbidity levels are excessive, additional purging while bypassing the flow-through cell may be necessary to avoid silt build up in the cell and around the multiple parameter instrument probes. There is no defined upper limit for turbidity with respect to directing the purge water to the flow-through cell; it is up to the field technician’s judgment. Visual indications of suspended material or discoloration and obvious silt accumulation in the purge bucket may be useful indicators. Historical records may be useful in determining what amount of turbidity is generally encountered. It is important to remember that there is no rush to begin collecting field parameter measurements; the purge time starts when the first water is drawn from the well. Allowing some additional purging before water is routed to the flow-through cell may ultimately decrease the overall time to reach parameter stability. Stabilizing the drawdown and avoiding silt accumulation in the flow-through cell are the initial priorities. When the flow rate has been established and turbidity is not excessive, redirect the flow through the 3-way stopcock or “T” to the flow-through cell. Silt levels should be monitored and the flow-through cell should be emptied if silt build up is occurring. This is to be avoided, however, as the DO probe will spike if exposed to ambient air and generally will take 15 minutes or more to stabilize again. Allowing excess turbidity to be purged out before allowing water to enter the flow cell is preferred, if possible. Additionally, if the flow-through cell is at the appropriate 45-degree angle (Section 7.2.8), silt that does enter the cell should settle away from the probes.

7.2.13. Collect all purge water in the graduated bucket. Generally, low-flow methods do not include minimum purge volumes; refer to the project work plan for confirmation.

7.2.14. Record the indicator parameters and flow rate at intervals determined by the flow rate and flow-through cell volume. The generally accepted approach is to record parameter measurements at 5-minute intervals, however, the entire volume of water in the flow-through cell should be exchanged at least once between readings. To check this, divide the flow-through cell volume by the flow rate to result in minutes per turnover. Reading intervals shall not be less than 5 minutes; however, to ensure that water in the flow through cell is exchanged between readings, the length of the intervals may be increased if slower pumping rates are required.

When monitoring groundwater indicator field parameters and sampling under this SOP, the sampler must be aware of and avoid conditions that cause groundwater degassing, groundwater aeration, groundwater temperature fluctuation, in-well thermal currents, and cross-contamination.

The field parameters measured during low flow have either direct or indirect temperature components. Stabilizing the temperature of the water between the time it is drawn into the tubing and the time it exits the flow-through cell will often shorten the time needed for the other field parameters to stabilize. Protecting the tubing and flow-through cell from direct sunlight is generally the most important component of stabilizing the purge water temperature and obtaining the most precise measurements capable through low flow methods.

7.2.15. Turbidity measurements should be collected before the flow-through cell. Use the 3-way stopcock or “T” to divert water directly into the measurement vial (also referred to as a cuvette). Where ambient groundwater temperatures are cool and/or surface humidity is high, condensation may form on the vial. It is acceptable to immerse the vial in water at stable surface air temperature for a few minutes to equilibrate the field measurement sample and wipe moisture off of the vial prior to placing it in the meter to be measured. If the turbidity vial is not being measured immediately after collection, remember to gently agitate the vial to re-entrain particulates that may have settled out. If turbidity measurement vials become stained with iron flocculent or other groundwater constituents, a rinse with a small amount of a 1:1 hydrochloric acid and water solution may remove the staining.

7.2.16. The tubing and flow-through cell should be monitored for air bubbles. Bubbles in the cell may be freed by gently tapping the cell. Stationary bubbles in the tubing may be worked toward the cell and eventually the outlet by lowering the tubing to encourage water to push the bubble(s) downstream. When using a peristaltic pump, persistent bubbles or intermittent flow may indicate that the tubing is too large for the flow rate, that the water level is at the limits of the pump’s capacity to lift it, or that the groundwater is effervescing due to geochemical characteristics. Whenever possible, arrange the equipment so that the pump is above the wellhead and the flow-through cell is above the pump. The tubing from the wellhead to the flow-through cell should be as short as is practical; loops and humps should be eliminated to the extent possible.

7.2.17. Continue purging until indicator parameters stabilize. Record the readings on the project-specific field form included in Attachment A. Stabilization is considered to be achieved after three consecutive readings for all parameters are within the following limits:

Turbidity -	+/- 10% for values greater than 5 NTU; if three consecutive turbidity measurements are less than 5 NTU, consider the parameter stable.
DO -	+/- 10% for values greater than 0.5 mg/L; if three consecutive measurements are less than 0.5 mg/L, consider the parameter stable.

Specific Conductance - +/- 3%

Temperature - +/- 3%

pH - +/- 0.1

ORP - +/- 10 mV

Calculate stability using the lowest and highest of three sequential readings for each parameter; sequence is not important. Use the percent difference formula [(high-low)/high x 100] to calculate percent difference and compare results to the stability criteria above. **Examples of this calculation are shown in Attachment B.**

7.2.18. After the indicator parameters have stabilized according to the above criteria, record the stabilization time and collect analytical samples. Fill sample bottles directly from the tubing in the well by disconnecting the tubing from the 3-way stopcock or sample T. Do not collect samples from tubing after the stopcock or sample T or the flow-through cell – samples should be collected as close to the pump as possible. The project work plan may specify an order of sample collection based on project-specific factors. Typically, the flow rate shall not be changed during sample collection; however, the flow rate may be reduced after collection of non-VOC and non-gas samples if necessary to allow for "laminar flow" (undisrupted flow) during collection of VOC volumes. In this case, VOC and groundwater gas samples would be collected last among the laboratory and field analytes to preserve the flow rate for the remainder of the sampling suite. The pump rate is never increased to accommodate large volumes. If field analyses are to be completed, these sample volumes are generally collected after the samples to be submitted to a laboratory and at the stable pump rate. If field quality control (QC) samples are to be collected (i.e., field duplicate or matrix spike samples), then these QC samples are collected after the original field sample is collected for all parameters.

7.2.19. In certain situations which will be outlined in the project work plans, when turbidity meets the stabilization criteria but remains above 25 NTU's, additional considerations are warranted. If total metals are being collected, an additional filtered sample for metals using a 0.45 micron in-line filter may be required by the work plans to also be collected to compare to the total metals sample. An alternative method would be to send the laboratory two samples: an unfiltered and unpreserved sample that the laboratory can filter within 24 hours of collection for dissolved metals analysis and a preserved sample for total metals analysis. It is preferable that the dissolved metals are field filtered if turbidity values are greater than 5 NTU.

7.2.20. Place samples in a cooler with loose ice immediately after collection. Transfer samples to the project sample manager as soon as possible for processing and shipping.

7.2.21. In general, limit purge water parameter monitoring to 2 hours and collect samples at the end of the 2-hour period, regardless of stabilization. The project work plan may provide guidance for extending the purge period based on parameter trends or other factors. There is no lower limit for the purge period. Once the water level and indicator parameters stabilize and the minimum volume is purged, i.e., the volume of the well tubing and any drawdown, the sample may be collected.

7.2.22. Problems, discrepancies, unexpected or unusual observations (such as contrasting DO and ORP values), and potential exceptions to the SAP or other project documentation should be communicated to the FOL at the time that they are recognized. At a minimum, the FOL should be aware of such occurrences before purging is stopped and the work area broken down. Additional meter calibration may be warranted.

7.2.23. After collecting the samples, turn off the pump and monitoring equipment and remove the non-dedicated equipment (pump or tubing) from the well. Leave or re-install dedicated tubing in the well or dispose of appropriately. Refer to the project work plans for site-specific procedures.

7.2.24. Record the total volume accumulated in the graduated bucket. Complete all other required notes and documentation in the field book, tablet, or on the field log, as appropriate. The project work plans may provide additional information regarding the required data. Unless otherwise specified, duplication of data on field logs and in field books is not necessary.

7.2.25. Decontaminate all non-dedicated equipment that will be reused in accordance with the project work plan.

7.3 Data and Records Management

In most cases, the samples should be immediately returned to the staging area and turned over to the FOL or sample manager for processing and shipping. Unless site logistics prevent it, this should be done prior to breaking down and demobilizing from the well. Alternately, the sample manager or other site personnel may be available to courier samples to the staging area for appropriate storage. The samples will be transferred to holding coolers or refrigerators until they are packed for shipping. The FOL or sample manager will maintain a log of the samples that will include the sample designator (and well number if different), the analytical parameters, the number of containers, the collection date and time, and any notes regarding exceptions to the SAP or other project documentation and/or quality control. All field data logsheets, notes, and/or electronic filesshall accompany the samples and be turned in to the FOL with the samples after review by the sampler for completeness and accuracy. These documents serve as a chain of custody for the samples while they remain on-site. Communicate any significant observations not noted on the field log to the FOL.

The FOL will review the field logsheets and other project specific field data (such as field analyses completed) on a daily basis. Discrepancies and/or omissions should be addressed as soon as possible, preferably the same day as sample collection and prior to the next sample collection. When it is logistically reasonable, it is preferred that copies be made as soon as possible as a backup. Likewise, the data should be provided to the project manager at the end of each sample day, if feasible. If electronic tablets are used, the field logsheets may be saved in the project files while in the field.

The FOL will maintain a log of daily events to include, where applicable, the wells sampled, the sampler, the analytical parameters, problems or exceptions, duplicate or matrix QC samples collected, sample transfer/shipping dates and times, and general site conditions. Some or all of this information may be collected in the sample management software, Scribe. Refer to SOP No. DOC-002.

7.4 Communication and Technical Direction

Field personnel shall support one another and maintain open communications during all aspects of the field activities. When a technical point is in question, field personnel shall communicate with the FOL for clarification and/or additional direction. If the project work plans do not provide sufficient information, the FOL should consult with the project manager unless otherwise directed. Deviations, exceptions, and/or omissions from the project work plan or generally accepted practice should be communicated to the project manager as soon as feasible. The FOL will maintain records of all such communications in a field book or other acceptable format detailing the issue, the outcome, and individuals involved in the decision.

7.5 Demobilization

The FOL is responsible for ensuring that all required data have been collected and that the site is secured before authorizing complete demobilization. The FOL should confirm with the project manager that the crew is authorized to begin demobilization unless otherwise directed. At a minimum, the site conditions should be no worse than at the beginning of field activities. The FOL or designee will ensure that all instruments and equipment are accounted for and either stowed for future use or transported to the office. In some cases, taking an inventory of equipment and expendables may be appropriate.

8.0 QUALITY CONTROL/QUALITY ASSURANCE

As discussed in Section 7.3, the FOL will review field logs and other documentation on a daily basis and address issues as soon as feasible. The requirements for field duplicates, trip blanks, equipment blanks, matrix spike/matrix spike duplicates, performance evaluation samples, temperature blanks, sample management/chain of custody procedures, shipping requirements, and custody seals will be specified in the SAP or other project work plans. Follow Nobis SOPs where established.

9.0 REFERENCES

US Environmental Protection Agency Region I; *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*, EQASOP-GW 001, July 31, 1996 (Revised January 19, 2010).

ATTACHMENTS

A Low-Flow Groundwater Sampling Field Log
B Example Stability Calculations

ATTACHMENT A

Nobis
Engineering a Sustainable Future

Low-Flow Field Log

Date: ______ Page: ____ of ____

Site Name: ______________________

Job Number: ______________________

Sampler: ______________________

Well ID: ______________________

Sample ID: ______________________

Reviewed By: ______________________

Measurement Reference Point (MP): __________ (PVC, Casing, Ground, etc.)

Depth to GW: __________ (ft from MP)

Depth to Bottom: __________ (ft from MP)

Pump Intake Depth: __________ (ft from MP)

Well depth as installed: __________ (ft bgs)

Screen interval (range): __________ (ft bgs)

Purging start time: ______________________

Parameter stabalization (Y/N): ______________________

Two hour time limit reached (Y/N): ______________________

Sample time: ______________________

Total volume purged (gals): ______________________

Time at purge completion: ______________________

Equipment Vendor: ______________________ Turbidity Meter: ______________________ Multimeter: ______________________

Pump Type: ______________________ Serial #: ______________________ Serial #: ______________________

Notes (Initial PID reading, SOP deviations, etc.):

Lab Analyses:

QC Info (Duplicate, MS/MSD)

Clock Time	Bladder Pump Discharge/ Refill	Purge Rate	Depth to Water	Draw down	Cum. Draw down	Temp ±3%	Spec. Cond. ±3%	pH ±0.1	ORP ±10	DO ±10% if >0.5 mg/L	Turbidity ±10% if >5 NTU	Comments/Gas Pressure/Observations	Stability Calculator (auto)
HHMM	sec./sec. or setting	ml/min	ft. below MP	ft.	ft.	°C	µS/cm^c		mV	mg/L	NTU		
0:00													

Low-Flow Field Log

Nobis — Engineering a Sustainable Future

Site Name: 0
Job Number: 0
Sampler: 0

Date: 1/0/1900
Page: ___ of ___

Well ID: 0
Sample ID: 0
Reviewed By: 0

Measurement Reference Point (MP): 0 (PVC, Casing, Ground, etc.)
Depth to GW: 0 (ft from MP)
Depth to Bottom: 0 (ft from MP)
Pump Intake Depth: 0 (ft from MP)
Well depth as installed: 0 (ft bgs)
Screen interval (range): 0 (ft bgs)

Purging start time: 0:00
Parameter stabalization (Y/N): 0
Two hour time limit reached (Y/N): 0
Sample time: 0:00
Total volume purged (gals): 0
Time at purge completion: 0:00

Equipment Vendor: 0
Pump Type: 0
Turbidity Meter: 0
Serial #: 0
Multimeter: 0
Serial #: 0

Notes (Initial PID reading, SOP deviations, etc.): 0

Lab Analyses: 0
QC Info (Duplicate, MS/MSD) 0

Clock Time	Bladder Pump Discharge/ Refill	Purge Rate	Depth to Water	Draw down	Cum. Draw down	Temp ±3%	Spec. Cond. ±3%	pH ±0.1	ORP ±10	DO ±10% if >0.5 mg/L	Turbidity ±10% if >5 NTU	Comments/Gas Pressure/Observations	Stability Calculator (auto)
HHMM	sec./sec. or setting	ml/min	ft. below MP	ft.	ft.	oC	µS/cm		mV	mg/L	NTU		

SOP No: SA-003 Draft Revision: 4

ATTACHMENT B

Attachment B

SA-003 Low-Flow Groundwater Sampling

Example Calculations

Parameter Stability Calculation

percent difference formula [(high - low) / high] x 100 = percent difference

For three successive specific conductance readings of 530 μS/cm, 500 μS/cm, and 520 μS/cm; stability is defined as ±3%:

Use the highest and lowest readings of the three →

[(530 μS/cm – 500 μS/cm) / 530 μS/cm] x 100 = 5.6% → **not stable**

For three successive specific conductance readings of 530 μS/cm, 515 μS/cm, and 520 μS/cm; stability is defined as ±3%:

Use the highest and lowest readings of the three →

[(530 μS/cm – 515 μS/cm) / 530 μS/cm] x 100 = 2.8% → **stable**

Well and Tubing Volumes

Tubing Volume Per Foot

for tubing OD (in.)	0.25 (1/4)	0.375 (3/8)	0.5 (1/2)	0.625 (5/8)
tubing ID (in.) =	0.17	0.25 (1/4)	0.375 (3/8)	0.5 (1/2)
volume (gal./ft.) =	0.0012	0.0026	0.0057	0.0102

Well Volume Per Foot

for casing ID (in.)	1.25	1.5	1.75	2	2.25	3	3.5	4	6
volume (gal./ft.) =	0.06	0.09	0.12	0.16	0.21	0.37	0.5	0.65	1.47

OD = outside diameter, ID = inside diameter

Minimum Purge Volume Calculation

drawdown or tubing length (ft.) x volume per foot (gal./ft.) = V_d (gal.) or V_t (gal.)

for a 2-in. ID well with a 0.27-ft. drawdown and 30 ft. of 0.17-in tubing→

0.27 ft. x 0.16 gal./ft. = 0.043 gal. V_d

30 ft. x 0.0012 gal./ft. = 0.036 gal. V_t →

V_d + V_t = minimum purge volume → 0.043 gal. + 0.036 gal = 0.079 gal. minimum purge

Supporting Conversions and Tubing / Well Volume Calculations

ID (in.) / 2 = radius (r) in.

π (Pi) ≈ 3.14

1 $ft.^3$ = 1,728 $in.^3$ or 1,728 cubic in. per cubic ft.

[$in.^3$ x (1 ft. / 12 in.) x (1 ft. / 12 in.) x (1 ft. / 12 in.) = $ft.^3$]

1 $ft.^3$ = 7.48 gal. or 7.48 gallons per cubic foot

$\pi \times r^2$ = area of a circle ($in.^2$) →

for a round cylinder, area ($in.^2$) x length (in.) = volume of cylinder ($in.^3$) →

volume of cylinder ($in.^3$) x 1 $ft.^3$ / 1,728 $in.^3$ = volume of cylinder ($ft.^3$) →

volume of cylinder ($ft.^3$) x 7.48 gal. / $ft.^3$ = volume of cylinder (gal.)

for a 2-in. ID well, the volume of water in a 1-ft. section is:

r = 1 in. → π x (1 in.)^2 → 3.14 x 1 $in.^2$ = 3.14 $in.^2$ = cross section area →

the volume of 12 in. of 2-in. well = 3.14 $in.^2$ x 12 in. = 37.68 $in.^3$ →

37.68 $in.^3$ x 1 $ft.^3$ / 1,728 $in.^3$ = 0.021 $ft.^3$ →

0.021 $ft.^3$ x 7.48 gal. / $ft.^3$ = 0.16 gal.

1.0 SCOPE, APPLICATION, AND LIMITATIONS

This Standard Operating Procedure (SOP) has been prepared by Nobis Engineering, Inc. (Nobis) to establish methodologies for collecting drinking water/residential well samples. This procedure includes the minimum required steps and quality checks that project samplers are to follow and the technical requirements and required documentation to be completed during drinking water/residential well sampling.

2.0 INTRODUCTION

This method of sampling includes collection of an aqueous sample from a residential or other private water supply well. The sample is intended to represent the quality of water being consumed directly by humans; therefore, typically strict standards exist for drinking water due to immediate health concerns. The sample shall be collected from an access point as close to the actual water supply well as possible.

3.0 DEFINITIONS

Not Applicable

4.0 CAUTIONS

Collecting residential samples that involve entering a residence should be done in pairs for safety purposes (when possible). Care should be taken to present oneself professionally when dealing with the public. Precautions should be taken to prevent contact with any samples and/or sample containers to prevent contamination. The Project Manager and the site specific Health and Safety Plan (HASP) will provide further details regarding particular site measures.

5.0 PERSONNEL QUALIFICATIONS

Samplers will be trained in drinking water / residential well sampling techniques prior to the field event. Field personnel should be familiarized with the appropriate contact measures with the residents prior to sampling.

6.0 EQUIPMENT AND SUPPLIES

- Field book (and/or data recording sheets)
- Well installation and boring logs and forms
- Marker, indelible (black)
- Stopwatch (for measuring flow)
- Graduated cylinder/measuring cup
- Paper towels
- Decontamination supplies
- Sample labels
- Chain-of-custody forms
- Sample bottles (often pre-preserved)
- Water filters for field filtering samples (as needed)
- Labels

- Preservatives
- Personal protective equipment (PPE): safety glasses, nitrile gloves at a minimum.
- Zip lock bags

7.0 PROCEDURES

7.1 OFFICE PREPARATION AND MOBILIZATION

Prior to field work, equipment and supplies (including laboratory bottleware) should be prepared and appropriate project documents shall be reviewed by the sampling team including the Quality Assurance Project Plan (QAPP), Standard Operating Procedures (SOPs), HASP, Work Plan, etc. Contact with the resident(s) should be made and if required an access agreement granted prior to sampling at the residence.

7.2 FIELD PROCEDURES

7.2.1 Drinking Water/Residential Well Sample Collection

- Samples should be obtained from the location closest to the entrance of the residence and prior to any conditioning or filtration. Generally, there is a spigot located at the pressure tank. When possible, samples should be collected at the pressure tank.

- Water lines should be flushed prior to sampling to ensure that formation water is being sampled in-lieu of water that has been standing in the water lines for a period of time. Generally, flushing the water at a sink or hose at the residence for a period of at least 10 minutes is sufficient to replace standing water in the water lines. Flushing time should be increased appropriately with respect to the distance between the site building and the well.

- If the sample cannot be collected from the pressure tank or prior to conditioning and/or filtration; an explanation should be noted in the field notes as to why the sample was collected from where it was, the type of conditioning and/or filtration conducted on the water including the most recent filter and media changes, and the added flushing time.

- Prior to sampling, screens and aerators should be removed from the faucet or spigot, if present. A container should be placed beneath the spigot to catch drips. The spigot should be purged for 5 seconds. The spigot should be valved so a manageable steady stream of water flows without splashing, or spraying. The sample containers should be placed directly beneath the stream at a 45 degree angle from the vertical, with the stream contacting the inside of the container to remove excess air bubbles.

- When sampling a point-of-entry (POE) system, sample the system effluent first and work back to the system influent to prevent cross-contamination.

- When sampling for bacteria analyses, use common-household grade bleach and a cotton-swab to wipe the rim of the faucet prior to sampling.

- Typically, sample containers are pre-preserved, but add preservative to the samples if required.

If residential/drinking water sampling requires field parameter measurements, be sure to use a clean container in which the YSI multi-parameter probe will be completely immerged. Complete the calibration of the YSI multi-parameter meter in accordance with SOP FS-005. Follow SOP FS-002 for collecting water quality measurements with the multi-parameter meter. In short, prior to or after sampling, fill the container and record the measurements as they stabilize. It is not required to take multiple readings.

Decontamination

All equipment coming in contact with the sampled media must be decontaminated prior to use at a subsequent location. The decontamination procedure is as follows:

- Flush the equipment with potable water.
- Flush the equipment with a non-phosphate detergent solution.
- Flush the equipment with analyte-free deionized ultra filtered (DIUF) water.
- Flush the equipment with Certified ACS-grade isopropyl alcohol.
- Flush the equipment with analyte-free deionized ultra filtered (DIUF) water.

7.3 DATA AND RECORDS MANAGEMENT

All samples collected must be documented and recorded in a log book or on sample log sheets in accordance with the QAPP. At a minimum, the following should be recorded as part of the documentation: the property location, resident names, date and time of initial contact, summary of conversations with the resident(s), sample identification, date and time of collection, purge volume/time, parameters sampled for, and water supply well details (depth, age, etc.).

All records should be copied to the FOL/Sample Manager and subsequently to the Lead Chemist and Project Manager as soon as possible following sample collection.

7.4 COMMUNICATION AND TECHNICAL DIRECTION

Field data and information recorded on log sheets or field book will be reviewed daily by the Field Operations Lead (FOL) and/or Sample Manager. The notes will be scanned and placed into the job folder located on Nobis' computer server at the end of the sampling event.

Other Documentation

- Photograph number and description of photo, when required.
- Observable physical characteristics - odor, color, turbidity, immiscible layers, formation of precipitates, condition of spigots, valves.
- Samples collected (enter all sample numbers collected at this location)

7.5 DEMOBILIZATION

At the end of equipment use, rinse and decontaminate all components and store in the appropriate case. Clean up any tools and water spillage caused by the sampling. If anything had to be moved in the residence in order to access the sampling location, return the items to their original location. Inform the resident of the anticipated timeframe for delivery of the analytical results.

8.0 QUALITY CONTROL / QUALITY ASSURANCE

Quality control for this sampling method involves the collection of field quality control samples including field duplicates, matrix spike/matrix spike duplicate samples, trip blank samples, equipment blank samples, and temperature blank samples. The number of these samples will vary by site. Performance Evaluation (PE) samples are used to provide an independent check of a laboratory's ability and performance. Refer to the site QAPP for the requirements.

The following collection sequence will be used for sample collection:

- Field sample;
- Field duplicate;
- Matrix spike; and
- Matrix spike duplicate.

9.0 REFERENCES

N.H. Department of Environmental Services. New Hampshire Sample Collection & Preservation Manual for Drinking Water, October 2001

Standard Operating Procedure (SOP)
SOP No. SV-001

Sub-Slab Soil Vapor Intrusion Sampling

This Standard Operating Procedure (SOP) No. SV-001 establishes methodologies for soil gas sample collection. This procedure includes the minimum required steps and quality checks that project samplers are to follow when sampling soil gas using this technique. This SOP addresses the technical requirements and required documentation to be completed during soil gas sampling.

Verina Consulting Group Inc. (VERINA) follows ASTM Practice D7663-12 (2018)e1, Standard Practice for Active Soil Gas Sampling in the Vadose Zone for Vapor Intrusion Evaluations. Therefore, for additional detail regarding the Scope and Application of this procedure, please refer to the ASTM Practice.

Some project parameters and/or requirements may not be fully addressed by this SOP. Under some circumstances, the Project Work Plan may be needed to clarify, expand, or modify the SOP.

This SOP does not address installation of soil gas probes and monitoring wells. Selection and installation are dependent on project requirements.

INITIAL BUILDING SURVEY

A survey of the building or structure to sampled must be completed as an initial step in the vapor intrusion investigative process. When surveying a building or structure for the first time, be sure either the property owner or a knowledgeable tenant will be available to help answer the survey questions. Additionally, be sure to collect the following information about the building/structure:

- how many floors the building has, if the lowest level has a concrete or earthen slab, or if the lowest level consists of a crawl space;
- approximate area (square feet) of the building/structure footprint;
- potential sources of background contamination and their location(s) (household chemicals, paints, gasoline-powered equipment and gasoline storage cans, etc.);
- sensitive population uses within that building/structure (a.k.a. school, daycare, hospital, etc.);
- inspect the lowest level of the building/structure for any underground utilities, sumps, or cracks/holes within/under the building slab and note their locations, which may act as preferential pathways. If possible, obtain a copy of a subsurface utility map for the property from the municipality or utility company; and
- approximate distance between the slab and the groundwater table.

The survey form must be updated each time a soil gas or indoor air sampling event takes place at that particular building or structure, or any time there is a change in the use of the building or structure.

SUB-SLAB SOIL VAPOR SAMPLING (Temporary or Permanent Sampling Ports):

Items Required

Before leaving for the field to conduct a soil gas sampling event via a temporary sampling port, be sure to bring/prepare the following:

- 1 L, stainless steel Summa canisters from an accredited laboratory with flow controllers set for a 5- minute sampling period, one per sample location, and associated laboratory chain-of-custody (COC)
- Extra Summa canisters and flow controllers (check with project manager first to determine if the budget can support these items)
- Adjustable wrench for loosening the lock nuts
- Building Survey and Sampling Form
- VERINA's Soil Gas Sampling Log
- Helium shroud
- 99.99% helium canister with regulator
- Helium detector (MGD 2002 or equivalent)
- PID
- Tedlar bag
- Lung box (Vac-U-Chamber or equivalent)
- Air sampling pump with 200 mL/minute purge rate capability (SKC Pump or equivalent)
- Medium range air sample pump flow meter (Bios Defender 510-M or equivalent)
- Teflon-lined, ¼" ID x 3/8" OD poly tubing (need approximately 2-3' per sampling location)
- Various extra pieces of 3/16" ID x 3/8" OD silicon or vinyl tubing
- Tubing cutters/utility knife
- 100% natural modelling clay (found at most craft stores)
- Hammer drill
- 1/2" diameter drill bit of, at minimum, 18" in length (make sure bit fits the hammer drill)
- Water and sprayer to minimize silica dust
- Concrete patch along with mixing bucket(s) and trowel
- Dust pan with brush or shop-vac.
- A gallon or two of clean water
- Paper towels and trash bags may also be handy.

Sampling Procedure:

1. Prior to the initiation of soil gas sampling at an individual building or structure, the vapor intrusion survey form needs to be completed or updated.
2. Select the soil gas sampling location by considering the following factors:
   - The sample location should be biased towards any preferential pathways (NOTE: if an underground utility is seen as a preferential pathway for this particular property, be sure to stay at minimum 3 feet away from utilities)
   - The sample location should not be done in an area where VOCs are in use, unless their use can be temporarily suspended in that area
   - The sample location should be biased towards the source plume (a.k.a. if the subject site which has the plume is located on the east side of the building, try to pick a sampling location near the east wall of the building)
   - The ease of access and convenience to property owner and tenants, aiming to pick an inconspicuous location (for example, in a closet or under a rug)
3. Calibrate the PID.
4. Once a sample location is chosen, use the hammer drill to drill flush through the slab until the underlying soils are reached, which is determined once the soil starts exiting the drill hole. Use the dust pan and brush or shop vac to clean up dust generated around the drill hole.
5. To construct the temporary sampling port, insert the Teflon-lined tubing into the drill hole ,

making sure the tubing does not touch, but sits just above the underlying soil. Cut Teflon-lined tubing so approximately 6 inches of it sticks out of drill hole. Use the clay to secure the tubing within the drill hole. Put some clay around the tubing within the hole as well as above the slab, surrounding the tubing. Work clay surrounding the tubing to the slab surface. Smooth out the clay so that no gaps, holes, or cracks occur between the tubing, clay, and slab surface, aiming to create a good seal between the tubing and the slab with the clay. For new permanent soil vapor monitoring locations, install the Vapor Pin® per manufacturer's instructions. Collect a PID reading from the tubing and record on the sampling log.

6. Notice the brass T-coupling within the helium shroud, which is connected by tubing to the outlet labelled "To Lung Box". Connect one open side of the T-coupling to the sampling port, being careful not to break the seal between the clay and slab or from the vapor pin.
7. Prior to preparing the 1L Summa canister, ensure the valve knob is completely closed by turning it to the right. Using the adjustable wrench, remove the brass nut from the mouth of the 1L Summa canister and attached the flow controller to the mouth. Lightly tighten the flow controller to the canister with the wrench. Write the sample ID on the canister's tag. Record the Summa canister and flow controller ID numbers on the sampling log.
8. Cut off approximately 1 foot of Teflon-lined tubing and connect to the canister's flow controller. Connect the other side to the brass T-coupling within the shroud, again being careful not to break the seal between the sampling port and slab or vapor pin. If the seal is breached, it must be fixed before proceeding. Turn the helium shroud upside-down and over the sampling setup so the train (Summa canister, the brass T, and the sampling port) is contained under the shroud. The shroud must lay flush with the slab. The Summa canister can be laid on its side if necessary.
9. Turn on the air sampling pump and connect the intake with some silicon tubing to the "suction" side of the flow meter. Start the pump and collect continuous readings of the flow with the flow meter. Observe the reading on the flow meter, which should be no greater than 200 mL/minute. Adjust the air pump if needed. With the SKC sample pump, this is done by using the red-capped pen provided to adjust the "flow adj" pin on the front of the pump. Once the air pump's flow is adjusted, disconnect from the flow meter. Stop the pump and connect to the "vacuum" side of the lung box.
10. Open the lung box. Open the Tedlar bag and connect to the "sample" inlet INSIDE of the lung box, and close lung box. Use some silicon/vinyl tubing and connect the "sample" port on the outside of the lung box to the "to lung box" outlet on the helium shroud. Make sure the outlet nozzle is in the off position.
11. Prepare the helium detector by connecting the probe tip to the top of the helium meter. Turn on the helium meter and allow for it to go through a 60-second warm up period and self- zeroing. Insert the probe tip to the "helium meter" outlet on the shroud, ensuring the outlet nozzle is open. Connect the helium canister with some silicon/vinyl tubing to the "helium inlet" nozzle on the shroud, making sure the nozzle is open.
12. Open the valve on the helium canister and observe the reading on the helium detector. Initially, the detector will read in "ppm" but will eventually read as % as the helium concentration increases. Note that 1% = 10,000 ppm. Allow the helium to fill the shroud until the detector reads at least 10% helium.
13. Turn off the helium and close the "helium inlet" nozzle. Open the "to lung box" nozzle and start the pump connected to the lung box. Observe the helium reading once the pump is started and record this reading (the maximum helium reading) as well as the start pumping time on the sampling log. The Tedlar bag will start to fill, as can be seen through the window of the lung box. Run the pump for a minimum of five minutes and until the Tedlar bag is at least ½ full. Do not run for less than five minutes so at least 1 L may be

purged from the probe.

14. Once the Tedlar bag is at least ½ full, stop the pump and turn off the "to lung box" nozzle on the shroud. Quickly open the lung box and close the Tedlar bag.
15. Record the current helium reading (a.k.a. the minimum helium reading) from the "helium meter" outlet on the shroud on the sampling log.
16. Let the pump run for an additional 10 minutes to ensure at least 3 L have been purged from the probe. Record the final total volume purged on the sampling log.
17. Insert the helium detector probe tip into the Tedlar bag and open. Record the highest helium concentration observed from the Tedlar bag and record on the sampling log. Next, take a PID reading from the Tedlar bag and record. Compare the helium concentration from the bag to the minimum (stop pumping) helium concentration detected from the shroud. If the difference is greater than 10% of the "helium beneath shroud (% minimum)" value (a.k.a. the stop pumping value), the seal of the sampling train has failed the leak test. The clay of the sampling probe must be repaired/reworked to ensure a tight seal between the tubing and the slab. Once repaired, the helium leak test (steps 9 – 15) must be repeated. Once a successful leak test is conducted, you may proceed to step 18.
18. Close all outlet/inlet nozzles on the shroud. Carefully lift the shroud to access the Summa canister, being sure not to disturb the sampling probe and its seal with the slab. Turn the Summa canister valve on and record the initial canister vacuum and the start time on the sampling log.
19. Five minutes later, turn off the Summa canister. Record the final canister vacuum and stop time on the sampling log. **Be sure the canister has a little vacuum left!** If the canister has "0" vacuum left, the sample must be rejected. Prepare a new Summa canister and recollect the sample (steps 19-20).
20. Once the sample is successfully collected, remove the sample probe from the slab. Discard the sample probe and the used Teflon-lined tubing from the brass T. Use the concrete patch to repair the drill hole in a neat manner.
21. Fill out the laboratory COC, being sure to include the Summa ID number, the flow controller ID number, the start and stop time and vacuum readings, as well as the interior temperature at the sample location(s). Additionally, fill in the weather-related parameters on the COC, which can be found from www.wunderground.com.

Appendix C

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Contractor Daily Reports

Daily Report No.	**REPARED BY:**	**PROJECT NUMBER:**
Weather:		**DATE:**

NAME:	HRS	ROLE/DISCIPLINE:	COMPANY:	EQUIPMENT LIST:	VISITORS/AFFILIATION:
DAILY TOTAL:					

SUBCONTRACTORS:	Health and Safety/Environmental Monitoring

WORK PERFORMED BY CONTRACTOR

WORK COMPLETED BY SUBCONTRACTORS

KEY SITE OBSERVATIONS AND NOTES