NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Environmental Remediation, Region 7
615 Erie Boulevard West, Syracuse, NY 13204-2400
P: (315) 426-7519, (315) 426-7551 | F: (315) 426-2653
www.dec.ny.gov

September 7, 2018

Harbor View Square, LLC
Attn: Rebecca Newman
1201 East Fayette St, Suite 26
Syracuse, NY 13210
djakimoski@housingvisions.org

Re: Harbor View Square
Site ID No. C738040
City of Oswego, Oswego County
Pre-Design Investigation Work Plan

Dear Ms. Newman:

The New York State Department of Environmental Conservation (Department) and the New York State Department of Health (NYSDOH) have reviewed the Pre-Design Investigation Work Plan (Work Plan) for the Harbor View Square (site), dated June 2018, which was prepared by Synapse Property Resources and Holt Consulting (Synapse) on behalf of Harbor View Square, LLC (Volunteer) along with the Community Air Monitoring Plan (CAMP) submitted on September 6, 2018 and prepared by Synapse. The Work Plan, with the CAMP, is hereby approved with the following minor modification.

- Work Plan, Section 3, Final Sentence – This is revised to read, “All requirements of the Community Air Monitoring Program (CAMP), submitted to the NYSDEC on September 6, 2018 and prepared by Synapse Property Resources and Holt Consulting, will be followed during any intrusive work at the Site.”

Please submit one hard copy of the Work Plan and CAMP to the Department and submit electronic copies (pdf) to the Department and NYSDOH. The Volunteer must obtain and comply with any necessary State, local or federal permits. The Department requires notification at least seven days in advance of field work. Please also update your contact list for the site. Please replace William Daigle with Susan Edwards (susan.edwards@dec.ny.gov). If you have any questions, please do not hesitate to contact me at 315-426-7411 or joshua.cook@dec.ny.gov.

Sincerely,

Joshua P. Cook, P.E.
Professional Engineer 1

ec: Susan Edwards (NYSDEC)
Harry Warner (NYSDEC)
Joshua Cook (NYSDEC)
Maureen Schuck (NYSDOH)
Richard Jones (NYSDOH)
Diana Jakimoski (Housing Visions)
Roger Creighton (Synapse)
Brian Macrae (Synapse)
Jeffrey Holt (Holt Consulting)

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
68 West First Street
OSWEGO, NEW YORK

NYS BCP Site No. C738040

Prepared by:

Synapse Risk Management
360 Erie Boulevard East
Syracuse, New York, 13202
(315) 475-3700

and

Holt Consulting
P.O. Box 660
Valatie, New York, 12184

Revised
June 2018

ENGINEERING CERTIFICATION

I, Jeffrey R. Holt, P.E., certify that I am currently a NYS registered professional engineer as defined in 6 NYCRR Part 375 and that this Predesign Investigation Work Plan was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigations and Remediation (DER-10).

HOLT CONSULTING

JEFFREY R. HOLT, P.E.

JEFFREY R. HOLT
57039

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1 INTRODUCTION

This Predesign Investigation Work Plan (PDIWP) has been prepared by Synapse Risk Management, with engineering services provided by Holt Consulting (collectively referred to as "Synapse"), on behalf of Harbor View Square, LLC to provide the plan for additional investigation of documented existing bedrock groundwater contamination as prescribed in the *Record of Decision, 68 West First Street, Operable Unit Number 01: On-Site Area* at the New York State Brownfield Cleanup Program (BCP) Site Number C738040, referred to as Harbor View Square (the "Site"). The results of this investigation will be used to design the strategy for remediation of existing contamination as part of the redevelopment of the Site for commercial and residential use.

This plan is consistent with requirements set forth in the New York State Department of Environmental Conservation (NYSDEC) Division of Environmental Remediation, *Technical Guidance for Site Investigation and Remediation*, May 2010 (DER-10), and the remediation prescribed in the *Record of Decision, 68 West First Street, Operable Unit Number 01: On-Site Area, Environmental Restoration Project, Oswego, Oswego County, Site No. E738040, November 2013* (ROD) prepared for the Site by the NYSDEC.

2 SITE BACKGROUND

2.1 Site History

The initial Site use was as Fort Oswego. The Fort was used as a military installation until the mid-1750's. The Site was used for industrial purposes from at least 1880 until the early 1980's. The past industrial operations at the site include a tinwork manufacturing facility, lumberyards, a planing mill, Oswego Casket Company, Global Match Company, machine shops and a wire manufacturing facility, which was owned and/or operated by the Flexo Wire Company in 1960 and the Copperweld Steel Company, Flexo Wire Division in 1972. Prior uses that appear to have led to site contamination include solvent usage and disposal, reportedly associated with the wire drawing operations; coal storage, usage and coal ash disposal; and metal working operations, including machining and annealing.

In 2003, the City of Oswego took ownership of the Site after it had lain vacant for a period of years following the Flexo Wire use. The site is currently utilized by the City of Oswego Department of Public Works (DPW), which operates a metal fabricating workshop, a woodworking shop and an automobile maintenance shop at the site. The DPW also utilizes the Site for seasonal storage of equipment, trucks and supplies. The site is currently zoned for commercial use (B2 – Central Business); however, the proposed reuse of the site includes commercial space and apartments or condominiums, which would be a restricted residential use.

2.2 Site Location and Description

The Site is located at 68 West First Street in the City of Oswego, Oswego County (see Figure 1). The Site covers approximately 2.438 acres and consists of the block bounded by West First Street to the east, West Second Street to the west, West Schuyler Street to the south and Lake Street to the north (see Figure 2). The Site is owned by the City of Oswego and is also referred to as the former Flexo Wire site.

The generally flat-lying Site slopes gently to the east toward the Oswego River, located approximately 390 feet to the east. The river flows north into Lake Ontario, which, at its nearest point, is located approximately 250 feet north of the Site. The area to the west of the Site is primarily residential. The area to the south contains a mixture of residential and commercial properties, and to the north there is a municipal parking area, a boat launch, a marina, a United States Coast Guard facility, and a marine museum located on property owned by the Oswego Port Authority. To the east and northeast are industrial properties, including a major oil storage facility, the City of Oswego West Side Excess Flow Management facility and a cement shipping terminal.

The northwestern portion of the site is covered by a one-story concrete slab-on grade, steel-framed masonry building which covers approximately 20,900 square feet. Starting at approximately the middle of the southern Site boundary, a retaining wall of varying height of up to approximately eight feet and in fair to poor condition extends west along West Schuyler Street. At the corner of West Schuyler and West Second Streets, the retaining wall turns north and extends along much of the western Site boundary, supporting West Second Street. The retaining wall forms a portion of the western wall of the main Site building.

A one-story building connects to, and extends east from, the northeastern corner of the main building. This smaller building covers approximately 780 square feet. To the east and south of the building, the site is paved. A grassy area extends north from the paved areas to Lake Street.

2.3 Geology

Soil at the Site consists of historic fill, described as a mixture of sand, silt, ash, wood, brick and other debris. Beneath the surface soils, the site is underlain by the Late Ordivician sandstone of the Oswego Formation. The sandstone bedrock was described in previous investigations from cores as medium bluish grey sandstone with red shale lenses. Horizontal bedrock fractures were observed to be oriented with local bedding. Vertical fractures in the bedrock were also observed (OBG, 2013).

Fill was encountered in previous investigations from ground surface to the top of bedrock, which was very shallow on the western side of the site (zero to two feet below the ground surface), and somewhat deeper on the east side of the site (four to 10 feet below the ground surface). Bedrock was encountered at depths ranging from directly below the building slab, to a depth of approximately ten feet in the northeast corner of the site. The ground surface and bedrock surface slope down to the east-northeast.

2.4 Hydrology

Previous investigations encountered groundwater, primarily located in the deeper sandstone bedrock. The shallow bedrock groundwater is located directly below the top of bedrock, up to fifteen feet below the bedrock surface, which is at a maximum of 18.5 feet below the ground surface. The deeper bedrock groundwater was monitored from approximately 30 to 35 feet below the ground surface. Groundwater flow is to the east/northeast towards the Oswego River in both the shallow bedrock groundwater and deeper sandstone bedrock groundwater (CHA, 2011, OBG, 2013).

2.5 Site Remedial Investigations and Environmental Characterization

Several investigations of the subsurface Site conditions have been performed and subsequent reports have been issued. A Remedial Investigation/Remedial Alternatives Report was issued by CHA in 2011, a Supplemental Subsubsurface Investigation/Alternatives Analysis Report was issued by OBG in 2013. Following these reports, the NYSDEC issued two Records of Decision (RODs) in 2013: one ROD for Operable Unit (OU) Number 01: On-Site Area; and one for OU Number 02: Off-Site Area. The RODs present the remedy selected by NYSDEC to address documented contamination at each OU. This work was done under the NYSDEC Environmental Restoration Program as site number E738040.

The purpose of the investigations was to define the nature and extent of any contamination resulting from previous industrial activities at the Site. The primary contaminants of concern (COCs) for the site include several chlorinated volatile organic compounds (CVOCs); specifically tetrachloroethene (PCE) and trichloroethene (TCE) and their degradation products, which include 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-

dichloroethene (trans-1,2-DCE), and vinyl chloride (VC). Other COCs of interest include; several metals, including lead, mercury and others, as well as polycyclic organic hydrocarbons (PAHs).

2.5.1 Soil

Results of previous soil sampling are presented in the attached Figure 3. PAHs and metals are present in soil across the site at concentrations greater than Part 375 soil cleanup objectives (SCOs) for the protection of public health for restricted residential use. In general, the levels were only slightly greater than SCOs; however, a few isolated locations contained higher levels. Lead was detected in one location at 38,800 parts per million (ppm), compared to its restricted residential SCO for the protection of public health of 400 ppm; however, samples collected near this location had much lower levels of lead (maximum of 319 ppm), and the next highest lead concentration detected was 875 ppm. Mercury was detected at a maximum concentration of 52 ppm in one location, compared to its restricted residential SCO for the protection of public health of 0.81 ppm. Samples collected near this location had much lower levels of mercury, and the next highest level of mercury detected during the investigation was 4.5 ppm. Benzo(a)pyrene (a PAH) was detected at a maximum concentration of 4.9 ppm, compared to its restricted residential SCO of 1 ppm, and it exceeded 1 ppm in 7 out of 23 samples collected.

PCE, TCE and their degradation products in general were detected in soil at relatively low concentrations, but in some instances at concentrations which exceed the SCOs for the protection of groundwater. The highest concentrations of VOCs were detected in samples collected to the east of the southern half of the on-site building, which is also east of the utility lines connecting the former sump and the former 15,000-gallon underground storage tank. Of the VOCs, TCE was present at the most significant concentrations; up to 1 ppm, compared to its SCO for the protection of groundwater of 0.47 ppm. Cis-1,2-DCE was detected at concentrations up to 0.49 ppm, compared to its SCO for the protection of groundwater of 0.25 ppm. Other degradation products were detected at lower concentrations or not at all in soil. PCE was detected less frequently than TCE, at a maximum concentration of 0.022 ppm, compared to its SCO for the protection of groundwater of 1.3 ppm.

2.5.2 Groundwater

The groundwater results were of previous investigations are shown in Figure 4. The results were compared to the Standard Criteria or Guidance (SCG) for groundwater – Ambient Water Quality Standards and Guidance Values (TOGs 1.1.1), 6 NYCRR Part 703, Surface and Groundwater Quality Standards. TCE was detected in groundwater at concentrations that ranged from 4.6 to 280 parts per billion (ppb). The detected TCE concentrations exceeded the SCG for groundwater of 5 ppb in 11 of 12 samples. Additionally, the degradation products also detected were: cis-1,2-DCE in nine of 12 samples at concentrations ranging from non-detect to 1,100 ppb (SCG = 5ppb); trans-1,2-DCE in three of 12 samples in concentrations ranging from non-detect to 26 ppb (SCG = 5 ppb); 1,1-DCE in one sample at a concentration of 8 ppb (SCG = 5 ppb) and vinyl chloride in 3 of 12 samples at concentrations ranging from non-detect to 67 ppb (SCG = 2 ppb).

The highest concentrations of TCE detected on-site were in samples collected from monitoring wells east of the southern sump. This suggests the primary source of groundwater contamination is located in or near the southern portion of the building, most likely the southern sump, and the groundwater contamination extends east from that area.

TCE and cis-1,2-DCE were present the most often and at the highest concentrations (9.4 to 240 ug/L and 7.6 to 1,100 ug/L, respectively). When the other degradation products were detected, they were present at lower concentrations. Total VOC contamination was higher in the deep bedrock well, when compared to the adjacent shallow bedrock well.

2.5.3 Soil Vapor

PCE, TCE and their degradation products were detected at elevated concentrations in soil vapor and sub-slab vapor. TCE and PCE were detected in soil vapor and sub-slab vapor samples at concentrations up to 34,000 micrograms per cubic meter (ug/m3) and 590 ug/m3, respectively. Indoor air samples were not collected during the investigation, because the building is currently planned to be demolished.

3 PREDESIGN INVESTIGATION

The NYSDEC ROD for OU-1 specifies that the Site remediation consist of the following parts: expanded excavation, focused in-situ chemical treatment (ISCT), Site cap and natural attenuation. This PDIWP presents the scope of the investigation needed to design the ISCT. The predesign investigation will be performed using high resolution site characterization techniques to understand the Site bedrock geology and chemistry. The findings from this investigation will be used to design the remediation program. This investigation will be focused on the area indicated on Figure 6.

All intrusive work will be performed in accordance with the PDIWP Health and Safety Plan (HASP), as presented in Appendix D. All Synapse subcontractors will be advised of the Synapse HASP during Site activities. All requirements of the NYSDEC Community Air Monitoring Program (CAMP), will be followed during any intrusive work at the Site, as presented in Appendix E.

3.1 Bedrock Investigation

The bedrock investigation will be performed using high definition site characterization methods to identify discrete vertical intervals in which the existing contamination is present. This will allow for a precise interpretation and evaluation for the presence of contamination in the bedrock mass to a level not achievable through conventional bedrock investigation methods. The understanding from this investigation will enable a focused and efficient remediation of the contamination.

A total of five exploratory bedrock holes will be advanced using a Geoprobe 3230 drill rig, or equivalent, in the approximate locations presented in Figure 6, however, actual locations may vary based on conditions encountered in the field. Prior to any subsurface work, the Synapse drilling subcontractor will file a request through Dig Safely New York for subsurface utility clearance by member companies. In borings where overburden soil are encountered four-foot macrocore samplers with Teflon liners will be utilized to collect continuous soil samples ahead of the continuous flight augers. Soil samples collected from the borings will be field-screened utilizing a photoionization detector (PID) to identify the potential presence of VOCs and logged utilizing the Unified Soil Classification System (USCS).

The bedrock investigation will be overseen by a Synapse geologist or engineer. The two eastern-most locations will be advanced using a diamond core HQ-sized (2.5-inch diameter) triple-tube core barrel system. The three western-most borings will be installed using down-hole air hammer (DTH) technology. If bedrock is not encountered at the surface, overburden soils will be removed to bedrock and a four-inch diameter steel surface casing will be grouted into place at the top of bedrock using Portland cement and the casing should have a minimum stick up height of two feet. The grout will be allowed to cure 24 hours prior to drilling or coring the bedrock unit. Upon boring completion, the boring locations will be measured and recorded by a New York State licensed surveyor, with a planned horizontal and vertical accuracy of ± 0.1 feet and ± 0.01 feet, respectively.

Prior to advancing any bore or boring, the down-hole drilling equipment will be cleaned and decontaminated before each use. This will be done using a hot water pressure washer over a lined decontamination area. Water from the decontamination area will be collected and placed into 55-gallon drums for off-site disposal pending the results of waste characterization sampling.

All boreholes will be decommissioned in accordance with NYSDEC guidance document CP-43 Monitoring Well Decommissioning Policy, presented in Appendix E.

3.1.1 Cores

The Cascade Technical Services' (CTS) CORE Discrete Fracture Network (CORE DFN) technology is a rock core sampling and analysis method that will be used to assess the distribution of CVOCs in the fractured sandstone bedrock of the Oswego Formation, located beneath the Site. This approach is ideal for fractured sedimentary rock environments where the rock matrix has significant primary porosity (the pore spaces in the rock). The primary porosity may contain a significant portion of the contaminant mass, having diffused from the fractures above. The CORE DFN methodology will be used on the two cored borings. Background information on the CORE DFN technology is included as Appendix A.

CTS provides the CORE technology on a commercial basis under agreement with Professor Beth Parker (University of Guelph) and Professor Tadeusz Gorecki (University of Waterloo). This type of investigation has been performed at sites in the United States and Canada as part of ongoing research projects. The CORE approach was developed by Parker from a literature search for information on such methods used by others, and from previous studies conducted by the University of Waterloo (e.g. Parker and Sterling, 1999; Sterling, 1999; Sterling et al., 2005; Turner, 2001; Hurley, 2003; Meyer, 2005) at a variety of fractured rock sites with chlorinated solvent contamination. The process and equipment have evolved over the course of many research projects, resulting in a high level of data quality and efficiency.

Using five-foot runs with the HQ triple core barrel (produces a 2.5" O.D. core), a geologist will log and select sample locations from each core run based on types of fractures, start and end time of run, estimated drilling water lost during run, description of bedrock type, weathering, texture, color, recovery, PID readings and evidence of groundwater and/or DNAPL fluid flow. The geologist will exercise judgment during sampling to provide an average sample frequency of one sample every one to two feet. Duplicate samples will be collected a frequency of one per every tenth sample as set forth in DER-10 2.1 (c)3.iii and iv. The collected samples will be processed immediately on site by the CTS MobiLab (see Appendix B for reference information on MobiLab and accreditation certificate).

With the onsite laboratory, analytical results will be available in less than an hour of sample collection. This information will be used to define the total depth of each location. Cores will be advanced to a minimum depth of 50 feet bgs, or until a core run does not have concentrations of CVOCs exceeding the SCGs, as defined above and in the RI and ROD.

The rock core contaminant analysis are performed on small sections of rock collected along the entire length of the core with an average 12-inch spacing resulting in high resolution determination of the contaminant mass distribution. This average spacing is typically for sedimentary rock such as sandstone, limestone and dolostone, where the contaminants have minimal sorption. The select rock core samples will be crushed and preserved in the field by methanol preservation. The preserved samples will be analyzed by microwave extraction and analysis of the methanol extraction. Rock cores will also be analyzed for geochemical properties such as porosity, permeability and fraction organic carbon (f-oc). The rock core analytical analyses provides total contaminant mass concentration which are converted by calculations into dissolved and sorbed fractions as appropriate. The rock core analytical results will be compared to ambient groundwater standards set forth in TOGS 1.1.1 for identified constituents of concern (COCs). The borehole advancement will be terminated at the corresponding depth where concentrations are determined to be non-detect or below the instruments method detection limit (MDL).

Once the cores have been obtained and the borings have been completed, the corehole will be sealed with a blank liner from Flexible Liner Underground Technologies (FLUTe liner) to prevent cross contamination of the borehole (see Sterling et. al., 2005) and preserve open hole for future use. Additional information regarding the FLUTe liner system is in Appendix C. The rock cores generated from the installation will be stored on site for reference purposes. All cores should be labeled and stored in a secure lockable container to prevent tampering.

3.1.2 Borings

Three additional bedrock borings will be advance with DTH air hammer technology to the west of the cored holes, at the approximate locations shown in Figure 6. These borings will be installed after the cored locations and will be advanced to approximately the same depth below ground surface as the cores. A downhole video imaging technology will utilized to evaluate and document subsurface conditions at these boring locations. To maintain the integrity of the borings and minimize potential contamination transport within the boring, FLUTe liners with the FACT activated carbon will be deployed down the open borehole as quickly as possible once the drilling equipment has been removed. The procedure for deploying the FLUTes is described in Appendix C.

Once in place, the FLUTes will be left in boreholes for approximately two weeks, to allow CVOCs present in the bedrock to react with the liner. The FLUTEs should not be deployed longer that two weeks and should be visually inspected a minimum of once per week to ensure the integrity of the system. If the FLUTe liners are found be leaking they will be removed and replaced with new FLUTe liners. The FLUTEs will then be removed from the boring. Once out of the boring, a field scientist will collect information on depth intervals that reacted with the exterior NAPL liner. The activated carbon liner will then be removed from the FLUTe, and the entire carbon strip will be analyzed in order to locate depths of contamination in the formation. . The collected carbon liner samples will be placed in a labeled container and be submitted for laboratory analysis of VOCs by USEPA Method 8260C to confirm the concentrations and constituents of the plume, transmitted under standard chain of custody protocols. If NAPL is identified in any of the five borings it will be containerized in a similar method as the other drilling fluids.

After processing, the blank FLUTe will be deployed back down the borehole. Water and bedrock spoils generated from the boring installation will be containerized on site in labeled 55-gallon drums, pending waste characterization sample results before being disposed of at a regulated facility. Only potable water will be utilized for all field activities including drilling water, decontamination water and for filling the FLUTe liners.

3.1.3 Groundwater

The information gained from the five borings will be assessed to identify the depth intervals of bedrock holding the CVOCs. These depths will then be targeted using a discrete groundwater sampling device, such as the Water FLUTe system, the purging and sampling procedures are presented in Appendix F – Sampling Guidelines for Water FLUTe Systems. The Water FLUTe system allows for the collection of discreet groundwater samples from the previously identified depth intervals. The number of intervals to be targeted, and therefore the number of water samples to be collected, as well as the method for targeting the intervals, will be determined after the data from the borings has been reviewed.

The Water FLUTe system allows for a single groundwater sample to be collected from each targeted interval in general conformance with the United States Environmental Protection Agency (USEP) low flow sampling protocol (USEPA, 2010). Prior to purging, the following information will be collected from the location and recorded on the groundwater sampling form:

- Date, time, and weather conditions;
- Location identification and depth interval;
- Photoionization (PID) reading from the top of the boring before the cap is removed;
- Thickness of NAPL in the water, if present;
- pH, dissolved oxygen, temperature, specific conductance and oxidation/reduction potential;
- Total depth of the well or boring from the top of casing or surveyors mark if present;
- Depth from the top of casing to the water being sampled;
- Estimated water volume in well or boring.

As further discussed in Appendix F Prior to groundwater sample collection, the target interval will be purged by applying gas pressure to the tubing to force the water in the pump tube and sample tube to the surface. The required pressure is control by a regulator and is calculated based on sampling depth. A minimum of four purge strokes are recommended to remove water that may have been in contact liner. Groundwater sampling can commence beginning with the fifth purge stroke of the system. The FLUTe system port are identical in length which allows for multiple intervals to be sampled simultaneously offering a time savings. . The interval will be purged until the parameters have stabilized and reading will be recorded every three to five minutes or a purge volume equal to the volume of the flow-through cell, as follows:

- **Drawdown** – less than 0.3 feet;
- **pH** – three consecutive values within ±0.1 units;
- **Dissolved oxygen (DO)** – within 10% for values greater than 0.5 mg/L, or if three consecutive DO values are less than 0.5 mg/L;
- **Temperature** – three consecutive temperature values within 3%;
- **Turbidity** – within 10% for values greater than 5 Nephelometric turbidity units (NTU), or if three consecutive turbidity values are less than 5 NTU;
- **Specific Conductance (SPC)** – three consecutive values within 3%; and
- **Oxidation/Reduction Potential (ORP)** – three consecutive ORP within ± 10 millivolts.

The information above will be recorded on groundwater sampling logs.

Immediately prior to sampling, the depth from the top of casing to the water being sampled will be collected. All depth measurements will be recorded to the nearest 0.01 feet. After sampling, the start and end time for sampling, sampling method and pH, DO, temperature, turbidity, SPC and ORP will be recorded on the well sampling log.

The collected groundwater samples will be labeled and placed immediately in an iced cooler for submittal under standard chain of custody protocols to a New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP) accredited laboratory for analysis of VOCs by USEPA Method 8260C and Metals by USEPA Methods 6010 and 7471. Table 1 summarizes the proposed samples.

4 LABORATORY ANALYSIS

4.1 Bedrock Samples

The collected bedrock samples collected by the geologist, consisting of thin (typically less than 2”) pieces of the core from the determined depths, or cut to determine if the zone of interest is continued (via trim saw) and processed by a second scientist to properly fit the apparatus. The core sample will be placed in a closed stainless steel crushing cell fitted with o-rings and crushed with a stainless steel piston at pressures as high as 6,000 psi. The crushed sample will then be extruded from the cylinder directly into a pre-weighed 40 mL VOA vial containing a known volume of purge and trap grade methanol. Through this method, the amount of air passing by the sample while being crushed is minimized as well as the time required to completely crush the rock fragments into the desired particle size. The stainless steel crushing vessels and associated tools will be decontaminated using a triple rinse procedure following each use. Equipment blanks are collected periodically to demonstrate the process is effective at removing contamination. The crushing equipment, balances, methanol dispensers, computers and other equipment are housed in Cascade’s data collection trucks onsite, serving as a secure work space with lights, heat, air conditioning, electrical power and a variety of tools and equipment. The specialized stainless steel crushing chambers and tools are decontaminated by a third Cascade staff member using a 4 stage process. This process reduces the difficulty and time required to decontaminate the crusher and improves sample integrity by reducing the potential for losses due to volatilization during the crushing process.

The crushed samples will be immediately analyzed by the onsite, NYSDOH ELAP accredited, Mobile-Lab. Background information on the MobiLab, as well as a copy of the accreditation certificate, have been included as Appendix C. First the samples will undergo microwave assisted extraction (MAE). Typical solvent extractions using shaking or sonication require five weeks in order to extract all of the contaminant mass even following crushing. Using MAE, this extraction time is reduced to less than an hour. Analysis of the extract will be USEPA method 8260C conducted under a full quality assurance/quality control (QA/QC) system that is designed to meet the objectives set forth by the EPA’s SW-846 methodologies.

Additional bedrock samples will be collected for physical property analyses, including porosity, bulk density, organic carbon content, chloride diffusion coefficient and matrix permeability. These samples will be placed in laboratory-provided containers, labeled and delivered under standard chain of custody protocols to the Golder Associates Laboratory, Mississauga, Ontario for analysis. Typically, these samples are collected on an average of every 20-feet of core with the intention of getting samples from representative lithology.

4.2 FLUTe FACT Samples

FLUTe FACT liners will be attached to the blank liners and installed in the locations advanced with DTH drilling methods. The liners will be allowed to come into equilibrium with the borehole over a two week period. The liners will be removed from the boreholes and sub-sectioned into 2 foot vertical strip samples to allow for easier handling and to further sub-section liners into sizes that will fit into the glass containers and to isolate areas where NAPL is present. The entire carbon strip will be analyzed in order to locate depths of contamination in the formation. These sub-samples will be preserved and prepared for laboratory analysis in methanol filled glass containers. The samples will be analyzed for CVOCs by USEPA method 8260C.

4.3 Groundwater Samples

The groundwater samples will be analyzed for VOCs by USEPA Method 8260C and by Metals by USEPA Method 6010B/7000A by a NYSDOH ELAP accredited laboratory. As discussed previously, the number of total samples to be collected and analyzed will be determined after review of the bedrock boring information.

5 QUALITY ASSURANCE

Once all of the results of field testing and sample analysis have been received, the data will be reviewed, tabulated and mapped. All analysis will be performed by NYSDOH ELAP accredited laboratories. Detection limits will be below the SCGs established in the ROD.

Laboratory data will be presented in electronic data deliverable (EDD) format for EQUIS upload. Analytical Services Protocol (ASP), Category B Deliverables and a Data Usability Summary Report (DUSR) will be prepared to Quality Assurance/Quality Control of the data. Table 1 is the Analytical Methods/Quality Assurance Summary Table.

5.1 Data Quality Usability Objectives

Consistent with the ROD for OU-1, the Data Quality Usability Objectives of the data from the PDIWP is that they will be used to develop the ISCT program to remediate the VOCs in bedrock. The objectives are expressed in terms of precision, accuracy, representativeness, completeness and comparability. These are each further defined in the following subsections.

5.1.1 Precision

Precision is a measure of the reproducibility of sample results. The goal is to maintain a level of analytical precision consistent with the objectives of the sampling and analysis program. To maximize precision, sampling and analytical procedures will be followed.

5.1.2 Accuracy

Accuracy is defined as the degree of agreement of a measure with an accepted reference of “true value”. Both field and analytical accuracy will be monitored through initial and continuing calibration of instruments.

5.1.3 Representativeness

Representativeness is the degree to which sampling data accurately and precisely represent site conditions. The samples proposed as part of this PDWIP have been designed to assess the presence of environmental impacts at the time of sampling.

5.1.4 Completeness

Completeness is defined as a measure of the amount of valid data obtained from an event compared to the amount that was obtained. The completeness of data will be assessed and presented in the Data Usability Summary Report.

5.1.5 Comparability

Comparability is the degree of confidence with which one data set can be compared to another. This will be maintained throughout the investigation by following the sampling and analytical procedures presented in this plan.

5.2 Field Sampling Quality Objectives

The objectives of the field sampling and testing activities are to maximize confidence in the data in terms of the Data Quality Usability Objectives, as presented in section 5.1. Data quality checks will be made in the form of field duplicates and trip blanks, as presented in Table 2.

6 CALIBRATION PROCEDURES

Laboratory calibration procedures will be performed on a regular basis, as described in the laboratory quality assurance manuals, provided in Appendix H.

Team members will be familiar with the field calibration, operation and maintenance of the equipment, and will perform the prescribed field operating procedures outlined in the operation and field manuals for the respective equipment. Field personnel will keep records of all field instrument calibrations and field checks in the field logbooks. Calibration information recorded in field logbooks will include date, time, instrument made and model, a description of the calibration procedure and any instrument deviations.

If any on-site monitoring equipment should fail, replacement equipment will be provided of the malfunction will be repaired in a timely manner.

7 SCHEDULE

The schedule for beginning this investigation is dependent on funding by Harbor View Square, LLC. A potential schedule is presented in Table 2, below:

Table 2 - Predesign Investigation Schedule

Activity	Dates
Receive Funding Award	4/15/18
PDIWP Submittal to NYSDEC	6/15/18
Submit Soil Management Plan	7/5/18
Baseline Groundwater (COC/PFOA)	6/30/18
PDIWP Approval by NYSDEC	7/19/18
Archeology Investigation	8/15/18 – 9/30/18
Harbor View Construction	10/31/18 – 4/1/20
Soil Remediation	10/31/18 – 12/30/18
Bedrock Borings	11/5-11/8/2018
FLUTe Study	11/12-11/15/2018
Groundwater Sampling	12/18-12/22/2018
Summary Report Submittal	02/27/2019

8 KEY PERSONNEL

Synapse will staff this investigation with professionals having expertise in the tasks to be performed and experience working on NYSDEC sites. Key project personnel are listed below. Professional qualifications are included as Appendix G.

Mr. Roger R. Creighton, rcreighton@synapsellc.com, of Synapse will be the program manager for this investigation. Mr. Creighton holds a B.S. in Engineering. He has been supporting public and private sector clients within environmental and geoscience applications for over 19 years, including several BCP investigation and remediation projects. Mr. Creighton will be responsible for strategic planning, finalizing the scope of work, project implementation, budget and schedule management, technical management and overall management of the project.

Mr. Jeffrey Holt, P.E., jholt@holtconsulting.net, of Holt Consulting will be the engineer of record for this project. Mr. Holt has both a B.S and M.S. in geology and has been a licensed Professional Engineer in multiple states, including New York State, since 1978. He has been providing environmental engineering services to clients for over 40 years. Mr. Holt will be responsible for detailed engineering aspects of the investigation.

Mr. Brian Macrae, bmacrae@synapsellc.com, of Synapse will be the Quality Assurance Officer (QAO). Mr. Macrae holds a bachelor’s degree in civil engineering from Clarkson University. Mr. Macrae has been providing environmental consulting services to private and public sector clients for over 20 years.

Mr. Michael Jordan, mjordan@cascade-env.com, of Cascade will be the drilling and technical advisor for the CORE DFN and FLUTe liner and sampling portions of the project. Mr. Jordan holds a Bachelor’s degree in Geology and is a licensed driller in 13 states. Mr. Jordan has over 22 years of experience in subsurface sample collection for environmental and geotechnical purposes.

9 REPORT

The results of this predesign investigation will be presented in a predesign summary report and include the following:

- Certification by a qualified environmental professional or professional engineer;
- Summary of work conducted and conclusions;
- Summary tables with analytical results;
- Figures, boring logs and rock cores;
- Photographs of all rock cores;
- FLUTe retrieval, sampling logs and photographs;
- Monitoring well construction and sampling logs;
- CAMP data;
- Generated waste summary and disposal receipts; and
- Summary of estimate investigation costs.

10 REFERENCES

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Sterling, S.N. (1999). *Comparison of Discrete Depth Sampling Using Rock Core and a Removable Multilevel System in a TCE Contaminated Fractured Sandstone*. M.Sc. Thesis, Department of Earth Sciences, University of Waterloo, 108 pp.

Sterling, S. N., B. L. Parker, J. A. Cherry, J. H. Williams, J. W. Lane Jr., and F. P. Haeni, (2005). *Vertical Cross Contamination of Trichloroethylene in a Borehole in Fractured Sandstone.* Ground Water, 43(4), 557-573.

Turner, C.M. (2001). *Origin and Behavior of TCE and Metolachlor Contamination in a Fractured Dolostone Water Supply Aquifer.* M.Sc. Thesis, Department of Earth Sciences, University of Waterloo, 158 pp.

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TABLES

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

TABLE 1

Sample Summary
Harbor View Square
68 West First Street
Oswego, New York
NYS BCP Site No. C738040

Media	Number of Locations	Sample Frequency	Matrix	Sample Depth	Analytical Parameters	Analytical Method	Sample Rationale	Sampling Method
Bedrock	2	TBD	Bedrock	TBD	VOCs	USEPA Method 8260C	Identify location of CVOCs in bedrock	Core
					Physical Characteristics including: porosity, bulk density, organic carbon content, chloride diffusion coefficient and matrix permeability		Determine bedrock physical parameters and understand bedrock matrix diffusion and mass distribution characteristics to develop remedial injection program	
FLUTe Activated Carbon Liners	3	TBD	Carbon	TBD	VOCs	USEPA Method 8260C	Identify location of CVOCs in bedrock	FLUTe FACT
Groundwater	5	TBD	Water	TBD	VOCs / Metals	USEPA Methods 8260C / 6010/7471A	1 - Confirm CVOCs in groundwater corresponds to bedrock observations; 2 - Understand bedrock groundwater environment for remediation program design	FLUTe Low flow sampling
Soil, Groundwater and Drilling Fluids, Rock Cores, Liners & PPE	TBD	TBD	Soil, Groundwater Drilling Fluids, Rock Cores, Liners & PPE	TBD	TCLP VOCs & Metals, TCLP Mercury	USEPA Methods 8260C / 6010/7471A	Characterization for disposal purposes	Composite Sample

Notes:

1. TBD = To Be Determined (the number of samples to be collected and analyzed will be determined either in the field (bedrock and FLUTe) or after the bedrock information is received (groundwater)
2. VOCs = Volatile Organic Compounds
3. CVOCs = Chlorinated Volatile Organic Compounds
4. MS/MSD Samples to be collected on a 5% frequency
5. Duplicate groundwater samples to be collected at a frequency of 1 sample per 20 samples.
6. Trip blanks should be include with each laboratory shipment that contains samples for VOC analysis.

TABLE 2

Analytical Methods/Quality Assurance Summary Table
Harbor View Square
68 West First Street
Oswego, New York
NYS BCP Site No. C738040

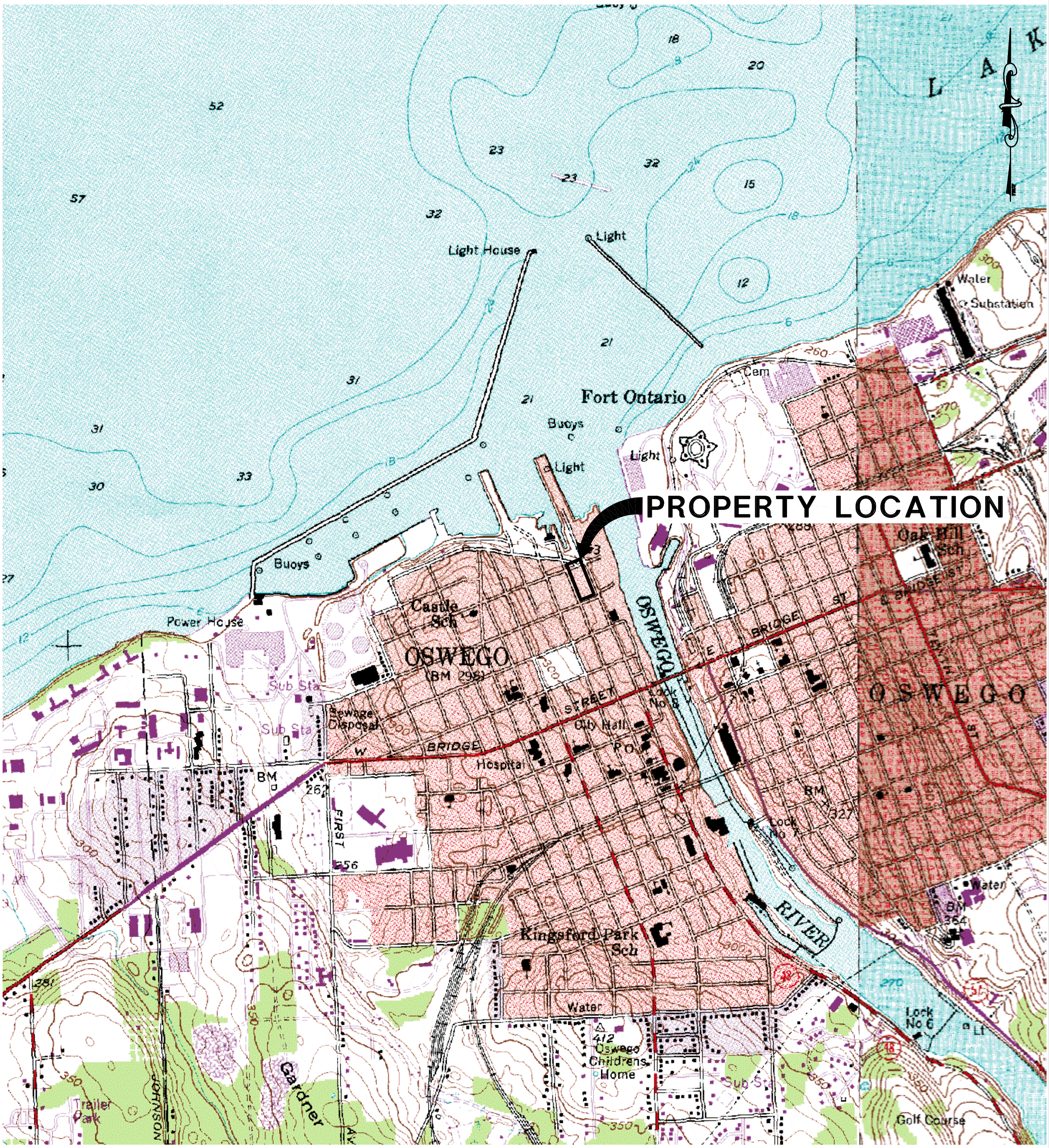
Sample Marix Type	Sample Frequency	Equipment Blank Frequency	Trip Blank Frequency	Analyitcal Parameters	Anaytical Method	Analytical Reporting Requirement	Matrix Spike Frequency	Field Duplicate Frequency	Sample Preservation	Sample Container Type and Volume	Method Hold Time	P&T Grade Methanol Blank Frequency
Bedrock	1.5 feet	5%	1 per cooler	VOCs, Total Organic Carbon Physical characteristics including: porosity, bulk density, carbon content, chloride difusion coeffecient, matrix permiability	USEPA Method 8260C	Level IV	5%	5%	methanol	40-ml VOA	14 days	1 per Liter
Example Name	XYZ-03-50.50-VOC	XYZ-03-EB-01	XYZ-03-TB-01				XYZ-03-50.50-VOC-MS and XYZ-03-50.50-VOC-MSD	XYZ-03-FD-01				092226-R_MB-1
Carbon	Entire Strip	NA	1 per cooler	VOCs	USEPA Method 8260C	Level II	NA	NA	methanol	40-ml VOA	28 days	NA
Example Name	XYZ-03-51.0-51.5-FACT	NA	TBD				NA	NA				NA
Groundwater	TBD	NA	1 per cooler	VOCs	USEPA Method 8260C	Level IV	5%	5%	HCl	3 - 40 mL vials	14 days	NA
	TBD	NA	NA	Metals	USEPA Method 6010B/7000A	Level IV	5%	5%	NHO3	500-ml Plastic	180 days	NA
Example Name	MW-03	NA	NA				MW-03-MS and MW-03-MSD	MW-03-FD				NA

FIGURES

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018



SOURCE: USGS 7.5 MIN. TOPOGRAPHIC QUADRANGLES: OSWEGO WEST, N.Y., 1954, PHOTOREVISED 1978 AND OSWEGO EAST, N.Y., 1954, PHOTOREVISED 1978.

APPROXIMATE GRAPHIC SCALE:

0 2000' 4000'

P: EPA
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-SL3.DWG

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SYRACUSE, NEW YORK 13202

HARBOR VIEW SQUARE
NYSBCP SITE NO. C738040
68 WEST FIRST STREET
OSWEGO, NEW YORK

PROPERTY LOCATION PLAN

PROJECT NO.:
HSGVIS-24-16-05

DATE:
MAY 2017

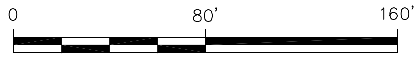
FIGURE NO.:
1

LEGEND

APPROXIMATE SITE BOUNDARY

NOTES:

1. 2015 AERIAL PHOTOGRAPH FROM NYSGIS CLEARINGHOUSE WEBSITE.
2. ALL LOCATIONS ARE APPROXIMATE.



GRAPHIC SCALE

P: BL
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-B01.DWG

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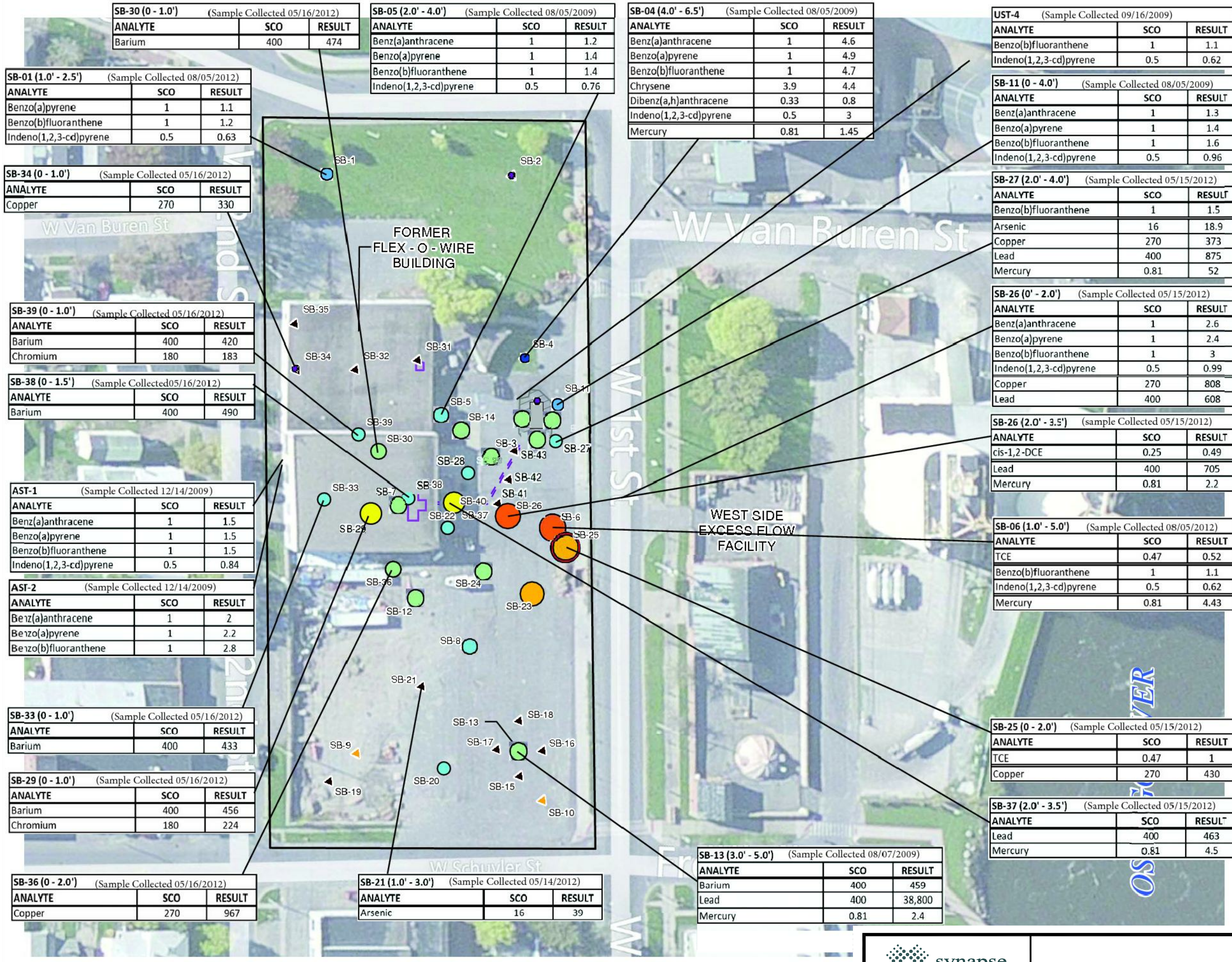
68 WEST FIRST STREET
OSWEGO, NEW YORK

AERIAL PROPERTY PLAN

PROJECT NO.: HSGVIS-24-16-05
DATE: MAY 2017
FIGURE NO.: 2



SB-30 (0 - 1.0') (Sample Collected 05/16/2012)		
ANALYTE	SCO	RESULT
Barium	400	474

SB-05 (2.0' - 4.0') (Sample Collected 08/05/2009)		
ANALYTE	SCO	RESULT
Benz(a)anthracene	1	1.2
Benzo(a)pyrene	1	1.4
Benzo(b)fluoranthene	1	1.4
Indeno(1,2,3-cd)pyrene	0.5	0.76

SB-04 (4.0' - 6.5') (Sample Collected 08/05/2009)		
ANALYTE	SCO	RESULT
Benz(a)anthracene	1	4.6
Benzo(a)pyrene	1	4.9
Benzo(b)fluoranthene	1	4.7
Chrysene	3.9	4.4
Dibenz(a,h)anthracene	0.33	0.8
Indeno(1,2,3-cd)pyrene	0.5	3
Mercury	0.81	1.45

SB-01 (1.0' - 2.5') (Sample Collected 08/05/2012)		
ANALYTE	SCO	RESULT
Benzo(a)pyrene	1	1.1
Benzo(b)fluoranthene	1	1.2
Indeno(1,2,3-cd)pyrene	0.5	0.63

SB-34 (0 - 1.0') (Sample Collected 05/16/2012)		
ANALYTE	SCO	RESULT
Copper	270	330

SB-39 (0 - 1.0') (Sample Collected 05/16/2012)		
ANALYTE	SCO	RESULT
Barium	400	420
Chromium	180	183

SB-38 (0 - 1.5') (Sample Collected05/16/2012)		
ANALYTE	SCO	RESULT
Barium	400	490

AST-1 (Sample Collected 12/14/2009)		
ANALYTE	SCO	RESULT
Benz(a)anthracene	1	1.5
Benzo(a)pyrene	1	1.5
Benzo(b)fluoranthene	1	1.5
Indeno(1,2,3-cd)pyrene	0.5	0.84

AST-2 (Sample Collected 12/14/2009)		
ANALYTE	SCO	RESULT
Benz(a)anthracene	1	2
Benzo(a)pyrene	1	2.2
Benzo(b)fluoranthene	1	2.8

SB-33 (0 - 1.0') (Sample Collected 05/16/2012)		
ANALYTE	SCO	RESULT
Barium	400	433

SB-29 (0 - 1.0') (Sample Collected 05/16/2012)		
ANALYTE	SCO	RESULT
Barium	400	456
Chromium	180	224

SB-36 (0 - 2.0') (Sample Collected 05/16/2012)		
ANALYTE	SCO	RESULT
Copper	270	967

SB-21 (1.0' - 3.0') (Sample Collected 05/14/2012)		
ANALYTE	SCO	RESULT
Arsenic	16	39

SB-13 (3.0' - 5.0') (Sample Collected 08/07/2009)		
ANALYTE	SCO	RESULT
Barium	400	459
Lead	400	38,800
Mercury	0.81	2.4

UST-4 (Sample Collected 09/16/2009)		
ANALYTE	SCO	RESULT
Benzo(b)fluoranthene	1	1.1
Indeno(1,2,3-cd)pyrene	0.5	0.62

SB-11 (0 - 4.0') (Sample Collected 08/05/2009)		
ANALYTE	SCO	RESULT
Benz(a)anthracene	1	1.3
Benzo(a)pyrene	1	1.4
Benzo(b)fluoranthene	1	1.6
Indeno(1,2,3-cd)pyrene	0.5	0.96

SB-27 (2.0' - 4.0') (Sample Collected 05/15/2012)		
ANALYTE	SCO	RESULT
Benzo(b)fluoranthene	1	1.5
Arsenic	16	18.9
Copper	270	373
Lead	400	875
Mercury	0.81	52

SB-26 (0' - 2.0') (Sample Collected 05/15/2012)		
ANALYTE	SCO	RESULT
Benz(a)anthracene	1	2.6
Benzo(a)pyrene	1	2.4
Benzo(b)fluoranthene	1	3
Indeno(1,2,3-cd)pyrene	0.5	0.99
Copper	270	808
Lead	400	608

SB-26 (2.0' - 3.5') (sample Collected 05/15/2012)		
ANALYTE	SCO	RESULT
cis-1,2-DCE	0.25	0.49
Lead	400	705
Mercury	0.81	2.2

SB-06 (1.0' - 5.0') (Sample Collected 08/05/2012)		
ANALYTE	SCO	RESULT
TCE	0.47	0.52
Benzo(b)fluoranthene	1	1.1
Indeno(1,2,3-cd)pyrene	0.5	0.62
Mercury	0.81	4.43

SB-25 (0 - 2.0') (Sample Collected 05/15/2012)		
ANALYTE	SCO	RESULT
TCE	0.47	1
Copper	270	430

SB-37 (2.0' - 3.5') (Sample Collected 05/15/2012)		
ANALYTE	SCO	RESULT
Lead	400	463
Mercury	0.81	4.5

LEGEND

TOTAL VOCs mg/kg

- ● 0.0022 - 0.005
- ● >0.005 - 0.0075
- ● >0.0075 - 0.01
- ● >0.01 - 0.025
- ● >0.025 - 0.05
- ● >0.05 - 0.1
- ● >0.1 - 0.25
- ● >0.25 - 0.5
- ● >0.5 - 1.0
- ● >1.0 - 1.075
- ▲ PRE–SSI SOIL BORING – NO VOC DATA
- ▲ SSI SOIL BORING – NO VOC DATA

NOTES:

1. FIGURE MODIFIED FROM FIGURE 4, 2013 REPORT BY O'BRIEN & GERE.
2. RESULT CONCENTRATIONS EXPRESSED IN MG/KG.
3. SCO – RESTRICTED RESIDENTIAL USE SOIL CLEANUP OBJECTIVE.

0 80' 160'
GRAPHIC SCALE

P: BL
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-B05.DWG

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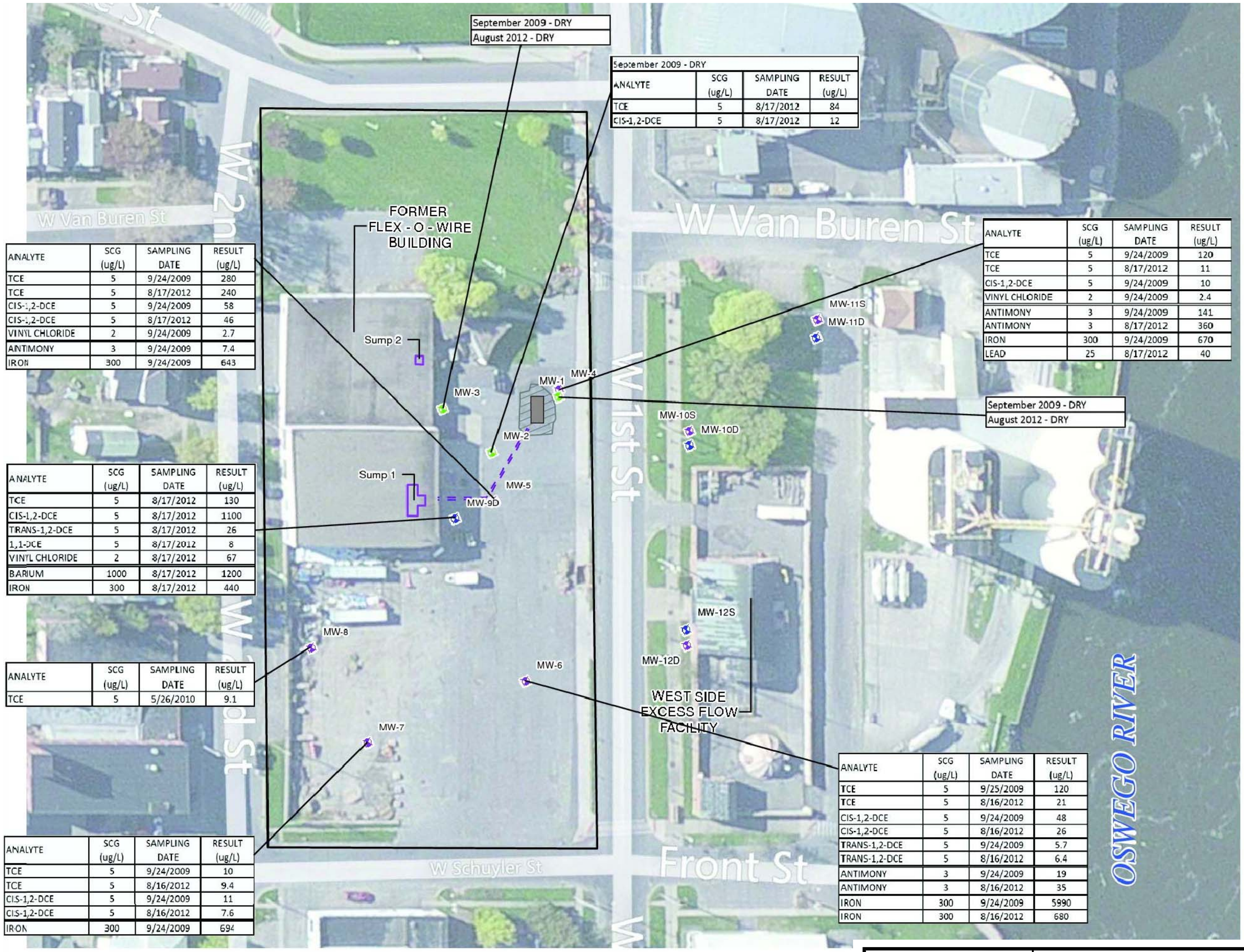
OSWEGO, NEW YORK

PREVIOUS SOIL BORING LOCATIONS AND ANALYTICAL EXCEEDANCES

PROJECT NO.: HSGVIS-24-16-05
DATE: MAY 2017
FIGURE NO.: 3



September 2009 - DRY
August 2012 - DRY

September 2009 - DRY

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	8/17/2012	84
CIS-1,2-DCE	5	8/17/2012	12

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	9/24/2009	280
TCE	5	8/17/2012	240
CIS-1,2-DCE	5	9/24/2009	58
CIS-1,2-DCE	5	8/17/2012	46
VINYL CHLORIDE	2	9/24/2009	2.7
ANTIMONY	3	9/24/2009	7.4
IRON	300	9/24/2009	643

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	9/24/2009	120
TCE	5	8/17/2012	11
CIS-1,2-DCE	5	9/24/2009	10
VINYL CHLORIDE	2	9/24/2009	2.4
ANTIMONY	3	9/24/2009	141
ANTIMONY	3	8/17/2012	360
IRON	300	9/24/2009	670
LEAD	25	8/17/2012	40

September 2009 - DRY
August 2012 - DRY

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	8/17/2012	130
CIS-1,2-DCE	5	8/17/2012	1100
TRANS-1,2-DCE	5	8/17/2012	26
1,1-DCE	5	8/17/2012	8
VINYL CHLORIDE	2	8/17/2012	67
BARIUM	1000	8/17/2012	1200
IRON	300	8/17/2012	440

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	5/26/2010	9.1

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	9/24/2009	10
TCE	5	8/16/2012	9.4
CIS-1,2-DCE	5	9/24/2009	11
CIS-1,2-DCE	5	8/16/2012	7.6
IRON	300	9/24/2009	694

ANALYTE	SCG (ug/L)	SAMPLING DATE	RESULT (ug/L)
TCE	5	9/25/2009	120
TCE	5	8/16/2012	21
CIS-1,2-DCE	5	9/24/2009	48
CIS-1,2-DCE	5	8/16/2012	26
TRANS-1,2-DCE	5	9/24/2009	5.7
TRANS-1,2-DCE	5	8/16/2012	6.4
ANTIMONY	3	9/24/2009	19
ANTIMONY	3	8/16/2012	35
IRON	300	9/24/2009	5990
IRON	300	8/16/2012	680

LEGEND

— —	PROCESS LINE
——	EXISTING SUMP
▨	EXCAVATION AREA
■	FORMER 15,000 GALLON UST

NOTES:

1. FIGURE MODIFIED FROM FIGURE 4, 2013 REPORT BY O'BRIEN & GERE.

0 80' 160'
GRAPHIC SCALE

P: BL
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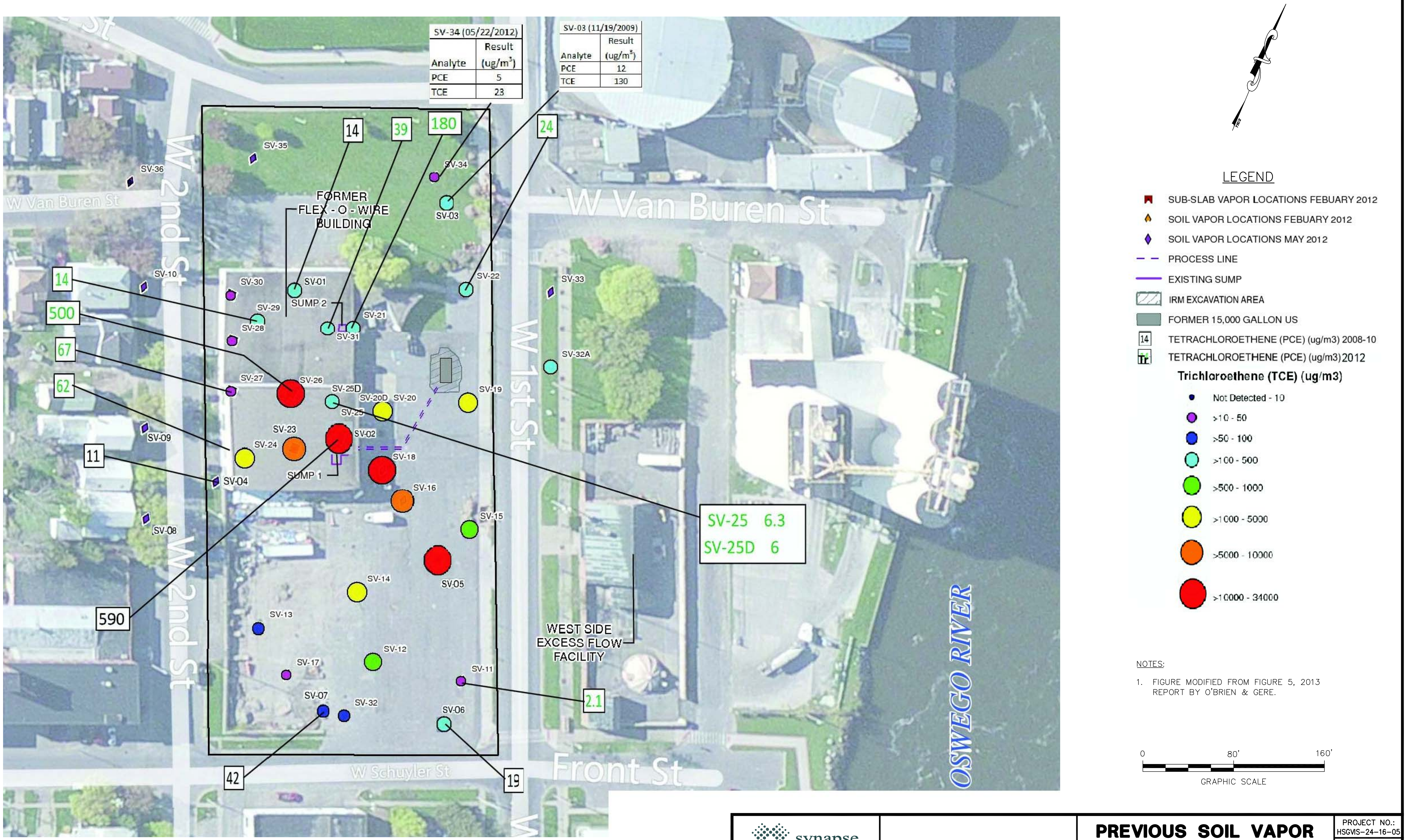
MONITORING WELL LOCATIONS AND PREVIOUS ANALYTICAL EXCEEDANCES

PROJECT NO.:
HSGVIS-24-16-05

DATE:
MAY 2017

FIGURE NO.:
4



SV-34 (05/22/2012)	
Analyte	Result (ug/m³)
PCE	5
TCE	23

SV-03 (11/19/2009)	
Analyte	Result (ug/m³)
PCE	12
TCE	130

LEGEND

- SUB-SLAB VAPOR LOCATIONS FEBUARY 2012
- SOIL VAPOR LOCATIONS FEBUARY 2012
- SOIL VAPOR LOCATIONS MAY 2012
- PROCESS LINE
- EXISTING SUMP
- ▨ IRM EXCAVATION AREA
- FORMER 15,000 GALLON US
- 14 TETRACHLOROETHENE (PCE) (ug/m3) 2008-10
- 14 TETRACHLOROETHENE (PCE) (ug/m3) 2012

Trichloroethene (TCE) (ug/m3)

- ● Not Detected - 10
- ● >10 - 50
- ● >50 - 100
- ● >100 - 500
- ● >500 - 1000
- ● >1000 - 5000
- ● >5000 - 10000
- ● >10000 - 34000

NOTES:

1. FIGURE MODIFIED FROM FIGURE 5, 2013 REPORT BY O'BRIEN & GERE.

P: BL
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-B07.DWG

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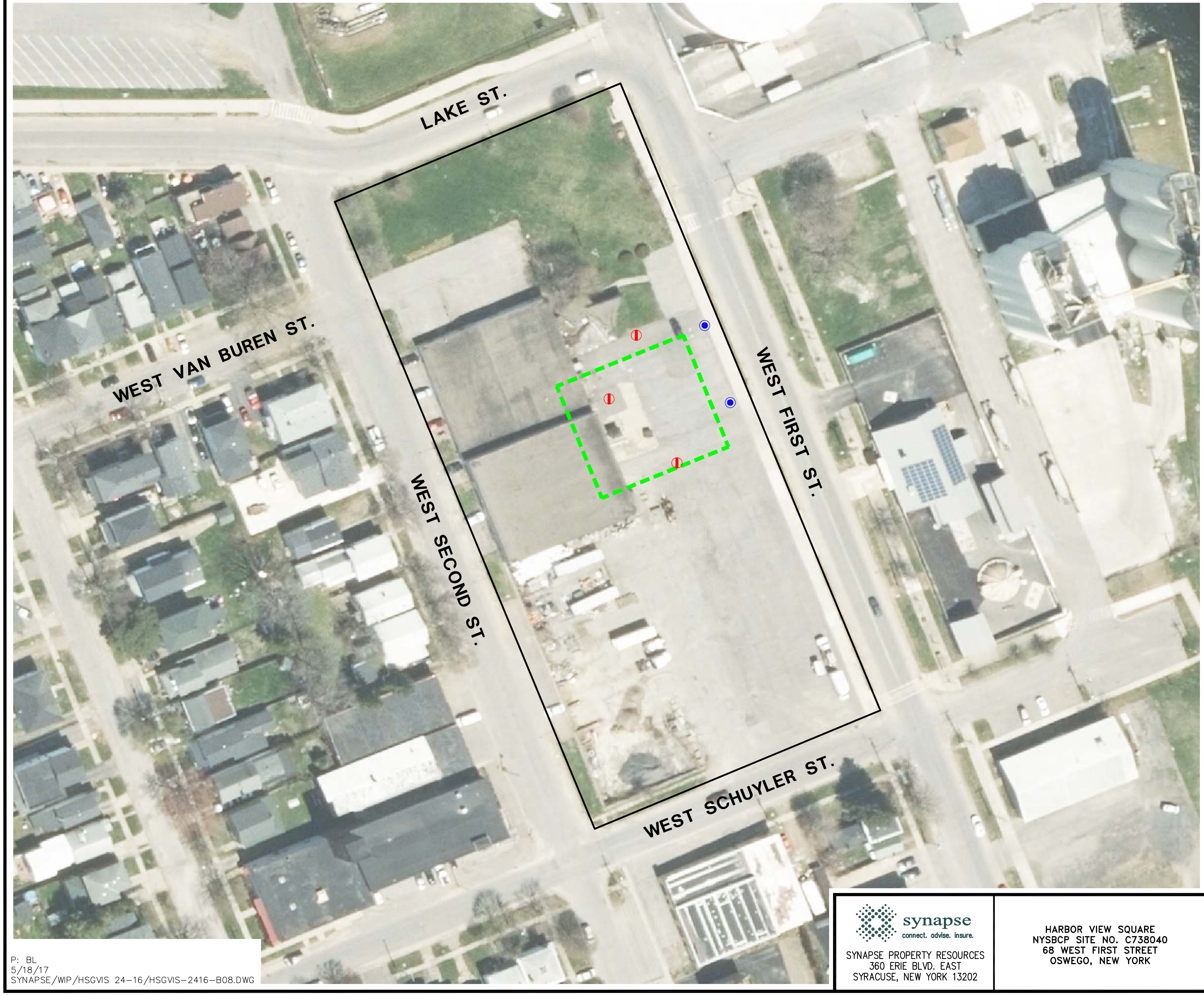
OSWEGO, NEW YORK

PREVIOUS SOIL VAPOR LOCATIONS AND ANALYTICAL RESULTS

PROJECT NO.: HSGVIS-24-16-05
DATE: MAY 2017
FIGURE NO.: 5



LEGEND

——— APPROXIMATE SITE BOUNDARY

◐ PROPOSED DOWNHOLE AIR HAMMER BORING

◉ PROPOSED BEDROCK CORE

▭ PRE-DESIGN INVESTIGATION FOCUS AREA

NOTES:

1. 2015 AERIAL PHOTOGRAPH FROM NYSGIS CLEARINGHOUSE WEBSITE.
2. ALL LOCATIONS ARE APPROXIMATE.

0 80' 160'

GRAPHIC SCALE

P: BL
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-B08.DWG

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SYNAPSE PROPERTY RESOURCES
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HARBOR VIEW SQUARE
NYSBCP SITE NO. C738040
68 WEST FIRST STREET
OSWEGO, NEW YORK

PROPOSED BEDROCK BORING LOCATIONS

PROJECT NO.:
HSGVIS-24-16-05

DATE:
MAY 2017

FIGURE NO.:
6

APPENDIX A
CORE DFN REFERENCE INFORNMATION

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

High-Resolution Site Characterization in Fractured Rock Environments

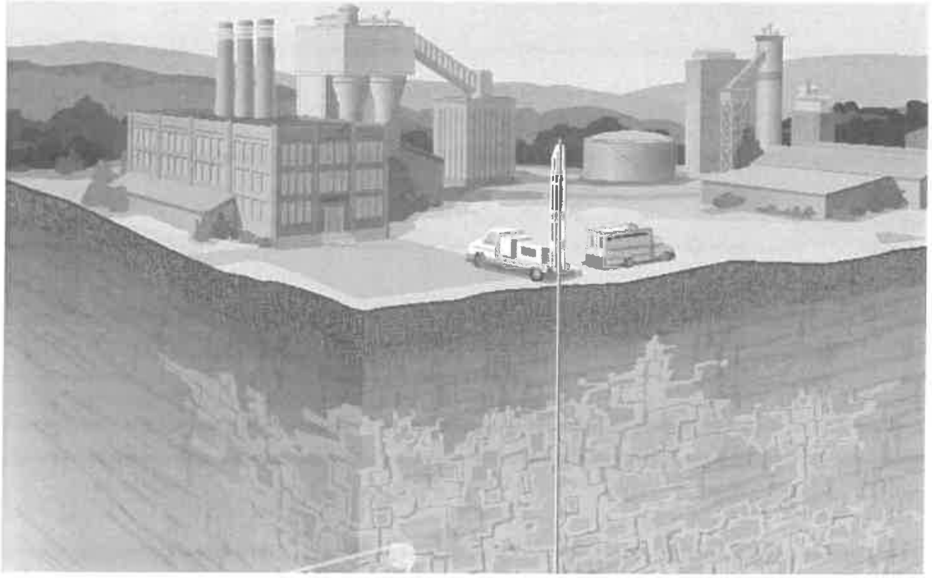
Building on extraordinary growth in understanding of the processes governing fate and transport of contamination in subsurface systems, Cascade Technical Services provides a unique and powerful approach to the investigation of fractured bedrock contamination.

CORE DFN™
DISCRETE FRACTURE
NETWORK APPROACH

CORE Discrete Fracture Network Approach™

CORE Discrete Fracture Network Approach™, was developed as a means to assess contaminant mass distribution in both the secondary porosity (fracture) and the primary porosity (matrix). The approach also provides a determination of transport pathways. CORE^{DFN} is a high-resolution investigation approach that definitively describes contaminant mass distribution and identifies which fractures are active transport pathways (not just hydraulically active ones).

The approach couples unique proprietary sampling and analytical methods backed up by rigorous QA/QC to provide reliable data that offer an unparalleled understanding of contamination in fractured rock.



In fractured rock with primary porosity of as little as 1%, the vast majority of the contaminant mass may be present in the rock matrix rather than the fractures. Groundwater flow occurs mainly in the fractures, but an investigation and remedy that focusses only on the transport pathways and not on the contaminant mass has a low likelihood of success.

CASCADE
DRILLING | TECHNICAL SERVICES

CORE^{DFN}

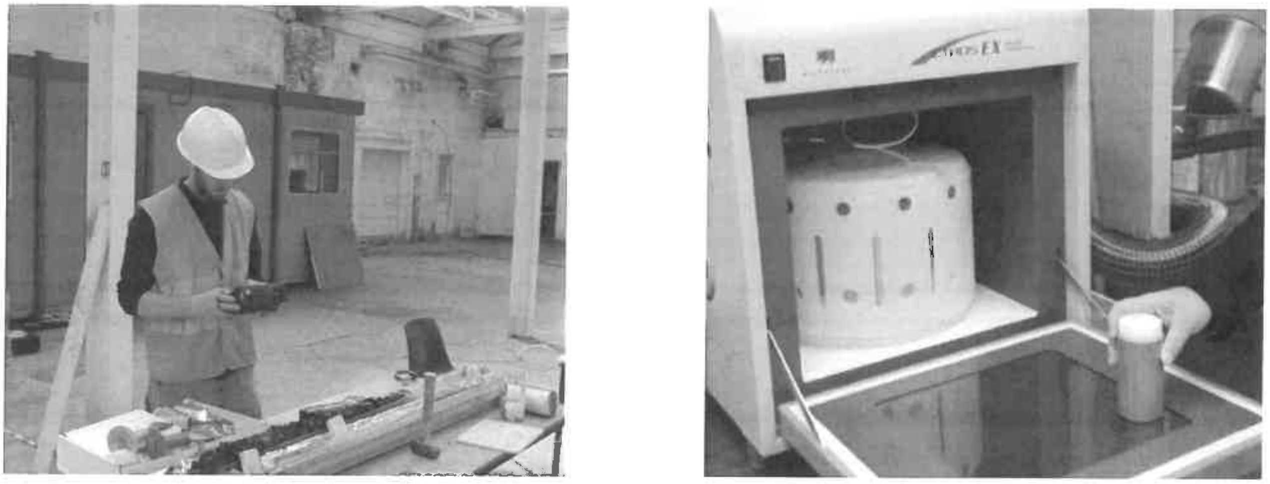
What does CORE^{DFN} Address?

- Mass distribution in a dual-porosity system.
- Migration pathway determination.
- Contaminant mass storage in the matrix pore water and sorption to organic matter in the matrix.
- Potential for strong plume retardation resulting from diffusion of mass from fractures into matrix.
- Potential for the matrix to be a long-term source of solutes as contaminant mass diffuses back to the fractures.

In bedrock aquifers comprised of sedimentary rock, the fracture porosity is often orders of magnitude smaller than the matrix porosity. While transport occurs through the fractures, the majority of contaminant mass is often in the matrix where its movement is diffusion rate limited.

Methods in Fractured Rock

CORE^{DFN} utilizes rock core contaminant analyses to determine the distribution of Volatile Organic Compounds (VOC) mass in the subsurface. In the traditional approach, sampling at fractured rock sites focuses on sampling groundwater in fractures. For sedimentary rock sites, however, the expectation is for contaminant mass storage to be dominated by the rock matrix due to diffusion of mass from the fractures into the matrix and subsequent storage as dissolved/ sorbed VOC mass. The rock core subsampling approach involves depth-discrete sampling and processing of rock core subsamples collected during drilling, with samples collected both adjacent to fractures and in the rock matrix between fractures, with the goal of understanding the extent to which contaminant mass has diffused from the fractures into the rock matrix.



Rock core samples are collected at a close spacing and then logged into a custom database on a handheld computer onsite before crushing, microwave extraction, and analysis.

APPENDIX B
CASCADE TECHNOLOGY SERVICESMOBILAB REFERENCE INFORMATION & NYSDOH ELAP ACCREDIATION CERTIFICATE

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

CASCADE
DRILLING | TECHNICAL SERVICES

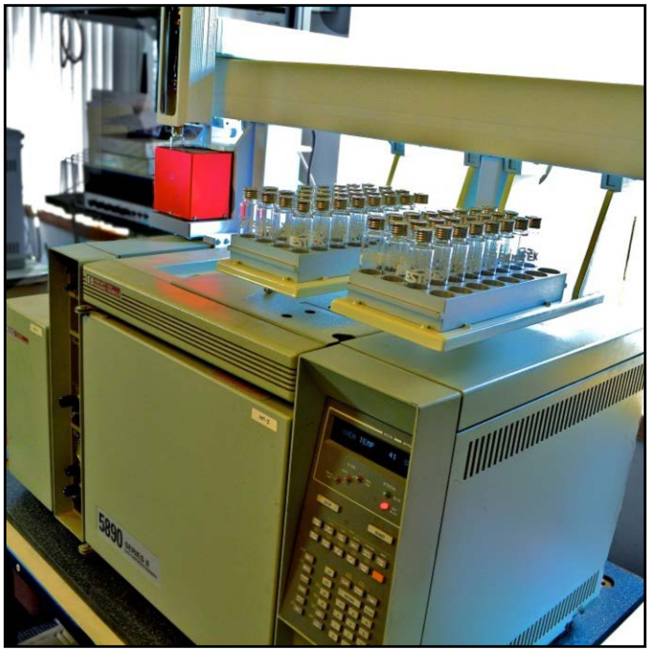
MobiLab™

Onsite Labs Aren't Just for Screening

Cascade Technical Services generates, manages, and presents fully defensible analytical chemistry data onsite, offering the subsurface investigation and remediation community a timely and extremely reliable product.

Our onsite labs are accredited by National Environmental Laboratory Accreditation Conference (NELAC) and offer the following:

- High-quality, defensible data
- Rapid turnaround times
- Cost savings as compared to fixed lab programs
- High sample throughput
- Project appropriate analytical programs



Solid phase microextraction with gas chromatography/mass spectrometry (GC/MS) provides fast, accurate, and certified results.

Benefits of Onsite Labs

- Increased QA/QC samples
- Resolve equipment contamination issues quickly
- Samplers spend more time sampling and less time packing coolers
- Samples cannot get lost/broken by courier, because courier is not needed

MobiLab™
DEFENSIBLE REAL-TIME ANALYTICS

Defensible, Accurate and Certified Data

Cascade Technical Services' onsite laboratories operate under the laboratory standards developed by the National Environmental Laboratory Accreditation Program (NELAP) and are certified for volatile organic compounds (VOCs) in water and soil matrices.

Our QA/QC program adheres strictly to EPA SW-846 800 Series guidelines, ensuring results that are as accurate, precise, and defensible as those of fixed labs.

MobiLab™

Twenty-Minute Turnarounds

Innovative techniques such as Solid Phase Microextraction (SPME) allow us to provide an unmatched combination of quality, speed, and economy to our clients.

SPME is an extremely simple sample concentration technique for air, water, and soil matrices.

SPME is performed using fast, inexpensive, and easy-to-use equipment that is designed for field applications.

A full analytical sequence (including sample login, extraction, analyses and reporting) for a list of 40 compounds takes only 20 minutes.

Cost Savings

We are able to generate a large quanity of analytical data all within one day through the use of innovative analytical procedures, autosamplers, and sound project planning, Our SPME autosampler, is capable of analyzing one sample every 12 minutes and can be easily configured to handle high-priority samples when rapid results are needed.

Our labs are normally charged at a day rate as opposed to a per sample price. Compared to a program in which a fixed lab is used for 24-hr rushed analyses, our onsite lab becomes efficient when the sampling team generates more than 17 groundwater samples per day. Significant savings can be realized if more than 17 samples are being collected daily.

Our mobile units will set up at your facility to generate, manage, and present fully defensible data.

Project-Appropriate Analytical Programs

Unlike fixed laboratory programs that are designed to accommodate samples from a variety of sites with a wide range of data quality objectives, we strive to set up our needs of the project at hand. Starting early in the project planning phase, we identify a project's quality objectives in order to maximize the efficiency of the analytical program.

Our labs are fully equipped to provide analytical services equivalent to that of a fixed lab; we can, however, customize our analytical program for individual projects in order to provide a more cost-effective program. Instead of managing a heavily burdened analytical program involving sixty target analytes and significant reporting requirements, a more streamlined analytical program allows the analyst to focus on managing data and disseminating these data to the project team.

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

NY Lab Id No: 12004

MR. MICHAEL ROSSI
CASCADE TECHNICAL SERVICES VERMONT. - MOBILE
UNIT #2
1 HOME FARM WAY
MONTPELIER, VT 05602

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved analytes are listed below:

Fuel Oxygenates

Methyl tert-butyl ether	EPA 8260C

Volatile Aromatics

1,2,4-Trichlorobenzene, Volatile	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
Benzene	EPA 8260C
Chlorobenzene	EPA 8260C
Ethyl benzene	EPA 8260C
Isopropylbenzene	EPA 8260C
Naphthalene, Volatile	EPA 8260C
Styrene	EPA 8260C
Toluene	EPA 8260C
Total Xylenes	EPA 8260C

Volatile Halocarbons

1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C

Volatile Halocarbons

1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C
Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Carbon tetrachloride	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
Dibromochloromethane	EPA 8260C
Methylene chloride	EPA 8260C
Tetrachloroethene	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260C
Trichloroethene	EPA 8260C
Vinyl chloride	EPA 8260C

Volatiles Organics

1,4-Dioxane	EPA 8260C
Carbon Disulfide	EPA 8260C

Sample Preparation Methods

	ASTM D6520-00

Serial No.: 56327

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NELAP RECOGNIZED TNI ACCREDITATION BODY

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

NY Lab Id No: 12004

MR. MICHAEL ROSSI
CASCADE TECHNICAL SERVICES VERMONT. - MOBILE
UNIT #2
1 HOME FARM WAY
MONTPELIER, VT 05602

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE
All approved analytes are listed below:

Volatile Aromatics

1,2,4-Trichlorobenzene, Volatile	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
Benzene	EPA 8260C
Chlorobenzene	EPA 8260C
Ethyl benzene	EPA 8260C
Isopropylbenzene	EPA 8260C
Naphthalene, Volatile	EPA 8260C
Styrene	EPA 8260C
Toluene	EPA 8260C
Total Xylenes	EPA 8260C

Volatile Halocarbons

1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C
1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C

Volatile Halocarbons

Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Carbon tetrachloride	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
Dibromochloromethane	EPA 8260C
Methylene chloride	EPA 8260C
Tetrachloroethene	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260C
Trichloroethene	EPA 8260C
Vinyl chloride	EPA 8260C

Volatile Organics

1,4-Dioxane	EPA 8260C
Carbon Disulfide	EPA 8260C
Methyl tert-butyl ether	EPA 8260C

Sample Preparation Methods

EPA 5035A-H/ASTM D6520-00

Serial No.: 56328

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APPENDIX C
FLUTE LINER REFERENCE INFORMATION

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

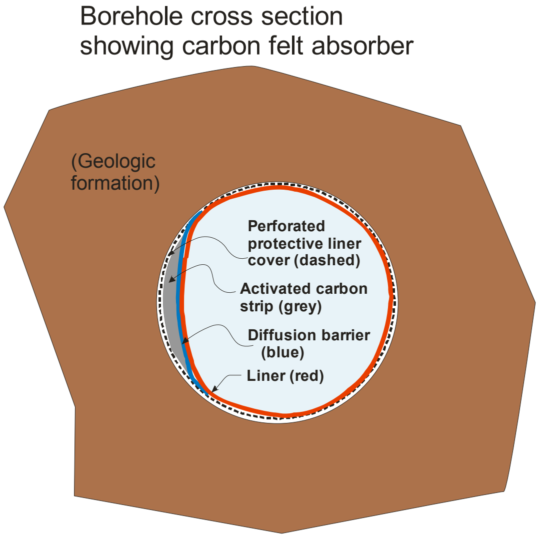
June 2018

FLUTe™ Flexible Liner Underground Technologies, Ltd. L.C.
For a medley of innovative designs
6 Easy St., Santa Fe, NM 87506
505-455-1300, www.flut.com

The FACT System and How It is Used

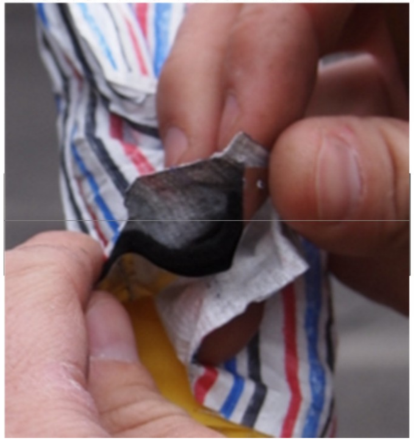
The FACT (FLUTe Activated Carbon Technique) is a method developed by FLUTe for mapping the distribution of contamination in the pore space and fractures of a borehole wall. The technique incorporates a 0.125 x 1.5 inch strip of activated carbon felt into the typical hydrophobic cover of the NAPL FLUTe system normally used for mapping the subsurface presence of a wide variety of NAPLs. The NAPL FLUTe cover is typically installed into a borehole on the outside of an everting FLUTe blank liner. The installation of a NAPL FLUTe cover with the added activated carbon strip allows one to draw, by diffusion, the dissolved contaminants from the formation into the activated carbon. Recovery of the liner by inversion prevents the carbon from contact with any other portion of the borehole wall. At the surface, the carbon is then sectioned for chemical analysis. With the combination of the NAPL cover and the FACT, one can map both the NAPL and the dissolved phase of many other contaminants.

Fig. 1. FACT Components



The FACT felt geometry is shown in the drawing, Fig. 1. The felt is located on the inside surface of the ~1 mil thick hydrophobic cover. Between the carbon and the liner is located a thin flexible diffusion barrier that isolates the carbon from the liner. The barrier is stitched to the cover on both sides of the carbon strip. The liner presses the diffusion barrier, carbon felt and perforated cover firmly against the borehole wall. The cover material is usually dye striped on the outside surface for the purpose of mapping the presence of the NAPL by developing a stain on the inside surface of the cover. The photo, Fig. 2, shows a FACT carbon felt strip sandwiched between the lower silver colored diffusion barrier and the upper striped, white NAPL FLUTe cover.

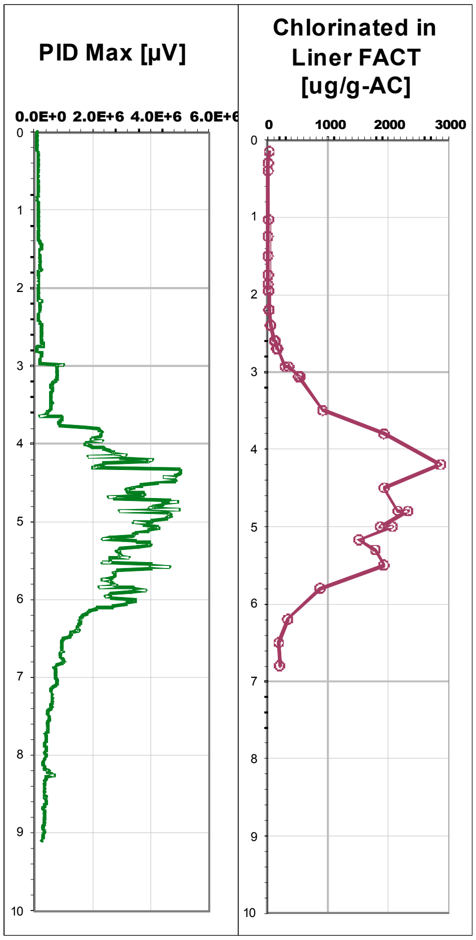
Fig. 2. The carbon felt between the cover and the diffusion barrier



Once the carbon felt sandwich is removed from the hole, the liner is removed from outside of the inverted cover and the carbon felt is sectioned as desired and placed in sample bottles with methanol. The methanol extracts the contaminant from the carbon, and the methanol is analyzed in the lab. The procedure is very similar to analysis of a soil sample. Several labs have experience analyzing the carbon felt.

The FACT method was first tested in Denmark in 2010 where it was compared to measurements performed in contaminated sediments using both the Geoprobe MIP and soil sample analysis. The NAPL/FACT liners were actually installed through Geoprobe rods. The graph (Fig.3) shows the excellent comparison with the MIP results. The comparison was equally good with the soil samples. The FACT results are in terms of contamination per gram of carbon and not directly related to the concentration in the formation. Rather, the contaminant concentration in the carbon is more directly related to the concentration gradient and diffusion coefficient of the contaminant in the formation pore or fracture space. In other words, the carbon concentration is a measure of the availability of the contaminant. The carbon is typically analyzed for the concentrations of individual species. To date, most assessments have been for NAPLs.

Fig. 3. Comparison of MIP with FACT



The protection provided by the NAPL FLUTe cover and the brief exposure (a few seconds) to the resident borehole water during the eversion of the carbon felt into place against the borehole wall greatly reduces any concern about the contact of the system with the borehole water. The borehole water is usually pumped from the hole as the liner is everted. The exposure time during the inversion of the liner during its removal is also brief. The FACT is typically left in place for 48 hr. to allow the diffusion process from the formation into the carbon. A diffusion calculation shows that two days is long enough to "see" about 0.5cm into the borehole wall with a pore space of 20%. Obviously, it is wise to seal the borehole with the FLUTe liner system as quickly as possible after the hole is drilled to minimize cross connection and the effect of the borehole water on the pore water in the formation.

Whereas the first rigorous test of the method was done in Denmark in soil, the FACT method is uniquely easy to use in fractured rock which is where this method has been more frequently used. A master's thesis is available by Monique Beyer of the Danish Technical Univ. which is a rigorous assessment of the FACT analysis method and its use for a fractured rock site. There is very little loss in the handling of the carbon. Subsequent papers are in preparation by those participating in the same project which will be comparing the use of the FLUTe NAPL/FACT, the Water FLUTe, and other methods in a limestone formation in Denmark. Ask FLUTe (info@flut.com) for a copy of the Beyer Thesis. For more information, call FLUTe at 505-455-1300, or email info@flut.com. Other FLUTe methods are described on the web site www.flut.com. Note there is no "e" in the web address.

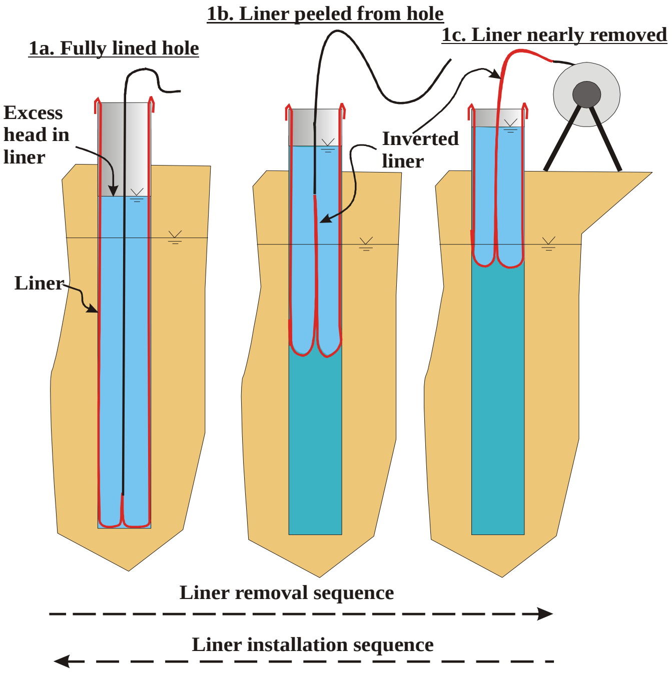
FLUTe™ Flexible Liner Underground Technologies, Ltd. L.C.
For a medley of innovative designs
6 Easy St., Santa Fe, NM 87506
505-455-1300, www.flut.com

The FLUTe® Blank liner

Method: The FLUTe blank liner is a tubular urethane coated nylon borehole liner which is normally everted into place as shown in Fig. 1. It is easier to understand the everting process if one starts with the lined hole of Fig. 1a. The excess head inside the liner, above the water table in the formation, forces the liner out against the hole wall and forms a continuous seal of the hole much like a continuous packer. By pulling up on the tether shown in the figure, the liner inverts and can be peeled from the hole wall as the tether and then the liner are wound on a reel at the surface (Fig. 1b-1c).

The installation procedure for the blank liner is the reverse procedure (Fig. 1c-1a). The inside-out liner is pulled from the reel and clamped to the top of the casing. The liner is pushed down into the casing to form an annular pocket. Water is added to the interior of the liner forcing the liner against the hole wall and down the hole, pulling the liner from the reel. As the liner "everts" down the hole (the reverse of peeling it out of the hole), the water in the borehole is forced into the formation. The liner will continue to descend in the borehole until it reaches the bottom of the hole or until all flow paths in the borehole are sealed by the liner and the water beneath the liner can not be forced into the formation.

Fig. 1. Blank liner removal and installation sequence



Uses: The blank liner is a convenient method for sealing the borehole to prevent contaminant transport in the hole. Many geophysical measurements can be performed inside the liner, with the liner sealing the hole. Those measurements are: gamma and gamma-gamma logs, induction coupled electric log (resistivity), sonic logs of several kinds, temperature logs, radar measurements, and neutron moisture logs in the vadose zone. A very attractive use of the blank liner is the measurement (i.e., location and flow rate) of all significant flow paths in the borehole while the liner is descending into position. For details on this *Hydraulic Conductivity Profiling Technique*, visit www.flut.com, or call us at 888-333-2433.

The blank sealing liner is also used to prevent the leakage of grout from the borehole while sealing the annulus between a casing and the hole wall, or while simply grouting a borehole in a karst formation. FLUTe blank liners are manufactured to the borehole dimensions and come in a variety of tensile strengths and coatings for the particular application. After the blank liner seals the borehole and the flow paths measured, the *Water FLUTe®* allows multi level water sampling.

Hydrologic Measurements with Flexible Liners

by

Carl Keller

Principal Scientist

Hydrologic Measurements with Flexible Liners

Carl Keller, (carl@flut.com)

Flexible Liner Underground Technologies (FLUTe)

Table of Contents

Abbreviations and Unique Terms

ACT – air coupled transducer system

BGS – below ground surface

Blank – the simple borehole liner without attachments

DNAPL – dense non-aqueous phase liquids

EP – the depth of the end, or the end point, of an everting/inverting liner

FACT – FLUTe activated carbon technique

FLUTe – Flexible Liner Underground Technology, LLC

GCMS – Gas Chromatograph Mass Spectrometer

LAHD – Liner Augmentation of Horizontal Drilling method

MIP – Membrane Interface Probe, a direct push device by Geoprobe

NAPL FLUTe – the color reactive covering of a blank liner for NAPL detection

NAPL- non aqueous phase liquids

Packer – inflatable bladder on a pipe used to plug a borehole

PCE – perchloroethylene, “dry cleaning fluid”, a DNAPL

PID – photo ionization detector.

Profiler – the name given to the FLUTe transmissivity profiling machine

RHP – the reverse head profile and method

SWF- Shallow Water FLUTe – The Water FLUTe system for shallow water tables

Spacer – the permeable surround of a liner that defines the interval from which a fluid sample is to be extracted.

Straddle packer – a pair of inflatable bladders for isolation of an interval in a borehole for the purpose of injection, extraction or head measurement.

Stroke – the volume expelled during the pumping procedure or the act of expelling a volume of the Water FLUTe pump system.

TCE – trichloroethylene, a common degreaser, a DNAPL

TOC – top of casing

Vadose FLUTe – the multi-level vadose pore fluid sampling system

Water FLUTe – the multi-level ground water sampling systemWell Development – The process of removing mud and cuttings from fractures in the borehole wall.

1.0 Introduction

The FLUTe Flexible liner technology as described herein is primarily directed to the mapping of subsurface hydrologic conditions. Flexible liner methods have been used for over twenty years[1]. Because the basic method was considered revolutionary before 1995, it was slow to be accepted in place of traditional practice in the hydrologic community. However, the several versions of the FLUTe flexible liner methods are now used in all the US states and in 12 foreign countries.

The purpose of this monograph is to provide the information needed by a hydrologist in order to determine whether the flexible liner methods are suitable for his/her use. The technology has evolved to include many kinds of applications for mapping ground water flow characteristics and mapping the distribution of contaminants in the ground water. Each of the main methods is described in a separate chapter.

The focus of the technology has been to provide a convenient means of assessing the distribution of both ground water quality, head distributions and flow characteristics of formations intersected by boreholes. These liner methods do not include chemical analysis of samples or the routine collections of ground water samples in open cased holes. The customer collects the samples for analysis, or uses the flow data provided by the several methods for incorporation into the numerical flow models used for site characterization or for a refinement of the site conceptual model. The primary advantage of the flexible liner methods is the very high spatial resolution of the hydrologic state and the recording of hydraulic head histories.

As with any new method, the experience gained has led to numerous refinements and an increase in the range of applications. The most recent developments have been in applications in boreholes with relatively high artesian heads.

Many of the liner designs are custom applications built to the customer's specifications. This is a natural consequence of the unpredictable characteristics of subsurface conditions. However, while those custom designs are in fabrication, the borehole is usually sealed with a flexible liner to maintain as possible the original conditions. Some custom design specifications are as simple as borehole depth and diameter. Other systems require the customer to define the details such as sampling intervals for the multi-level systems.

The several FLUTe systems have been named to distinguish each system from the other FLUTe systems. That terminology is explained in each chapter and in the list of abbreviations.

Some comparisons with traditional practice are provided for the methods being described. There are always exceptions to the generalizations of method comparisons. The comparisons are only offered for assistance in the understanding. More explicit information, such as installation and sampling procedures, is available on the FLUTe website, www.flut.com , or from FLUTe, and in referenced journal articles and other publications. Inclusion of such details would obscure the basics as described here.

---

[1] The basic method was invented in 1989 by Carl Keller who founded the company *Flexible Liner Underground Technologies*, also known as *FLUTe*, in 1996.

The format of this monograph is to start with a description of the basic liner and the mechanical procedure of installation and removal from a borehole. Subsequent chapters address the many uses that have evolved over several decades.

2.0 Basic Liner Mechanics

2.1 Liner materials

Flexible liners are necessarily strong and flexible. However, stronger is usually associated with less flexible. The basic tubular liner is made of a strong nylon fabric with a high quality urethane coating on the inside or on both sides. The urethane coating is very important because the liner must also be impermeable over its entire length. Tensile strengths of liners range from 100 to 400 lb/inch.

The liner installation and removal procedure is usually done using the mechanism of eversion or inversion respectively. Eversion is simply the reverse of inversion. While the mechanism is relatively simple, it is not obvious. The removal process, by inversion, is often easier to understand and will be described first.

Starting with the liner in place in a stable, uncased borehole (often in fractured rock), Fig. 2.1a, the liner is filled with water to a level above the water table in the formation. In that state, the difference in the water table in the formation and the water table in the liner (called the excess head, ΔH) forces the liner against the borehole wall. The liner is thereby "pressurized" and forms a seal against the borehole wall. Because the liner is thin and flexible, the liner conforms to the borehole wall better than the much thicker wall of a traditional packer.

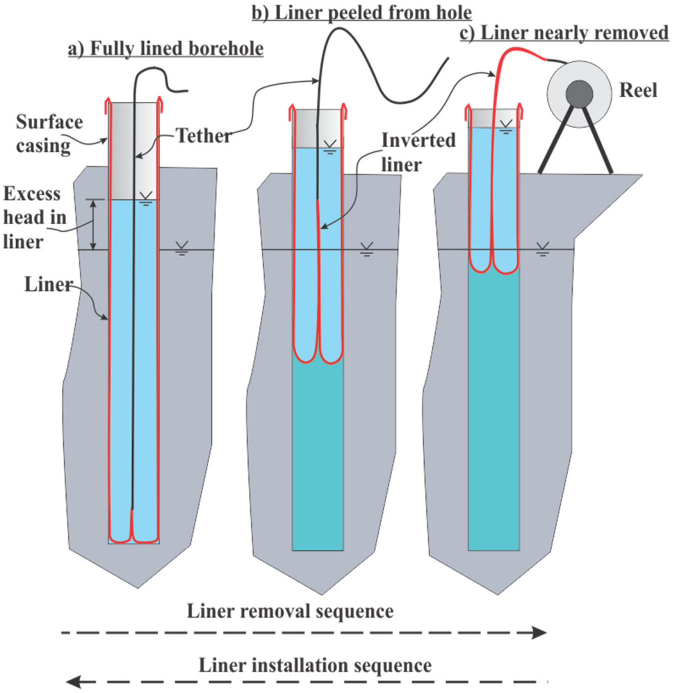


Fig. 2.1. a) Water filled liner sealing the borehole, b) *inverting* liner being "peeled" from the borehole, c) tether followed by the liner being rolled onto a reel at the surface as the liner is inverted from the borehole. Note, the reverse sequence from right to left is the installation of the liner by *eversion*.

2.2 Inversion mechanism for removal

The bottom end of the liner is sealed and a strong cord called a tether is attached to the inside bottom end of the liner (Fig. 2.1a). If one pulls upward on the tether, the liner can either invert at the bottom end (Fig. 2.1b), or, if the excess head is very small, the liner might slide upwards at the bottom end of the liner forming a buckle of the liner which jams the liner in the borehole preventing its removal. This is to be avoided. The excess head in the liner must be sufficient to prevent the liner sliding on the borehole wall, allowing only the inversion of the liner as the tether is raised.

As the liner inverts, the inverting end of the liner (called the eversion point, EP) rises in the borehole like a piston which develops a low pressure beneath the liner. If the borehole wall is permeable, water will flow into the borehole beneath the EP and reduce the partial vacuum that would otherwise develop. As the tether is raised, the inverting liner draws water from the formation into the borehole volume between the bottom end of the liner and the bottom of the borehole. The tether, followed by the liner, now inside-out, can be rolled onto a reel at the surface (Fig. 2.1c) as the liner is withdrawn.

Whereas the above sequence starts with the liner removal by inversion, the usual installation procedure starts with the liner on the shipping reel and the liner is everted into the borehole. Using that simple procedure, the liner installation requires only a clamp for the top of the casing and a water source (e.g., a garden hose).

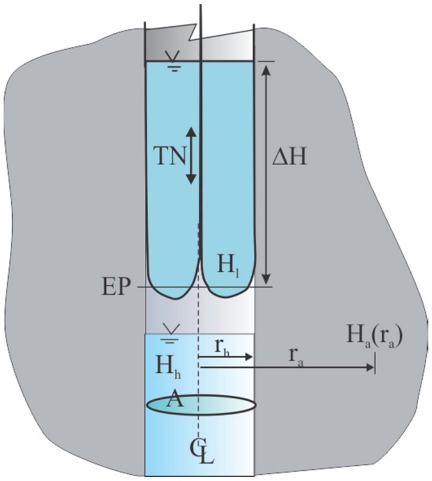


Fig. 2.3. Terminology of the liner installation. The excess head in the liner is ΔH, the tension in the liner, TN, and the borehole cross section, A, the head in the borehole, H_h, the original head in the formation, H_a, and the Eversion Point , EP, elevation of the end of the liner. Note in the drawing the liner is still above the water level in the borehole.

2.3 Eversion mechanism for emplacement

The installation of the liner by eversion is the opposite procedure from the inversion of the liner from the borehole. The liner is usually shipped to the site on a shipping reel as shown in Fig. 2.1c. The liner is inside-out on the reel. The open end of the liner is passed over the end of the surface casing and clamped in place. Pushing the liner down into the surface casing forms an annular pocket in the liner, Fig. 2.1b. By adding water to the annular pocket and feeding the liner downward into the casing, the water column in the annular pocket increases which raises the pressure against the bottom end of the liner at the EP. That increasing pressure forces the liner more deeply into the borehole. Fig. 2.3 illustrates the terminology used hereafter. The tension, TN, on the inverted liner being fed from the shipping reel increases according to the approximate relationship,

$$TN = \tfrac{1}{2}\,\Delta H\, A = \tfrac{1}{2}\,(H_l - H_h - \Delta H_m)\,\pi\, r_h^2 \qquad (2.3.1)$$

Where ΔH is the difference in pressure inside the liner, H_l, and the pressure beneath the liner, H_h, minus the minimum pressure difference needed to evert a liner, ΔH_m, and A is the cross sectional area of the liner dilated by the water fill. The minimum eversion pressure, ΔH_m, has been measured for many sizes and thicknesses of liners. Until the end of the liner (the EP) reaches the water table in the borehole, ΔH is just the height of the water column in the liner reduced by ΔH_m and ΔH continues to increase as water is added to the liner. A minimum ΔH_m is required to evert the liner, but a larger ΔH is not needed to extend the liner until the liner enters the water table in the borehole. If the water column in the liner is long but the EP is still above the water table in the borehole, the tension on the tether or liner can become very large. For example, a 10 ft water column in an 8” diameter liner can produce a tension, TN, of more than 100 lbs force. When the EP enters the water in the borehole, ΔH is the difference in the head inside the liner and in the borehole beneath the liner minus ΔH_m. However, as the liner enters the water level in the borehole, the head beneath the liner, H_h, will increase. If no more water is added, the liner will continue to descend until the ΔH is less than the minimum ΔH_m and the liner will stop everting. Adding more water increases ΔH and will drive the liner deeper into the borehole. It is noteworthy that the liner is not dragged against the borehole wall but only contacts the interior of the liner as the inverted liner descends to the EP where it everts against the hole wall. Therefore, even in very ragged boreholes, there is little abrasion of the liner and the eversion process allows the liner to conform very well with a rough borehole wall.

As the liner descends into the borehole, the head in the borehole beneath the liner EP will increase until the water flow rate out of the borehole into the formation equals the liner displacement rate. The liner displacement rate, Q, is V_{EP} A, where V_{EP} is the descent velocity of the liner EP and A is the liner cross section or the borehole cross section, whichever is smaller. This flow rate must equal the lateral flow rate from the borehole which, according to the Thiem equation is

$$Q = T \,\Delta H_h\, 2\pi / \ln (r_a/r_h) = V_{EP}\, A \qquad (2.3.2)$$

where T is the transmissivity of the open borehole beneath the liner EP, ΔH_h is the increase in driving pressure in the borehole above the ambient head, r_a is the range to the edge of the cone of influence (where the ambient head has not been perturbed by the flow through the borehole wall), and r_h is the borehole radius. The ratio r_a/r_h is defined as R and often assigned a value between 300 and 600 (Haimson, et al, 1983).

If T is very small, the flow rate out of the borehole is low and therefore the liner descent rate is slow. Increasing H_l in the liner will increase ΔH_h and the liner will descend faster. The fact that equation 2.3.2 assumes one dimensional radial flow is usually ignored. Equation 2.3.2 also assumes steady state laminar flow in the formation. That is discussed in Sections 5.

As the liner descends and seals the flow zones in the borehole wall the transmissivity, T, of the borehole below the liner must decrease. Therefore the liner descent rate, V_{EP} with a constant ΔH_h, will decrease with the liner depth in the borehole. For practical reasons, when the liner EP velocity, V_{EP}, has dropped to a prescribed low value, the tether is attached to an anchor at the top of the borehole, the liner descent is stopped, and the borehole is judged to be temporarily sealed. This borehole sealing characteristic is useful and will be discussed in sections 3 and 5.

The advantages are that the liner seals the borehole for the full length of the installation and it requires less than one hour for most installations. Because the air column between the top of the casing and the water level in the borehole can be trapped and compressed by the liner descent, an air vent tube is usually lowered to near the water table prior to the liner installation to allow the escape of the air trapped beneath the liner. This is especially important if the surface casing extends to the water table or the vadose zone is of very low permeability.

The basic method of everting a blank liner can be performed in horizontal boreholes, in piping with large radius turns and in angled boreholes. Blank carrier liners have been used to install cure-in-place liners in the walls of the Smithsonian Museum of Natural History in Washing DC from the basement upwards for 100 ft to the roof. The everting liner can be made to propagate through elbows in piping or along a lake bed under water. The driving fluid need not be water, but the pressure difference, ΔH, across the end of the liner will propagate the liner by eversion. These attributes are discussed more in Sec. 8.

In summary:

- The liner is installed by eversion, displacing the borehole water into the formation.
- The liner is removed by inversion and draws formation water into the borehole.
- If the pressure difference across the end of the liner is too low during removal, the liner can be buckled and jammed in the borehole. This must be avoided.
- The higher the excess head in the liner, the more quickly it descends.
- The liner seals flow zones in the borehole wall as the liner passes those zones.
- See the FLUTe web site, www.flut.com, for an animation of the installation and removal procedure.

3.0 Blank liners for sealing boreholes

3.1 Installation method and equipment

Blank liners are a very useful form of the flexible liner. Blank liners have no attachments except a tether connection as shown in Fig. 3.1.1. Also blank liners have an interior sleeve welded to the inside surface of the liner to contain a "bubbler tube" as shown in Fig. 3.1.1. The bubbler tube is used to monitor the water level in the liner during installation in boreholes with deep water tables. A constant small flow of air through a bubbler tube produces a pressure in the tube above the end of the tube that is directly proportional to the depth of the tube submergence below the water. An air vent is connected to the bottom end of the liner near the tether attachment. The reason for the air vent at the bottom end of the liner is to vent air trapped inside the inverted liner on the shipping reel. As the inverted liner descends into the borehole, the water pressure outside the inverted liner forces any trapped air in the everted liner upward toward the closed end of the liner. The trapped air can cause the end of the liner to dilate (Fig. 3.1.2) against the lined borehole wall. Because of the large surface area of the dilated liner, a modest air pressure can produce so much drag as to stop the liner descent. The air vent allows the trapped air to escape upward through the interior of the liner, but the check valve prevents water flow out of the pressurized interior of the liner. In some

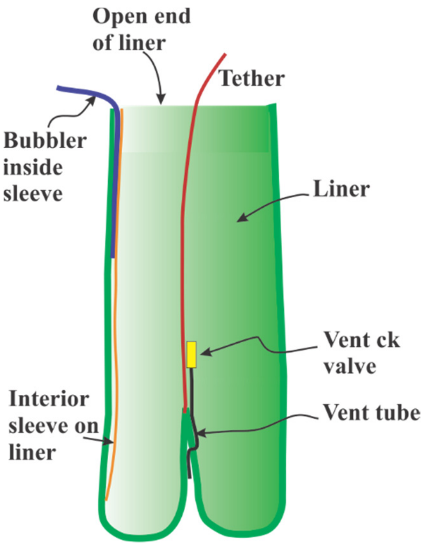


Fig. 3.1.1. Drawing of a liner showing interior sleeve, bubbler tube, tether attachment to the liner, air vent check valve and vent tube through inverted end of liner.

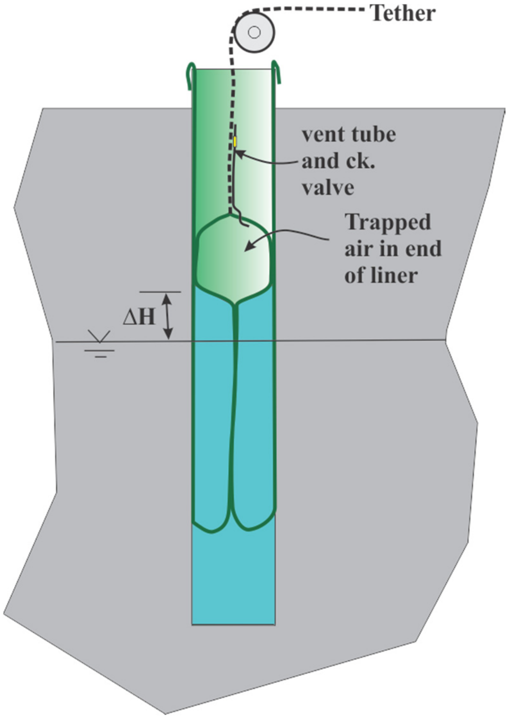


Fig. 3.1.2. The formation of an air balloon due to trapped air in the end of the liner during the installation. The dilated liner can drag so heavily against the borehole as to stop the liner descent. The vent tube allows the trapped air to escape.

situations, a vacuum is applied to the air vent tube to speed the removal of the air trapped in the liner. This helps to prevent the formation of the air balloon in the end of the liner. However, if the liner descent rate is not important (as in Section 5) the addition of a small amount of water (less than 10 ft) on top of the balloon will speed the venting of the trapped air.

The blank liner can be installed, as described in Sec. 2, directly from the shipping reel. However if the shipping reel cannot be located near the wellhead, a "wellhead roller" is used to redirect the liner from horizontal off the reel to vertical as the liner enters the borehole. An explicit video description of the installation and removal of a blank liner is available from FLUTe.

Blank liners are often installed by the customer or the drilling company immediately after the borehole is completed and developed. In that manner, several boreholes can be completed with each one sealed to prevent cross connection flow in an open borehole. Such cross connecting flow can confuse subsequent measurements of water quality with depth in the borehole (Sterling, et al, 2005).

A useful technique to determine the highest head anywhere in the borehole is the following:

1. Install the blank liner with a sufficient excess head to provide a good seal (e.g., 10 ft above the water level in the open borehole).
2. Pump the water level down inside the liner in one foot increments.
3. Tag the water level in the liner after each step change in water level.
4. When the water level stops descending after each water removal, or starts to rise. after the water removal, that level is the water level of the highest head in the borehole

This water level is often higher than the blended head in the open borehole and sometimes indicative of artesian aquifers. The reason that the water level in the liner has stopped descending is because the higher head in the borehole is collapsing the liner. After this measurement, refill the liner to seal the borehole.

3.2 The removal method and equipment

The installation procedure of sections 2.3 and 3.1 is relatively easy. The liner removal process is more complex and can result in damage of the liner if not done carefully. A basic need during the removal is to apply sufficient tension to the tether to cause the liner to invert and to keep ΔH sufficient to prevent buckling of the liner due to the liner slippage on the borehole wall. Since that sufficient tension is often 100-500 lbs, it cannot be done by hand. FLUTe has several devices for application of such high tension. They involve a wellhead roller and winch system (called a Green Machine, Fig. 3.2.1). Another special FLUTe device is a "Linear Capstan" (Fig. 3.2.2) which provides a measured tension with speed control of the motor driving the liner removal. The greater the tension, the lower the head beneath the liner and the greater ΔH (equation 2.1.1).

Fig. 3.2.1. Photo of the Green Machine showing the wellhead roller and capstan used to winch the liner from the borehole. The machine folds to a relatively flat profile for shipment.

As the liner is inverted from the borehole, the liner interior volume decreases and the water level rises in the liner. Therefore ΔH, the excess head in the liner, increases. If ΔH is too large, the liner may burst or the tension will increase to a dangerous level, so a pump is positioned <u>above the water level in the formation</u> to remove water from the liner as the liner is inverting (Fig. 3.2.3). The details of the removal procedure and precautions are provided in the instruction video available from FLUTe.

A common question is how well does the flexible liner seal the borehole? Figure 3.2.4 is a snapshot from a borehole video of the interior of a liner. This video by Pete Pehme is available from FLUTe. The large ledge in the upper left hand corner of the photo actually has a liner draped over it. The liner is only ~20 mils thick and conforms extremely well with the borehole wall. The liner appears to be painted on the borehole wall. Note how the liner is forced into the vugs on the hole wall in this porous dolostone. This is easier to understand when considering the total force against a 1 ft section of a 4" diameter liner in an HQ core-hole (3.78" ID) with a ΔH of 1 psi. The total force urging the liner against the borehole wall is ~140 lbs force/ft. That force coupled with the typical friction coefficient of 0.5 of the liner on the borehole wall leads to a resistance to sliding of the liner in the borehole of ~70 lb per foot of the 4 inch borehole. For this reason, a dilated liner cannot be pulled directly out of the hole. The liner inversion is required. All liners are sized to be somewhat larger than the nominal borehole diameter to assure that the liner is in intimate contact with

Fig. 3.2.2. The FLUTe Linear Capstan showing the zigzag path of the liner through the chain driven rollers with a variable speed motor drive and tension measurement. With minimum hand tension, the machine can pull more than 500 lb. of tension on a liner.

the borehole wall. However, in enlarged portions of the borehole, the effective borehole diameter is often greater than the liner diameter. Those enlargements are usually very rough and are not sealed by the liner, or by packer systems (discussed Section 5). The liner seals the borehole where it can be sealed. Note, if the liner bursts or is punctured, the value of ΔH drops to near zero and a buckled and jammed liner condition is likely while trying to invert the liner. The time required for removal may be as long as the time of the liner installation, since both procedures require flow into, or out of, the formation. It is useful that the removal of a blank liner can further develop the borehole (Keller, 2013)

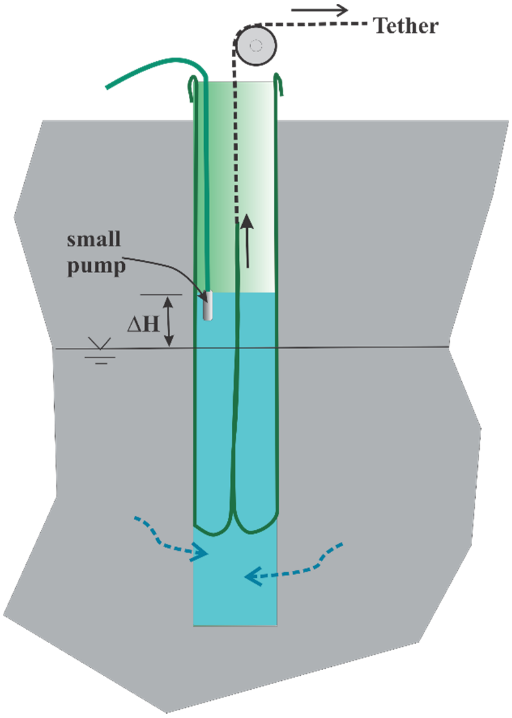


Fig. 3.2.3 Small pump positioned inside the liner to remove the liner water as the water level is raised by the inversion of the liner. As liner is inverted, water flows into the borehole beneath the liner. Note the pump must be well above the water table in the formation.

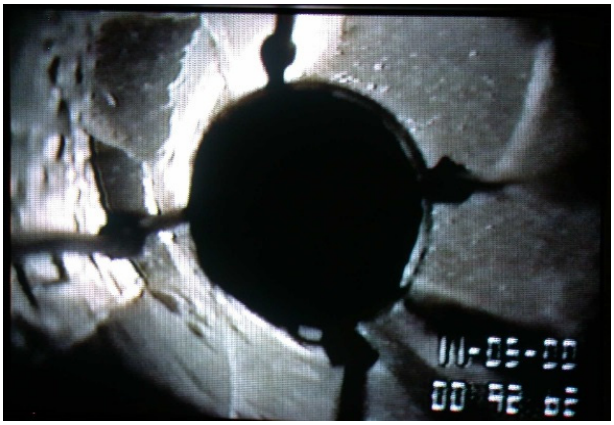


Fig. 3.2.4. Snapshot of the interior of a liner showing how well the liner conforms to the vugs in the borehole wall and the ledge in upper left of photo. (Large black central object is the back of the light source.)

If the blank liner is not to be reused, the liner can be removed by pumping the water out of the interior of the liner, causing it to collapse, and the liner can be lifted from the borehole. However, that process leads to abrasion of the liner with many small leaks in the liner.

3.3 Comparison with packers

Packers have been the traditional means of temporarily sealing boreholes. Figure 3.3.1 shows the flow in the formation near a typical packer emplacement with a vertical gradient in the borehole and greater than zero vertical conductivity in the formation. It is easy to see that, unless the packer is located in an aquitard, some bypass of the packer will occur to the open borehole below the packer. The formation vertical conductivity and the head difference across the packer controls the amount of bypass in the formation. The borehole roughness controls the seal quality of the packer against the borehole wall. For a rough wall, that seal is poor.

The liner as a thin flexible coated fabric conforms well to the borehole ruguosity. The long liner does not have an open borehole above the liner, so the bypass to an open hole is not possible. In general, a sufficient seal of the borehole is achieved if the vertical flow at the contact of the liner with the borehole wall is less than the flow that would occur through the native material before the borehole was drilled. In a conductive formation the borehole sealed with a liner will have less vertical flow than would occur through the material removed by the drilling process. The same would be true of a packer, except the open hole above and below the packer offers no resistance to vertical flow. Furthermore, the gradient across a packer is much larger than the gradient in the formation. Because the borehole is completely sealed by a liner, the vertical flow in the formation is essentially the natural flow without the influence of the borehole.

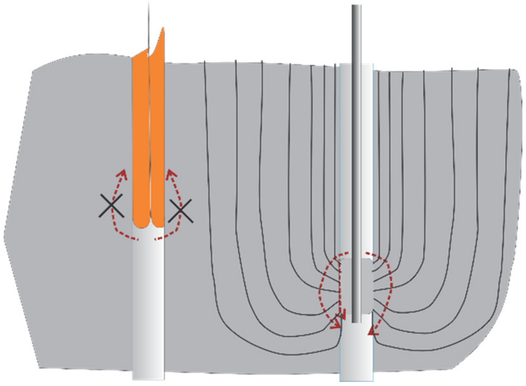


Fig. 3.3.1. Drawing on right of the excess head contours near a packer with a higher head above the packer. Bypass flow (dashed lines) can occur both in the formation and at the packer contact with the borehole wall. In contrast, on the left, there is no bypass to an open hole with an everting liner.

If the liner leaks and loses the excess head for sealing, then it may not seal the borehole. It is important to not damage the coating of the liner and to maintain the excess head needed for a good seal. A video is available from FLUTe which describes the liner installation procedure in detail.

In summary:

- The blank liner is easily installed.
- The liner must be removed carefully.
- The pressure difference between formation fluid and the liner fill fluid must not be so large as to burst the strong liner where the liner is unsupported in a borehole enlargement.
- Removal of the liner with excessive tension or insufficient ΔH can lead to a burst of the liner or a buckle of the liner, respectively. Both conditions prevent the liner inversion.
- In general, the borehole seal of a continuous liner is better than that of a discrete packer.
- The liner must be protected from damage to the coating which would cause a leak in the liner.

4.0 Use of the blank liner with special coverings

4.1 The NAPL FLUTe cover

Fig. 4.1.1. Dye striped exterior of a NAPL FLUTe cover as mounted on the exterior of an everting blank carrier liner.

Fig. 4.1.2. Stains from TCE in fractures. The normally white inside surface of the NAPL cover shows where TCE has contacted the cover in a 3 inch core-hole. The core from this borehole showed no NAPL in the fractures probably due to flushing by drilling fluid.

The blank liner is dilated against the borehole wall by the interior water pressure. Therefore an exterior covering of the blank liner will also be pressed against the borehole wall. Several coverings have been used with blank liners. The cover called a NAPL FLUTe is a thin (~1 mil) hydrophobic covering with dye stripes on the outside of the covering as shown in Fig. 4.1.1. The covering is attached to the exterior of the liner so that as the liner everts into the borehole, the cover material moves with the liner and is pressed firmly against the borehole wall. If the cover contacts a non-aqueous phase liquid (NAPL), the NAPL will be wicked into the hydrophobic cover. If that liquid is a solvent such as TCE or PCE, the NAPL will dissolve the dye stripes on the exterior of the cover and carry the dye into the hydrophobic material. That dye transport produces a strong stain of the white interior surface of the cover material. The NAPL cover does not usually need more than an hour in the borehole to react. Removal of the liner by inversion removes the cover material from the borehole and does not allow the cover material to contact any other portion of the borehole as the cover is carried to the surface inside the inverted liner. The cover material is removed from the interior of the inverted liner at the surface to observe any stains caused by contact with a NAPL. A tape measure next to the cover allows the determination of the depth of the staining NAPL in the formation. NAPLs more dense than water are called DNAPLs. Examples of DNAPL stains are shown in Figures 4.1.2- 4.1.4. Since both TCE and PCE are of greater density than water, they are called DNAPLs. Hence the color reactive cover provides a means of locating fractures or bedding planes which contain the DNAPL. The stains only develop if the DNAPLs are not dissolved. The dissolved phase does not provide significant staining of the cover material. Other DNAPLs such as creosote and coal tar are also

Fig. 4.1.3 Stains on the inside surface of a NAPL FLUTe showing the location of the DNAPL. Tape measure on the right provides depth BGS.

Fig. 4.1.4. Coal tar stains at a fracture observed on the NAPL FLUTe cover in a 4 inch borehole.

wicked into the cover material producing dark brown to black stains because of the normal color of coal tar. Figure 4.1.4 shows a coal tar stain on the interior surface of the NAPL FLUTe cover. A video of the stain development due to TCE is shown on the FLUTe web site, www.flut.com.

While the normal NAPL FLUTe installations are into open stable boreholes, NAPL FLUTe covers have been installed on liners through direct push rods and through driven casing in unstable sediments. A proprietary technique allows the rod or casing to be withdrawn leaving the pressurized liner in the borehole pressing the cover against the borehole wall and also supporting the borehole against slough. After sufficient exposure, the liner and cover are inverted from the borehole for examination.

4.2 The FACT

Since the color reactive cover does not respond to the dissolved phase of the NAPLs, an activated carbon felt strip has been added to the interior surface of the NAPL FLUTe cover. A diffusion barrier between the carbon felt and the liner further isolates the carbon felt so that it can only wick contaminants from the borehole wall pore space or fractures. The outer NAPL FLUTe cover prevents significant adsorption of borehole water in the few seconds of exposure during the eversion process. Figure 4.2.1 shows the construction of the NAPL FLUTe cover with the addition of the activated carbon felt. Figure 4.2.2 is a photo of the assembly. The Activated carbon

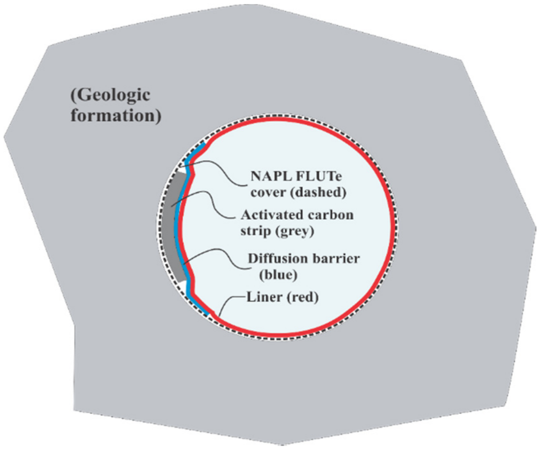


Fig. 4.2.1. FACT cross section. Outer cover is the NAPL FLUTe hydrophobic material, underlain by the activated carbon felt strip, which is separated from the liner by a diffusion barrier. The liner presses the assembly against the borehole wall. Contaminants diffuse through the thin, perforated NAPL FLUTe cover to the carbon.

felt system is called a FACT (FLUTe Activated Carbon Technique). The combination is also called a NAPL/FACT.

The activated carbon felt wicks the contaminants by diffusion and therefore the carbon must be left in place much longer than the NAPL FLUTe cover to which it is attached in order to gain a reasonable replica of the dissolved contaminant distribution in the borehole wall pore space. The NAPL FLUTe, described above, may react with NAPLs in less than a minute if the cover contacts the NAPL. The FACT may require 1-2 weeks of exposure to collect the dissolved phase of TCE in a saturated formation. In the vadose zone, the diffusion rates for solvents are 3-4 orders of magnitude higher in air than in water. Therefore the FACT residence in the borehole in the vadose zone can be only several days for a useful replica of the contaminant distribution to be adsorbed in the carbon.

Fig. 4.2.2. Photo of FACT showing the dye striped NAPL FLUTe cover, the black carbon felt, and the silver diffusion barrier.

The activated carbon felt strip is removed from the borehole by inversion of the liner. The activated carbon will contain a replica of the relative contaminant distribution in the borehole wall. The activated carbon must be sectioned for analysis. The volatiles are extracted from the carbon with methanol, typically, and the methanol analyzed with a GCMS to identify the species and the relative amounts in the carbon.

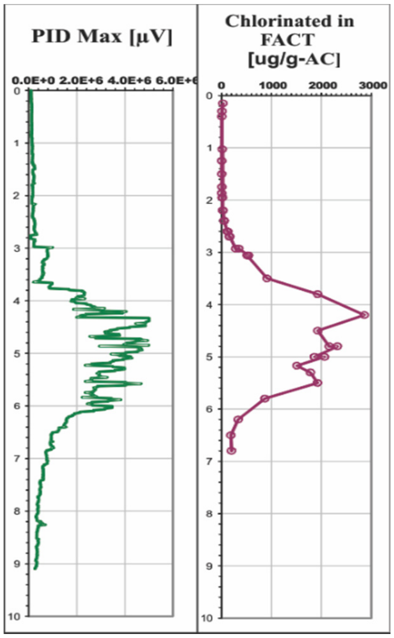


Fig. 4.2.3. FACT results compared to the Geoprobe MIP measurement. Soil samples showed the same distribution.

The diffusion process is dependent on characteristics of the pore space and the accessibility to contaminant migration. Those same factors will affect the contaminant transport in the formation and the rate of adsorption in the carbon. An exception may be a clay or organic carbon also can bind the contaminants. However, clay and carbon are a small portion of most fractured rock. A comparison with core concentrations from the same hole has shown that the core does not show the fracture water contamination, but the FACT does. Since the carbon results are µg/g of carbon, they are not directly related to the pore or fracture concentrations. However, the relative distribution is still useful to location of the contaminants. Section 4.2.2 shows the remarkable correlation of the FACT concentrations with the fracture water samples.

4.2.1 The FACT in the vadose zone

This technique was first tested at a site in Denmark with vadose zone soil samples and Geoprobe MIP (PID) measurements in adjacent boreholes. The results shown in Fig. 4.2.3 provided an excellent match of the contaminant distribution measured by the

FACT with the other methods. However, the primary utility of the FACT method is in boreholes in formations where soil samples or the Geoprobe MIP technique cannot be used such as in fractured rock.

4.2.2 The FACT in saturated fractured rock

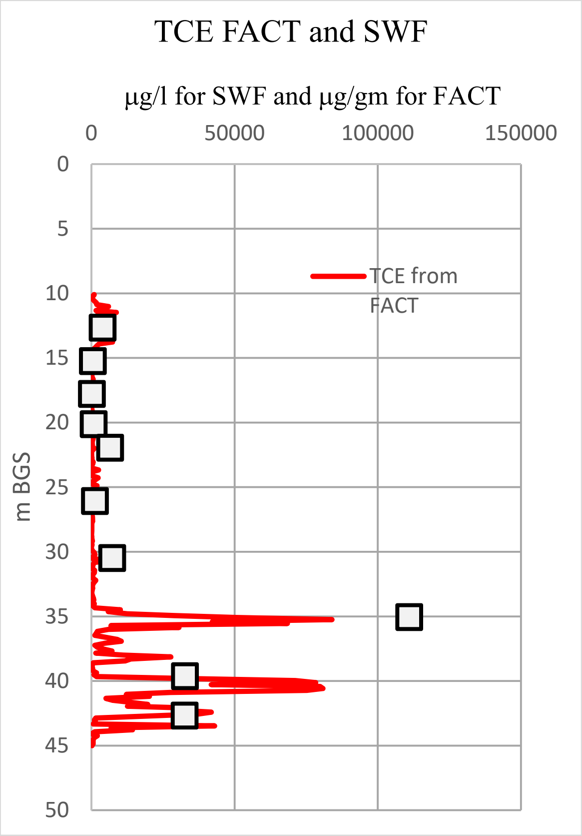


Fig. 4.2.4 The red curve is the FACT results (µg/g) for the 6 inch segments from the NAWC borehole. The squares are the water samples at 10 discrete intervals of ~10 ft each obtained with a FLUTe MLS. The good correlation suggests the FACT is heavily influenced by fracture flows.

The FACT was installed with the NAPL FLUTe cover in a fractured rock borehole at the Naval Air Weapons Center facility near Trenton, NJ. The borehole was cored and a NAPL/FACT was installed to 150 ft in a shale and mudstone formation describe by Goode et al. 2014. The FACT carrier liner was removed after 2 weeks and a transmissivity profile of the borehole was performed using the same blank liner for the FLUTe transmissivity profile method described in Section 5. A head profile was also obtained using the FLUTe "reverse head profile" (RHP) described in Section 6. The FACT carbon felt was subdivided over its entire length into 6 inch segments. The FACT result in µg/g of carbon is shown in Fig. 4.2.4. A FLUTe multi-level water sampling and head measurement system, MLS, described in section 7, was later installed in the borehole with 10 water sampling intervals. The resulting water concentrations (µg/l) for TCE, 3 months after the MLS was installed, are plotted adjacent to the FACT concentrations in Fig. 4.2.4. The agreement is very good. It is surprising that the two plots fit on the same scale but different units. A comparison with the core concentrations in the same hole did not show the high levels in the lower one third of the borehole where the higher FACT levels were observed. Whereas the FACT draws from both the pore space and the fracture flows, the comparison with core and with water samples shows that the fracture flows were probably the dominant contribution to the FACT. A small DNAPL stain on the cover was only observed at the 40 ft depth.

FACT carbon samples as long as 3 ft have been analyzed. The reduction in analytical cost is significant with some associated loss of spatial resolution. However, the entire length should be measured.

An application by the Danish Technical University of the FACT system, and other FLUTe methods, is described in Broholm et al. 2016. The site was in Denmark in a chalk formation with TCE and PCE contamination. The paper also addresses the analysis of the FACT carbon.

4.3 The transparent liner

Since there is such a disparity in the residence times for the two systems (i.e., the NAPL FLUTe and the FACT) that even if they are fabricated as one system, it is considered useful to use a relatively transparent blank liner as the carrier liner. In that case, the stains formed on the inside surface of the NAPL FLUTe cover can be viewed with a down-hole camera. Since the liner is usually filled with clear water, the stains are readily visible. This eliminates the necessity of a premature removal of the FACT system and the development of the NAPL stains over time is an indication of the relative amount of NAPL in the fractures or pore space. The transparent liner can also be used for the time of arrival of some kinds of tracers injected in nearby wells such as potassium permanganate solutions. The dark purple stains of the permanganate are easily visible through the transparent liner and are indicative of the fractures conducting the tracer and the arrival times of the permanganate transport. Both data sets are useful for assessment of the flow of fluids in fractured rock. It is best if the transparent liner is at a higher head than the injected fluid at the borehole source. Otherwise, the injected fluid may collapse the liner causing an extreme stain.

4.4 Other absorbers and reactive coverings on liners

Liners have been produced with a wide array of absorbent materials on the exterior of the liner since 1991. At the National Labs, liners have been emplaced to absorb pore water samples in the vadose zone (see details in section 8.1). The objective was to determine the range of migration of tritiated water in the subsurface. Absorbers have also been used beneath settling ponds to monitor for uranium migration from the ponds. The absorbers were placed in high angle boreholes to better intersect vertical transport paths. FLUTe has often suggested that there are other useful kinds of absorbers. Some may contain a reactive fluid to map ore bodies by reacting with the formation components. The absorber can be removed and developed like photographic film to map compounds of many kinds in the subsurface. Photograph film has been used on blank liners to map subsurface radioactivity. It has even been suggested that a thick layer of hydrophobic material on a liner would be helpful in the removal of NAPLs from fractures in rock. Liners can be installed in piping as easily as in boreholes.

Tests have been done to determine if the fluorinated compounds (an emerging contaminant) can be mapped with the activated carbon. Only a few of the common PFC/PFAs are readily adsorbed by the carbon. Those were the longer chain compounds. Generally, it is better to use the water sampling system described in section 7 for mapping the fluorinated compounds. A special spacer geometry is available for that purpose.

In summary:

- The location of a variety of NAPLs in fractured rock is aided by the installation of a color reactive cover on the flexible liner.
- The dissolved phase of contaminants with an affinity for adsorption in activated carbon allows one to obtain a replica of the distribution of the contaminant in the formation intersected by the borehole using the FACT.
- The transparent liner has numerous advantages in that it allows a time series of observations of NAPL stains and tracers moving through fractures in the rock.

- There are probably many kinds of absorbers that can be installed in boreholes which can be useful for mapping a variety of distributions.

5.0 Use of Blank Liners to Measure a Transmissivity Profile

5.1 The transmissivity measurement method

It was discovered by FLUTe that the liner descent rate in a water filled borehole can be used to map the location and flow rates of fractures intersecting the borehole. However, the proprietary procedure requires that the excess head driving the liner and the tension on the liner be maintained relatively constant. Under those conditions, the liner will suffer a drop in its descent velocity each time a flowing fracture is sealed by the descending liner. That velocity change multiplied by the cross sectional area of the borehole is the flow rate that existed in the fracture before it was sealed. Another perspective of the method is that when each fracture or other flow path is sealed by the descending liner, the remaining transmissivity beneath the EP of the liner is reduced. Since the liner displacement of water must equal the flow into the borehole wall beneath the liner (equation 2.1.2), a change in T, ΔT, must be matched by a change in the liner velocity. Figure 5.1.1 depicts the liner position and velocity at depth z_1 and after passing a fracture to depth z_2 in one time step. The velocity change, v_1-v_2, can be used to determine the flow rate into the fracture before it was sealed by the liner. That detailed calculation is described hereafter.

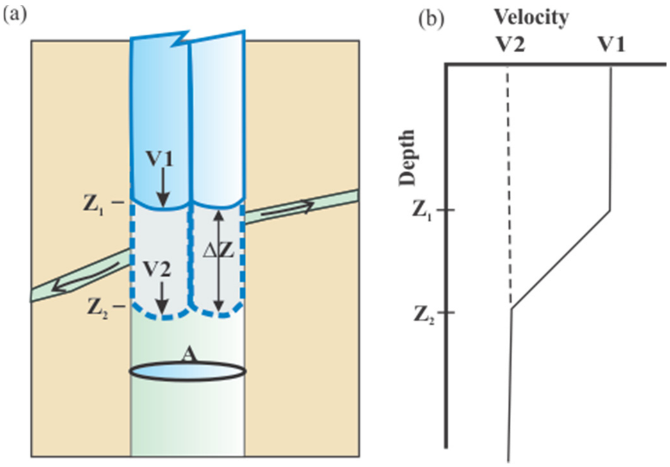


Fig. 5.1.1 a) The liner velocity change upon sealing a flowing fracture. The velocity change (v_1-v_2) multiplied by the borehole cross section, A, is the flow rate ΔQ into the fracture before it was sealed. The velocity plot shows how the calculated velocity change occurs over the full interval Δz during one time step, Δt, even though the fracture seal occurs over a very short interval.

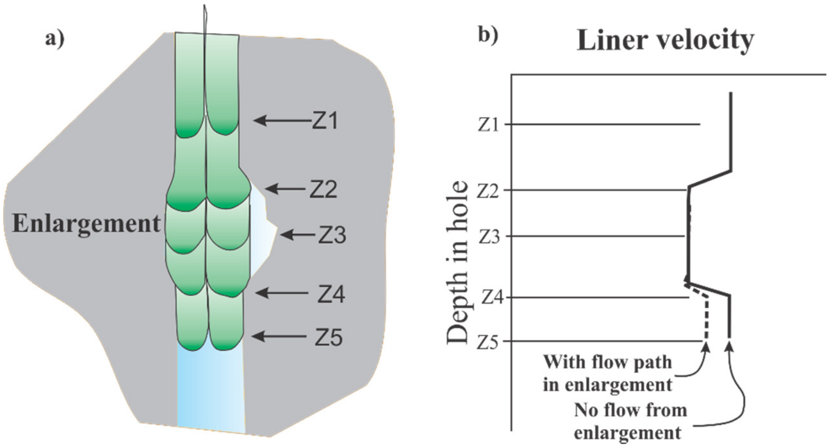


Fig. 5.1.2. Effect of an enlargement on a) liner shape and b) liner velocity. The liner velocity is reduced in proportion to the enlargement of the liner cross section. If a flow path exits in the enlargement, the liner will exit the enlargement with a lower velocity than the entrance velocity.

However, there are other changes on the liner velocity that are not related to flow into the borehole wall. The drawing of Figure 5.1.2a shows what occurs when the liner propagates through an enlargement of the borehole. Because the effective cross section of the borehole is larger in the enlargement, the product of velocity and the liner cross-section (equation 2.1.2) must be unchanged unless there is flow into the borehole wall in the enlargement. In other words, if the liner cross section is larger, the velocity must be less. As the liner propagates out of the enlargement, the velocity will increase due to the smaller cross-section of the liner. A plot of an actual liner velocity with depth in the borehole (Fig. 5.1.3) shows numerous drops in velocity at enlargements followed by an increase in velocity as the liner enters the smaller diameter borehole beyond the enlargements. The temporary drop in velocity caused by the enlargement is not necessarily relevant to a change in the transmissivity beneath the liner.

In order to ignore such temporary drops in velocity, a monotonically decreasing curve is fit to the data of Fig. 5.1.3 as shown in Fig. 5.14. When one sees such a drop in velocity, there is probably flow in the enlarged portion of the hole only if the monotonic fit does not have the same value before and after the drop in velocity. If there is a flow path in the enlarged interval, the liner will exit with a lower velocity than the liner entered the enlargement (dashed line in Fig. 5.1.2b). The transmissivity is calculated from the monotonic fit which ignores any temporary drops in velocity. Since the liner of fixed diameter does not always dilate to the full diameter of an enlargement, the relative effect of an enlargement may depend upon the size of the liner relative to the borehole diameter. In Fig. 5.1.4, the drops in velocity at 88 and 100 ft are less than would occur if the enlargement exceeded the diameter of the liner. The change of velocity in an enlargement depends on the square of the change in liner diameter.

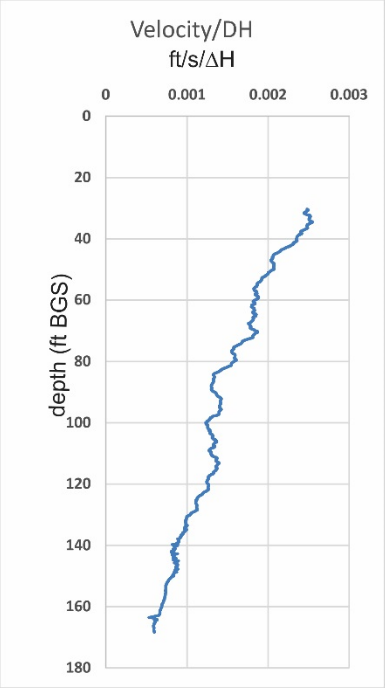


Fig. 5.1.3. Example of actual liner velocity profile with depth of the liner in a borehole with many enlargements.

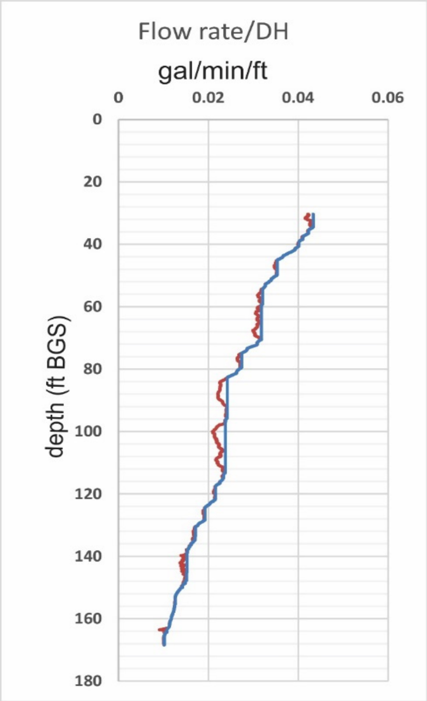


Fig. 5.1.4. Monotonic curve (blue line) fit to velocity/flow rate data (red line) from Fig. 5.1.3. Note the temporary velocity decreases in the enlargements are well within the limits of the liner diameter, which was 10% greater than the hole diameter. If the liner was fully dilated in this hole, the velocity would decrease by 20%.

Since the driving pressure can affect the velocity, and the actual driving pressure is not easily kept constant, the liner velocity in Fig. 5.1.3 has been divided by the driving pressure in the borehole which removes some of the variation due to head changes in the borehole. Multiplying the monotonic velocity per unit driving pressure by the liner cross section provides the rate of flow per unit driving pressure (Fig.5.1.4) out of the borehole beneath the descending liner. The flow rate changes are the actual flow rates into the fractures before each fracture is sealed by the liner.

The same logic applies to any permeable feature intersecting the borehole such as a bedding plane or permeable bed. For a uniform permeable bed, the velocity change is distributed over the thickness of the bed. The velocity of the liner descent is calculated from the depth of the liner at each time step. The typical time step is one half second, therefore velocity changes are calculated for each interval traversed by the liner in one half second. Hence the high spatial resolution that can be achieved for the transmissivity profile.

The transmissivity of the interval traversed by the liner in one recording time step is calculated using the Thiem equation:

$$\Delta T= \Delta Q/\Delta H_h \ln(r_a/r_h)/2\pi = (v_i-v_{i+1}) A \ln(r_a/r_h)/ (2\pi (H_h-H_a)) \qquad (5.1.1)$$

Where ΔQ is the change in velocity multiplied by the borehole cross-section, ΔH_h is the difference between the borehole pressure and the ambient pressure in the formation at a distance r_a from the borehole center, and r_h is the borehole radius. Since r_a is often not well known, it is estimated. Because it occurs in the log term, an error in the ratio is not a major error in the calculation. Figure 5.1.5 shows the spatial relationship of the parameters used in the calculation of the transmissivity. As described earlier, H_h is the head in the borehole during the liner descent, H_a is the head in the formation before the borehole pressure was increased by the descending liner.

Figure 5.1.4 is an actual flow rate curve (red) as a function of borehole depth. The small drops below the monotonic curve (blue) at 88 and 100 ft are due to borehole enlargements. The transmissivity calculated from the flow rate for each time step is shown in Fig. 5.1.6. The spatial interval is dependent upon the recording time step (typically ½ second) and the velocity of the liner. In other words, the faster the liner descent, the longer the interval traversed in one time step. In order to make the result more comparable throughout the borehole, the short interval transmissivity was integrated over one foot intervals to produce the result of Fig. 5.1.7 which one should get from a series of one foot long straddle packer tests with no leakage. The red curve of the graph of Fig. 5.1.7 is an estimate of the transmissivity resolution threshold estimated as 1% of Fig.5.1.8.

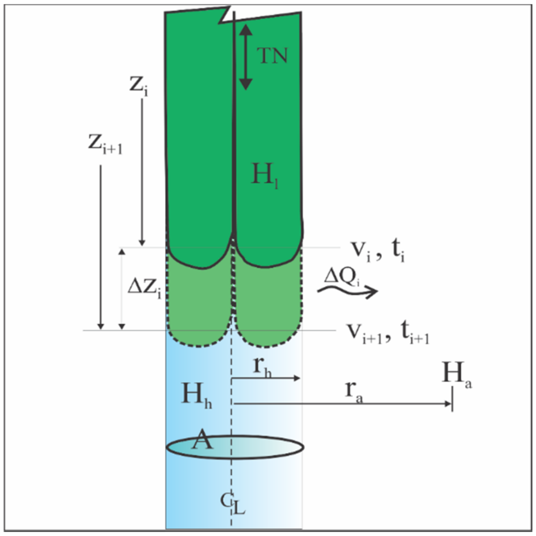


Fig. 5.1.5. Drawing of spatial terms used for the calculation of the transmissivity of the ith interval traversed in the ith time step. H_h is the borehole pressure/head and H_a is the formation ambient pressure/head.

Figure 5.1.8 is the integral from the bottom of the borehole to the top of the discrete transmissivity results shown in Fig. 5.1.6. Not surprising, it has the same shape as the monotonic curve of Fig. 5.14. The graph of Fig. 5.1.8 is especially useful in determining the transmissivity of any interval in the borehole. The difference in the graph values at an upper elevation and a lower elevation is the transmissivity of that interval. For example, the transmissivity at 60 ft is 0.06439 cm^2/s and 0.0506 cm^2/s at 100 ft. The 40 ft interval has a transmissivity of 0.00933 cm^2/s. This will be used more in Section 6 for the head profile calculation.

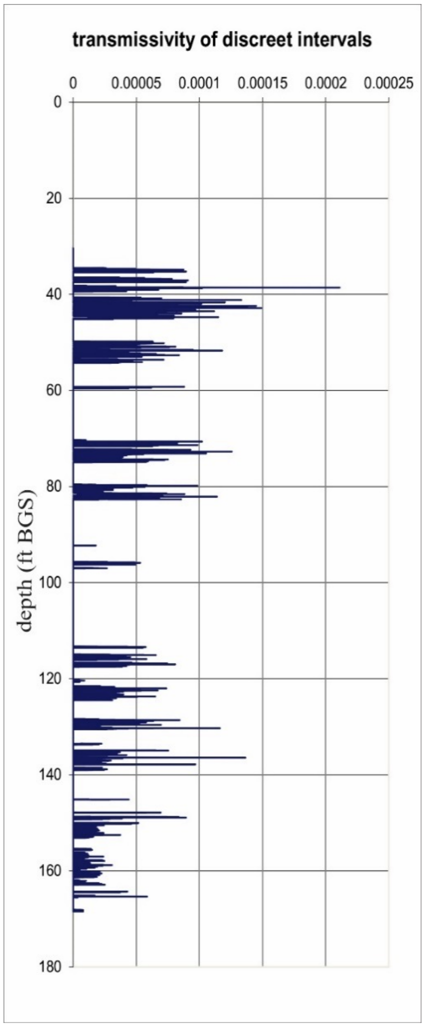


Fig. 5.1.6. The transmissivity as calculated for each time step over the travel distance of Δz_i using the monotonic fit of Fig. 5.1.4. At lower portions of the borehole the data points are much more closely spaced which may divide the flow of a high angle fracture into numerous transmissivity steps.

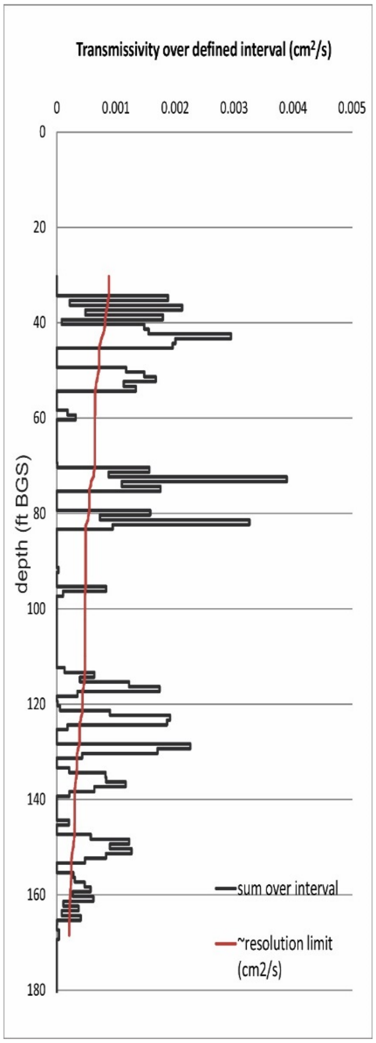


Fig. 5.1.7. The integration of Fig. 5.1.6 over one ft. intervals. This is equivalent to packer tests, without leakage, over 1 ft intervals. The red curve is an estimate of the level of reliability. Peaks below that level may not be reliable.

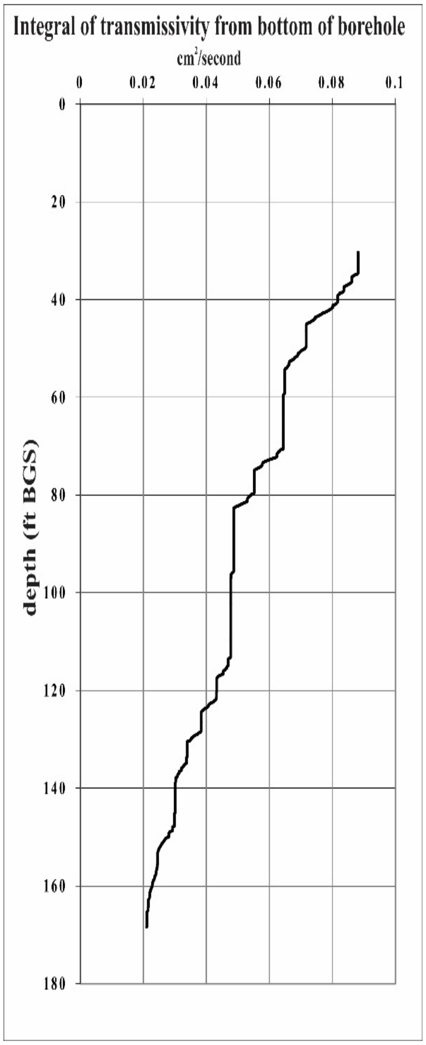


Fig. 5.1.8. Integral of Fig. 5.1.6 from the bottom of the borehole to the top. Note, this has the same shape as the monotonic curve in Fig. 5.1.4. This graph allows the determination of the transmissivity of any interval throughout the depth of the profile.

The advantage of the liner transmissivity measurement profile is twofold. First, an entire borehole of 100 to 600 ft depth may be measured with high spatial resolution in 1-2 hours. Second, there is no concern about leakage past the liner as can occur with straddle packer tests. All other transmissivity profiling methods require more time and provide lower spatial resolution in that time. Because the liner is usually moving faster at the upper end of the borehole, the spatial resolution is not as fine as near the bottom of the profile. The journal article by C. Keller, et al 2014 describes in greater detail how various factors can affect the transmissivity results. The transmissivity profile is often used to aid in the selection of sampling intervals to be included in the multi-level system design described in section 7. For example, in Fig. 5.1.7, sampling intervals centered on 43, 52, 73, 82, 117, 123, 129, 137 and 151 ft. might be considered for monitoring of water quality and head with the multi-level system described in Section 7,

5.2 The transmissivity profiling equipment

The transmissivity measurement includes the measurement of the liner tension, the liner depth in the borehole, the water level inside the liner, and the head in the borehole below the liner for each time step. The drawing of Fig. 5.1.1 shows the basic features of the profiling system which measures the important parameters. The depth meter and tension control are added to the normal blank liner installation with a recording transducer at the bottom of the borehole. The photo in Fig. 5.2.2 shows a typical hardware arrangement for the transmissivity profile measurement. No crane truck or drill rig is required.

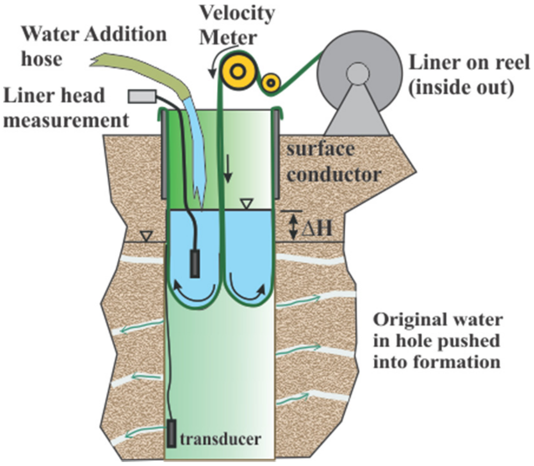


Fig. 5.2.1. Drawing of the profiler features. The profiling system controls the tension and allows monitoring of the water level in the liner and the head in the borehole beneath the liner. The data is recorded to a laptop computer.

Fig. 5.2.2. Photo of profiling equipment in the field. The data is recorded to a laptop computer during the installation. Water is usually pumped from a tank into the liner to maintain a nearly constant driving pressure in the borehole.

The liner is fed from the shipping reel though the profiler system into the borehole. In some situations of slow flowing boreholes, the head beneath the liner can be reasonably calculated from the liner tension and the water level inside the liner according to the equation 2.3.1.

5.3 Other Examples of Results

Figures in Section 5.1 are the actual results from a typical borehole transmissivity measurement. Another profile with a 90 fold higher flow rate than Fig. 5.1.4 is shown in Fig. 5.3.1. With such a high flow rate, the resolution of velocity changes (on the order of 1% of the velocity) is much more limited. However, below 185 ft, the resolution is comparable. Another profile such as in Fig. 5.3.2 shows the difference that one can see in a profile of a different hole. The liner has a slight rise in velocity as it exits the casing into a smaller hole, there are some enlargements at 67 and 79 ft. (obvious, even without the monotonic fit) and a very large flow zone at 90 ft. Thereafter, the transmissivity is much more distributed in the formation until 210 ft. Every profile shows such differences. It is not easy to deal with flow rates over 150 gal/min. The profile of 5.3.1 with an excess head of 20 ft requires a water addition to the liner of over 100 gal./min.

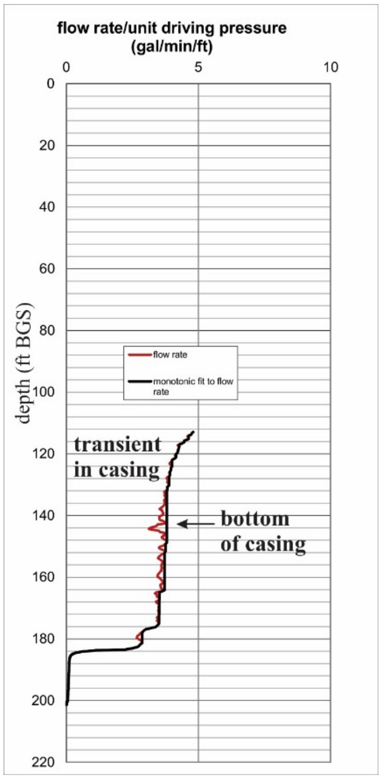


Fig. 5.3.1. An example of fast flow near the bottom of the hole at 185 ft. The transient is seen decaying in the casing and did not need correction. The transmissivity of this borehole is 90 fold higher than that of Fig. 5.1.4. Therefore the limit of transmissivity resolution is ~90 times greater. Small flow zones like those of Fig. 5.1.4 would not be reliably detected until below 185 ft.

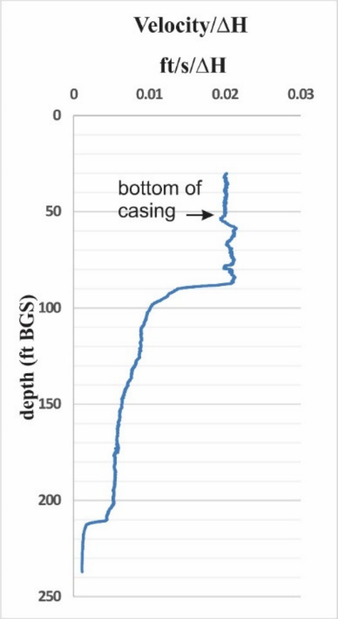


Fig. 5.3.2. Another flow velocity curve showing a very different profile. There are two major flow zones (90 and 211 ft). No monotonic fit is shown for this curve. Such a fit would show apparent enlargements at 67 and 79 ft. The borehole has a slight enlargement at the bottom of the casing after which the liner velocity increases due to the borehole being smaller than the casing.

5.4 Comparison with straddle packer results

The Fig. 5.4.1 shows the difference in the flow field expected for a descending liner and the flow for a straddle packer. The liner flow field is essentially one dimensional radial outward flow ignoring the actual 3D nature of fracture flow. In contrast, the straddle packer flow field diverges with distance from the straddled interval. Another difference is shown in the drawing in Fig. 5.4.2. This illustrates potential leak paths for a straddle packer system for by-pass of a packer at either the contact of the packer with the borehole wall or through the formation. That leakage into the open borehole above or below the straddle packer system can lead to an error in the transmissivity calculated. The liner flow field does not have such potential bypass to an open borehole from the pressurized borehole beneath the liner.

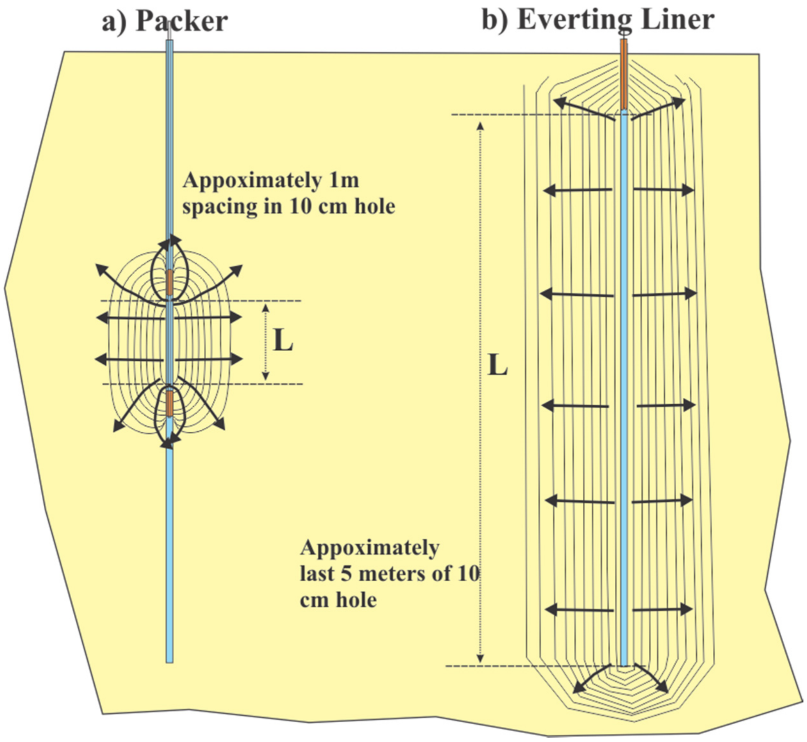


Fig. 5.4.1. Flow field of straddle packer versus that of a liner measurement. The packer flow field during injection, even with a 1 m spacing, diverges to a more spherical flow field intersecting the borehole above and below the packer. The liner flow field after the transient is relatively 1D cylindrical, despite the random fracture orientations, and there is no bypass of the liner to an open hole.

There are situations where the liner does not produce superior results to a straddle packer test. One is the situation where most of the borehole transmissivity for a highly transmissive borehole is at the bottom of the hole. In that case, most of the borehole is traversed in a very short time until the liner seals the highly transmissive zone. Fig. 5.3.1 shows such a profile. For the curve in Fig. 5.3.1, the resolution is relatively poor above 185 ft. In that case, the straddle packer measurements above 185 ft should provide higher resolution.

If the straddle packers are not leaking, straddle packers can generally measure lower transmissivity intervals better than a liner measurement. In general, if the quest is for the transmissive zones and those are not located primarily at the bottom of the borehole, the liner measurement may be more cost effective. Because of the very low velocity in a low transmissivity borehole such as one might expect in a rad-waste site assessment, the liner is not a practical transmissivity measurement.

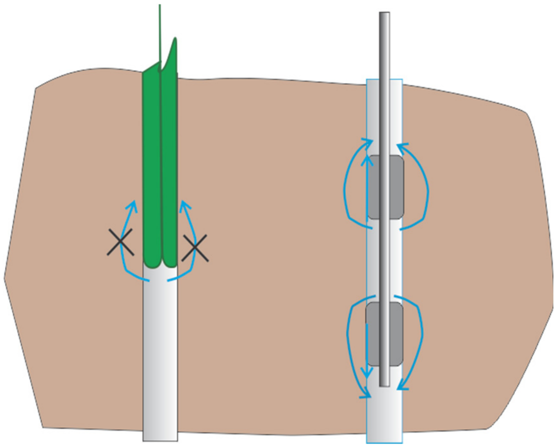


Fig. 5.4.2. Showing the potential bypass of straddle packers. The liner advantage is that there is no open hole to allow connection. The packer bypass can occur both in the formation and at the contact with the borehole wall. For rough borehole walls and highly fractured media, the liner can still provide a useful seal.

Another situation where a straddle packer may be more useful is in the upper 10-20 ft of the saturated borehole. In that interval, the liner goes through a transient velocity peak until the nominal steady state flow condition is established throughout the borehole. In that transient region, the liner measurement has poorer resolution. However a transient correction is commonly applied to that interval for the liner measurement. Those details are addressed in the paper by Keller, et al, 2014. Another practical limit for the liner method is if the open borehole has a vertical downward flow rate exceeding 150-200 gal/min. If that flow rate is concentrated in one flow feature, the resolution is very poor above that feature.

The paper by Keller, et. al, 2014 compares the transmissivity results to packer test results. The comparison is qualitatively very good. However, for high flow zones the assumption of laminar flow for the liner measurement can be violated resulting in an under estimate of the transmissivity. Quinn, et. al., 2011, addresses the differences in packer measurements of transmissivity with varying driving pressures. The comparison in Keller, 2014 with Quinn's measurements, which were done at relatively low flows, shows the error in highest flow zones to be about a 50% under estimate of T with the liner measurement. However the high flow zones are obvious in the liner measurement. The liner inability to identify very low flow zones is also apparent in the Quinn comparison. That limitation does not negate the general utility of the T profile.

Summary:

- The FLUTe transmissivity profiling method usually provides a high spatial resolution of the transmissivity throughout the borehole.
- The time required to perform the measurement is as little as 10% of the time required for lower resolution straddle packer testing.
- The liner does not suffer bypass leakage as occurs for straddle packer tests.
- The straddle packer measurement may be better in very low transmissivity boreholes, or in boreholes with most of the transmissivity in the bottom of the borehole
- When the profile is completed, the liner is usually left in place to seal the borehole against cross connecting flows as can occur in an open borehole.

6.0 Blank Liner for Measurement of a Head Profile

6.1 The purpose of a formation head measurement

The definition of aquitards is particularly important to the understanding of the ground water flow (Maxey, 1964). Maxey pointed out long ago that aquifers are not necessarily associated with geologic units but rather on extensive lateral permeability which can vary substantially within a geologic unit. Therefore other hydrologic measurements must be made to define aquifers, aquitards or aquicludes. A head measurement can help define the presence of aquitards and assist in the definition of those intervals which may then be best monitored with a multi-level sampling system (such as described in section 7.0) for water quality and long term vertical gradient definition. Those same aquitards can be barriers to vertical migration of contaminants.

The use of a blank liner to measure the formation head profile is a relatively new addition to the flexible liner methods (Keller, 2016). The FLUTe transmissivity profiling technique (section 5.0) has been used in over 300 boreholes since 2007. However, that method often assumes a constant head distribution in the formation. That is usually assumed to be the blended head in the open borehole if no other information is available on the head distribution in the formation. But, the transmissivity calculation from the liner velocity data depends on the head in the formation (Equation 5.1.1). Therefore, a head measurement technique is helpful to refine the transmissivity profile calculated from the liner measurement. Also, the vertical transport of contaminants and the recharge of subsurface aquifers depend upon the definition of the vertical head gradient.

As described above (Section 5.), there are serious difficulties associated with the attempt to isolate an interval in the borehole with straddle packers due to the fact that the open borehole above and below the straddled interval can influence the measurements performed in the straddled interval. Only in a situation where the packers are located in aquitards can the straddled interval be well isolated, and yet the straddle packer measurement is still subject to the effects of the open hole before the packers are sealed against the borehole wall (Pat Quinn, et al, 2015). The method described hereafter is not open to flow from above the measurement interval because the entire upper hole is sealed by the liner.

The primary benefit of the head profile method described (Keller, 2016) is that it is done in a very short time compared to some other traditional head measurements in boreholes and it does not require a multi-level or clustered well installation. However this technique only measures the head distribution at the time of the measurement, so a multi-level system still has merit for head measurements over time in well isolated intervals.

This head profile method is not a new description of the mathematical modeling of ground water flow. It is an application of relatively common concepts and mathematical models using a new procedure and new equipment. The liner head measurement has been named the Reverse Head Profile, RHP.

6.2 The procedure for measuring a head profile

6.2.1 The calculation

An initial assumption is that there is little flow into or out of the borehole beneath the stationary liner after a transmissivity profile has been completed and the liner is anchored at the surface and is still in the borehole. Figure 6.2. shows the geometry of the transducer at the bottom of the hole and the stationary liner when the transmissivity profile was completed.

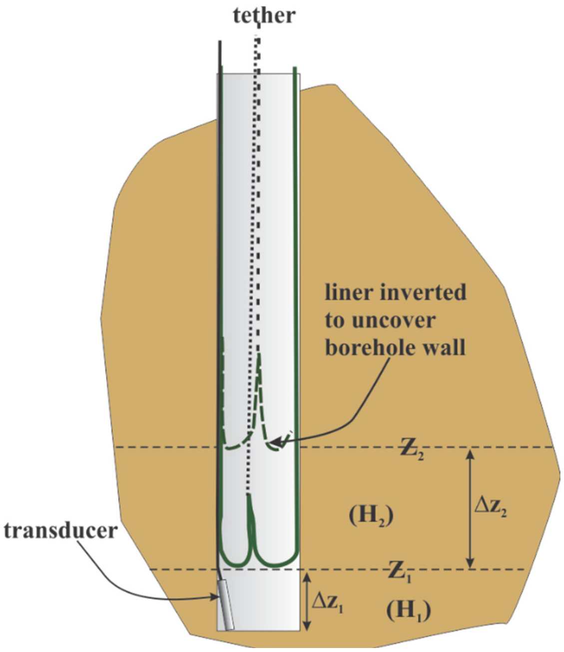


Fig. 6.2. Liner geometry at the end of the transmissivity profile and after the first inversion for the RHP.

The only flow into or out of the borehole is that to achieve an equilibrium pressure in the unsealed interval beneath the liner. The unsealed portion of the hole after the liner is anchored is defined as the first interval, ΔZ_1. The equilibrium borehole pressure in that interval is defined as BH_1. The transmissivity for that interval is read from the integral transmissivity curve as T_1. The flow rate into the first interval would be:

$Q_1 = T_1\ \Delta H_1\ 2\ \pi /\ \ln(R),$ (6.2.1)

where $\Delta H_1 = BH_1 - H_1$, where H_1 is the formation head. But BH_1 equals H_1 when equilibrium has been achieved, so Q1 =0. R is the ratio of ra/rh as defined in section 5.0.

The liner is then inverted to a higher elevation, Z_2. The liner is then halted allowing the borehole beneath the liner to achieve a new equilibrium pressure, BH_2, measured by the transducer at the bottom of the hole, which may be different than the first interval measured. The newly uncovered interval is defined as the second interval, ΔZ_2. A pair of flow equations is defined according to equation 6.2.1 for the first and second interval respectively. The flow into or out of the first interval with the liner at Z_1 ft is:

$Q_1 = T_1\ \Delta H_1\ 2\ \pi /\ \ln(R),$ (6.2.2

where ΔH_1 is the new difference between the equilibrium pressure measured, BH_2, and the pressure H_1 in the formation, now $\Delta H_1 = BH_2 - H_1$.

The equation of the second interval is:

$Q_2 = T_2\ \Delta H_2\ 2\pi/\ln(R),$ 6.2.3

where ΔH_2 is $HB_2 - H_2$. T_2 is the transmissivity of the interval ΔZ_2 obtained from the result such as Fig. 5.1.8. Since the inflow is equal to the out flow between the ΔZ_1 interval and the ΔZ_2 interval,

$Q_1 + Q_2 = 0$ (6.2.4)

Using the expressions for Q_1 and Q_2 (Equations 6.22 and 6.2.3),

$T_1\ \Delta H_1 + T_2\ \Delta H_2 = 0$. In detail that is: $T_1\ (BH_2 - H_1) + T2\ (BH_2 - H_2) = 0$,

where H_2 is the head in the newly uncovered portion of the formation and BH_2 is the equilibrium pressure measured in the borehole after the second interval was uncovered. Since T_1, T_2, BH_2 and H_1 are known, the equation can be solved for H_2 as a function of the known values. The result is:

$H_2 = T_1(BH_2 - H_1)/T_2 + BH_2$ (6.2.5)

If another portion of the borehole is uncovered, the sum of the flows from all three intervals is equal to zero:

$T_1\ (BH_3 - H_1) + T_2\ (BH_3 - H_2) + T_3\ (BH_3 - H_3) = 0$, which leads to

$H_3 = (T_1\ (BH_3 - H_1) + T_2\ (BH_3 - H_2))/T_3 + BH_3$

Or in general, $H_i = (T_1\ (BH_i - H_1) + T_2\ (BH_i - H_2) + \ldots)/T_i + BH_i$ (6.2.6)

This procedure allows one to determine the head in the formation for each interval uncovered by inverting the liner in a stepwise manner from the bottom to the top of the borehole and measuring the equilibrium pressure after each interval is unsealed. This is not possible without the knowledge of the transmissivity of each interval as measured according to Section 5.

6.2.2 The use of the RHP to refine the transmissivity profile for T_i

The transmissivity measurement described in Section 5 is often done with no initial knowledge of the actual head distribution in the formation. That limitation is overcome with the use of a relatively high head inside the liner (when possible) to make the individual head variations less important in the transmissivity calculation. The head in the formation without any foreknowledge is assumed to be equal to the equilibrium head (the water table, in the open hol). However, with the result of the RHP measurement, the use of the open borehole water table assumption is not necessary.

The RHP results can be used in the original transmissivity profile calculation to obtain a better transmissivity profile and then a better integral T profile from which to obtain better interval transmissivities, T_i, for use in the RHP calculation. It is noteworthy that neither the original flow rates measured for the T profile nor the equilibrium heads measured for the RHP are changed in the iteration.

This refinement has been used on several RHP measurements. The changes have only been significant when the formation vertical head distribution was significantly different from the blended head in the open hole or when the T profile was done with a small excess head as may be the case with a shallow water table where a higher excess head is not available. The iteration was done for the following example in Section 6.3, but because the water table was relatively deep and the vertical gradient relatively small, the iteration did not produce a significant change.

6.3 A result of the RHP method.

A test in 2015 produced the head profile in Fig. 6.3.1. The transmissivity profile was done 3 months earlier and the liner was left in place to seal the hole. The reverse head profile was done as the liner was being removed to install a multi-level sampling system. The RHP was done in 3 hours. A multi-level system was installed the day after the head profile was performed and the measured head profile in the multi-level system (MLS) was obtained immediately. The MLS manual water table measurements are compared to the RHP in Fig. 6.3.1 (the blue curve). The blended head level is also plotted at 16.16 ft. The agreement is excellent with the possible exception of the red square. The red data point is where T_i in equation 6.2.6 is a very low value and therefore not well measured. A test in the data reduction procedure identifies the intervals of very low transmissivity and plots them as a red square. The uncertainty of the red data point is large. The probable head value in such a low conductivity layer should lie between the head in the more conductive layer above and the more conductive layer below the layer of low conductivity. This is so probable that the red square can logically be moved to lie on a line between the head above and below. The nearly constant small offset between the RHP values and the manually tagged levels is within the uncertainty of the depth and calibration of the transducer in the borehole beneath the liner. That offset will be translated to the RHP head calculated.

Figure 6.3.2 (left) is the transmissivity distribution used for the head profile in 6.3.1. It is noteworthy that the blended head is nearly the head in the interval of highest transmissivity (50-60 ft) as it should.

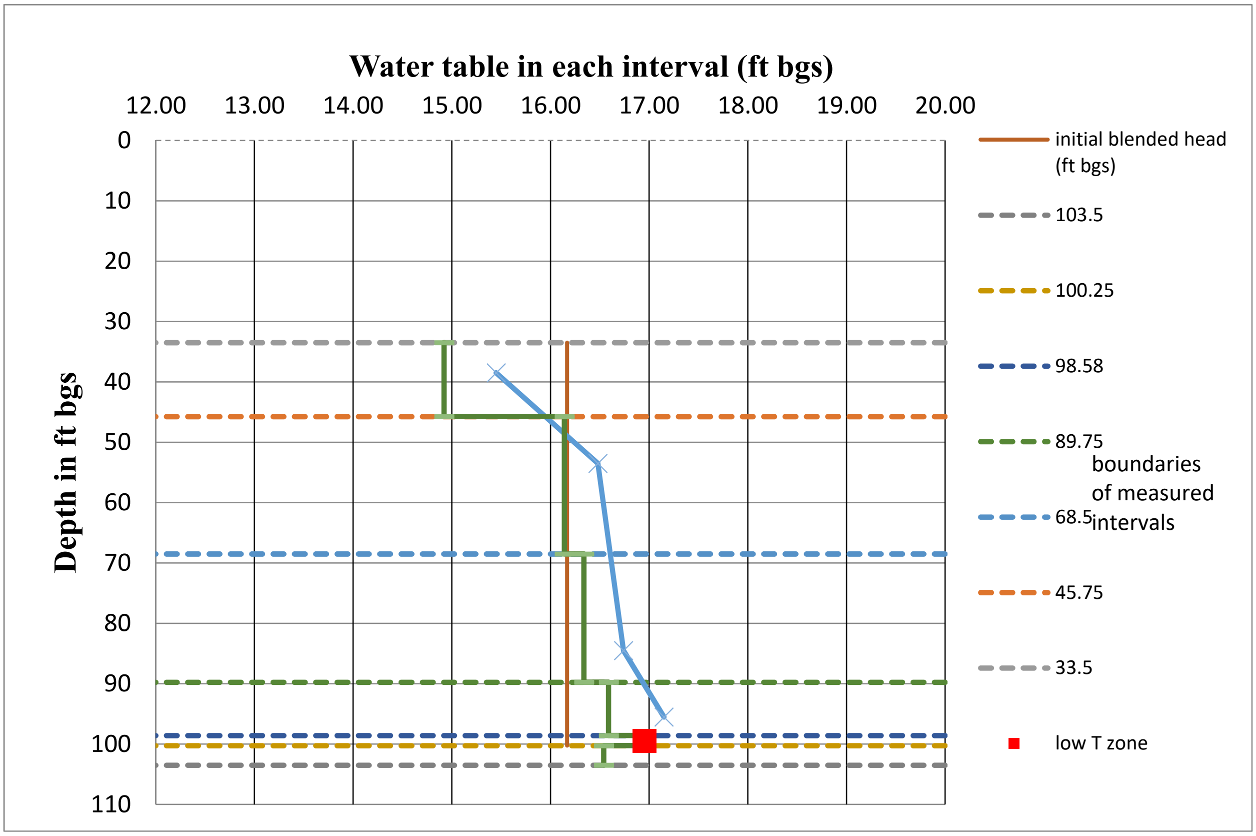


Fig. 6.3.1. The water tables calculated with the reverse head profile (RHP) method (the green curve) shown as constant over each measurement interval. The blue curve is the measured water table at four 5 ft. intervals in a multi-level system (the Water FLUTe as described in section 7). The red data point indicates an interval of low transmissivity and therefore large uncertainty. A hydrologist would expect the red square to lie between the more reliable heads above and below the low T interval.

Because the formation head is known for each interval and the highest equilibrium head in the borehole is essentially the blended head, it is easy to use the equation 6.2.3 to calculate the flow into and out of the borehole for each measurement interval when the borehole is open. Figure 6.3.2(center) is the calculated flow into and out of the open borehole. Integrating the flow of Fig. 6.3.2(center) from the bottom to the top produces a synthetic equivalent of a flow meter log as show in Figure 6.3.2(right).

It is noteworthy that the blended head in Fig. 6.3.1 matches the formation head in the interval of highest transmissivity between 50 and 60 ft as is appropriate.

The time to achieve near equilibrium in this borehole was less than 15 minutes for each halt of the liner. Subsequent measurements have shown that the time to obtain a reasonable approximation of the equilibrium pressure can be very long (> 1 hr.). A method has been developed to determine, from the first portion of the decay curve, the coefficient of the time in the exponential decay to the asymptotic equilibrium level. Using that coefficient, the equilibrium asymptote can be determined without the long wait to equilibrium. However, the lower the transmissivity, the smaller the storativity, and the larger the hole diameter, the longer is the time to approach equilibrium at each stopping point in the measurement.

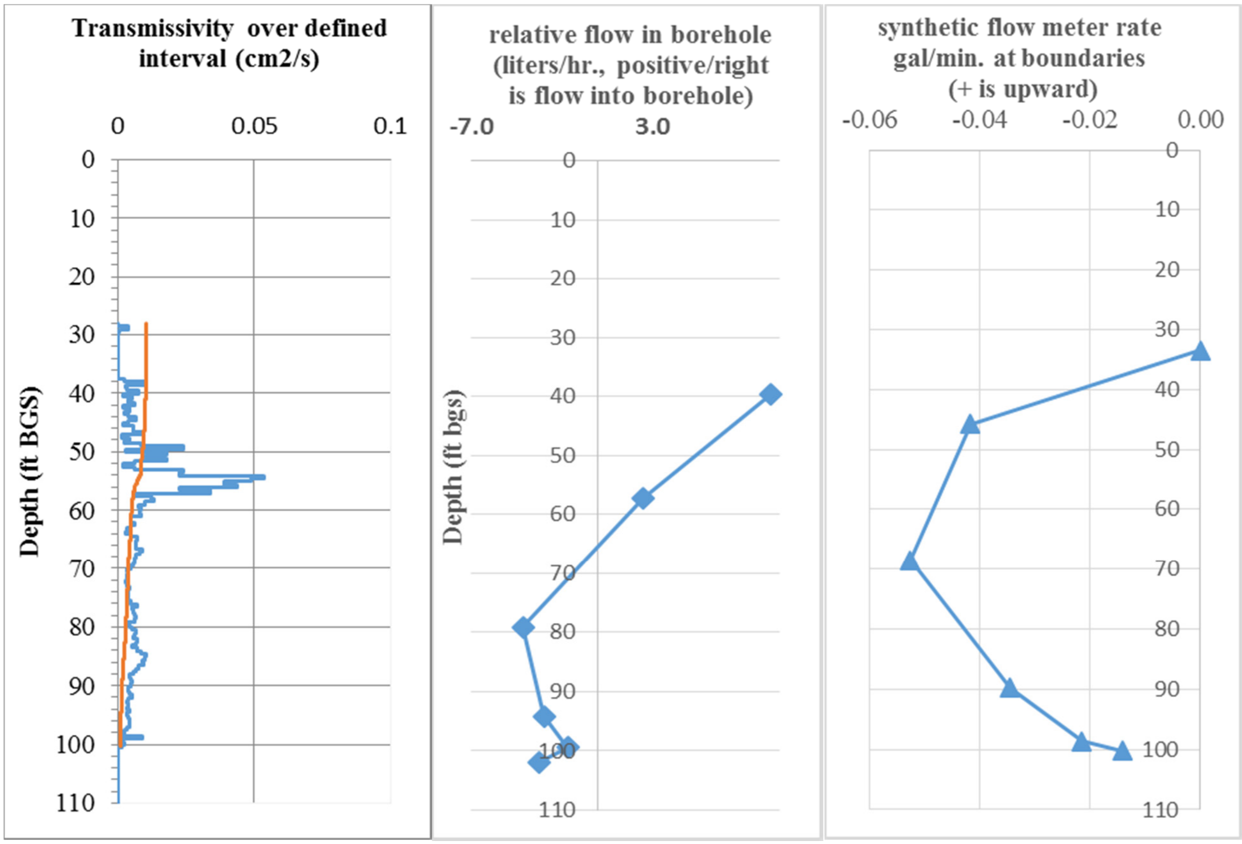


Fig. 6.3.2. The left most graph is the transmissivity for the RHP in the above example. The center graph is the flow into and out of the open borehole using the RHP and the transmissivity values for each interval. The right graph is the synthetic flowmeter log developed by integrating the center graph values from the bottom to the top.

There is not a very strong gradient in this result, and the head driving the liner for the transmissivity profile was well above the blended head in the borehole. Therefore when the measured head profile was entered into the transmissivity profile calculation for the borehole in order to refine the transmissivity profile, and those refined results were then entered into the head profile calculation, there was little change in the head profile calculated. However, in some boreholes the use of the RHP to refine the initial transmissivity result, which is based on an assumed constant head in the formation, can lead to a significant improvement in the transmissivity profile and also in the subsequent head profile. It is noteworthy that the iteration does not change the flow measurement of the T profile nor the equilibrium heads of the RHP. They simply converge to a more consistent result. It is useful to make the adjustment of the red square head values suggested before entering the RHP result into the transmissivity calculation iteration. Otherwise the poorly measured low T values can destabilize the iteration. The iteration of the transmissivity profile is most useful for shallow water table measurements where the liner is not so strongly driven and when the RHP shows a strong gradient in the formation.

Most RHP measurements are best made immediately after the transmissivity profile and not long after the borehole is drilled. Then the transmissivity profile and head profile are most useful in the development of the site conceptual model and in the selection of the sampling intervals for the multi-level system described in Section 7 for long term monitoring. The results described above have the advantage of the head profile confirmation immediately after the RHP. It has been noted that the head profile can change with nearby pumping and infiltration events.

In summary:

- The continuous transmissivity profile obtained with a liner allows one to determine the transmissivity of any interval in the borehole.
- Since a pressure transducer is usually located in the bottom of the borehole, the liner can be inverted in a stepwise manner after a transmissivity profile measurement to determine the formation head of each new interval when it is uncovered by the liner inversion.
- The formation head profile is useful for identification of aquitards and serves as a refinement of the transmissivity profile.
- The method has been named a Reverse Head Profile (RHP) in that the liner installation is reversed to obtain the head distribution. The method requires the FLUTe transmissivity profile be performed in order to obtain the transmissivity of discrete intervals.

7.0 Multi-level Sampling and Head Measurement System

7.1 Basic design and installation technique

The Water FLUTe system consists of the basic sealing liner fitted with exterior spacers to define the intervals from which the samples are extracted, a pumping system to draw water directly from the formation and a means of determining the water table at each sampling interval. This system provides many sampling intervals in a single borehole while sealing the entire borehole, except for each sample interval. The tubing of the system is constructed of PVDF which has exceptionally low absorption (tested by Parker, L, et al, 1997, 1998) as compared to other types of tubing such as low density polyethylene (the most commonly used tubing). The PVDF tubing allows the sample extraction to occur over relatively long periods of time such as in the case for low conductivity formations. The pumping system is driven by either nitrogen or other more inert gases. Unlike some gas driven systems, there is little risk of aerating the sample even while purging and sampling from all ports simultaneously. The simultaneous purging capability can greatly reduce the time in the field for sample collection. The water table levels are obtained with either a manual water level meter lowered into each port pump or using two kinds of transducer geometries for monitoring each port separately. A paper by Cherry, et al, 2007 addresses the details of the Water FLUTe system.

The flexible liner seals the entire borehole, much like the blank liner. The liner is installed by eversion. Because the relatively thin liner allows most of the borehole volume to be used for the sampling system, there are numerous advantages available. Those will be described in the sections 7.5 and 7.6. All the water in the borehole is contained inside the liner and does not need to be purged because it is not in contact with the formation water.

7.1.1 The basic design:

The drawing in Fig. 7.1.1 shows the main elements of the Water FLUTe system for a single port. The annular spacer on the exterior of the liner is about 1/4" thick and very permeable in the plane of the spacer. It is also very flexible. This allows the spacer and associated hardware to be everted into the borehole. A port through the liner is located behind the spacer so that any formation water entering the spacer is conducted to the port and flows down the port-to-pump tube inside the liner. The port-to-pump tube is contained in a flexible sleeve welded to the interior surface of the liner. The port-to-pump tube extends from the port to the bottom end of the liner and then upward in the interior of the liner to the first check valve in the pumping system.

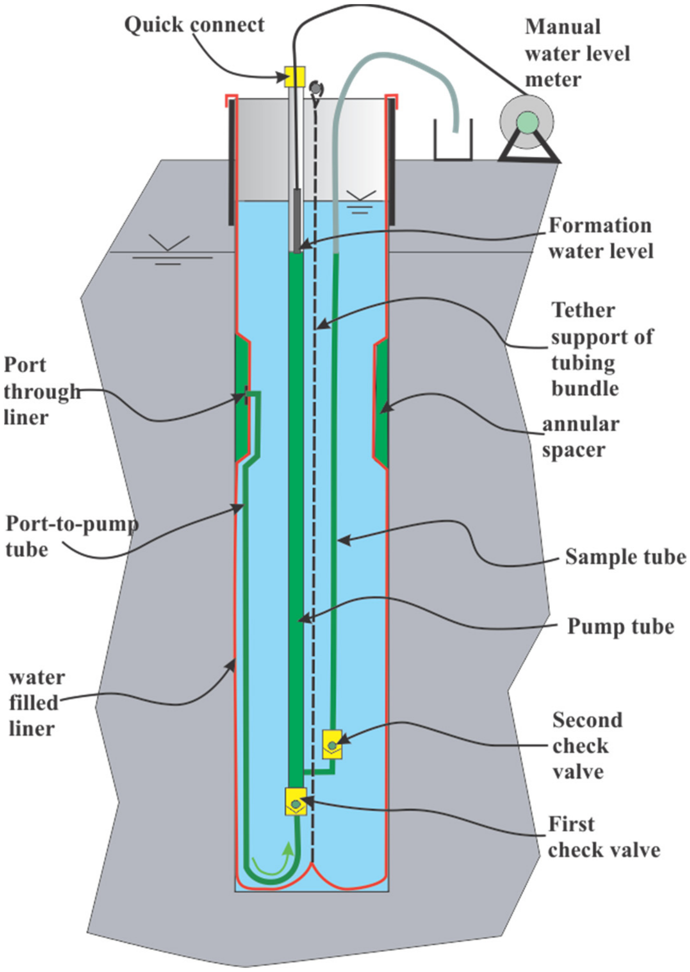


Fig. 7.1.1. Basic elements of WATER FLUTe design.

The pumping system is a U shaped tube with the pump tube much larger, typically, than the sample tube of the U. Water from the port flows through the first check valve to fill the pump tube to the natural water level for the formation water at the port and spacer. The sample water also flows through the second check valve and fills the sample tube to essentially the same level as in the pump tube. Application of a gas pressure to the top of the pump tube closes the first check valve and drives the water to the surface through the sample tube. The pump system is typically built to a length such that it extends 100 ft below the formation water table. In a borehole intersecting different aquifers, the 100 ft depth is usually defined as below the water level measured in the open hole. The pump tube is usually of ½" ID and contains approximately one gallon of water when in equilibrium with the formation. For boreholes which do not extend 100 ft. below the water table, the pumping system is shorter.

The typical Water FLUTe system is fitted with 2-15 spacers, with a corresponding pump and tubing system for each port. The central pumping systems and tubes to the bottom of the liner are sheathed in a diagonally woven sheath to resemble a large snake. The tubing from the bottom end of the liner extends upward in sleeves to each respective port. The constraint of the tubing in sleeves allows the liner and tubing to be everted into the borehole, followed by the pump and tubing bundle. The pumping system and sleeves are supported on a very strong tether which connects to the bottom end of the liner as for a blank liner. The tether is anchored at the wellhead to support the tubing bundle and the tubing bundle is separated at the wellhead into a pump and sample tube for each port as shown in the photo of Fig. 7.1.2.

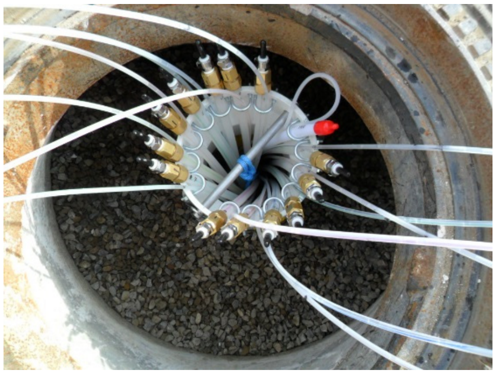


Fig. 7.1.2 Wellhead showing pump tube separations and slender sample tubes

7.1.2 The installation procedure:

The Water FLUTe liner system is shipped to the site inside-out on a reel. The installation is very similar to a blank liner installation as described in section 2. The liner is clamped to the top of the surface casing, pushed downward to form an annular pocket and water is added to the annular pocket to drive the liner to the bottom of the hole. The tubing bundle follows the everting liner into the borehole (see Fig. 7.1.3). Figure 7.1.4 is a photo of a Water FLUTe installation with a braking system on the shipping reel to support the hanging load of many ports and a deep borehole. The liner is filled to a level well above the highest head in the formation to dilate the liner against the borehole wall for a good seal. The seal is much like that described in section 3 for a blank liner.

Fig. 7.1.3. Water FLUTe being installed in a 600 ft., 6 inch diam. borehole with 12 ports. The Green Machine is being used as wellhead roller to align liner with borehole. The grey hose and valve are for water addition to liner.

While the Water FLUTe system is being fabricated to the customers' specifications, the borehole is often sealed with a blank liner to prevent cross connection. The blank liner is often used to perform a transmissivity profile (section 5) to aid in the selection of useful sampling intervals. The blank liner is removed by inversion before the Water FLUTe liner is installed by eversion.

Water FLUTe systems are installed directly from the shipping reel without the need for a drill rig or crane truck to support the system during installation. Since many boreholes are not sufficiently permeable at the bottom end of the hole to allow the liner to easily evert to the bottom of the hole, a tube is first lowered to the bottom of the hole to remove the water trapped beneath the end of the everting liner. The liner is then deflated by removal of some of the interior water, the tube is removed, and the liner is refilled to the prescribed level for a good seal of the borehole. Liners have been in place for fifteen years or more without any indication of aging. The top of the liner at the wellhead must be protected from exposure to the sun.

Another important feature of the Water FLUTe system is that it is removable by inversion of the liner from the borehole. If the borehole has a low transmissivity, the liner can be removed by removing all of the water from inside the liner and pulling the collapsed liner from the borehole.

Fig. 7.1.4. FLUTe braking system for lowering Water FLUTe PVDF pumping system into borehole with deep water table.

7.2 The water sampling procedure:

The pumping system is gas driven usually with a bottled gas such as nitrogen. The gas system is set to the "purge pressure", the gas tube is connected with a quick connect fitting to the top of the pump tube. A valve is opened to allow the gas pressure to displace all of the water from the pump system through the sample tube. Then the gas pressure is vented to the atmosphere and the pumping system refills from the spacer and the formation. The gas pressure is applied a second time and the pump is emptied again. The recommended procedure is to apply the gas pressure to four purge strokes expelling four full pump volumes. The purge pressure to be used is provided with each system based upon the length of the pumping system. Once the purge of all the water from the pumping system has been done and the system is filled with formation water, a lower gas pressure is used for the sample collection.

The gas source is set to the "sample pressure". This sample pressure is less than the purge pressure and does not allow all of the water to be expelled from the pump (see Fig. 7.2.1. This lower pressure application assures that the drive gas will not be driven through the sample water. The first flow from the sample tube during the first sample pressure application is discarded to assure that none of the aerated droplets of the purge sequence are included in the sample collected. The discard volume is recommended for each system. Typically, the discard volume is one-eighth of the pump tube water filled volume. If more sample water is needed, the sampling procedure can be repeated by lowering the gas pressure, allowing refill of the system and applying the gas pressure again. No discard is needed for the additional sampling strokes of the pumping system.

It is especially noteworthy that all pumps can be driven simultaneously with a single application of the gas pressure. This is done using a manifold with a tube to each pump tube. Fig. 7.2.2 is a photo of the use of a manifold to purge 12 ports simultaneously in a 6 inch diameter hole.

7.3 Manual head measurement procedures

The water level in the pump tube is the water table in the formation upon the first flow into the pumping system (Fig. 7.1.1). However, if the water level falls in the formation, the first check valve may prevent the water level in the pump tube from dropping with the water table in the formation. Therefore, it is prudent to expel one pump volume of water and let the water level in the pump tube recover to the current level in the formation before measuring the water table depth. In some designs, a normally-open first check valve is used to allow the water level in the pump tube to follow the water table in the formation. The water level is measured by lowering an electric water level meter (typically, a slender meter with ¼” weights) down the interior of the pump tube.

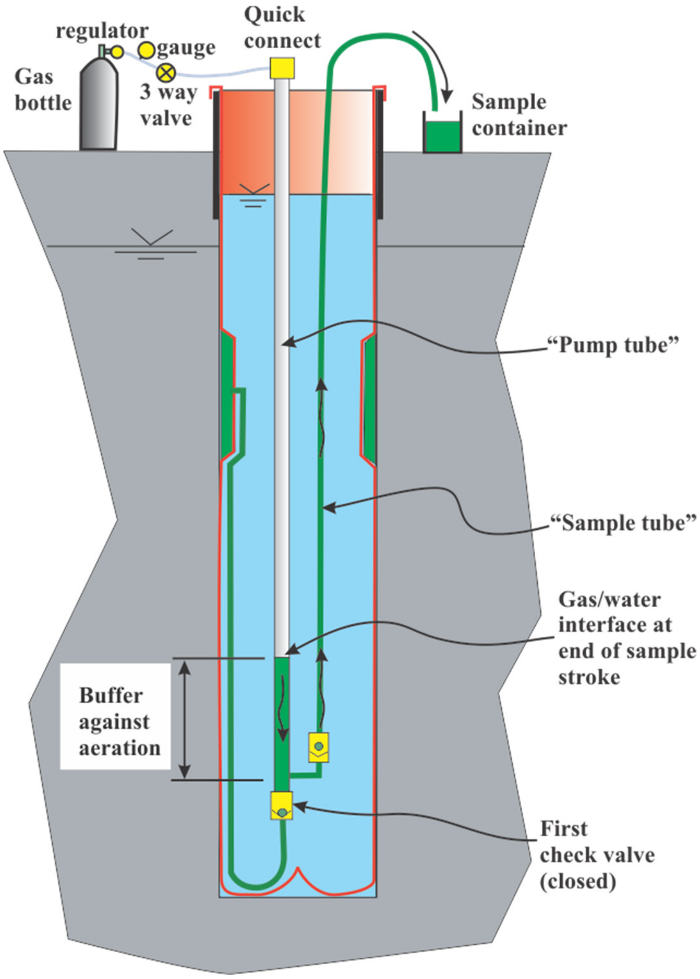


Fig. 7.2.1. Pumping procedure showing buffer

Fig. 7.2.2. Simultaneous purge of 12 ports with monitoring of purge volume from each port.

7.4 Use of transducers

7.4.1 Downhole transducers

It is also common to include a recording pressure transducer installation for each port in the tubing bundle. Fig. 7.4.1 shows two kinds of installations. The first and most common is for the transducer to be located just below the first check valve. That allows the transducer and cable to be part of the tubing bundle and does not require that it evert with the liner. A cable to the surface allows the data recorded to be down loaded. The transducer installation does not limit the number of sampling ports available for a given borehole diameter. The only disadvantage of this transducer installation is that the transducers are committed to the system and in the event of any transducer failure, it is not easy to recover the transducer for repair or replacement.

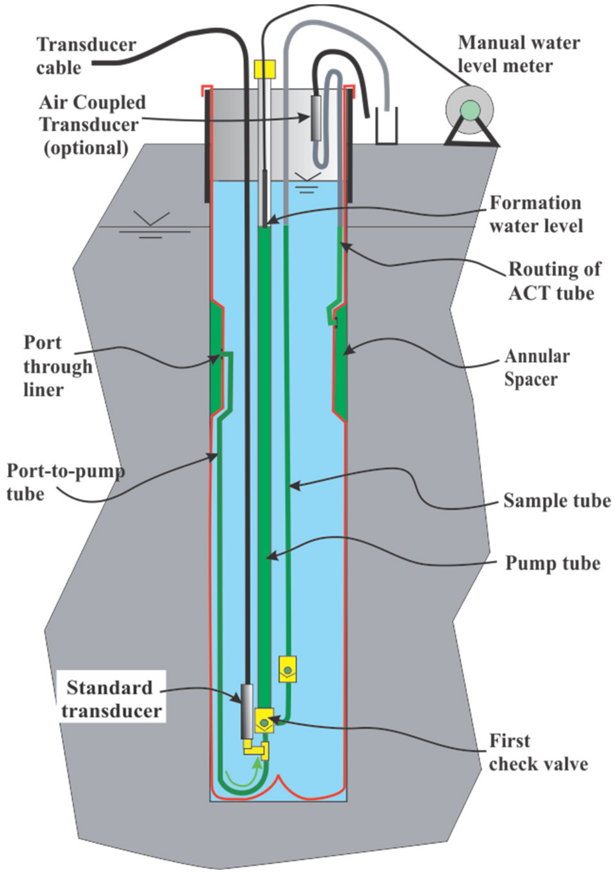


Fig. 7.4.1. The standard transducer is located deep in the liner below the first check valve. The ACT system transducer is much more accessible, at the surface, inside the casing. The ACT transducer is connected to an ACT tube from the spacer.

7.4.2 Air coupled transducers

In the second kind of transducer installation, the transducer is located at the surface and coupled to the spacer using a second port behind the spacer (Figure 7.4.1). This air coupled transducer geometry is a proprietary system called an ACT (Air Coupled Transducer). The surface installation allows the transducers to be reused or replaced as needed. The ACT transducers are high resolution low pressure range transducers which measure the air pressure of the air column above the water table in the tube to the surface. The simple test of the system shows that the transducer can follow the water level change at 48 ft within ¼” on the one second time scale (see Fig. 7.4.2). The ACT transducers are best located inside the surface casing to avoid surface temperature variations. A simple spreadsheet provided converts the air pressure history to a water level history and corrects for temperature effects on the air pressure in the tubing. That correction is a deviation from the simple data set from a downhole transducer. The initial water level measured in the pumping system is used to calibrate the ACT system.

The ACT technique has been expanded to include an air coupled water level meter which allows one to measure the depth to water in a very slender tube (e.g., ¼” OD). This design is of special utility if the Water FLUTe pump tube is a much smaller tube than the standard ½” ID design. For example, if the sampling system need not produce more than half a liter per stroke and the pressure transducer is down hole, the air coupled water level meter allows one to measure the water level in the pump system to confirm the transducer measurement even if the pump tube is a ¼” OD tube and too small for an electric water level meter. The air coupled water level meter is also useful to obtain the initial water level in the ACT system, a necessary measurement for that procedure.

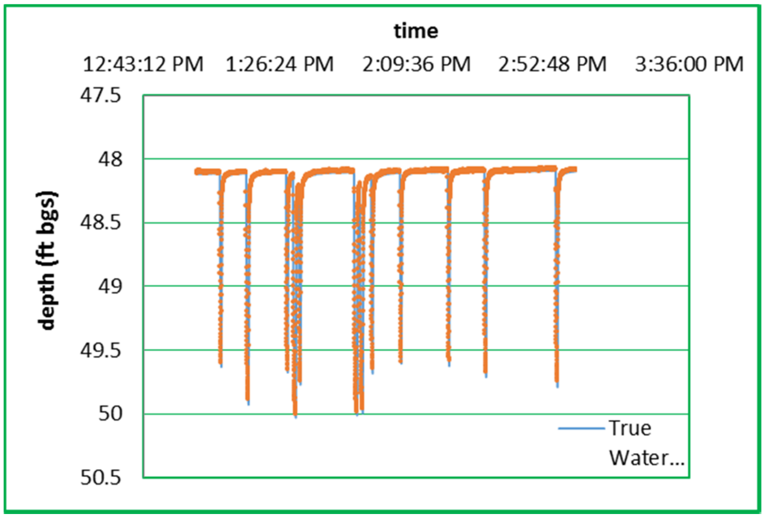


Fig. 7.4.2. The water table is 48 ft below the surface and drops ~2 ft each time the domestic well pump starts. The water table calculated from the ACT data points follows a submerged transducer measurement (the continuous curve) within ¼ inch on the1 s. time scale.

7.5 The Shallow Water FLUTe system

The MLS design shown in Figure 7.5.1 is called the Shallow Water FLUTe, SWF, system. It uses the same sealing liner and the same spacer design. However, the tube from each port extends upward in sleeve instead of downward. At the surface the water sample can be withdrawn with a peristaltic pump or other vacuum system. The water table at each port can be measured using a FLUTe vacuum water level meter which draws the water in the tube to the surface (See Fig. 7.5.2). The water level in the sight tube is a distance H above the surface The valve is closed when the water level appears in the sight tube. The vacuum necessary to lift the

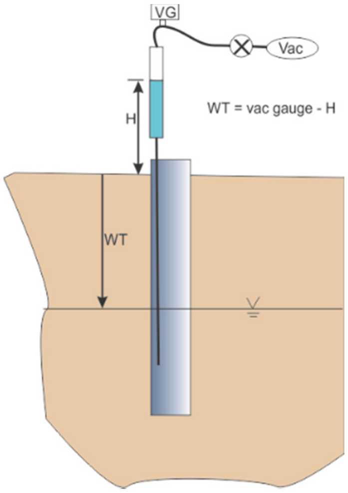


Fig. 7.5.2. Vacuum water level meter. WT= VG-H, the water table depth bgs.

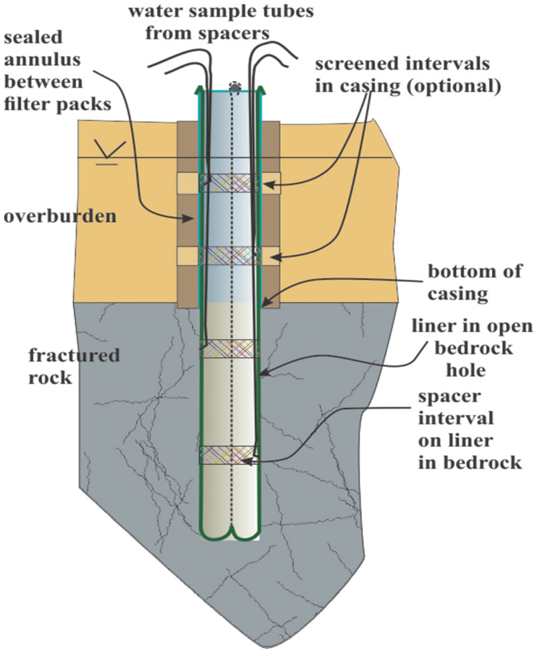


Fig. 7.5.1. The Shallow Water FLUTe systems with sampling intervals in the saturated and vadose zones and also inside a cased interval with matching screens.

water to the surface is read from a digital vacuum meter in ft. of water. The measured height, H, of the meniscus above the ground surface is subtracted from the vacuum reading to produce the depth of the water table below the surface. This method can only be applied easily for water tables less than 20-25 ft below the surface. Hence the name Shallow Water FLUTe system. However, the SWF is only intended for borehole depths of less than 200 ft. At greater depths the flow with a peristaltic pump is painfully slow.

A SWF can be built with smaller tubes and more ports and deeper water tables if a water table history is the only need. The initial water table is then obtained by injecting a small amount of air into the tube as in a common “bubbler” design and then using the ACT for measuring the water table history thereafter.

The advantages of the SWF design are several fold:

1. The cost is significantly less than the Water FLUTe due to the lower labor and material costs. This may be the least expensive MLS in some situations.
2. The system is more compact and lower weight and can usually be shipped on a reel similar to that used for a blank liner
3. The interior of the liner is relatively open and is often used to store the ACT transducers inside of the liner.
4. The liner can be everted into the borehole using an air driven system that avoids the need for scaffolding for shallow water tables in order to provide sufficient pressure to evert the liner into the borehole.
5. Ten sampling intervals have been used in 4 inch diameter holes compared to the usual Water FLUTe limit of 6 ports. More ports are possible in larger diameter boreholes.

7.6 Comparison with other multi-level systems

The summary below is a list of the characteristics of the Water FLUTe system. A primary difference from other multi-level systems is the continuous seal of the borehole with the flexible liner. This is a significant advantage over the use of straddle packers for isolation of the intervals to be sampled. The large interior volume of the liner allows the use of relatively larger pump tubes and transducers. Other multi-level systems are often constrained to the interior of a 2” ID casing. The ability to remove the Water FLUTe multi-level system for warranty repairs, or at the end of use, is another significant advantage. Because of the liner seal of the borehole, there is no need for the expense, or potential sample contamination, of using an annular grout seal outside of a casing in an open stable borehole. Because the FLUTe liner system is pressure tested in the factory fully assembled before shipping, there is less concern with any field assembly in inclement weather or contamination of the system in the assembly in the outdoor environment.

Vadose gas sampling ports can be added to a Water FLUTe above the water table in the formation. Those are described in section 8.0.

Summary:

- The flexible liner MLS seals the entire borehole except for the defined sampling intervals. No sealing grouts are used.

- The sampling intervals are defined by an exterior spacer with a port in the liner which draws the sample directly from the formation.
- The systems (with rare exceptions) are everted into the borehole.
- All systems have been installed in boreholes with or without artesian conditions.
- All ports can be purged simultaneously.
- Purge volumes are typically 4 gal., but much larger volumes are easily obtained.
- All systems are fabricated and leak checked in the factory fully assembled.
- All systems are usually installed in less than one day.
- The Water FLUTe systems are installed by FLUTe trained personnel.
- All systems are removable except for liners rarely filled with grout to withstand extreme pressure differentials in the formation.
- Head measurements are performed manually or with recording transducers.
- Vadose pore gas sampling intervals can be added above the water table.

8.0 FLUTe vadose measurements

8.1 Pore gas sampling

8.1.1 The geometry

The in-place geometry of the vadose sampling system is shown in Fig. 8.1.1. The installation is completely above the water table. The liner can be everted into the borehole with a variety of driving fluids from air, to water or mud. The usual installation is done with water to the bottom of the borehole and the liner is then dilated with air to urge the liner against the borehole to isolate each sampling interval. An air tight seal is required at the top of the liner if the liner is to be dilated with air. In most cases, a small air pump is used to maintain the liner interior pressure in combination with a pressure relief valve set to the desired pressure. The air pump is often powered by a solar panel for remote locations. For short boreholes, it is easy to use water as the fill and pressurizing fluid. A water fill is reasonable for boreholes up to 40 ft in depth in the vadose zone. Vadose liner systems have also been installed in driven casing (e.g., in sonic casing) in unstable media. In those situations, the interior of the liner is filled with dry sand and the liner system is not removable by inversion.

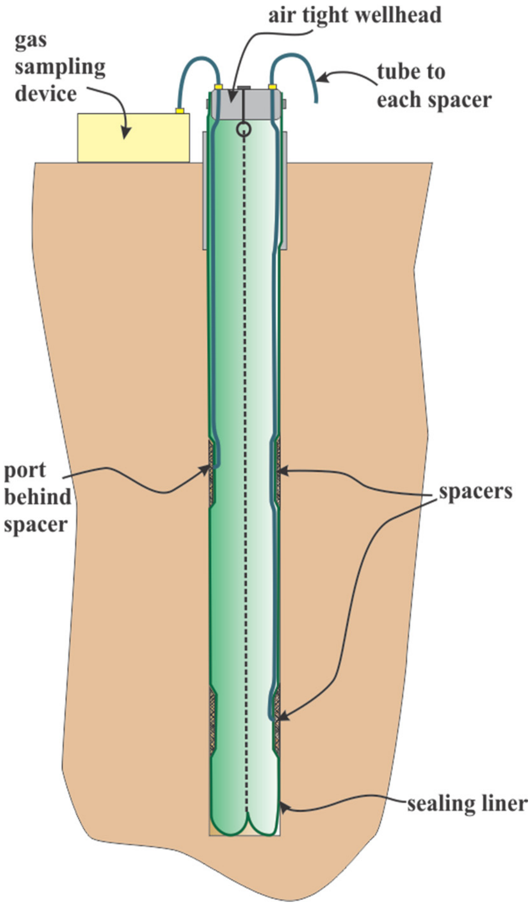


Fig. 8.1.1. The vadose gas sampling liner system

The number of gas sampling intervals is only limited by the space for tubing in the interior sleeves of the liner. 10-15 ports are common. Vadose sampling ports are sometimes included above the water table on a Water FLUTe system to combine both water and pore gas sampling in open stable boreholes. Pore gas sampling systems have been installed to over 1700 ft.

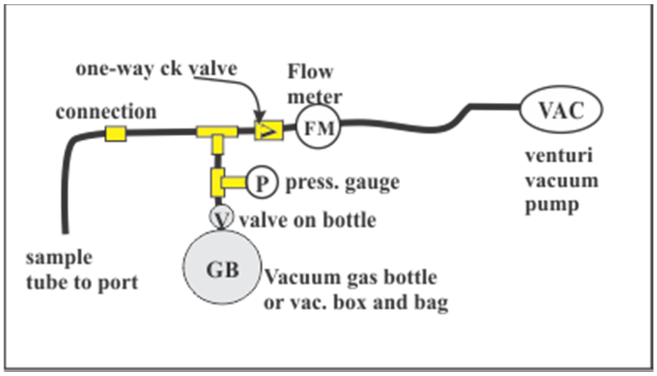


Fig. 8.1.2 Pore gas sampling system. Vacuum pump purges tubing and sample is collected by opening the valve to the gas bottle. Flow meter allows determination of sufficient purge volume. The check valve prevents backflow when vacuum pump is stopped before gas collection.

8.1.2. The gas sampling procedure

A representative pore gas sample can be drawn to the surface after the interstitial volume of the spacer and the tube volume have been purged. A typical design for a vacuum pump and gas sample collection volume are shown in Fig. 8.1.2. The system includes a flow meter to measure the flow rate in order to determine when a sufficient gas volume has been purged. A simple venturi vacuum pump provides a steady gas flow which greatly aids the flow meter reading versus the positive displacement vacuum pumps which can produce pulsating flows. Once the required volume of gas has been purged, the gas sample is drawn into the gas collection volume. That collection volume can be either a vacuum bottle or a flexible bag housed in a vacuum box. An alternative approach can use a peristaltic pump for extraction of the gas from the formation and for filling a *Tedlar* sample bag. The flow meter is still desirable, but a balloon volume can also be used as a flow measurement determination. The tubing volume is usually small.

8.2 Pore Liquid Sampling

8.2.1 The use

The pore water sampling liner system is installed in the same manner as the pore gas sampling system. Pore water can be obtained from the vadose zone if the capillary tension is not too high (i.e., the pore space has relatively high water saturation). The samples are collected into absorbent covers on a liner everted into place. Keller, et al. 1993 describe the wicking process and the characteristics of a variety of absorbent materials in a variety of vadose conditions. Sometimes a wire pair with two contacts is positioned behind the absorber to monitor the increase in saturation during the absorption process. When the absorber has gained as much water as possible (i.e., the capillary tension of the absorber equals that of the formation), the electrical resistance between the two contacts stops decreasing. The resistance measurement should not be done with a DC circuit.

8.2.2 The geometry of pore liquid sampling

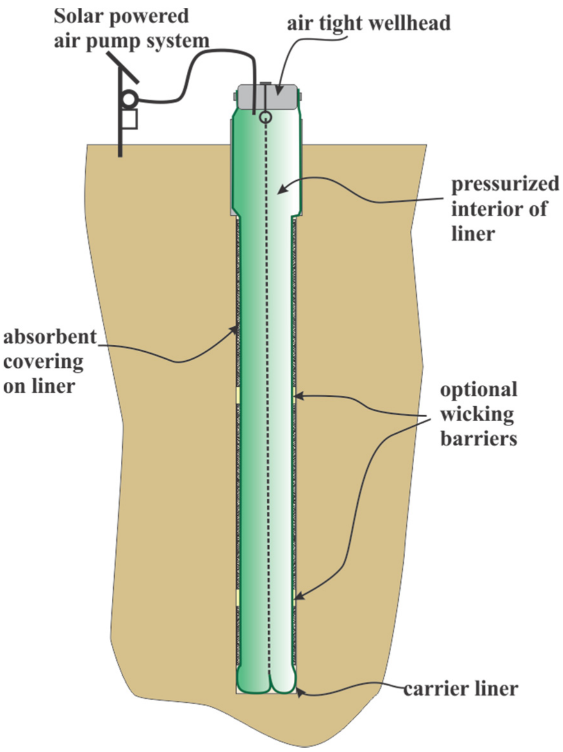


Fig. 8.2.1. Pore water absorber system on carrier liner. Covering can be instrumented sections or continuous. Absorbers are recovered after liner is inverted from the borehole. Typical solar powered air pump shown.

The geometry of the absorber covered liner, Figure 8.2.1, shows the absorber geometry used for the collection of pore water samples. The liners are usually everted into open stable boreholes. In some situations, the vadose liner with absorbers is everted into a borehole already containing a pore gas sampling vadose system. The smaller everting absorber collection system is driven with a higher pressure than the original liner such that the second liner displaces the first liner. When in place, the driving pressure (usually air pressure) of the second liner is dropped allowing the absorber carrier liner to collapse and to wick a sample from the borehole wall. The second liner is then removed by re-inflating the liner and inverting it from the borehole, allowing the original liner to dilate back against the borehole wall.

8.2.3 The sampling procedure for pore water

When the absorber has been left in place for a sufficient time period, the carrier liner is inverted from the borehole. The carrier liner is then everted horizontally into a tubular poly-film in the same manner as it was everted into the borehole. The absorbent covering can be disconnected from the bottom of the carrier liner and the carrier liner is inverted from the interior of the absorbent covering. The collapsed absorber can then be sealed in segments by elastic bands on the poly-cover. The poly-cover is to reduce evaporation before the absorber is analyzed for the distribution of contaminants. The absorbent covering often contains wicking barriers to prevent longitudinal migration of the absorbed liquid in the absorbent covering to improve spatial resolution.

Other kinds of attachments to liners include electrical contacts on the outside of the liner connected with wires to the surface for tomographic resistance measurements. Instruments have been lowered down the borehole and isolated by everting a liner over them.

In Summary:

- Both pore gas and pore liquid systems are available as flexible liners for pore fluid collection in the vadose zone.
- The pore gas sampling liners are usually removable by inversion unless sand filled

- It is noteworthy that the vadose sampling systems were the original Flexible Liner Systems and have been in use for several decades.

9.0 Use of Liners in Angled, Horizontal and Tortuous Boreholes or Pipes

Flexible liners can be driven with a variety of fluid fills. Some liners are installed in boreholes using a heavy mud to overcome artesian conditions. Others are installed in angled holes with water. Some FLUTe liners have been installed under buildings in horizontal pipes laid in trenches prior to construction of the building. The pipes were connected to vertical wells beneath the building. Figure 9.1.1 shows the geometry of such an installation.

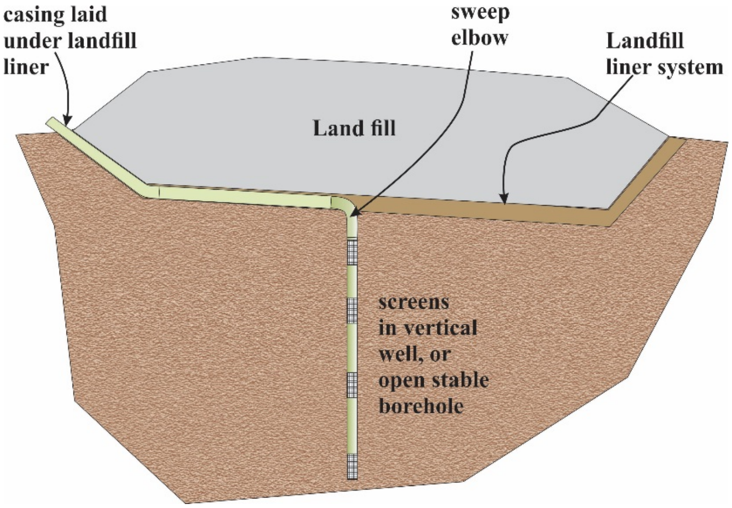
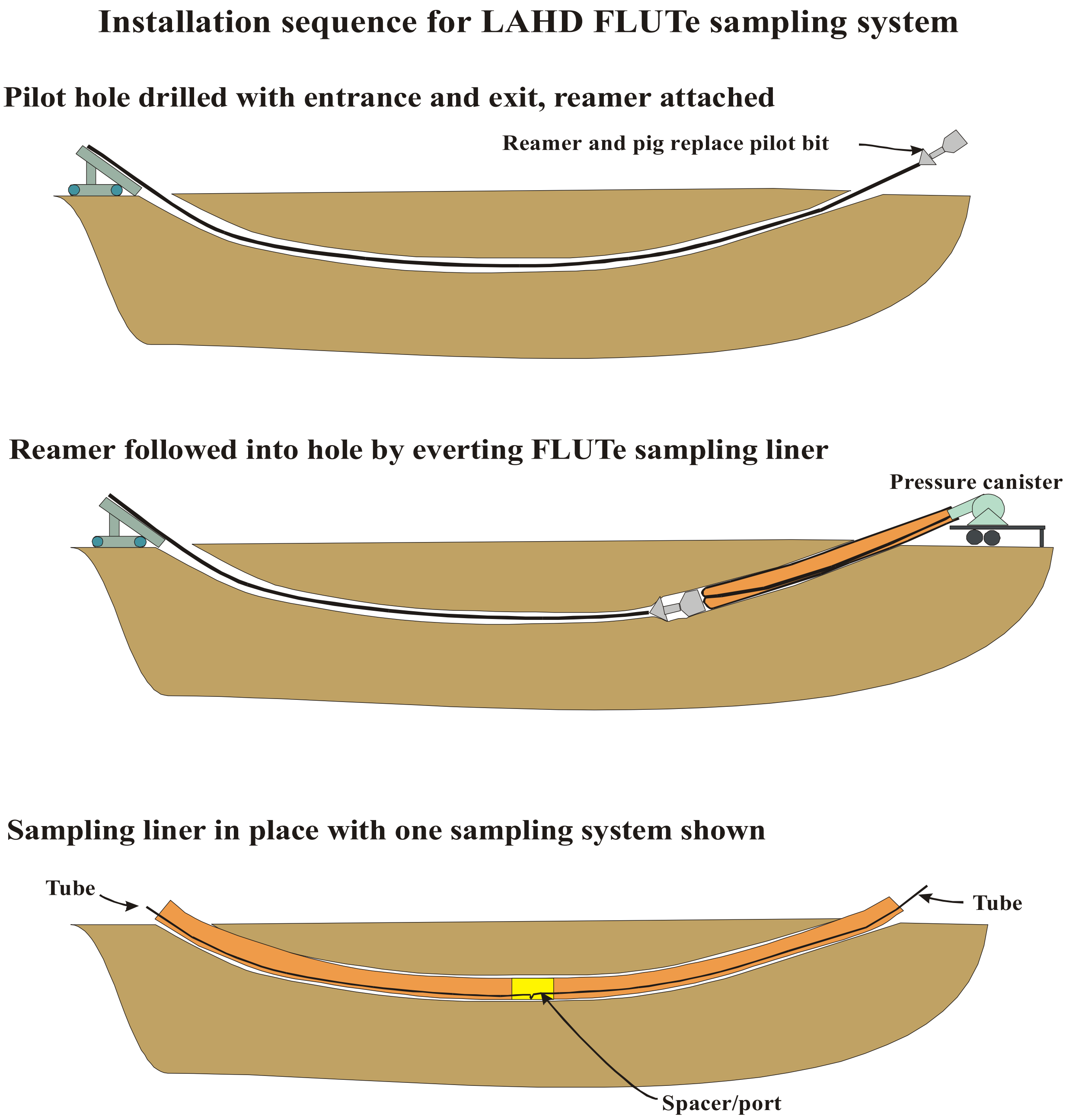


Fig. 9.1.1 Flexible liners can be everted into horizontal boreholes and piping containing numerous sweep elbows. This allows the transport of a variety of devices for measurements in tortuous passages as shown

Liners have been installed in horizontal drill holes in a number of procedures. In one procedure called a LAHD (Liner Augmentation of Horizontal Drilling), the liner was driven against a pig which is towed behind the reamer. See the geometry in Fig. 9.1.2. In that case, the liner forced the drilling mud and cuttings of the reaming process out of the horizontal borehole at the wellhead. When the reaming was completed, the liner supported the borehole wall against collapse. The liner carried into position numerous ground water sampling ports. The horizontal installation with a horizontal drill rig was beneath a landfill. Fig. 9.1.3 shows the equipment during the installation. The liner was everted from an air canister with a water fill of the liner.

Other liners have been installed vertically upward from the basement of the Smithsonian Museum of Natural History to the roof top 100 ft above. The driving fluid was air.

This ability to install FLUTe sampling systems in horizontal geometries is not often used. Perhaps it is because the capability is not well known. A common installation is in angled holes using water as the driving fluid. It is noteworthy that for boreholes showing major deviations from vertical that the liners are installed as easily as in more nearly plumb holes. A video of the installation in a crooked piping system is available on the FLUTe website. The video demonstrates a liner passing through 450 degrees of turns in the 4 inch piping system.



Installation sequence for LAHD FLUTe sampling system

Pilot hole drilled with entrance and exit, reamer attached

Reamer followed into hole by everting FLUTe sampling liner

Sampling liner in place with one sampling system shown

Fig. 9.1.2 The installation of a liner following a horizontal drill reamer. The liner supports the borehole and forces the mud and cuttings out the entrance at the drill rig. The liner can emplace several sampling intervals at the same time while following the reamer.

Fig. 9.1.3 LAHD installation from canister following the reamer under a landfill. Liner is shown everting out of horizontal hole 400 ft from the entrance. Liner is still clean because it was everting through the mud. The liner emplaced 8 sampling ports under the landfill.

Summary:

- Flexible liner systems have been installed by eversion in many directions
- In mine tunnels with horizontal or vertical upward emplacements
- In angled holes from the surface
- Upward in tortuous piping in the walls of buildings
- Using a wide variety of driving fluids and long term pressurization fluids.

10.0 Conclusion

The FLUTe flexible liners of many kinds have been used for over 20 years in a variety of novel geometries and for many kinds of measurements or emplacements. However, the primary focus has been hydrologic measurements. Most experience has been at contaminated ground water sites. The technology has evolved over that time frame so that some of the methods are relatively new (e.g., the formation head profile technique). The use of flexible liner methods is now extended from contaminated ground water sites to mining sites and municipal water supply assessments. The unique continuous seal of the borehole by the flexible liner without the need for sealing grouts and the ease of removal are features that are especially attractive. There are many more detailed descriptions and videos of the flexible liner methods on the FLUTe website, www.flut.com.

FLUTe methods are now in use in many countries and all US states. The development of strong leak proof flexible fabrics has been essential to the birth of these methods. In many cases these techniques are complimentary to traditional hydrologic practice. In some cases, they replace traditional practice. This monograph is intended to acquaint the larger hydrologic community with the option of flexible liner methods. The FLUTe Company has been primarily focused on development of these methods. Now it is important to explain the methods to the larger community who can use these flexible liner systems.

As an overview of the variety of flexible liner methods, This monograph does not treat the important details. The details are available in separate papers and reports. Those details are available from FLUTe or on the web site www.flut.com.

*Note: the methods described in this monograph are proprietary and covered by 21 US patents and some patents in 11 different countries.

Acknowledgements.

The early use of liner systems by Prof. John Cherry and Prof. Beth Parker at the Univ. of Waterloo and the University of Guelph has been very helpful to the verification and the FLUTe refinement of the flexible liner methods. Their willingness to try these novel designs has made the acceptance of the technology much faster than without their help. Joe Rossabi challenged me to develop the NAPL FLUTe installation method. Anders Christensen of Denmark has provided enthusiastic testing opportunities for some of our early designs. Special thanks goes to all those other people bold enough to try the early versions of the flexible liner methods. Without that interest, the technology would have died. Of course, the FLUTe employees who have carefully built these systems and those who have installed them successfully, even under severe weather conditions, have made the success of the technology possible.

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APPENDIX D
HEALTH AND SAFETY PLAN

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

Site-Specific
Health and Safety Plan for

Harbor View Square
68 West First Street
Oswego, New York
NYS BCP Site No. C738040

Prepared by:

synapse

Synapse Property Resources
360 Erie Boulevard East
Syracuse, New York 13202

SYNAPSE
HEALTH AND SAFETY PLAN
REVIEW AND APPROVAL

CLIENT: Harbor View Square, LLC	SITE NAME: Harbor View Square
PROJECT NAME: Brownfield Cleanup Program Remediation	PROJECT NUMBER: *HSGV 24-16*
START DATE: April 15, 2017	END DATE: November 15, 2019

Roger R. cREIGHTON Project Manager	Signature:________________________	Date:_______________
Roger Creighton Synapse Health and Safety Coordinator	Signature:________________________	Date:_______________
Varies Site Health and Safety Officer	Signature:________________________	Date:_______________
Brian Macrae Managing Partner	Signature:________________________	Date:_______________

This Health and Safety Plan has been written for the use of Synapse Property Resources (*Synapse)* employees and approved *Synapse* subconsultants, subcontractors and clients.

Our work can be hazardous, and it is imperative that we never forget that! It is the intent of this document to address our risks. The health and safety guidelines in this Plan were prepared specifically for this site, its conditions, purposes, dates and personnel and must be amended if conditions change. This Plan must not be used on any other site without prior research by trained health and safety specialists.

Synapse claims no responsibility for its use by others for purposes unrelated to this project. This Plan will provide useful information to subcontractors and will assist them in developing their own HASP. Subcontractors and subconsultants should sign this plan (See Attachment 7) as an acknowledgement of hazard information and notice that they must ensure that the risks posed by work on this site are addressed. Synapse is readily available to assist subcontractors in identifying and addressing their employees' risks.

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Attachment 6 – Daily Production Health & Safety Briefing

Attachment 7 – Acknowledgment & Agreement Form

Attachment 8 – Community Air Monitoring Plan (Bound Separately)

1.0 Objectives and Goals of this HASP

The purpose of this HASP is to:

- **Document a proactive, scientific exposure assessment for this site and project that identifies and provides an understanding of health and safety risks.**
- **Document proactive precautions to avoid the risks and stay safe.**

Our goal of this HASP is to:

- **Complete site work described in the Remedial Work Plan without any incidents; no injuries, no illnesses, no impacts to the environment or to property and equipment. NONE! We have zero tolerance for incidents of any type. We expect all subcontractors and other project participants to share this goal.**
- **Comply with the provisions and requirements set forth by OSHA.**

2.0 Scope of Work

The Scope of Work includes the implementation of the Brownfield Cleanup Program Remedial Work Plan (RWP), which will consist of a series of plans. This HASP was prepared for the use of Synapse personnel and subcontractors while performing the following tasks:

Bedrock Drilling and Sampling

This task will include observation of the installation of five bedrock holes at the site, as described in the Pre-Design Investigation Work Plan (PDIWP).

Archeological Survey

This task will consist of observation of the archeological survey. Several exploration trenches will be advanced in the area of the former Fort Oswego, as shown in Attachment 1.

Contaminated Soil Excavation and Clean Fill Placement

This task includes the excavation of existing contaminated site soils in the area of the former UST, beneath the former process lines, and beneath Sump 1 and Sump 2. Upon removal of the soils, soil samples will be collected from the excavation base and sidewalls. The collected samples will be submitted for laboratory analysis under standard chain-of-custody protocols to confirm all contamination was successfully removed. Synapse anticipates the excavation to extend to bedrock, expected to be between two and five feet below ground surface (bgs). If additional contamination remains on the bedrock surface, a remediating compound will be applied to the base of the excavation. The excavation will then be backfilled with certified clean fill, mechanically compacted into place.

Bedrock Injections

This task includes observation of injections into the bedrock. This plan will be updated to include the scope of work for the injection progam when it has been defined.

3.0 Background Information on the Project Site

The Site is located at 68 West First Street in the City of Oswego, Oswego County. The Site covers approximately 2.438 acres and consists of the block bounded by West First Street to the east, West Second Street to the west, West Schuyler Street to the south and Lake Street to the north. The northwestern portion of the site is covered by a one-story concrete slab-on grade, steel-framed masonry building which covers approximately 20,900 square feet. The primary contaminants of concern (COCs) for the site include several chlorinated volatile organic compounds (CVOCs); specifically tetrachloroethene (PCE) and trichloroethene (TCE) and their degradation products, which include 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), and vinyl chloride (VC). Other COCs of interest include; several metals, including lead, mercury and others, as well as polycyclic organic hydrocarbons (PAHs).

4.0 Property Owner Safety Procedures

Not applicable.

5.0 Site Plan

A site plan is included in **Attachment 1.**

6.0 Emergency Response

If an incident occurs, the following steps will be taken

- *The Site Health & Safety Officer (SHSO) will evaluate the incident and assess the need for assistance and/or evacuation.*
- *The SHSO will call for outside assistance as needed.*
- *The SHSO will act as liaison between the outside agencies and on-site personnel.*
- *The SHSO will ensure that the Project Manager (PM) and Synapse(HR) are notified of the incident; and*
- *The SHSO will take appropriate measure to stabilize the incident scene.*

The SHSO must be familiar with the directions to the hospital given in **Attachment 2.**

Injury or Illness

If an injury or illness occurs, take the following action:

- Determine if emergency response (fire/ambulance) support is necessary. If so, dial **911**. Provide the location of the injured person and other details as requested. If it makes sense to take an individual to the hospital, follow the directions in **Attachment 2.**

- Get First Aid for the person immediately. Utilize first aid kit in vehicle. Also utilize the bloodborne pathogens kit. *(Make sure you have both kits, or one combined kit).*

- Notify the SHSO immediately. The SHSO is responsible for preparing and submitting the Incident/Near Miss Investigation Report to Synapse's within 24 hours of the incident, as well as notifying the employee's supervisor and Project Manager. Use the Incident/Near Miss Investigation Report and Root Cause Analysis Flowchart in **Attachment 3**. Synapse phone is (315) 475-3700. ***(Note: All incidents must be reported to Synapse within 24 hours, but the actual investigation need not be completed within 24 hours.)***

- The SHSO will assume responsibility during a medical emergency until more qualified emergency response personnel arrive at the site.

First Aid Procedures for Minor Cuts, Scratches, Bruises, etc.

- Each occupational illness or injury shall be reported immediately by employees to SHSO. The SHSO will complete the Incident/Near Miss Investigation Report in **Attachment 4** and report the incident to Synapse.

Medical Cases Not Requiring Ambulance Service

- Medical cases normally not requiring ambulance services are injuries such as minor lacerations, minor sprains, etc.

- The SHSO will ensure prompt transportation of the injured person to a physician or hospital following the directions in **Attachment 2**.

- A representative of Synapse/sub-contractor should always drive the injured employee to the medical facility and remain at the facility until the employee is ready to return.

- If the driver of the vehicle is not familiar with directions to the hospital, a second person shall accompany the driver and the injured employee to the hospital

- If it is necessary for the SHSO to accompany the injured employee, provisions must be made to have another employee, properly trained and certified in first aid, to act as the temporary SHSO.

- If the injured employee is able to return to the jobsite the same day, he/she should bring with him/her a statement from the doctor containing such information as:

- Date
- Employee's name
- Diagnosis
- Date he/she is able to return to work, regular or light duty
- Date he/she is to return to doctor for follow-up appointment, if necessary
- Signature and address of doctor

If the injured employee is unable to return to the jobsite the same day, the employee who transported him should bring this information back to the jobsite and report it to Synapse at (315) 475-3700 and Synapse Health & Safety Coordinator, Roger Creighton at (315) 849-0905.

Emergency Cases Requiring Ambulance Services

- Medical cases requiring ambulance services would be such cases as severe head injuries, amputations, heart attacks, etc.

- Should ambulance service be necessary, the following procedures should be taken immediately.

  - Contact necessary ambulance service and company emergency services by dialing **911** and notify the SHSO for the site.

  - Administer first aid until ambulance service arrives.

  - While the injured employee is being transported, the SHSO should contact the medical facility to be utilized.

  - One designated representative should accompany the injured employee to the medical facility and remain at the facility until final diagnosis and other relevant information is obtained.

Death of an Individual or Hospitalization of Three or More Employees

The procedure as outlined in "First Aid and Medical Cases", above, should be followed. If the injured person dies, then SYNAPSE, local officials and coroner must be notified ***immediately***. Synapse will notify the **local OSHA office within 8 hours of the incident or fatality** in the event of fatality or hospitalization of three or more employees.

Response to Spills or Cut Lines

Prevent problems by documenting the location of underground lines (e.g., product, sewer, telephone, fiber optic) before starting site work. If a line or tank is drilled through, or another leak occurs, document the event as soon as possible using the Incident Investigation Report in **Attachment 3. Notification of the event must be made to Synapse immediately**. Include dates, times, actions taken, agreements reached, and names of people involved. Use additional pieces of paper to document the event completely. The SHSO, PM and client must be notified immediately. The PM will notify the regulatory authority or utility as necessary.

In the event of a spill/release, follow this plan:

1. Stay upwind of the spill/release.
2. Wear appropriate PPE.
3. Turn off equipment and other sources of ignition.
4. Turn off pumps and shut valves to stop the flow/leak.
5. Plug the leak or collect drippings, when possible.
6. Use sorbent pads to collect product and impede its flow, if possible.
7. Call Fire Department immediately if fire or emergency develops.
8. Inform Synapse Project Manager about the situation.
9. Determine if the client wants Synapse to repair the damage or if the client will use an emergency repair contractor.
10. Based on agreements, contact emergency spill contractor for containment of free product.
11. Advise the client of spill discharge notification requirements and determine who will complete and submit forms. *(Do not submit or report to agencies without the client's consent.)* Document each interaction with the client and regulators and note, in writing; name, title, authorizations, refusals, decisions, and commitments to any action.
12. Do not transport or approve transportation of contaminated soils or product until proper manifests have been completed and approved. Be aware that soils / product may meet criteria for hazardous waste.
13. Do not sign manifests as generator of wastes; contact PM to discuss waste transportation.

Notifications – a spill/release requires completion of an Incident Investigation (II) as per Synapse's LPS program. **The PM must involve the client/generator in the Incident Investigation process. Synapse's incident investigation form must be completed (see Attachment 3) and submitted to Synapse within 24 hours. The client/generator is under obligation to report to the proper government agencies. If the spill extends into waterways, the Coast Guard and the National Response Center (800) 424-8802 must be notified immediately by the client or with his permission.**

All spills/releases must be reported to *NYSDEC Hotline at (800) 457-7362 immediately after spill/release identification.*

7.0 Contractor Emergency Action Plan

The SHSO will ensure that the Subcontractor/Contractor is capable of efficient evacuation/emergency response in the event of an emergency. Subcontractor/Contractor's employees will be trained by their employer in site-specific evacuation/emergency procedures, including alarm systems and evacuation plans and routes.

The Subcontractor/Contractor shall instruct its employees that in the event of an emergency such as a fire, release, or accident involving injuries, they are required to dial **911**. The reporting employee is to state the problem clearly and fully and remain on the line until dismissed by the operator.

Synapse staff and Subcontractor/Contractors working in an area where an emergency exists shall evacuate to a safe location, preferably upwind, away from the area and take attendance. The gathering location will be: **on the corner of West First and West Schuyler Streets.**

(If the emergency causes the route to a gate surrounding the site is closed, the Synapse staff and Subcontractor/Contractors shall move to an open area upwind of the hazard area, and remain there until instructed by emergency response personnel (i.e., police, fire, ambulance, paramedics, etc.) to do otherwise.)

Subcontractor/Contractor has the responsibility to account for its own employees and to provide such information immediately to emergency response personnel upon request.

Synapse staff and Subcontractor/Contractor may not reenter the emergency site without specific approval from emergency response personnel.

In the event of fire ignition in close proximity to Synapse staff and Subcontractor/Contractor's employees, those persons shall evacuate the area and notify emergency personnel unless the fire is readily extinguished with portable dry chemical equipment on-hand. **When in doubt, emergency response personnel shall be notified.**

8.0 Local Emergency Contact Names and Phone Numbers

DIRECTIONS AND MAP TO THE HOSPITAL – SEE ATTACHMENT 2

EMERGENCY CONTACTS	NAME	TELEPHONE NO.
Hospital	Oswego Hospital	315-349-5511 (911)
Ambulance	Oswego County Ambulance	315-592-4145 (911)
Police	Oswego Police Department	315-343-1212 (911)
Fire	Oswego Fire Department	315-343-2161 (911)

9.0 Government Contact Names and Phone Numbers

AGENCY	NAME	TELEPHONE NO.
Utility Location	Dig Safe New York	(800) 526-0400
NYSDEC	NYSDEC Hotline	(800) 457-7362

10.0 Project Personnel and Relevant Information

A question about this project posed by neighbors, the press, or other interested parties should be directed immediately to:

Name: Matthew Hoskins **Company**: Synapse **Phone:** 315-475-3700

Subcontractors shall review and sign the form in **Attachment 7 ACKNOWLEDGMENT & AGREEMENT FORM**

PROJECT JOB TITLE	NAME	TELEPHONE NO.	GENERAL PROJECT RESPONSIBILITIES	TRAINING DATES	
				40 Hr HAZWOPER	**8 Hr Refresher**
Site Health and Safety Officer	Varies	Varies	Implementing this HASP. Has authority to stop work. Perform air quality tasks. Take charge of all incidents. Review subcontractor's HASP	Varies	varies
Project Manager	Roger Creighton	315-475-3700 315-254-8547cell	Overall financial and logistics. Contact client and subs to understand all hazards. Discuss with SHSO. Follow-up all incidents upon notice.	1995	2017
Project Staff	Varies	Varies	Conduct work in accordance with JSA and this HASP. Report all incidents and near misses immediately to Project Manager.	Varies	Varies
Subcontractor Cascade Environmental	Michael Jordan	802-229-1883 Office 802-498-3828 Cell	Responsible for coordination of the all bedrock cores and borings.	1996	2017
SYNAPSE Health & Safety Coordinator	Roger Creighton	315-475-3700 Office 315-254-8547 Cell	Respond with corporate resources to all incidents as appropriate. Assist in HASP review. Assist in incident investigation.	1996	2017
Synapse Managing Partner	Brian Macrae	315-475-3700 Office 315-254-8638 Cell	Assist with incident review, recordkeeping.	1994	2003

11.0 Maximum Concentrations of Contaminants Identified Onsite

Listed below are the maximum concentrations of primary contaminants of concern in the soil/groundwater that are expected to be encountered at the site.

Substance	**Date of Sample**	**Media**	**Sample Concentration** *(Note units of measure, ppm)*
PCE	2012	Soil	<25 mg/kg
TCE	2012	Soil	<25 mg/kg
1,1-DCE	2012	Groundwater	<25 mg/L
Cis-1,2-DCE	2012	Groundwater	<25 mg/L
Trans-1,2-DCE	2012	Groundwater	<25 mg/L

12.0 Potential Airborne Concerns

- ***A site specific Community Air Monitoring Plan has been prepared and is provided as Attachment 8, to be utilized in conjunction with this HASP and sets forth the following objectives:***

  1. ***Protect human health and the environment form exposure to site contaminants associated with the soil boring activities set forth in the*** **VCACWP*.***
  2. ***Minimize risk of exposure to offsite receptors to site contaminants potentially associated with the soil boring activities set forth in the*** **VCACWP*.***

13.0 Detailed Project Steps with Hazard Assessments and Precautions

Traffic Control Plan:

(Incidents on sites have shown the need for a well-thought out traffic control plan. This plan must consider:

- *Level of traffic activity on a site and provide for the safety of all workers on the site. E.g., a gasoline site that is open to the public should require sawhorse barricades to protect workers.*
- *Cones and caution tape have proven ineffective in a number of situations. Other traffic control precautions include candles, oversized cones with flags, placing vehicles between staff and the public, etc.*
- *We must cordon off as much space as is necessary to ensure our safety. This must be discussed with clients as it may mean closing down additional gasoline pumps or entrances to a factory, etc.*
- *Company and personal vehicles should be parked as far away from potential traffic as possible.*
- *How contractor heavy equipment, e.g., vacuum trucks, drill rigs, cranes, loader/diggers, etc will be parked and maneuvered around the site. All heavy equipment movements must be coordinated in advance to avoid incidents.*
- *Review local regulations for: formally developed traffic control plans signed by licensed individuals, police details, flagmen, hours of activity, closure of streets to move equipment, etc.)*

Work on this project will be conducted during the hours: 7 A.M. & 7 P.M.

Shutoff valves/switches for utilities and products:

To be determined on site

Jewelry safety: Jewelry can be dangerous. Large ear rings, long necklaces, loose-fitting bracelets, rings, watches, etc. can become entangled in machinery and cause removal of limbs, as well as be conductive of electricity. Use caution and avoid unnecessary hazards!

NOTE: Synapse staff and subcontractors are not to enter an excavation without first contacting Roger Creighton, Health & Safety Coordinator (315) 475-3700.

Bedrock Borings

Field staff must review job-specific work plan and coordinate with project manager to verify that all up-front logistics are completed prior to starting work including, but not limited to, permitting, access agreements, and notification to required contacts (e.g. site managers, inspectors, clients, subcontractors, etc.). A tailgate safety meeting must be performed and documented at the beginning of each work day. Safe Performance Self Assessment (SPSA) procedures must be used throughout the project. Weather conditions (heat, cold, rain, and lightning) must also be considered.

❶ Job Steps	❷ Personal Protective Equipment	❸ Potential Hazard	❹ Critical Actions
Clear boring locations.	Gather necessary PPE. PPE must include: reflective vest for traffic, steel toed and shank shoes, hard hat, safety glasses with side shields, ear plugs/muffs, leather gloves for the non-chemical aspects of work; Chemical resistance PPE to include: full-face respirator with organic vapor cartridges, appropriate gloves, and other PPE as needed.	Traffic hazards, overhead and underground installations, product releases, property damage, dealer inconvenience.	● Reference Overhead and Underground Utility Checklist. ● Coordinate with facility contact (or designee) to minimize potential conflicts. ● Review proposed locations against available construction drawings and known utilities, tanks, product lines, etc. ● Mark out the proposed excavation locations. ● Call underground utility locating service for public line location clearance, and get list of utilities being contacted. If necessary, coordinate private line locator for private property.
Cascade will set up necessary traffic control.	Reflective vest, steel toed and shank shoes, hard hat (if required by job site).	Potentially can be struck by vehicle during placement. Vehicle accident as a result of improper traffic control equipment placement.	● Use buddy system for placing traffic control. ● Address traffic issues, as required.
Set up exclusion zone(s), stockpile area and establish work areas/heavy equipment pathways.		Injury or exposure to public or other onsite personnel. Slip/fall hazards. Onsite vehicular accident with heavy equipment.	● Implement exclusion zone set-up instructions. ● Set up clear walking paths between work stations.
Hand digging/post-holing where necessary to expose	Steel toed and shank shoes, hard hat, safety glasses with side shields, hearing protection,	Damage to lines (and associated physical hazards or property	● Use hand tools whenever possible.

Field staff must review job-specific work plan and coordinate with project manager to verify that all up-front logistics are completed prior to starting work including, but not limited to, permitting, access agreements, and notification to required contacts (e.g. site managers, inspectors, clients, subcontractors, etc.). A tailgate safety meeting must be performed and documented at the beginning of each work day. Safe Performance Self Assessment (SPSA) procedures must be used throughout the project. Weather conditions (heat, cold, rain, and lightning) must also be considered.

❶ Job Steps	❷ Personal Protective Equipment	❸ Potential Hazard	❹ Critical Actions
and protect underground installations as needed.	reflective safety vest, and leather gloves for the non-chemical aspects of work.	damage). Back strain. Injury or vehicle damage from falling into holes.	● Use proper lifting techniques. ● Barricade/cover holes until job is complete.
Assist with set up of heavy equipment.	Wear reflective vest for traffic, steel toed and shank shoes, hard hat, safety glasses with side shields, hearing protection devices, and leather gloves.	Damage caused by heavy equipment while accessing set-up location. Struck by equipment.	● Verify clear pathway to boring locations. ● Provide as-needed hand signals and guidance to driver to place rig. ● Visually inspect equipment (fire extinguisher on board, no oil or other fluid leaks, cabling and associated equipment in good condition, pressurized hoses secured with whip-checks or adequate substitute, jacks in good condition). ● Maintain eye contact with operator.
Commence borings	Use PPE as follows: ➢ Level D (all the time): Safety glasses, hard hat, disposable ear plugs, long-sleeved shirts and pants, steel-toed boots. ▪ For contact with moist soil or liquid: **Gloves:** 0.008-inch gauge Nitrile gloves, leather work gloves **Boot Covers:** PVC, Neoprene or equivalent **Chemical resistant Suit:** Tyvek ➢ Upgrade to Level C (if necessary): Level D plus half-mask respirator with safety goggles or full face respirator ▪ **Cartridges:** Organic Vapor/HEPA ▪ **Gloves:** 0.008-inch gauge inner Nitrile gloves, with 0.11-inch gauge outer Nitrile gloves and leather work gloves ▪ **Boot Covers:** Neoprene ▪ **Chemical Resistant Suit:** PE Tyvek	Heat or cold exposure, exposure to chemical hazards, hitting an underground or overhead utility, flammable or oxygen-deficient atmosphere from accumulated vapors, trip and fall, side wall cave-in, equipment failure, noise.	● Monitor weather conditions and take breaks as needed for cold or hot weather. ● Keep work area clear of tripping or slipping hazards. Perform periodic visual inspections of heavy equipment and keep it at least 5' from excavation edge, or one foot away from the edge for every foot of depth if greater than 5' deep. ● Perform necessary soil classification.
Collect samples in accordance with sampling plan. (samples to be analyzed on site by Cascade)	Steel toed and shank shoes, hard hat, safety glasses with side shields, hearing protection, reflective safety vest, and chemical resistant gloves.	Injury from heavy equipment. Exposure to site contaminants.	● Stay out of drill rig moving parts whenever possible. ● Use agreed-upon hand signals with heavy equipment operators. ● Monitor air around excavation in accordance with **Section 12**.
<u>General</u>			
Typical work	Steel toed and shank shoes, hard hat, safety glasses with side shields, hearing protection, reflective safety vest, and leather gloves for the non-chemical aspects of work. If you suspect that equipment is contaminated, wear chemical resistant gloves during decontamination of equipment.	Weather related incidents: automobile accidents, slips and falls.	● Check weather reports daily. Project visits will not be performed during inclement weather. Sampling may be performed during light rain mist. Wear raincoats. ● Drive at speed limit or less as needed to keep safe distance from vehicle in front, avoid short stops.

Field staff must review job-specific work plan and coordinate with project manager to verify that all up-front logistics are completed prior to starting work including, but not limited to, permitting, access agreements, and notification to required contacts (e.g. site managers, inspectors, clients, subcontractors, etc.). A tailgate safety meeting must be performed and documented at the beginning of each work day. Safe Performance Self Assessment (SPSA) procedures must be used throughout the project. Weather conditions (heat, cold, rain, and lightning) must also be considered.

❶ Job Steps	❷ Personal Protective Equipment	❸ Potential Hazard	④ Critical Actions
No eating, drinking, or smoking on-site. No contact lenses on-site.		Exposure to site contaminants	
A safety meeting will be held each day, even if there is only one person working on the project on any given day.			● Topics will always include the work scheduled for the day and restatement of the hazards and means to avoid them. Other topics may include sampling in general and advances in technology and how it may be applied to the project. Use **Attachment 6** for logging the topics discussed.

Excavation Oversight

Field staff must review job-specific work plan and coordinate with project manager to verify that all up-front logistics are completed prior to starting work including, but not limited to, permitting, access agreements, and notification to required contacts (e.g. site managers, inspectors, clients, subcontractors, etc.). A tailgate safety meeting must be performed and documented at the beginning of each work day. Safe Performance Self Assessment (SPSA) procedures must be used throughout the project. Weather conditions (heat, cold, rain, and lightning) must also be considered.

❶ Job Steps	❷ Personal Protective Equipment	❸ Potential Hazard	❹ Critical Actions
Clear excavation area.	Gather necessary PPE. PPE must include: reflective vest for traffic, steel toed and shank shoes, hard hat, safety glasses with side shields, ear plugs/muffs, leather gloves for the non-chemical aspects of work; Chemical resistance PPE to include safety glasses, appropriate gloves, and other PPE as needed.	Traffic hazards, overhead and underground installations, product releases, property damage, dealer inconvenience.	● Reference Overhead and Underground Utility Checklist. ● Coordinate with facility contact (or designee) to minimize potential conflicts. ● Review proposed locations against available construction drawings and known utilities, tanks, product lines, etc. ● Mark out the proposed excavation locations. ● Call underground utility locating service for public line location clearance, and get list of utilities being contacted. If necessary, coordinate private line locator for private property.
Excavation contractor will set up necessary traffic control.	Reflective vest, steel toed and shank shoes, hard hat (if required by job site).	Potentially can be struck by vehicle during placement. Vehicle accident as a result of improper traffic control equipment placement.	● Use buddy system for placing traffic control. ● Address traffic issues, as required.
Set up exclusion zone(s), in the work area.		Injury or exposure to public or other onsite personnel. Slip/fall hazards. Onsite vehicular accident with heavy equipment.	● Implement exclusion zone set-up instructions. ● Set up clear walking paths between work stations.
Set up CAMP equipment	Use PPE as follows: ➢ Level D (all the time): Safety glasses, hard hat, disposable ear plugs, long-sleeved shirts and pants, steel-toed boots.	Heat or cold exposure, exposure to chemical hazards, hitting an underground or overhead utility, flammable or oxygen-deficient atmosphere from accumulated vapors, equipment failure, noise.	● Monitor weather conditions and take breaks as needed for cold or hot weather. ● Keep work area clear of tripping or slipping hazards. Perform periodic visual inspections of heavy equipment and keep it at least 5' from test pit edge.
Clean site/demobilize	Steel toed and shank shoes, hard hat, safety glasses with side shields, hearing protection, reflective safety vest, and leather gloves for the non-chemical aspects of work.	Traffic. Safety hazard left on site. Lifting hazards.	● Use buddy system as necessary to remove traffic control. ● Leave site clean of refuse and debris. ● Notify station personnel of departure. ● Use proper lifting techniques or use mechanical assistance.
Package and deliver samples to lab		Bottle breakage (if any), back strain.	● Handle and pack bottles carefully (bubble wrap bags are helpful). Use proper lifting techniques.
General			
Typical work	Steel toed and shank shoes, hard hat, safety glasses with side shields, hearing protection, reflective safety vest, and leather gloves for the non-chemical aspects of work. If you suspect that equipment is contaminated, wear chemical resistant gloves	Weather related incidents: automobile accidents, slips and falls.	● Check weather reports daily. Project visits will not be performed during inclement weather. Sampling may be performed during light rain mist. Wear raincoats. ● Drive at speed limit or less as needed to keep safe distance from vehicle in front, avoid short stops.

Field staff must review job-specific work plan and coordinate with project manager to verify that all up-front logistics are completed prior to starting work including, but not limited to, permitting, access agreements, and notification to required contacts (e.g. site managers, inspectors, clients, subcontractors, etc.). A tailgate safety meeting must be performed and documented at the beginning of each work day. Safe Performance Self Assessment (SPSA) procedures must be used throughout the project. Weather conditions (heat, cold, rain, and lightning) must also be considered.

❶ Job Steps	❷ Personal Protective Equipment	❸ Potential Hazard	❹ Critical Actions
	during decontamination of equipment.		
No eating, drinking, or smoking on-site. No contact lenses on-site. No facial hair that would interfere with respirator fit.			
A safety meeting will be held each day, even if there is only one person working on the project on any given day.			● Topics will always include the work scheduled for the day and restatement of the hazards and means to avoid them. Other topics may include sampling in general and advances in technology and how it may be applied to the project. Use **Attachment 6** for logging the topics discussed.

14.0 Waste Characteristics

A. **Waste Generation** (Type(s)/Quantities Expected):

Anticipated (YES/NO): YES

Types: Liquid __X__ Solid __X__ Sludge _____ Other (describe)

Quantity (Expected Volume): 1 Drum

B. **Characteristics** (Expected):

Corrosive _____ Flammable/Ignitable _____ Radioactive _____ Toxic

Reactive _____ Unknown

Other (specify)

C. **Packaging requirements for waste material** (Expected):

- DOT-approved drums
- Baker tanks—water (possibly tankers if trucked off site)
- lined waste bins
- Excavated soil will be return to the excavation.

D. **Disposal and/or Treatment Methods Proposed:**

Attachment 1

SITE PLAN

LEGEND

APPROXIMATE SITE BOUNDARY

NOTES:

1. 2015 AERIAL PHOTOGRAPH FROM NYSGIS CLEARINGHOUSE WEBSITE.
2. ALL LOCATIONS ARE APPROXIMATE.

0 80' 160'

GRAPHIC SCALE

P: BL
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-B01.DWG

synapse
connect. advise. insure.

SYNAPSE PROPERTY RESOURCES
360 ERIE BLVD. EAST
SYRACUSE, NEW YORK 13202

HARBOR VIEW SQUARE
NYSBCP SITE NO. C738040
68 WEST FIRST STREET
OSWEGO, NEW YORK

AERIAL PROPERTY PLAN

PROJECT NO.:
HSGVIS-24-16-05

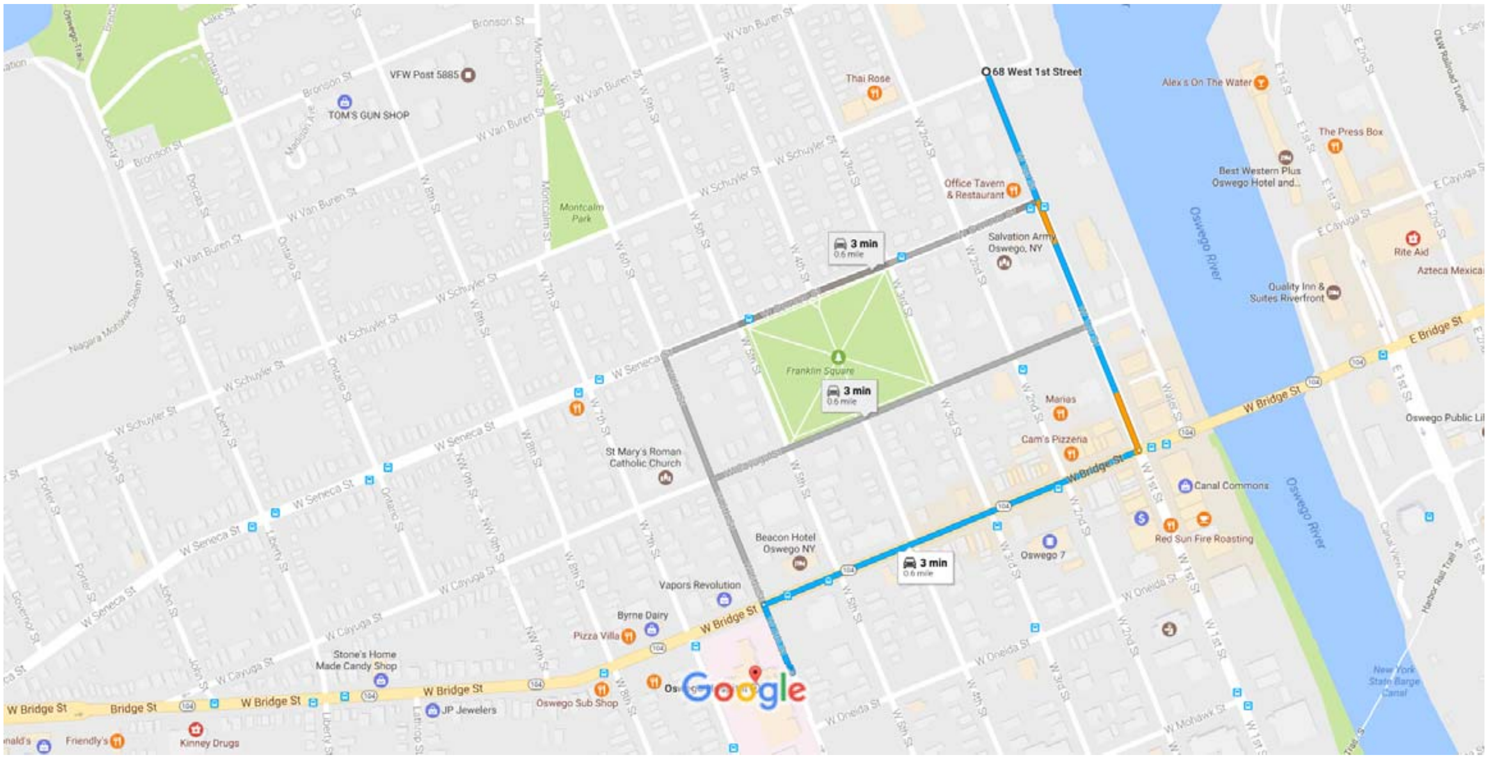
DATE:
MAY 2017

FIGURE NO.:
2

Attachment 2

DIRECTIONS TO OSWEGO HOSPITAL

Google Maps **68 W 1st St, Oswego, NY 13126 to Oswego Hospital** Drive 0.6 mile, 3 min



Map data ©2017 Google 200 ft

via W 1st St and W Bridge St — 3 min

Fastest route — 0.6 mile

via W Seneca St and W 6th St — 3 min

0.6 mile

via W 1st St and W Cayuga St — 3 min

0.6 mile

Attachment 3

Incident Investigation/ Near-Miss Investigation Report

INCIDENT TYPE

Date of Incident:

☐ Fatality
☐ Lost Workday
☐ LW Restricted Duty
☐ OSHA Medical or Illness w/o LW
☐ First Aid
☐ Industrial Non-Recordable
☐ Non-Industrial
☐ Off-the-Job Injury
☐ MVA
☐ Fire
☐ Spill/Leak
☐ Product Integrity
☐ Equipment
☐ Business Interruption
(TO BE COMPLETED BY HR)
☐ General Liability
☐ Criminal Activity
☐ Notice of Violation
☐ Near Miss

This report must be completed by the employee's supervisor or Site Health and Safety Officer immediately upon learning of the incident. The completed report must be reviewed and signed by the CEO and e-mailed or faxed to the Health & Safety Coordinator within 24 hours of the incident, even if employee is not available to review and sign. Employee or employee's doctor must submit a copy of the doctor's report to Synapse within 24 hours of the initial exam and any subsequent exams. Phone: 315-475-3700, Fax: 315-475-3780, E-Mail: vdemarchi@synapseriekmanagement.com. After hours or weekends, please call Roger Creighton Cell: 315-254-8547.

EMPLOYER

Company Name:
Work Location Address where incident occurred: Project Name:

EMPLOYEE

Name: SSN: Birthdate:
Employment Status: ☐ Full-Time ☐ Part-Time ☐ Hourly-As-Needed How long in present job?

INJURY OR ILLNESS INFO

Where did incident / near miss occur? (number, street, city, state, zip):
County: On Employer's premises? ☐ Yes ☐ No
Specific activity the employee was engaged in when the incident / near miss occurred:

All equipment, materials, or chemicals the employee was using when the incident / near miss occurred (e.g., the machine employee struck against or which struck employee; the vapor inhaled or material swallowed; what the employee was lifting, pulling, etc.):

Describe the specific injury or illness (e.g., cut, strain, fracture, skin rash, etc.):
Body part(s) affected (e.g., back, left wrist, right eye, etc.):
Name and address of Health Care Provider (e.g., physician or clinic): Phone No.:
If hospitalized, name and address of hospital: Phone No.:
Date of injury or onset of illness(MM/DD/YYYY) / / Time of event or exposure: ☐ AM ☐ PM
Time employee began work: ☐ AM ☐ PM Did employee lose at least one full shift's work? ☐ No ☐ Yes, 1st date absent (MM/DD/YYYY) / /
Has employee returned to work? ☐ Regular work ☐ Restricted work ☐ No, still off work ☐ Yes, date returned (MM/DD/YYYY) / /
Did employee die? ☐ No ☐ Yes, date (MM/DD/YYYY) / /
Date employer notified of incident / near miss: (MM/DD/YYYY) / /
To whom reported:
Other workers injured/made ill in this event? ☐ Yes ☐ No

Description of Incident / Near Miss: (Describe fully the incident / near miss events. Tell what happened and how it happened.)

Motor Vehicle Accident (MVA)

Professional Driver? ☐ Yes ☐ No

Total Years Driving:	Company Vehicle? ☐ Yes ☐ No	Operation Type:	Accident Situation:
Truck Transportation:	Years with Carrier:	Vehicle Type:	Equipment #:

Accident Location (street, city, state):

Hazardous Material? ☐ Yes ☐ No	Recordable? ☐ Yes ☐ No	No. of Vehicles Towed	No. of Injuries:	No. of Fatalities:

Spill/Leak/Product Quality

Product Name		Quantity		Product 2 Name		Quantity		Product 3 Name		Quantity	

Agency Notifications	

Cost of Incident

$

Third Party Incidents

Name of Owner		Address		Telephone	

Description of Damage:

Witness Name		Address		Telephone	
Witness Name		Address		Telephone	

#	Root Cause and Contributing Factors: Conclusion (Describe in Detail Why Incident / Near Miss Occurred)
1	
2	
3	
4	
5	

Root Cause(s) Analysis (RCA):

1. Lack of skill or knowledge
2. Lack of or inadequate operational procedures or work standards
3. Inadequate communication of expectations regarding procedures or work standards
4. Inadequate tools or equipment
5. Correct way takes more time and/or requires more effort
6. Short-cutting standard procedures is positively reinforced or tolerated
7. Person thinks there is no personal benefit to always doing the job according to standards
8. Uncontrollable

#	RCA #	Solution(s): How to Prevent Incident / Near Miss From Reoccurring	Person Responsible	Due Date	Closure Date

Investigation Team Members

Name	Job Title	Date

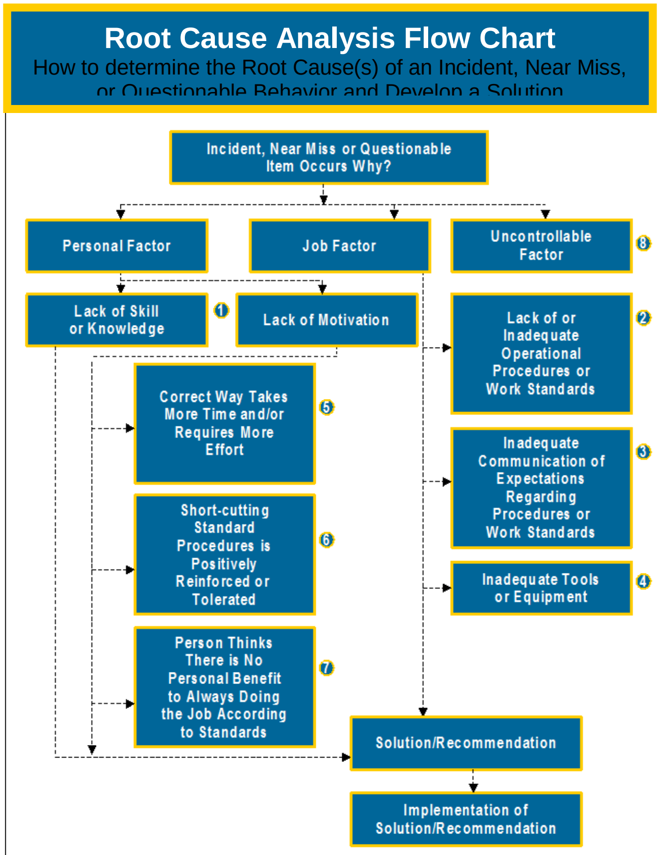
Results of Solution Verification and Validation

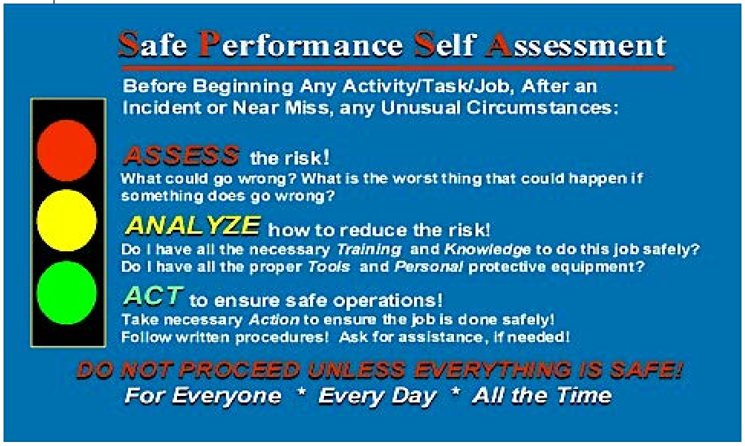
Reviewed By

Name	Job Title	Date
	First Line Supervisor	
	Other (name)	

Acknowledgment Signatures for Injuries/Illnesses

Title	Signature	Date
Health & Safety Coordinator: Roger Creighton		
Project Managers:		
Brian Macrae		
Paul Fisher		
Scott Matthews		
Chief Executive Officer: Vita DeMarchi		





Safe Performance Self Assessment

Before Beginning Any Activity/Task/Job, After an Incident or Near Miss, any Unusual Circumstances:

ASSESS the risk!
What could go wrong? What is the worst thing that could happen if something does go wrong?

ANALYZE how to reduce the risk!
Do I have all the necessary *Training* and *Knowledge* to do this job safely?
Do I have all the proper *Tools* and *Personal* protective equipment?

ACT to ensure safe operations!
Take necessary *Action* to ensure the job is done safely!
Follow written procedures! Ask for assistance, if needed!

DO NOT PROCEED UNLESS EVERYTHING IS SAFE!

*For Everyone * Every Day * All the Time*

Attachment 4
UTILITY CLEARANCE LOGS

Project: Harbor View

Location: Oswego, New York Date

Instructions. This checklist has to be completed by *a Synapse* staff members and subcontractors as a safety measure to insure that all underground utility lines, other underground structures as well as above-ground power lines are clearly marked out in the area selected for boring or excavation. **DRILLING OR EXCAVATION WORK MAY NOT PROCEED UNTIL (New Jersey One Call) HAS BEEN CONTACTED 72 HOURS PRIOR TO INVASIVE ACTIVITIES, FACILITY OPERATORS HAVE LOCATED UTILITIES WITHIN THE FACILITY, UTILITIES AND STRUCTURES ARE MARKED, AND THIS CHECKLIST HAS BEEN COMPLETED**. As a final measure to prevent hitting buried utilities during drilling, field personnel must hand auger or post hole dig a five-foot hole at the potential drilling location before commencing drilling. Alternate techniques such as vacuum excavation are acceptable provided they will not damage any buried utilities.

Assignment of Responsibility. *Synapse and Subcontractors* are responsible for having underground utilities and structures located and marked. Preferably, the utility companies themselves should mark out the lines.

Drilling or Excavation Sites. Attach a map of the property showing the drilling or excavation sites. If sites are widely separated, attach several map(s) indicating the area(s) checked for underground utilities or underground structures and the location of above-ground power lines.

Utilities and Structures

TYPE	NOT PRESENT	PRESENT	HOW MARKED[1]
Petroleum products line			
Natural gas line			
Steam line			
Water line			
Sewer line			
Storm drain			
Telephone cable			
Electric power line			
Product tank			
Septic tank/drain field			
Other			

[1] Flags, paint on pavement, wooden stakes, etc.

Client Approval (with attached map)	NAME	COMPANY	PHONE

Name and affiliation of person who marked out underground lines or structures.		
NAME	**COMPANY**	**PHONE**

Synapse Risk Management, LLC			
Field Team Leader		Date Completed	

SUBSURFACE CLEARANCE REVIEW
(To Be Used For ANY Invasive Work)

Site #: __________________ Synapse Project #: _____________________ Date: ________________

Borehole #s Reviewed: _____________________________ Clearance Performed by: _____________________
(Consultant Rep)

Yes No Pre-Mobilization

☐ ☐ 1. Is a scaled site plan, map or drawing showing the proposed borehole locations attached to this form?

☐ ☐ 2. Does each borehole location allow for clear entry and exit, adequate workspace, and a clear path for raising the mast and operating the drill rig and all support equipment?

☐ ☐ 3. Are all of the proposed borehole locations and associated areas of pavement cutting at least 3 feet from any subsurface utilities shown on client's building plans? PM check here ☐ if plans not provided by client (therefore not applicable to this job).

☐ ☐ 4. Are all of the proposed borehole locations and associated areas of pavement cutting at least 3 feet from any subsurface utilities shown on public right-of-way street improvement or other public property plan or site map? PM check here ☐ if not applicable to this job.

☐ ☐ 5. Has the Facility Manager indicated no knowledge of any subsurface utilities within 3 feet of the proposed borehole locations? (Review locations with the Facility Manager).

☐ ☐ 6. Are all of the proposed borehole locations and associated areas of pavement cutting at least 3 feet from any subsurface utilities identified during a geophysical survey? PM to check here ☐ if applicable to this job.

☐ ☐ 7. Have all Utility Locating Service providers notified by the public line locator marked out their facilities in the vicinity of the borehole locations or otherwise notified us that they do not have any facilities near the proposed borehole locations?

☐ ☐ 8. Are all proposed borehole locations and associated areas of pavement cutting at least 3 feet from a visual line connecting two similar looking manhole covers?

☐ ☐ 9. Are all proposed borehole locations and associated areas of pavement cutting at least 3 feet from a visual line perpendicular to the street from the water, gas, and electrical meters?

☐ ☐ 10. Are all proposed boring locations and associated areas of pavement cutting clear of pavement joints, curbs, crash posts, or other engineered structures?

☐ ☐ 11. Does the pavement lack signs of previous excavation (e.g. no pavement subsidence, no differences in pavement texture or relief, no pavement patching)? If there are signs, determine the purpose of the previous excavation and act accordingly.

☐ ☐ 12. Before drilling have you hand dug a hole to 5 feet below grade, if possible, and is the diameter of the hole greater than the outer diameter of the drilling auger? Note: a tile probe is a handy tool that can also assist you in clearing boreholes.

☐ ☐ 13. Does the soil you encountered in the hand-dug hole appear to be native material (i.e. free of clean gravel, clean sand, aggregate base [gravelly sand with ~10% fines], or other non-native looking material)?

☐ ☐ 14. You know that buildings require utilities. Have you made sure that you have identified all the expected utilities or have made sure that you can explain any missing utilities?

DO NOT DRILL if you answered "NO" to any of the above questions.

- Document the reason for a "NO" answer on the back of this form.
- Contact your supervisor for instructions and document instructed actions and results of actions on the back of this form.

Attachment 5a
AIR MONITORING EQUIPMENT CALIBRATION/CHECK LOG*

DATE	INSTRUMENT/ MODEL NO.	SERIAL NO.	BATTERY CHECK OK?	ZERO ADJUST OK?	CALIBRATION GAS (PPM)	READING (PPM)	LEAK CHECK	PERFORMED BY	COMMENTS

* Submit copies of logs to Health and Safety Coordinator, Roger Creighton within 24 hours, if a PEL is exceeded, or personal protective equipment level is upgraded at (315) 475-3700 or via email at rcreighton@synapseriskmanagement.com

Attachment 5b
AIR MONITORING LOG

DATE	TIME	LOCATION	SOURCE/AREA/ BREATHING ZONE	INSTRUMENT	CONCENTRATION/UNITS	SAMPLED BY

* Submit copies of logs to the Health and Safety Coordinator, Roger Creighton within 24 hours, if a PEL is exceeded, or personal protective equipment level is upgraded at (315) 475-3700 or via email at rcreighton@synapseriskamnagement.com

Attachment 6

DAILY PRODUCTION HEALTH AND SAFETY BRIEFING LOG

Date:	
Start Time:	
Issues Discussed:	
1.	
2.	
3.	
4.	
5.	
Attendees	
Print Name and Company	**Signature**
Meeting Conducted by:	
Name (Site Health and Safety Officer)	**Signature**

DISCUSSION IDEAS FOR THE DAILY PRODUCTION H&S MEETING

☐ Emergency response plan, emergency vehicle (full of fuel) and muster point
☐ Route to medical aid (hospital or other facility)
☐ Work hours, is night work planned?
☐ Hand signals around heavy equipment
☐ Traffic control
☐ Pertinent Legislation and Regulations
☐ Above and below ground utilities (energized or de-energized)
☐ Material Data Sheets (MSDS)
☐ To who, what, why, and when to report an incident
☐ Fire extinguisher and first aid kit locations
☐ Excavations, trenching sloping and shoring
☐ Personal protective equipment (PPE) and training
☐ Safety equipment and training
☐ Emergency telephone and telephone numbers (may not be 911)
☐ Eye wash stations and washroom locations
☐ Energy lock-out/tag-out procedures. Location of “kill Switches” etc.
☐ Weather restrictions
☐ Site security. Site hazards. Is special waste present.
☐ Traffic and people movements
☐ Working around machinery (both static and mobile)
☐ Sources of ignition, static electricity etc.
☐ Stings, bites, large animals and other naturally related injuries
☐ Working above grade
☐ Working at isolated sites
☐ Decontamination procedures (both personnel and equipment)
☐ Falls, trips, sprains and lifting injuries (how to prevent)
☐ Right to refuse unsafe work
☐ Adjacent property issues (residence, business, school, day care center)

Attachment 7

HEALTH AND SAFETY PLAN ACKNOWLEDGMENT AND AGREEMENT FORM

(All *Synapse* and subcontractor personnel must sign.)

"Zero Tolerance for Incident of ANY Kind. Work Together to Ensure A SAFE and High Quality Project

This Health and Safety Plan has been developed for the purpose of informing Synapse employees of the hazards they are likely to encounter on the project site, and the precautions they should take to avoid those hazards. Sub-contractors and other contractors at the site must develop their own Health and Safety Plan to address the hazards faced by their own employees. Synapse has provided a copy of this Plan to contractors in the interest of full disclosure of hazards of which we may be aware, and to satisfy Synapse's responsibilities under the Occupational Safety and Health Administration (OSHA) Hazard Communication standard. Similarly, contractors are required to inform Synapse of any hazards of which they are aware or that the contractor's work on site might possibly pose to SYNAPSE employees, including (but not limited to) the Material Safety Data Sheets for chemicals the contractor may bring on-site. This plan should NOT be understood by contractors to provide information on all of the hazards to which a contractor's employees may be exposed as a result of their work.

I further certify that I have received training and medical surveillance according to the Health and Safety Plan and the OSHA Standard on Hazardous Waste Operations and Emergency Response (29 CFR 1910.120):

All parties conducting site activities are required to coordinate their activities and practices with the project Site Health and Safety Officer. Your signature below confirms that you have read and understand the hazards discussed in this Plan, and understand that sub-contractors and contractors must develop their own Health and Safety Plan for their employees. You also understand you could be prohibited by the Site Health and Safety Officer or other *Synapse* personnel from working on this project for not complying with any aspect of this Health and Safety Plan.

Name	Title	Signature	Company	Date

APPENDIX E
CP-43: GROUNDWATER MONITORING WELL DECOMMISSIONING PLAN

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

CP-43:Groundwater Monitoring Well Decommissioning Policy

New York State Department of Environmental Conservation

DEC POLICY

Issuing Authority: Commissioner Alexander B. Grannis

Date Issued: November 3, 2009	**Latest Date Revised:**

I. Summary:

Groundwater monitoring wells provide essential access to the subsurface for scientific and engineering investigations (including monitoring wells installed for leak detection purposes). To a degree, every monitoring well is an environmental liability because of the potential to act as a conduit for pollution to reach the groundwater. To limit the environmental risk, a groundwater monitoring well must be properly decommissioned when its effective life has been reached. This document provides procedures to satisfactorily decommission groundwater monitoring wells in New York State. This policy also pertains to other temporary wells such as observation wells, test wells, de-watering wells and other small diameter, non-potable water wells. It does not pertain to water supply wells.

II. Policy:

Environmental monitoring wells should be decommissioned when:

1. they are no longer needed and re-use by another program is not an option; or
2. the well's integrity is suspect or compromised.

The method for decommissioning will be determined based upon well construction and environmental parameters. The method selected must be designed to protect groundwater and implemented according to current best engineering practices while following all applicable federal, state and local regulations. *Groundwater Monitoring Well Decommissioning Procedures* shall be maintained as an addendum to this policy.

This policy is applicable to all New York State Department of Environmental Conservation (DEC) programs that install, utilize and maintain monitoring wells for the study of groundwater, except monitoring wells for landfills regulated under 6 NYCRR Part 360 decommissioned in accordance with those regulations [*see* 6 NYCRR 360-2.11(a)(8)(vi)] and wells installed under the Oil, Gas and Solution Mining Law, Environmental Conservation Law Article 23. There is no specific time frame to dictate when to decommission a well; timing is dependent upon the use and condition of the well and shall be determined on an individual basis. Best professional judgment must be exercised when using the decommissioning procedures. Outside of DEC use, this policy is mandatory when incorporated into the specifications of a state contract, an Order on Consent or a permit. In all other situations, it shall serve as guidance.

III. Purpose and Background:

This document establishes a monitoring well decommissioning policy and provides technical guidance. Synonyms for well decommissioning include “plugging,” “capping” and “abandoning. For consistency, only the term “decommissioning” is used within this document.

Unprotected, neglected and improperly abandoned monitoring wells are a serious environmental liability. They can function as a pollution conduit for surface contaminants to reach the subsurface and pollute our groundwater. They also can cause unwanted mixing of groundwater, which degrades the overall water quality within an aquifer. Improperly constructed, poorly maintained or damaged monitoring wells can yield anomalous poor data that can compromise the findings of an environmental investigation or remediation project. Unneeded or compromised monitoring wells should be properly decommissioned in order to prevent harm to our groundwater.

Since 1980, the DEC has installed, directed or overseen the installation of thousands of monitoring wells throughout New York for various state and federal programs, such as Superfund, solid waste, Resource Conservation and Recovery Act (RCRA), spill response, petroleum bulk storage and chemical bulk storage. This guidance addresses the environmental liability associated with this aging network of wells.

Within its boring zone, a successfully decommissioned well prevents the following:

1. Migration of existing or future contaminants into an aquifer or between aquifers;
2. Migration of existing or future contaminants within the vadose zone;
3. Potential for vertical or horizontal migration of fluids in the well or adjacent to the well; and
4. Any change in the aquifer yield and hydrostatic head, unless due to natural conditions.

Monitoring well construction in New York varies considerably with factors such as age of the well, local geology and either the presence or absence of contamination. The predominant type of monitoring well in New York is the shallow, watertable monitoring well constructed of polyvinyl chloride plastic (PVC). The best method for decommissioning should be selected to suit the conditions and circumstances. Each decommissioning situation is to be evaluated separately using this guidance before a method is chosen and implemented.

IV. Responsibility:

The Division of Environmental Remediation (DER) is responsible for updating this policy and the *Groundwater Monitoring Well Decommissioning Procedures* (addendum) in consultation with the Division of Solid and Hazardous Materials (DSHM) and the Division of Water (DOW). Compliance with the guidance does not relieve any party of the obligation to properly decommission a monitoring well. Oversight responsibility will be carried out by the DEC Regional Engineer.

V. Procedure:

Groundwater Monitoring Well Decommissioning Procedures, the addendum to this policy, provides guidance on proper decommissioning of monitoring wells in New York State.

VI. Related References:

- Groundwater Monitoring Well Decommissioning Procedures, October 1986. Prepared by Malcolm Pirnie, Inc. for the New York State Department of Environmental Conservation, Division of Environmental Remediation.

- Standard Guide for the Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities, ASTM D 5299-99. American Society for Testing and Materials (ASTM). Philadelphia. 2005.

- 6 NYCRR Part 360 Solid Waste Management Facilities, New York State Department of Environmental Conservation, Division of Solid and Hazardous Materials.

- Specifications for Abandoning Wells and Boreholes in Unconsolidated Materials, New York State Department of Environmental Conservation, Region 1 - Water Unit, undated.

- Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, EPA 600/4-89/034, United States Environmental Protection Agency (EPA).

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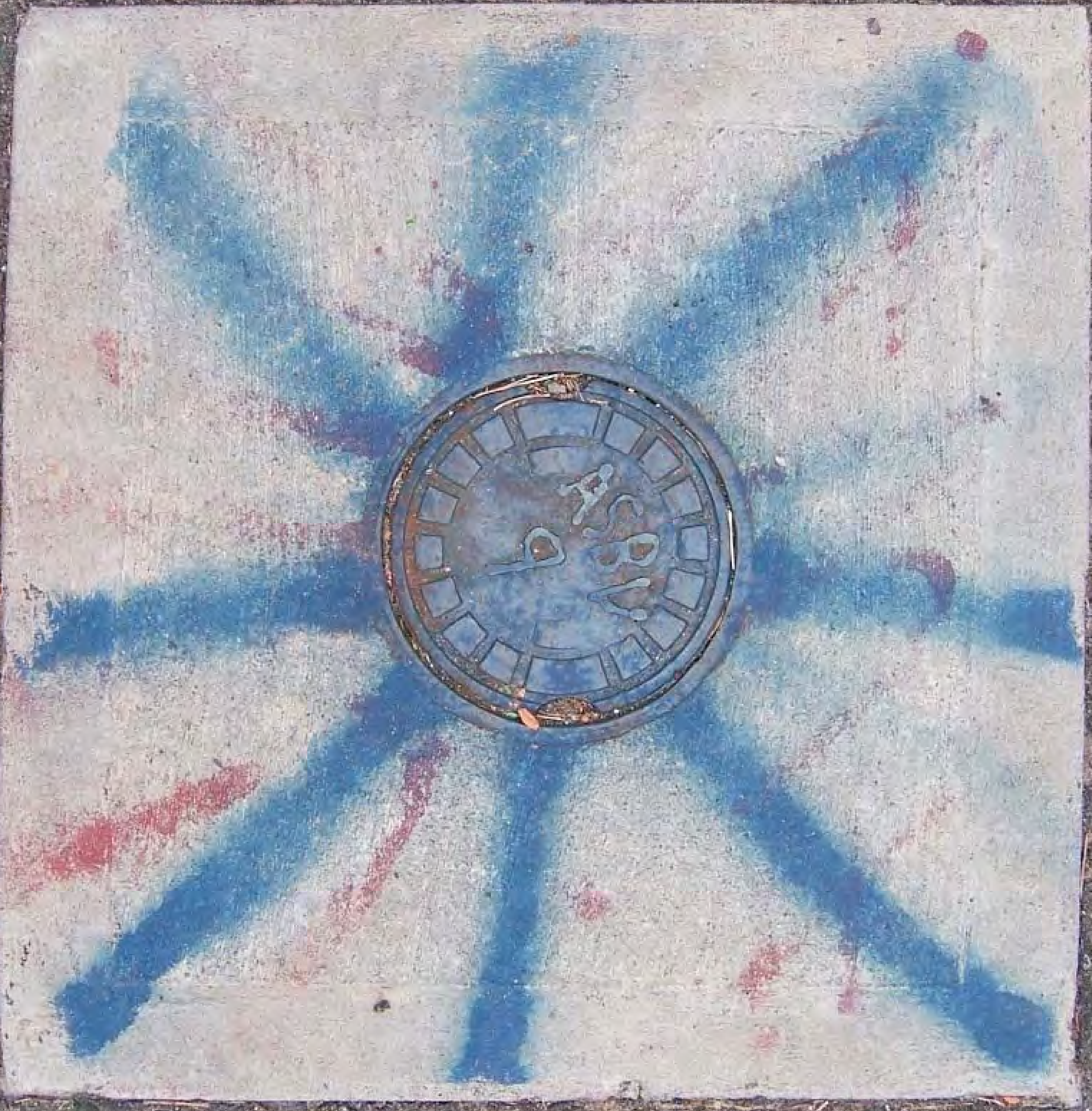
Final - August 2009

GROUNDWATER MONITORING WELL DECOMMISSIONING PROCEDURES



New York State Department of Environmental Conservation
Division of Environmental Remediation

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INTRODUCTION

This document, *Groundwater Monitoring Well Decommissioning Procedures*, is the addendum to CP-43, Groundwater Monitoring Well Decommissioning Policy, which provides acceptable procedures to be used as guidance when decommissioning monitoring wells in New York State. Please note that this document does not address some site-specific special situations that may be encountered in the field. Compliance with the procedures set forth in this document does not relieve any party of the obligation to properly decommission a monitoring well.

Unprotected, neglected and improperly abandoned monitoring wells are a serious environmental liability. They can function as a pollution conduit for surface contaminants to reach the subsurface and pollute our groundwater. They also can cause unwanted mixing of groundwater, which degrades the overall water quality within an aquifer. Improperly constructed, poorly maintained or damaged monitoring wells can yield anomalous poor data that can compromise the findings of an environmental investigation or remediation project. Unneeded or compromised monitoring wells should be properly decommissioned in order to prevent harm to our groundwater.

Previous versions of this guidance have been issued since 1995. Originally developed as a specification for well decommissioning at Love Canal, the procedures were rewritten to make them applicable across the state. From an engineering standpoint, the guidance has changed very little. Most situations do not require a complex procedure.

If you have any questions, please contact Will Welling at (518) 402-9814.

Sincerely,

Gerald J. Rider, Jr., P.E.
Chief, Remedial Section D
Remedial Bureau E
Division of Environmental Remediation

1.0 PREPARATION

If an unneeded monitoring well remains in good usable condition, an alternative to decommissioning might be the reuse by another agency program. DEC encourages reuse in situations where a well will continue to be used and cared for responsibly.

When reuse is not an option, the first step in the well decommissioning process is to review all pertinent well construction information. One must know the well depth and construction details. GPS coordinates and permanent labeling (if available) will be useful in confirming the well to be decommissioned. An inspection must be performed prior to decommissioning in order to verify the construction and condition of each well. Specific details and subsurface conditions form the basis for decisions throughout the decommissioning process.

Well Details

1. Is the well a single stem riser (all one diameter)?
2. Is the well a simple overburden well (no penetration into bedrock)?
3. Does the well riser consist of telescoping diameters of pipe which decrease with depth?
4. Is the well seal compromised (leaking, inadequate or damaged)?
5. If the well is PVC, is it 25 feet or shallower and not grouted into rock?
6. Can the riser be pulled and is removal of the well desired?
7. Is the well a bedrock well?
8. If the monitoring well is a bedrock well, does it have an open hole?
9. Is there a well assembly (riser and screen) installed within the bedrock hole?

Subsurface Conditions

10. Is the soil contaminated?
11. Does the well penetrate a confining layer?
12. If the well penetrates a confining layer, might overdrilling or casing pulling cause contamination to travel up or down through a break in the confining layer?
13. Does the screened interval cross multiple water-bearing zones?

For additional collection and verification of information, the "Monitoring Well Field Inspection Log" (Figure 1) can be used during a field inspection. After the well has been located and the information gathered, one is ready to select the decommissioning procedure in accordance with Section 2.

Special conditions, such as access problems, well extensions through capped and covered non-Part 360 landfills and seasonal weather patterns affecting construction, should be assessed in the planning stage. Decommissioning work requiring the use of heavy vehicular equipment on landfill caps should be scheduled during dry weather (if possible) so as to minimize damage to the cover. If work must be performed during the spring, winter or inclement weather, special measures to reduce ruts should be employed to maintain the integrity of a completed landfill cover system. As an example, placement of plywood under vehicular equipment can eliminate deep ruts that would require repair.

2.0 DECOMMISSIONING METHODS

The primary rationale for well decommissioning is to remove any potential groundwater pathway. A secondary rationale, often important to the property owner or owner of the well, is to physically remove the well. Removed well materials may be recycled and will not interfere with future construction excavation. The previous versions of these decommissioning procedures have stressed that physical removal of the well by pulling is preferable to leaving casing in the ground. Due to the added effort, expense and risk involved with pulling, the decision of whether to pull or not should be a separate consideration aside from selecting the sealing procedure.

One should select a decommissioning procedure that takes into account the geologic and hydrogeologic conditions at the well site; the presence or absence of contamination in the groundwater; and original well construction details. The selection process for well decommissioning procedures is provided by the flow chart, Figure 2. Answers to the questions in the preceding section are the input for this flow chart. The four primary well decommissioning methods are:

1. Grouting in-place;
2. Perforating the casing followed by grouting in-place;
3. Grouting in-place followed by casing pulling;
4. Over-drilling and grouting with or without a temporary casing.

In a complex situation, one or more decommissioning procedures may be used for different intervals of the same well.

The remainder of Section 2 discusses the well decommissioning methods and the selection process. Refer to Figure 2 for a flow chart diagram of the complete procedure selection process. The DEC Project Manager has the discretion to deviate from the flow chart, (Figure 2), based on site conditions and professional judgment.

2.1 Grouting In-Place

Grouting in-place is the simplest and most frequently used well decommissioning method and grouting itself is the essential component of all the decommissioning methods. The grout seals the borehole and any portion of the monitoring well that may be left in the ground. Because dirt and foreign objects can fall into an open well, whenever possible a well should be sealed first with grout before attempting subsequent decommissioning steps.

For the purpose of these decommissioning procedures, the well seal is defined as the bentonite seal above the sand pack. Aside from obvious channeling by in-flowing surface water around the well, an indication of the well seal integrity may be obtained through review of the boring logs and/or a comparison of groundwater elevations if the well is part of a cluster. Any problems noted on the boring logs pertaining to the well seal, such as bridging of bentonite pellets or running sands, or disparities between field notes (if available) and the well log would indicate the potential for a poor (compromised) well seal.

If the well seal is not compromised and there is no confining layer present, a single-stem, 2-inch PVC, monitoring well can be satisfactorily decommissioned by grouting it in-place. If the seal is compromised, casing perforation may be called for as discussed in Section 2.2.

As discussed in Section 2.4 and its sub-sections, this method is specified for the bedrock portion of a well, and is used for decommissioning small diameter cased wells. Grouting in-place involves filling the casing with grout to a level of five feet below the land surface, cutting the well casing at the five-foot depth, and removing the top portion of the casing and associated well materials from the ground. The casing must be grouted according to the procedures in Section 6. In addition, the upper five feet of the borehole is filled to land surface and restored according to the procedures described in Section 7.

For open-hole bedrock wells, the procedure involves filling the opening with grout to the top of rock according to the procedures in Section 5. A thicker grout may be required to fill any bedrock voids. If excessive grout is being lost down-hole, consider grouting in stages to reduce the pressure caused by the height of the grout column.

The standard mix with the maximum amount of allowable water will be required to penetrate the well screen and sand pack when a well assembly has been installed within a bedrock hole. For an assembly such as this, the grout should be mixed thinly enough to penetrate the slots and sand pack. The grout mixes are discussed in Sections 6.1 and 6.2.

2.2 Casing Perforating/Grouting In-Place

Casing perforation followed by grouting in-place is the preferred method to use if there is poor documentation of the grouting of the well annulus, or the annulus was allowed to be back-filled with cuttings. The grout will squeeze through the perforations to seal any porous zones along the outside of the casing. The procedure involves puncturing, cutting or splitting the well casing and screen followed by grouting the well. A variety of commercial equipment is available for perforating casings and screens in wells with four-inch or larger inside diameters. Due to the diversity of applications, experienced contractors must recommend a specific technique based on site-specific conditions. A minimum of four rows of perforations several inches long around the circumference of the pipe and a minimum of five perforations per linear foot of casing or screen is recommended (American Society for Testing and Materials, Standard D 5299-99, 1999). After the perforating is complete, the borehole must be grouted according to the procedures in Section 6 and the upper five feet of borehole restored according to the procedures in Section 7.

2.3 Casing Pulling

Casing pulling should be used in cases where the materials of the well assembly are to be recycled, or the well assembly must be removed to clear the site for future excavation or re-development. Casing pulling is an acceptable method to use when no contamination is present; contamination is present but the well does not penetrate a confining layer; and when both contamination and a confining layer are present but the contamination cannot cross the confining layer. Additionally, the well construction materials and well depth must be such that pulling will not break the riser. When contamination is likely to cross the confining layer during pulling, a temporary casing can be used. See Section 2.4.

Casing pulling involves removing the well casing by lifting. Grout is to be added during pulling; the grout will fill the space once occupied by the material being withdrawn. An acceptable procedure to remove casing involves puncturing the bottom of the well or using a casing cutter to cut away the screen, grouting, using jacks to free casing from the hole, and lifting the casing out by using a drill rig, backhoe, crane, or other suitable equipment. Additional grout must be added to the casing as it is withdrawn. Grout mixing and placement procedures are provided in Section 6. In wells or well points in which the bottom cannot be punctured, the casing or screened interval will be perforated or cut away prior to being filled with grout. This procedure should be followed for wells installed in collapsible formations or for highly contaminated wells.

At sites in which well casings have been grouted into the top of bedrock, the casing pulling procedure should not be attempted unless the casing can be first cut or freed from the rock.

2.4 Over-Drilling

Over-drilling is the technique used to physically remove an entire monitoring well, its sand pack and the old grout column and fill. In situations where PVC screens and risers are expected to sever and removal of all well materials is required, over-drilling will be required. Over-drilling is called for when a riser can't be pulled and it penetrates a confining layer. Compared to the other procedures, over-drilling is the least common method of well decommissioning.

A "temporary casing" may be necessary when extraordinary conditions are present, such as a high concentration of mobile contaminants in the overburden, depth to water is shallow, there is poor construction documentation or shoddy construction practices. The approach involves installing a large diameter steel casing around the outside of the well followed by drilling / pulling /grouting within this casing. The casing is withdrawn at the end of pulling, grouting and (perhaps) drilling. If the confining layer is less than 5 feet thick, the casing should be installed to the top of the confining layer. Otherwise, it is installed to a depth of 2 feet below the top of the confining layer. After the outer casing has been set, the well can be removed and grouted through pulling if possible or removed and grouted by drilling inside the casing.

Over-drilling is used where casing pulling is determined to be unfeasible, or where installation of a temporary casing is necessary to prevent cross-contamination, such as when a confining layer is present and contamination in the deeper aquifer could migrate to the upper aquifer as the well is pulled. The over-drilling method should:

- Follow the original well bore;
- Create a borehole of the same or greater diameter than the original boring; and
- Remove all of the well construction materials.

In over-drilling the difficulty lies in keeping the augers centered on the old well as the bit is lowered; it will tend to wander off. As a precaution, the well column should be filled with grout before over-drilling. Then without allowing the grout to dry, the driller proceeds with over-drilling the well. Grouting first guarantees that if the drill wanders off the old well and the effort is less than 100% successful, the remaining well portion will at least have been grouted. There are many methods for over-drilling. Please note that the following methods are not suitable for all types of casing, and the advice of an experienced driller should be sought.

- Conventional augering (i.e., a hollow stem auger fitted with a pilot bit). The pilot bit will grind the well construction materials, which will be brought to the well surface by the auger.
- A conventional cable tool rig to advance "temporary" casing having a larger diameter than the original boring. The cable tool kit is advanced within the casing to grind the well construction materials and soils, which are periodically removed with large diameter bailer. This method is not applicable to bedrock wells.

- An over-reaming tool with a pilot bit nearly the same size as the inside diameter of the casing and a reaming bit slightly larger than the original borehole diameter. This method can be used for wells with steel casings.

- A hollow-stem auger with outward facing carbide cutting teeth having a diameter two to four inches larger than the casing.

Prior to over-drilling, the bottom of the well should be perforated or cut away, and the casing filled with grout as with casing removal by pulling.

In all cases above, over-drilling should advance beyond the original bore depth by a distance of half a foot to ensure complete removal of the construction materials. Oversight attention should be focused on the drill cuttings, looking for fragments of well materials. Absence of these indicators is a sign that the drill has wandered off the well. If wandering is suspected, having previously filled the well with grout, the remaining portion which cannot be over-drilled can be considered grouted in-place. When the over-drilling is complete, grout should be tremied within the annular space between the augers and well casings. The grout level in the borehole should be maintained as the drilling equipment and well materials are sequentially removed. As with all the other methods, the upper five feet of borehole should be restored according to the procedures in Section 7.

3.0 SELECTION PROCESS AND IMPLEMENTATION

The decommissioning procedure selection flow chart, Figure 2, is to be used to select decommissioning methods. The selection process first identifies the basic monitoring well type. There are only two types of monitoring wells described in this guidance, overburden wells and bedrock wells. Bedrock wells typically have an overburden portion which in the selection process is to be treated as an overburden well. Techniques are specified for wells based upon their type and the other physical conditions present. Decommissioning techniques called for by the selection process have their practical limits; construction details dictate when a well stem can be pulled without breaking and when it cannot be pulled. The DEC project manager has the discretion to deviate from the flow chart, (Figure 2), based on site conditions, budgetary concerns and professional judgment. The remainder of this section will discuss types of monitoring wells in various settings along with recommended decommissioning techniques.

3.1 Bedrock Wells

Referring to Figure 2 and Section 2.1, if the well extends into bedrock, the rock hole portion of the well is to be grouted in-place to the top of the rock. The grout mix, however, may vary according to the conditions. A thicker grout may be required to fill voids and a thinner grout may be necessary to penetrate well screen and sand pack. Refer to the grout mixture specifications given in Section 6.1 and 6.2.

Prior to grouting, the depth of the well will be measured to determine if any silt or debris has plugged the well. If plugging has occurred, all reasonable attempts to clear it should be made before grouting. The borehole will then be tremie grouted according to Section 6.4 from the bottom of the well to the top of bedrock to ensure a continuous grout column.

After the rock hole is grouted, the overburden portion of the well is decommissioned using appropriate techniques described below. If the bedrock extends to the ground surface, grouting can extend to the ground surface or to slightly below so that the site can be restored as appropriate in accordance with Section 7.

3.2 Uncontaminated Overburden Wells

For overburden wells and the overburden portion of bedrock wells, the first factor in determining the decommissioning method is whether the overburden portion of the well exhibits contamination, as determined through historical groundwater and/or soil sampling results. If the overburden is uncontaminated, the next criteria considers whether the well penetrates a confining layer. In the case that the overburden portion of the well does not penetrate a confining layer, the casing can either be tremie-grouted and pulled or tremie grouted and left in place. As a general rule, PVC wells greater than 25-feet deep should not be pulled unless site-specific conditions or other factors indicate that the well can be pulled without breaking. If the well cannot be pulled, the well should be grouted in-place as accordance with Sections 2.1 and 2.2.

If a non-telescoped overburden well penetrates a confining layer, the casing should be removed by pulling (if possible) in accordance with Section 2.3. If the casing cannot be removed by pulling, the well should be grouted in-place or where complete removal is required, removed by over-drilling. Over-drilling will be based upon the site-specific conditions and requirements. If pulling is attempted and fails (i.e., a portion of the riser breaks) the remaining portion of the well should be removed by using the conventional augering procedure identified in Section 2.4. Note that if the riser is broken during pulling, it is highly unlikely that the driller will be able to target it to over-drill it. This is the reason why all wells should be grouted first. In all cases, after the well construction materials have been removed to the extent possible, the borehole will be grouted in accordance with Section 6 and the upper five feet will be restored in accordance with Section 7.

3.3 Contaminated Overburden Monitoring Wells/Piezometers

Contamination in the overburden plays a role in the selection process. Any contamination present in the overburden must not be allowed to spread as a result of the decommissioning construction. For wells and piezometers suspected or known to be contaminated with light non-aqueous phase liquid (LNAPL) and/or dense non-aqueous phase liquid (DNAPL), often referred to as “product,” the decision to decommission the well should be reviewed. Such gross contamination is a special condition and requires design of the decommissioning procedure. If decommissioning is determined to be the proper course of action, measurement of the non-aqueous phase liquid volume will be determined and this liquid will be removed.

If an overburden well (or the overburden portion of a bedrock well) is contaminated with LNAPL, DNAPL and /or dissolved fractions as indicated by historical sampling results, one must evaluate the potential for contamination to cross an overburden confining layer (if one exists) during decommissioning. A rock or soil horizon of very low permeability is known as a confining layer. Contamination in the overburden lying above a confining layer is a significant condition to recognize. To prevent mobile contaminants from crossing a confining layer during pulling or over-drilling, a temporary casing should be installed to isolate the work zone. One should follow the procedure selection flow chart. Some contaminated conditions call for over-drilling or a specially designed procedure.

A well in contaminated overburden may be grouted in-place as long as the grout fully seals the well and boring zone. If a well in contaminated overburden was constructed allowing formation collapse as annular backfill or if the well has a compromised well seal, one must either physically remove the well or thoroughly perforate the riser and grout it in-place.

If physical removal of the well is required and the overburden contaminants are likely to be dragged upward or downward during decommissioning, a temporary casing should be used to seal off the construction work zone. Casing pulling and overdrilling can be safely accomplished within the temporary casing. Section 2.4 discusses the temporary casing technique.

3.4 Telescoped Riser

If the riser is telescoped in one or more outer casings, the decommissioning approach depends upon the integrity of the well seal. If there is no evidence that the well seal integrity is compromised, the riser should be grouted in-place in accordance with Sections 2.1 or 2.2 and the upper 5 feet of the well surface should be restored in accordance with Section 7. If indications are that the well seal is not competent, it will be necessary to design and implement a special procedure to perforate and grout or remove the well construction materials. The presence and configuration of the outer casing(s) will be specific in the individual wells and will be a key factor in the decommissioning approach. The special procedure must mitigate the potential for cross-contamination during removal of the well construction materials.

4.0 LOCATING AND SETTING-UP ON THE WELL

Prior to mobilizing to decommission a monitoring well, one should notify the property owner and/or other interested parties including the governing regulatory agency. It is advisable that when at the well location, one should review the proposed well decommissioning procedure. Verify well locations and identification by their identifying markers and GPS coordinates. Lastly, verify the depth of each well with respect to depth recorded on the well construction log.

5.0 REMOVING THE PROTECTIVE CASING

Most monitoring wells installed in non-traffic locations are finished with an elevated, protective casing (guard pipe) and a concrete rain pad. Wells at gasoline stations, usually being in high-traffic areas, are typically finished with a flush-mount, curb box and protective 8" dia steel inspection plate rather than a stick-up riser. The curb box is usually easily removed from around the flush-mount well before pulling or over-drilling. In the case of stick-up wells, the riser pipe may be bonded to the guard pipe and rain pad. When the protective casing and concrete pad of a stick-up monitoring well are "yanked out," a PVC riser will typically break off at the bottom of the guard pipe several feet below grade. Once this happens, it may become impossible to center a drill rig upon the well. The riser may become splintered and structurally unstable for pulling. Unless grouted first, the well may fill with dirt. Before pulling a casing or over-drilling a well, a method must be devised for removing these protective surface pieces without jeopardizing the remaining decommissioning effort.

Generally, unless the protective casing is loose and can be safely lifted off by hand, *one* *should fill the monitoring well with grout before removing the outer protective casing.* This will ensure that the well is properly sealed regardless of any problems later when removing the protective casing. Remove the protective casing or road box vault initially only if the stick-up or vault will interfere with subsequent down-hole work which must be done before grouting. This down-hole work may include puncturing, perforating or cutting the screen or riser. But as a general procedure don't remove the protective casing or road box until after initial grouting is complete.

The procedure for removing the protective casing of a well depends upon the decommissioning method specified for the monitoring well. The variety of protective casings available preclude developing a specific removal procedure but often one can simply break up the concrete seal surrounding the casing and jack or hoist the protective casing out of the ground. A check should be made during pulling to ensure that the inner well casing is not being hoisted with the protective casing. If this occurs, the well casing should be cut off after the base of the protective casing is lifted above the land surface. At well locations where the riser has been extended, the burial of a previous concrete pad may require the excavation of soil to the top of the concrete pad to remove the well.

Steel well casing should be removed approximately five feet below the land surface so as to be below the frost line and out of the way of any subsequent shallow digging. The upper five feet of casing and the protective casing can be removed in one operation if a casing cutter is used.

Waste handling and disposal must be consistent with the methods used for the other well materials unless an alternate disposal method can be employed (i.e., steam cleaning followed by disposal as non-hazardous waste).

6.0 SELECTING, MIXING, AND PLACING GROUT

This section gives recipes for the “standard grout mixture” and the thicker “special grout mixture.” Mixing and placing grout is also discussed in this section. The goal of well decommissioning is to eliminate the capability of water to travel up or down within the volume of the former well and its boring. Success depends upon the correct grout mixture and placement where it is needed. There are two types of grout mixes that may be used to seal monitoring wells: a standard mix and a special mix. Both mixes use Type 1 Portland cement and four percent bentonite by weight. However, the special mix uses a smaller volume of water and is used in situations where excessive loss of the standard grout mix is possible (e.g., highly-fractured bedrock or coarse gravels).

6.1 Standard Grout Mixture

For most boreholes, the following standard mixture will be used:

- One 94-pound bag Type I Portland cement;
- 3.9 pounds powdered bentonite; and
- 7.8 gallons potable water.

Slightly more water may be used in order to penetrate a sand pack when a well screen transects multiple flow zones. This mixture results in a grout with a bentonite content of four percent by weight and will be used in all cases except in boreholes where excessive use of grout is anticipated. In these cases a special thicker mixture will be used.

6.2 Special Mixture

In cases where excessive use of grout is anticipated, such as high permeability formations and highly fractured or cavernous bedrock formations, the following special mixture will be used:

- one 94-pound bag type I Portland cement;
- 3.9 pounds powdered bentonite;
- 1 pound calcium chloride; and
- 6.0-7.8 gallons potable water (depending on desired thickness).

The special mixture results in a grout with a bentonite content of four percent by dry weight. It is thicker than the standard mixture because it contains less water. This grout is expected to set faster than the Standard Grout Mixture due to the added calcium chloride. The least amount of water that can be added for the mixture to be readily pumpable is 6 gallons per 94-pound bag of cement.

6.3 Grout Mixing Procedure

To begin the grout-mixing procedure, calculate the volume of grout required to fill the borehole. If possible, the mixing basin should be large enough to hold all of the grout necessary for the borehole.

Mix grout until a smooth, homogeneous mixture is achieved. Grout can be mixed manually or with a mechanized mixer. Colloidal mixers should not be used as they tend to excessively decrease the thickness of the grout for the above recipes.

6.4 Grout Placement

This guidance requires that grout be placed in the well from the bottom to the top by means of a "tremie." A tremie is a pipe, a hose or a tube extending from the grout supply to the bottom of the well. The tremie delivers the grout all the way down through the water column without its being diluted and mixed with the water that may be present in the well. The tremie pipe or tube is withdrawn as (or after) the well is filled with grout.

Using the tremie, grout is placed in the borehole filling from the bottom to the top. Two-inch and larger wells should use tremie tubing of not less than 1-inch diameter. Smaller diameter wells will call for a smaller tremie pipe. Grout will then be pumped in until the grout appears at the land surface (when grouting open holes in bedrock, the grout level only needs to reach above the bedrock surface). Any groundwater displaced during grout placement, if known to be contaminated, will be contained for proper disposal.

At this time the rate of settling should be observed. If grouting the well in place, the well casing remains in the hole. But if the decommissioning method has involved down-hole tools such as hollow-stem augers or temporary casing for overdrilling, these will be removed from the hole. As each section is removed, grout will be added to keep the level between 0 and 5 feet below grade. If the grout level drops below the land surface to an excessive degree, an alternate grouting method must be used. One possibility is to grout in stages; i.e., the first batch of grout is allowed to partially cure before a second batch of grout is added.

As previously described in Section 5.0, the outer protective casing "stick-up" should be removed only after a well has been properly filled with grout. This will ensure that the well is properly sealed regardless of any breakage which may occur when removing the stick-up. It is important to reiterate that when either casing pulling or over-drilling are required, due to the uncertainty of successfully pulling a well or over-boring a well, we insist that the driller tremie grout the well first. Then without allowing the grout to dry, the driller proceeds with pulling the casing or over-drilling the well.

Upon completion of grouting, ensure that the final grout level is approximately five feet below land surface. A ferrous metal marker will be embedded in the top of the grout to indicate the location of the former monitoring well. Lastly, a fabric "utility" marking should be placed one foot above the grout so an excavator can see it clearly.

7.0 BACKFILLING AND SITE RESTORATION

The uppermost five feet of the borehole at the land surface should be filled with material physically similar to the natural soils. The surface of the borehole should be restored to the condition of the area surrounding the borehole. For example, concrete or asphalt will be patched with concrete or asphalt of the same type and thickness, grassed areas will be seeded, and topsoil will be used in other areas. All solid waste materials generated during the decommissioning process must be disposed of properly.

8.0 DOCUMENTATION

A form which may be used in the field to record the decommissioning construction is included as Figure 3. Additional documentation may be required by a DEC project manager and samples are included in Appendix A. Programs within the DEC that maintain geographic data on monitoring wells strive to keep that data up to date. Owners of these data sets must be notified when a well is decommissioned. Historical groundwater quality data is linked to monitoring well locations so when a well is decommissioned, existing GIS data must be updated to reflect that fact but the coordinate location in the GIS database should not be eliminated. A metal detector may not be able to detect a deeply buried marker so if this locator is important for future utility runs or foundations, a map should be submitted to the property owner and the town engineer showing the decommissioned well locations. Global Positioning System (GPS) coordinates should be indicated on this map. Lastly, whatever documentation is produced should be provided to the property owner, the DEC, and all other parties involved.

9.0 FIELD OVERSIGHT

Over-drilling requires careful observation to detect whether the drill has wandered off the well. Grout preparation and tremie work should be carefully observed. The successful implementation of a decommissioning work plan depends upon proper direction, observation and oversight. Methods to be employed must be clearly worked through and all parties must understand what they have to do before going into the field. Flexibility is allowed where necessary but the work effort must be thorough and effective to protect our groundwater.

10.0 RELATED REFERENCES

- *Groundwater Monitoring Well Decommissioning Procedures*, October 1986. Prepared by Malcolm Pirnie, Inc., for the New York State Department of Environmental Conservation, Division of Environmental Remediation.

- American Society for Testing and Materials, A.S.T.M. D 5299-99, Standard Guide for the Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities. A.S.T.M.. Philadelphia. 2005.

- New York State Department of Environmental Conservation, Division of Solid and Hazardous Materials, 6 NYCRR Part 360, Solid Waste Management Facilities.

- New York State Department of Environmental Conservation, Region I - Water Unit, Specifications for Abandoning Wells and Boreholes in Unconsolidated Materials, undated.

- United States Environmental Protection Agency, The Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, EPA 600/4-89/034.

FIGURES

APPENDICES

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FIGURE 1

MONITORING WELL FIELD INSPECTION LOG

FIGURE 1

SITE NAME:

SITE ID.: ______
INSPECTOR: ______
DATE/TIME: ______
WEll ID.: ______

MONITORING WELL FIELD INSPECTION LOG
NYSDEC WELL DECOMMISSIONING PROGRAM

	YES	NO
WELL VISIBLE? (If not, provide directions below)		
WELL I.D. VISIBLE?		
WELL LOCATION MATCH SITE MAP? (if not, sketch actual location on back)......................		

WELL I.D. AS IT APPEARS ON PROTECTIVE CASING OR WELL: ....

	YES	NO
SURFACE SEAL PRESENT?		
SURFACE SEAL COMPETENT? (If cracked, heaved etc., describe below)		
PROTECTIVE CASING IN GOOD CONDITION? (If damaged, describe below)		

HEADSPACE READING (ppm) AND INSTRUMENT USED.. ______
TYPE OF PROTECTIVE CASING AND HEIGHT OF STICKUP IN FEET (If applicable) ______
PROTECTIVE CASING MATERIAL TYPE: .... ______
MEASURE PROTECTIVE CASING INSIDE DIAMETER (Inches): .... ______

	YES	NO
LOCK PRESENT?		
LOCK FUNCTIONAL?		
DID YOU REPLACE THE LOCK?		
IS THERE EVIDENCE THAT THE WELL IS DOUBLE CASED? (If yes,describe below)		
WELL MEASURING POINT VISIBLE?		

MEASURE WELL DEPTH FROM MEASURING POINT (Feet): .... ______
MEASURE DEPTH TO WATER FROM MEASURING POINT (Feet): .... ______
MEASURE WELL DIAMETER (Inches): .... ______
WELL CASING MATERIAL: .... ______
PHYSICAL CONDITION OF VISIBLE WELL CASING: .... ______
ATTACH ID MARKER (if well ID is confirmed) and IDENTIFY MARKER TYPE .... ______
PROXIMITY TO UNDERGROUND OR OVERHEAD UTILITIES.. ______

DESCRIBE ACCESS TO WELL: (Include accessibility to truck mounted rig, natural obstructions, overhead power lines, proximity to permanent structures, etc.); ADD SKETCH OF LOCATION ON BACK, IF NECESSARY.

DESCRIBE WELL SETTING (For example, located in a field, in a playground, on pavement, in a garden, etc.) AND ASSESS THE TYPE OF RESTORATION REQUIRED.

IDENTIFY ANY NEARBY POTENTIAL SOURCES OF CONTAMINATION, IF PRESENT (e.g. Gas station, salt pile, etc.):

REMARKS:

FIGURE 2

DECOMMISSIONING PROCEDURE SELECTION

NYSDEC Monitoring Well Decommissioning Procedure Selection

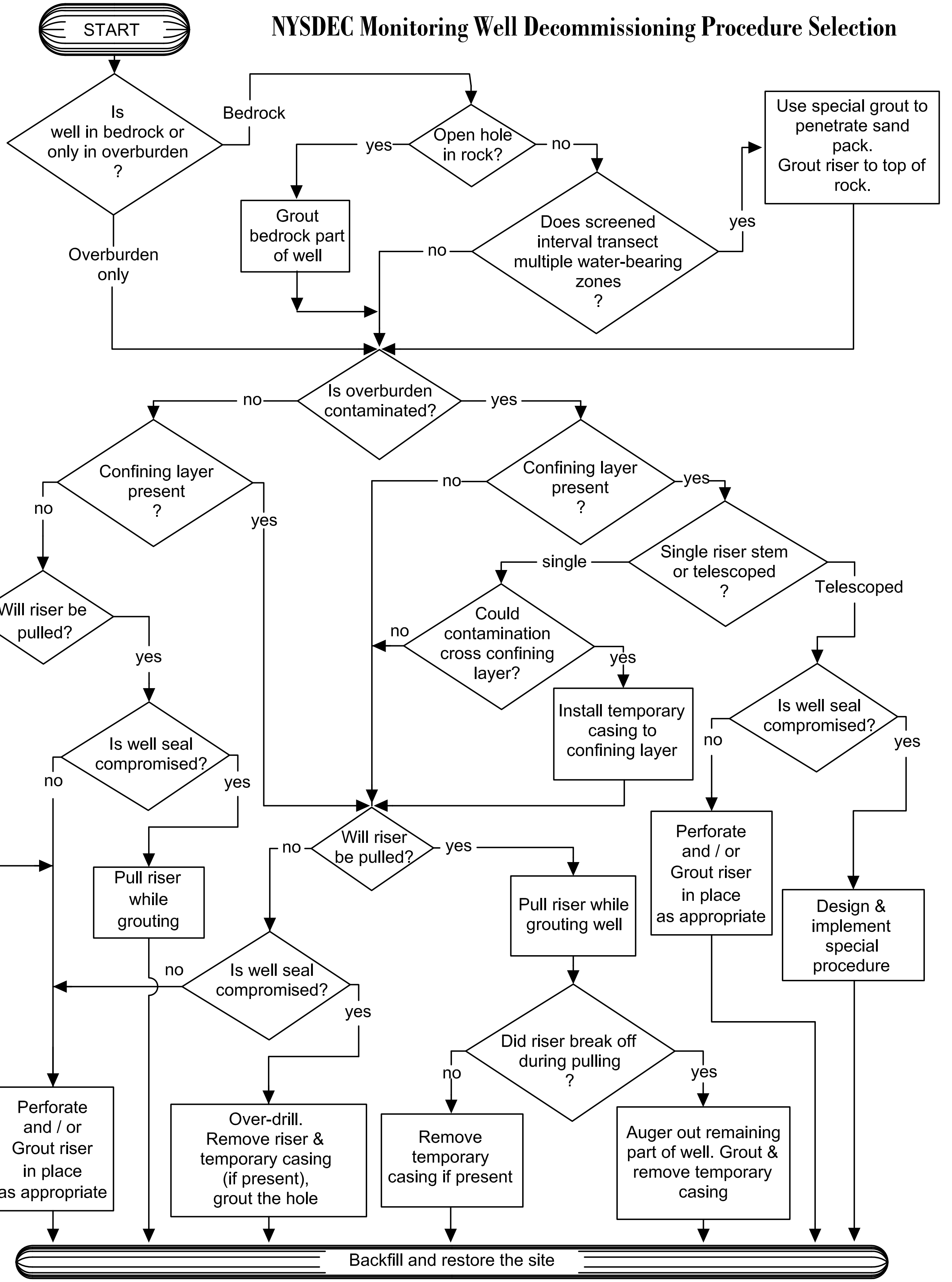


FIGURE 2

<u>FIGURE 3</u>

WELL DECOMMISSIONING RECORD

FIGURE 3

WELL DECOMMISSIONING RECORD

Site Name:

Site Location:

Drilling Co.:

Well I.D.:

Driller:

Inspector:

Date:

DECOMMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled

Drilling Method(s)

Borehole Dia. (in.)

Temporary Casing Installed? (y/n)

Depth temporary casing installed

Casing type/dia. (in.)

Method of installing

CASING PULLING

Method employed

Casing retrieved (feet)

Casing type/dia. (in)

CASING PERFORATING

Equipment used

Number of perforations/foot

Size of perforations

Interval perforated

GROUTING

Interval grouted (FBLS)

\# of batches prepared

For each batch record:

Quantity of water used (gal.)

Quantity of cement used (lbs.)

Cement type

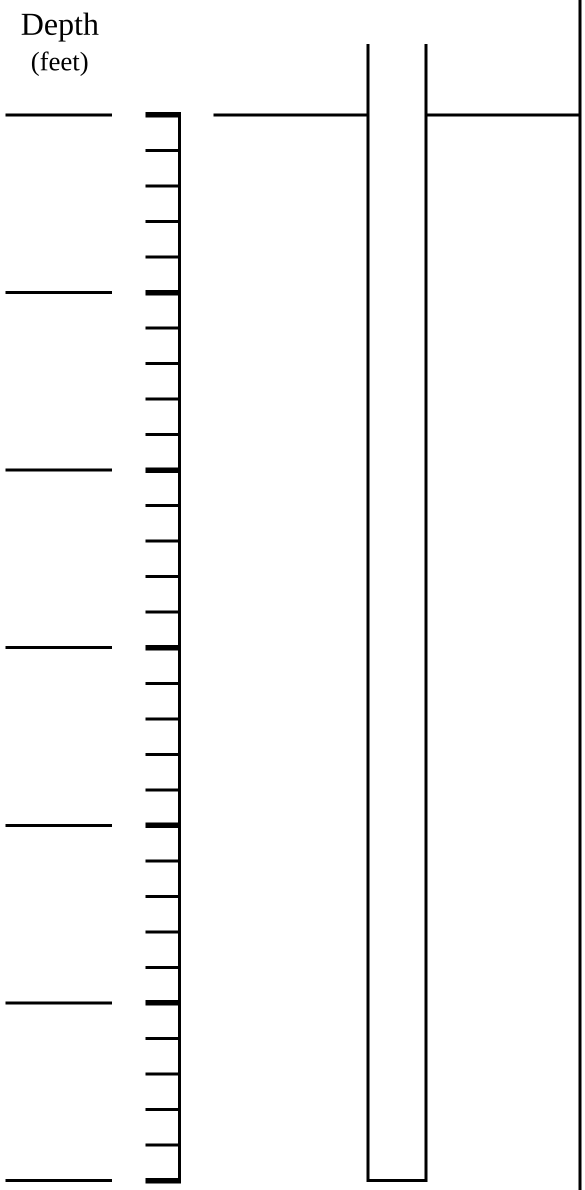
Quantity of bentonite used (lbs.)

Quantity of calcium chloride used (lbs.)

Volume of grout prepared (gal.)

Volume of grout used (gal.)

WELL SCHEMATIC*



COMMENTS:

* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

Drilling Contractor

Department Representative

APPENDIX A - REPORTS

APPENDIX A1 - INSPECTOR'S DAILY REPORT

APPENDIX A2 - PROBLEM IDENTIFICATION REPORT

APPENDIX A3 - CORRECTIVE MEASURES REPORT

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Appendix A1

Inspector's Daily Report

CONTRACTOR:
ADDRESS:

TELEPHONE:
LOCATION ________ **FROM** ________ **TO** ________
WEATHER ________ **TEMP** ________ **A.M.** ________ **P.M.** ________ **DATE** ________

CONTRACTOR'S WORK FORCE AND EQUIPMENT

DESCRIPTION	*H*	*#*	*DESCRIPTION*	*H*	*#*	*DESCRIPTION*	*H*	*#*	*DESCRIPTION*	*H*	*#*
Field Engineer						Equipment			Front Loader Ton		
Superintendent			Ironworker			Generators			Bulldozer		
						Welding Equip.					
Laborer Foreman			Carpenter								
Laborer									Backhoe		
Operating Engineer			Concrete Finisher								
Carpenter						Paving Equip. & Roller					
						Air compressor					

SEE REVERSE SIDE FOR SKETCH YES ☐ NO ☐ ________
WORK PERFORMED: ________

PAY ITEMS

CONTRACT		STA		DESCRIPTION	QUANTITY	REMARKS
Number	ITEM	FROM	TO			

TEST PERFORMED: ________
PICTURES TAKEN: ________

VISITORS: ________

QA PERSONNEL
SIGNATURE ________

REPORT NUMBER ________
SHEET ________ **Of** ________

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PROBLEM IDENTIFICATION REPORT

Date ____________________

Project ____________________ Job Number__________

Contractor ____________________

Subject ____________________

Day	Su	M	T	W	Th	F	Sa

Sky/Precip.	Clear	Partly Cloudy	Cloudy	Rainy	Snow
TEMP.	<32F	32-40F	40-70F	70-80F	80-90F
WIND	No	Light	Strong		
HUMIDITY	Dry	Mod.	Humid		

PROBLEM DESCRIPTION Reference Daily Report Number 1: ____________________

PROBLEM LOCATION - REFERENCE TEST RESULTS AND LOCATION (Note: Use sketches on back of form as appropriate):

PROBABLE CAUSES: ____________________

SUGGESTED CORRECTIVE MEASURES: ____________________

APPROVALS:

QA ENGINEER: ____________________

PROJECT MANAGER: ____________________

Distribution:

1. Project Manager
2. Field Office
3. File
4. Owner

QA Personnel
Signature: ____________________

Appendix A2 (Page 2 of 2)

MEETINGS HELD AND RESULTS

REMARKS

REFERENCES TO OTHER FORMS

SKETCHES

SAMPLE LOG

SAMPLE NUMBER

APPROXIMATE LOCATION OF STOCKPILE

NUMBER OF STOCKPILE

DATE OF COLLECTION

CLIMATIC CONDITIONS

FIELD OBSERVATION

SHEETS OF

CORRECTIVE MEASURES REPORT

Date ____________________

Project ______________________ Job Number __________

Contractor ____________________________________

Subject ____________________________________

Day	Su	M	T	W	Th	F	Sa

Sky/Precip.	Clear	Partly Cloudy	Cloudy	Rainy	Snow
TEMP.	<32F	32-40F	40-70F	70-80F	80-90F
WIND	No	Light	Strong		
HUMIDITY	Dry	Mod.	Humid		

CORRECTIVE MEASURES TAKEN (Reference Problem Identification Report No.): ____________________

RETESTING LOCATION: ____________________

SUGGESTED METHOD OF MINIMIZING RE-OCCURRENCE: ____________________

SUGGESTED CORRECTIVE MEASURES: ____________________

APPROVALS:

QA ENGINEER: ____________________

PROJECT MANAGER: ____________________

Distribution:

1. Project Manager
2. Field Office
3. File
4. Owner

QA Personnel
Signature: ____________________

APPENDIX F
SAMPLING GUIDELINES FOR WATER FLUTE SYSTEMS

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

FLUTe™ Flexible Liner Underground Technologies, Ltd. L.C.
For a medley of innovative designs
6 Easy St., Santa Fe, NM 87504
505-455-1300, www.flut.com

Sampling guidelines for *Water FLUTe* systems installed after May, 2009

Rev. April, 2010

Water level in the liner.

The liner water level should be ~10 ft above the highest formation water level to provide a good seal of the liner in the hole (5 ft minimum excess head). The formation water level can be measured via the “pump tube” for each port. The water level inside the liner should be tagged in the ½ x 5/8” tube labeled “TAG” adjacent to the sampling tubes. If the water level inside the liner is measured in the liner, outside the Tag Tube, lower the weighted tag line very slowly to avoid damage to the liner. Water can be added to the liner by simply pouring water into the liner or through the TAG tube, whichever is easier. Do not fill the liner more than 10 ft above the highest formation water level. The water level in the liner should be checked prior to each sampling episode. (Beware that filling the liner with de-ionized water can give a false water level reading.) It is not recommended to manually tag water levels more than 200 ft below the surface. The wet film adhesion may prevent the removal of the tag line. A special Teflon coated tag line can be used to extend that limit.

Water flow

The water flow into the pumping system is shown in Fig. 1. Water flows from the formation through the spacer pore space, through the port tube, through the first check valve, and fills the “pump tube”. The “sample tube” is also filled at the same time. The water level rises in the pump tube to the water table for that port.

Setting up the gas pressure source

The water is pumped with gas pressure. The FLUTe pump design is such that there is very low risk of aeration of the sample. The gas source is usually a nitrogen bottle with a regulator for setting the prescribed driving pressure. The arrangement of the FLUTe gas drive system is shown in Fig. 2. The regulator is set to the proper gas pressure defined later by closing the three way valve to prevent gas flow out of the quick connect fitting. The

pressure gauge on the FLUTe pump driver is much more sensitive than the regulator for setting the regulator pressure. The FLUTe pump driver must be securely connected to the regulator at the normal ¼” NPT connection on the regulator outlet.
The regulator is first attached to the top fitting on the gas bottle (a special nitrogen regulator fitting connects to a nitrogen bottle). Tighten the nut securely. Turn the pressure regulator handle counter-clockwise until is moves freely (the no pressure position). Rotate the main valve on the regulator (nearer the bottle) clockwise to fully closed. Open the valve on the bottle (counter clockwise). The main bottle pressure gauge on the regulator will rise to the bottle pressure. Close the regulator valve (clockwise) until the pressure starts to rise on the pressure gauge on the FLUTe pump driver (three way valve closed with no flow out of the quick connect). Adjust the regulator to the desired pressure for purging, provided by FLUTe. Connect the quick connect to the top fitting of the pump tube (see Fig. 2). Open the three way valve to drive the water out of the pump.

Purging

Water is pumped from the tubing by applying the gas pressure to the interface at the static water level in the pump tube (Fig. 1 and 2). The water is driven down in the pump tube and up through the second check valve to the surface via the sample tube. By driving the water with a sufficient gas pressure (the “recommended purge pressure”) to drive all of the water in the pump tube and the sample tube to the surface, the water in the pump tubing is nearly all expelled. The purge stroke (~1 gal. of water) is complete when gas is expelled from the sample tube following the water flow. <u>The pressure in the system must then be vented (i.e., dropped to atmospheric by turning the three way valve to the vent position)</u>, to allow the pump tube to refill by flow via the port tube. The recharge flow from the port tube consists of the port tube water, the water in the pore space of the spacer, and water from the medium. Because of the relatively large volume in the pump tube, most of the recharge is from the medium. The recharge will take about as long as the first purge stroke. However, a low conductivity medium will require more time.

Purging the pump tube a second time will remove any of the water that has resided in the spacer and port tube volume. That is highly recommended, since the water resident in the tubing and spacer is probably not typical of the formation water. If the refill has been prompt, the second purge water volume will be similar to the first stroke. Two more purge strokes, for a total of four purge strokes, are recommended to remove water that may have been in long contact with the liner or spacer. (Note, systems manufactured before May, 2009 use larger pumps and were only stroked twice. The purge volume is slightly larger for this new procedure and takes about the same time as the two stroke system. This new system stresses the liner less at the spacer and has numerous other advantages.)

Sampling

The sampling flow is best driven on the fifth cycle using a "recommended sampling pressure" which is less than that needed to drive gas through the bottom of the pump tube. The pressure recommended is that which will drive the water to near, but not out of, the bottom of the large tube. That recommended pressure, "the sampling pressure," is calculated in the spreadsheet provided with each system. The pressure regulator is set to the sample pressure, which is lower than the purge pressure. Opening the three way valve will now apply the sample pressure to the system causing flow from the sample tube.

The first flow of the sampling cycle sweeps along droplets of water left in the tubing from the purge cycle. That residual water is depleted of volatile components. Tests have shown that the first tube volume of the sample flow should be discarded as depleted in volatiles (the "discard volume" is also calculated in the spreadsheet). Thereafter, the samples can be collected from the sample tube outflow. The volume to be discarded is shown in the spreadsheet as "discard volume". The sample tube water flow rate will start fast, then slow, and finally stop. That occurs as the water column being driven approaches the applied pressure/head. The typical sampling pressure drives to within 25 ft. of the bottom of the pump tube (the U). The large buffer zone remaining in the pump tube assures against aeration of the sample.

This procedure should provide an ample sample (~3 liters) of good quality drawn directly from the formation. If a larger sample volume is needed, simply drop the pressure (i.e., vent the three way valve again), let the pump refill and apply the pressure again. No discard is needed for subsequent sampling flows.

Caution: If the pumping system refills very slowly, there may not be sufficient water in the pump to fill the "sample tube" to the surface when the stroke is performed. In that case, there will be spitting of gas from the sample water and it will be followed by a flow of gas only. The sample water should never show "spitting" and the sample stroke should never end with gas flow from the sample tube. The proper sample flow will slow until it stops flowing. Should this evidence of insufficient recharge be observed, allow the pump to refill for a longer time and repeat the sample stroke. One can tag the water level in the large tube, as described in the head measurement procedure, to assure that the pumping system has been sufficient refilled.

Measuring the head in the system

The water level at each port can be manually measured by removing the plug from the top of the pump tube and lowering a slender (~1/4") electric water level meter until it contacts the water level in the pump tube. It is not recommended to manually tag water levels more than 200 ft below the surface. The wet film adhesion may prevent the removal of the tag line. A special Teflon coated tag line can be used to extend that limit.

The water level in the large tubes may not be the current water level. After sampling, if there is any leakage of the second check valve (sand in the tube, etc…) the water in the sample tube can backflow into the larger tube, adding to the water that fills the large tube during the recharge. Also, if the water level in the formation is dropping between head measurements, the water level in the pump tube will not follow the descent if the first check valve is a good seal. For these two reasons, and for the freezing concern below, it is best to <u>finish the sampling stroke by raising the pressure to the "purge pressure" value</u> to purge the pumping system of all water. Then upon refilling, the level is the current head for each port. If head measurements are made between sampling events, <u>each port's pumping system should be first be purged one stroke</u> to allow the tubing to refill to the current head value. Always replace the plugs in the top of the pump tubes when finished sampling.

If the water might freeze in the sampling tubing near the surface, purge the entire volume of water from each sampling line, after sampling, before leaving it. Use the recommended purge pressure to remove all water, <u>not the sampling pressure</u>. **Each line should be blowing gas when the purge is**

complete. If the tubes were purged after sampling prior to head measurements, that is sufficient.

Since the Water FLUTe uses PVDF tubing, the purge of the entire system after sampling should not be neglected, even if head measurements are not to be made. This removes the water column in the sampling tube. For deep water tables, the long term pressure of the standing water in the sampling tube might lead to excessive creep of the tubing which is susceptible to "cold flow", a characteristic of Teflon like materials. (This is not a concern except for very deep water tables (>300 ft).

In most cases, the performance of a final purge of the system after sampling is useful, even if not essential.

Simultaneous purge and sampling of all tubes

The FLUTe pumping system for each port is essentially identical in length, pump volume and elevation in the hole. This allows all ports to be purged and sampled simultaneously for a great saving in sampling time. The only difference for simultaneous sampling is that the pressure source must include a tube to each port fitting at the wellhead. FLUTe offers a manifold pump driver system at extra cost (the single port driver is provided with the Water FLUTe). The recommended purge and sample pressures are the same as used for single port sampling.

In some cases, the buoyancy of the sampling system is so great when emptied of water during the simultaneous purge that the tubing bundle can cause the liner to invert. The sampling volume spreadsheet provided with the liner notes whether the system can be purged simultaneously. This is only a problem for smaller hole diameters, many ports, and a small excess head in the liner. The new pump design allows simultaneous sampling in most situations.

A short summary is provided as the following checklist:

<u>Check List</u>

1. Check/restore the water level in the liner.
2. Connect the gas driver source to the gas drive (pump) tube for the port.

3. Set the regulator to the recommended purge pressure.
4. Turn the three way valve and expel the tube water at the suggested purge pressure. Collect the purged water volume for verification of a good purge. Note the water flow time of the purge stroke (~4 min.).
5. Allow the tubing to refill. Repeat the purge. Collect the purge volume to assure the amount removed is at least the "port tube volume". Was the refill long enough?
6. Purge a total of four times, more if desired.
7. Allow the tubing to refill for the sample stroke.
8. <u>Reduce the driving pressure</u> to the "sampling pressure". Apply the pressure and collect the first flow to measure the discard volume. Discard that water. Collect the samples.
9. Perform a final purge of the water out of the sampling lines by raising the driving pressure to the purge pressure value.
10. When the sampling system has refilled, tag the water level, if desired, for the current water table. If a port system is refilling very slowly, tag it at a later time.

See the spreadsheet provided with each *Water FLUTe* for the recommended purge and sampling pressures. Those are the pressures that can also be used for a simultaneous purge of the several ports. The spreadsheet flags the condition where all ports should not be purged simultaneously. In most cases, several, to all, of the ports can be purged simultaneously.

Optimum sampling procedure:
Since it is often desirable to minimize the amount of time that the sample water resides in the pumping tubing, it is useful to note the actual time that is required for the recharge of the system. Since the fill rate slows dramatically for the last portion of the recharge, it is not necessary to wait for a complete refill. For most formations, the recharge is dominated by the tubing pressure drop. In that case, the time required for the purge stroke to be completed is about the same time required for the refill. (The exception is for a tight formation that recharges the tubing very slowly.) Hence the second purge can be started after waiting the same length of time as the first purge endured. If the second purge is of a similar volume (usually somewhat less) than the first purge volume, the refill time was long enough. After the same delay, the sampling stroke can be initiated. This timing of the strokes allows one to reduce the retention time in the pumping system. For the very large sample volumes produced, the refill time can be shortened

even more, as long as the sample volume is adequate after the discard of the first flow.

In some situations, the retention time is still too long. FLUTe can often increase the sample tube and port tube diameters for greater flow rates. However, the standard design is well matched for to a wide range of hole diameters, depths, and water table elevations. For very deep wells, the tubing may need to be of higher pressure capacity for the required driving pressures. For water table depths below 700 ft., this may be a concern. FLUTe initiated a design change from Nylon 11 to PVDF tubing in the Water FLUTe systems in 2002 to avoid any concern about tubing interaction with the sample water. However, the prescribed purge is sufficient for the use of Nylon tubing systems.

For special situations such as a very large difference (>50ft) between the water tables at the ports or large fluctuations in the water table, the pumping system may be extended to greater depths. However, the sampling procedure above is sufficient for that situation also.

Questions: Call 888-333-2433 and ask for Carl Keller, or a field engineer.

Figure 1. Water FLUTe pump system

(Single port system shown for clarity)

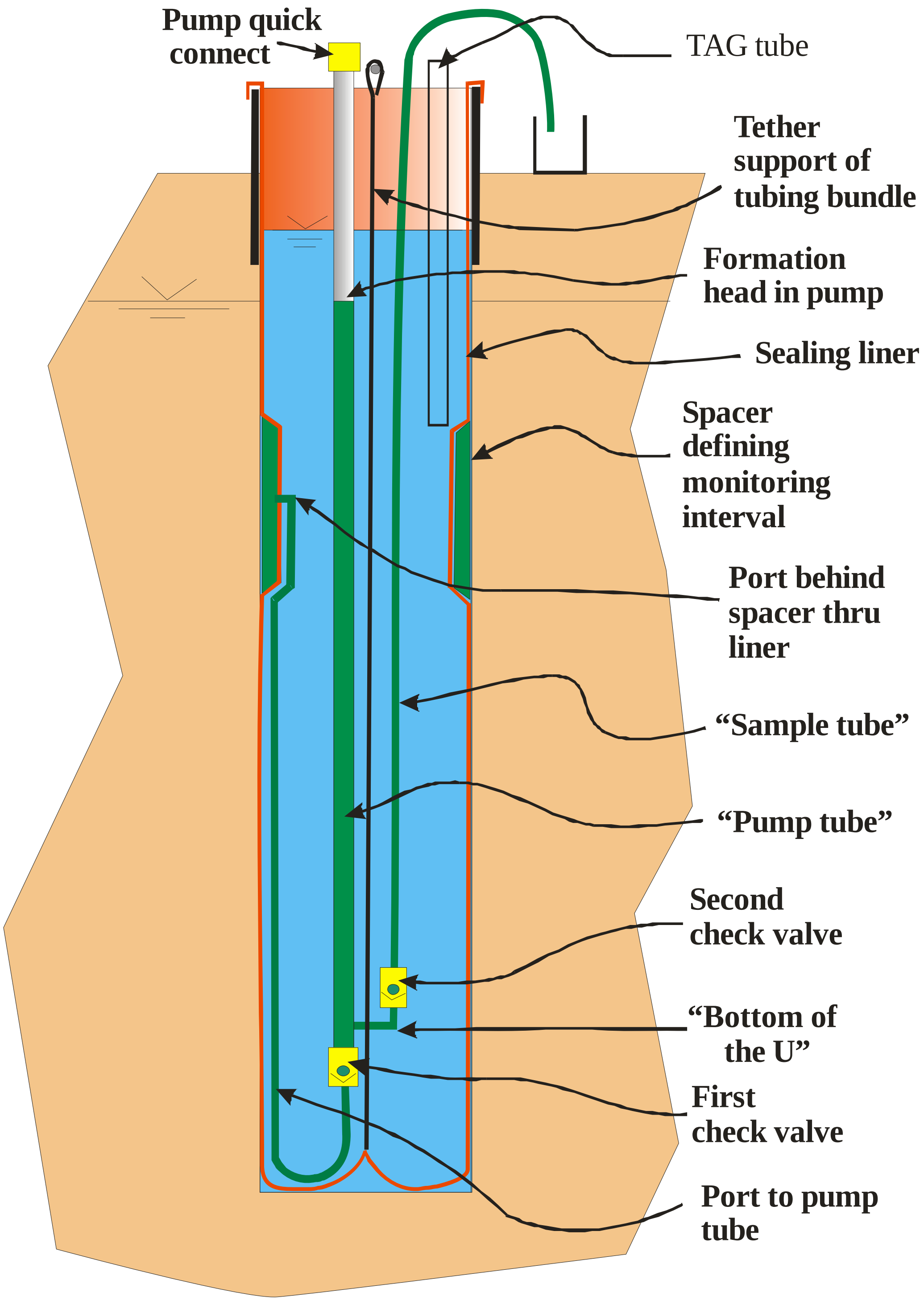
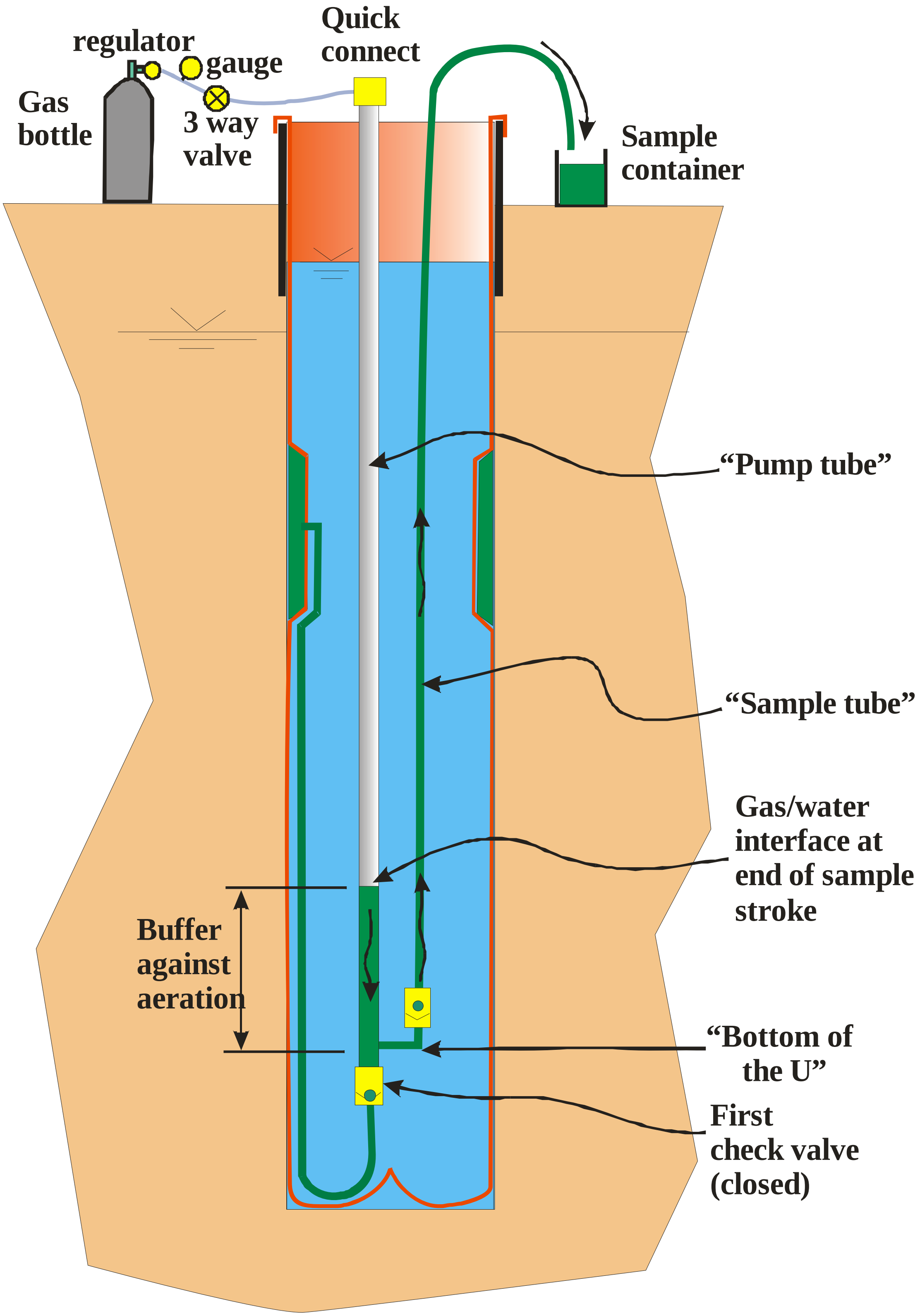


Fig. 2. Pumping Procedure



APPENDIX G
RESUMES FOR KEY PROJECT PERSONNEL

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

Roger Creighton

synapse
connect. advise. insure.

Mr. Creighton has over 17 years of professional experience working in the environmental and geoscience field. Mr. Creighton's professional experience has included assisting clients in the management of State and Federal Superfund sites, environmental facility compliance, environmental restoration projects, environmental health and safety and environmental risk management.

Environmental Regulatory Liaison – Mr. Creighton has helped private land owners to Fortune 500 clients navigate various environmental remediation and restoration projects.

- State and Federal Superfund (CERCLA) compliance monitoring;
- Development of Resource Recovery and Recovery Act (RCRA) compliance monitoring strategies;
- Implemented Toxic Substances Control Act (TSCA) inventory to ensure compliance;
- Implements soil vapor intrusion evaluations including chemical inventories of buildings > 300,000 square feet with multiple tenants;
- State and Federal Wetland permit management;

Environmental Facility Compliance – Mr. Creighton has helped clients manage risk associated with compliance with local, state and federal regulations. A typical market sector includes major oil storage facilities (MOSF) and solid waste management facilities (SWMF). Mr. Creighton has help clients navigate compliance issues including:

- USEPA Spill Prevention Control and Countermeasure (SPCC) Plans;
- Facility Management Plans;
- State Pollutant Discharge Elimination System (SPDES) permits;
- NYSDEC Part 360 regulations including beneficial reuse scenarios;
- SWMF Permit to Operate renewals and modifications;
- Petroleum and chemical bulk storage compliance;
- State and Federal facilitator and liaison for chemical bulk storage.

Environmental Health and Safety – Mr. Creighton currently serves as Synapse's Environmental Health and Safety Compliance Officer. In addition to his daily corporate responsibilities, Mr. Creighton experience includes development, management and implementation of health and safety programs at the State and Federal levels associated with various environmental programs.

Roger's H&S experience includes:

- Occupational Safety and Health Administration (OSHA) Compliance.
    - Employee Training;
    - Hazard Communication;
    - Medical Monitoring;
- Air Quality Compliance
    - Community Air Monitoring Plans;
    - Indoor Air Quality Studies;
    - Mold assessments

Environmental Risk Management – Mr. Creighton has work with insurance carriers in various support roles to quantify potential risks including the following:

- Development and implementation of liability management strategies;
- Provided technical support to insurance underwriter's to place various insurance policies;
- Claims management support; and
- Source and Cause Evaluations.

Work History

Synapse Risk Management – 2004 to present

Domani LLC – 2003 to 2004

Secor International – 1998 to 2003

Op-tech Environmental – 1997-1998

Blasland, Bouck and Lee – 1995 - 1997

Education

B.S. – Construction Management and Engineering, Environmental College of Science and Forestry, Syracuse, New York

A.A.S – Environmental Engineering, Hudson Valley Community College, Troy, New York

Certifications and Training

OSHA – 30 Hour General Industry Safety Certification, 1995

OSHA – 40 HAZWOPER and OSHA Hazardous Communication, 1998

Michael J. Jordan, P.G.
Technical Solutions Leader

PROFESSIONAL EXPERIENCE

Michael Jordan has over 20 years of professional experience with a focus on designing, managing, and executing subsurface investigations using a variety of subsurface drilling and data collection technologies. He serves as Cascade Technical Solutions Leader and oversees a staff of multiple drilling crews. Prior to joining Cascade, Mr. Jordan managed and executed multimedia site characterizations efforts at state and federally regulated sites. These efforts included the development and execution of High Resolution Site Characterization investigations. He has experience in the development and use of innovative investigation tools, including direct sensing, geophysics, diffusion sampling, and hydrogeologic testing. Mr. Jordan is a registered professional geologist in the State of New Hampshire and holds a B.S. in geology from Northeastern University in Boston. In addition, he is a licensed or registered driller in 10 states.

Cascade Technical Services
Technical Solutions Leader, Jan 2016- Present

- Manage drilling and remediation programs including; client relationships, project scoping/bidding, project implementation, regulatory outreach. Also, key member of companywide initiatives

Stone Environmental, Inc.
Director of Drilling and Remediation Services, 2008 - 2015

- Key member of a highly specialized site characterization program.
- Responsible for conceptual design and implementation of drilling and remediation efforts.
- Field data collection
- Data analysis and report writing
- Management of staff, equipment, and onsite health and safety.

The Johnson Company
Project Manager, 2005-2008

- Managed multiple state and federally regulated hazardous waste sites.
- Responsible for all phases of investigation, reporting, and negotiation with lead regulatory agency.
- Involved with scheduling, planning, and development of staff.

Geosyntec Consultants, Inc.
Project Geologist, 2000-2005

- Management and execution of site characterization, remedial design, and implementation of remedial designs at state and federally regulated sites.
- Focus included soil, sediment, surface water, pore water and groundwater investigations.
- Involved in startup of Acton office, including business development, recruiting, and management activities.

HIS Geotrans, Inc.
Staff Hydrogeologist, Project Geologist, 1996-2000

- Acquired extensive experience in field techniques, including investigations into the nature and extent of soil, sediment, surface water, pore water, and groundwater contamination
- Installation and development of monitoring and pumping wells
- Treatment system construction oversight and maintenance; and surveying.
- Also involved in report generation, proposal writing, and cost estimating for all phases of work under state and federal regulations.

Arkins/Talbot Construction
Carpenter, 1990-1996

- Involved in building, design, and estimation procedures for new home construction and major renovations
- Involved in wastewater management and site layout.

Camp, Dresser and McKee, Inc.
Laboratory Technician, 1992

- Student co-op position. Performed Total Suspended Solids, Total Petroleum Hydrocarbons, and Percent Moisture analysis.
- Prepared samples for Poly-Chlorinated Biphenyls and Volatile Organic Compounds analysis.
- Other duties included the receiving, storage, and disposal of soil and water samples.

GEI Technical Engineers, Inc.
Laboratory Technician, 1991

- Student co-op position. Conducted grain size and mechanical analysis of sands and clays through Atterburg limit, hydrometer and sieve analysis.
- Worked with spreadsheet and database software to provide concise presentation of the data.

CERTIFICATIONS

- Professional Geologist, New Hampshire (#509)
- Licensed Driller: VT, NH, MA, NY, NJ, CT, IW & IN
- Registered Driller: ME & RI

APPENDIX H
LABORATORY QUALITY ASSURANCE MATERIALS

PREDESIGN INVESTIGATION WORK PLAN

Harbor View Square
Oswego, New York

June 2018

CASCADE
DRILLING | TECHNICAL SERVICES

LABORATORY and FIELD SAMPLING QUALITY SYSTEMS MANUAL

Cascade Technical Services
1 Home Farm Way
Montpelier, Vermont 05602
802.778.3007

Revision 15

May 31, 2017

LABORATORY AND FIELD SAMPLING QUALITY SYSTEM MANUAL
Revision 15

Approval Signatures

5/31/2017
Michael Rossi Date
Director of Analytical Services

mjgreenwald 5/31/2017
Morgan Greenwald Date
Laboratory Quality Assurance Manager

Table of Contents

List of Figures

List of Appendices

1.0 Introduction, Purpose, and Scope

1.1 Introduction

Until January 2016, Cascade Technical Services Business Unit 205 based in Montpelier, Vermont (CTS-VT) was part of Stone Environmental, Inc. (Stone). Stone, also located in Montpelier, Vermont was established in 1993 in response to a need for highly trained geologists, hydrogeologists and project managers to perform field studies in support of the Federal, Insecticide, Fungicide, and Rodenticide Act environmental studies. In addition to field measurement and sampling, on-site mobile laboratory services were developed in 1998 to support the groundwater profiling field sampling studies. Field sampling studies were being performed in support of private industry, RCRA, CERCLA and other government agencies for detailed rapid site characterizations under the Investigation and Remediation Services Division, which was Stone's Field Sampling and Measurement Organization (FSMO). Detailed Site characterization is performed using specialized technologies such as the Waterloo profiler (Waterloo$^{\text{APS TM}}$), the discrete fracture network approach (CORE$^{\text{DFN}}$) and the Membrane Interface Probe (MIP). These technologies combine real-time hydrostratigraphic data with detailed contaminant concentration distributions to provide clear insight into source zones, plume cores, and plume fate and transport. In January 2016, Stone's Investigation and Remediation Services Division was purchased by Cascade Technical Services, which now includes the on-site mobile laboratory and FSMO technologies described above.

CTS-VT's analytical testing capabilities include chemical analyses of a variety of matrices including aqueous, solid, waste, and air. A list of CTS-VT's facilities (floor plans) and capabilities (laboratory and sampling equipment) is provided in Appendix A. A list of the laboratory's analytical methodologies and field sampling and measurement capabilities is provided in Appendix B.

The laboratory operates under the various state guidelines and operates under the rules and regulations of the following federal programs:

Clean Air Act
Clean Water Act
Comprehensive Environmental Response, Compensation, and Liability Act
Perry Johnson Laboratory Accreditation, Inc. Troy, MI
Resource Conservation and Recovery Act
Toxic Substances Control Act
TNI-National Environmental Field Activities Program
TNI-National Environmental Laboratory Accreditation Program

A list of the certifications and approvals held by the laboratory is provided in Appendix C. Original and current certificates are posted in the laboratories and available upon request from the QA Department.

1.2 Purpose

The purpose of the quality systems manual (QSM) is to establish the framework and assign responsibilities to ensure that the staff conforms to policy. This manual outlines how that system enables all laboratory staff to meet CTS-VT’s quality assurance policy and objectives. Additionally, this manual is used to inform users of the laboratory and field services of the quality practices in place. The framework on quality policies and procedures, and the Quality Systems Manual (QSM) are in accordance with the International Organization for Standardization (ISO) / International Electrotechnical Commission (IEC) 17025 Standard (ISO/IEC 17025:2005), The NELAC Institute (TNI)-National Environmental Laboratory Accreditation Program (NELAP), and TNI-National Environmental Field Activities Program (NEFAP) Volume 1. The laboratory and FSMO are accredited for part of their testing, calibration and sampling activities through Perry Johnson Laboratory Accreditation (PJLA) Inc., which operates in accordance with ISO/IEC 17011:2004.

The laboratory and FSMO have the responsibility and authority to operate in compliance with regulatory requirements in which the work is performed. In addition, the laboratory will operate in compliance with documented client requirements, when they do not conflict with regulatory requirements. The laboratory and FSMO will not enter into any client agreements that conflict with regulatory requirements. Where documented client agreements conflict with the policies and procedures given in this QSM but meet the regulatory requirements, the client agreement shall supersede the requirements in this QSM.

The QSM is reviewed annually for accuracy and updated as appropriate. The QSM is maintained by the Laboratory QA Manager and distributed under controlled distribution to all areas of the laboratory and MIP and Waterloo Profiler Services Team. It is the joint responsibility of the Laboratory QA Manager, the Laboratory Director and Executive Management to ensure that all staff working in these areas familiarize themselves with, and comply with, the procedures put forth in this QSM and associated documentation.

1.3 Scope

This QSM specifies the general requirements for the competence to carry out environmental tests, including sampling, where appropriate. Where the document uses the terms “must” and “shall”, this denotes required activities. Where a practice is described, this denotes guidelines as to how those activities are generally preformed. A more detailed description of an activity or procedure may be provided in CTS-VT’s standard operating procedures (SOPs). Note: CTS-VT staff will continue to work under applicable Stone SOPs during the transition to Cascade. Applicable Stone SOPs will be converted to Cascade format in future revisions. A master list of Stone’s SOPs, controlled documents and Accreditation Authority (AA) polices is provided in Appendix D. There is a firm commitment from all members of the laboratory and field sampling team to follow a comprehensive QSM. This commitment and dedication to quality is fully supported from the analytical chemist and field sampler to senior management in order to meet the objectives of our on-site analytical laboratory and field sampling services and to best serve our clients.

It is the policy of the company to discourage and reject all influence or inducements offered either by customers or suppliers which might adversely affect results or otherwise compromise the judgment or impartiality of the staff. It is the responsibility of the Laboratory Manager to inform customers and suppliers of this policy when necessary. In the event that any such influences or inducements are encountered, the staff members are instructed to inform management immediately. It is the responsibility of the Executive Management to take appropriate action to prevent recurrence.

2.0 References

See Appendix E

3.0 Terms and Definitions

See Appendix F

4.0 Organization and Management

4.1 Organizational Structure

CTS-VT's organizational structure is provided in Appendix G, Figure 4. The laboratory and field services are under direct supervision of Seth Pitkin, Group Officer and CTS National Director of Site Characterization Services, who reports to Michael Gray, CTS Senior Vice President of Technical Services.

The Laboratory Director has overall responsibility for technical operations of the laboratory, the Group Officer has overall responsibility for sampling services, and the Laboratory Quality Assurance (QA) Manager has overall responsibility for the quality system and its implementation. In the absence of the Laboratory Manager or Laboratory QA Manager, the technical directors will assume the responsibilities of the absent employee or delegate the responsibility to qualified personnel.

4.1.1 Roles and Responsibilities

The Laboratory QA Manager oversees the Quality Assurance Program within the laboratory and FSMO. In this way, objectivity in the evaluation of laboratory operations and sampling are obtained. The laboratory structure provides a means for communication from the analytical chemist up to the Senior Management. This organization facilitates the generation of data, several levels of data review, and the monitoring of the overall quality of the data produced in the laboratory before it is reported to the client. Resumes of key staff, experience and educational profiles for the entire analytical staff are available at the fixed facility in the employee's training record. These records are available upon request from the Laboratory QA Manager or the Office Manager.

The laboratory and FSMO have specific roles and responsibilities in producing a product of known quality. All appropriate personnel are expected to have a working knowledge of the QSM. A copy of the most recent QSM is available in the laboratory, and FSMO locations. It is expected that associates ensure that data are generated in compliance with this QSM. The responsibilities of certain key positions are detailed below.

The **Group Officer** is directly and ultimately responsible for ensuring data quality and providing direction at CTS-VT. Responsibilities include:

- Assist in leadership and management of services.
- Participate in development of overall CTS-VT Policies.
- Ensure that CTS-VT QA policies are followed.
- Provide general supervision and support for Laboratory Manager and Staff.
- Monitor projects that originate from services.
- Ensure commitment to the development and implementation of the management system
- Communicate to the organization the importance of meeting customer requirements as well as statutory and regulatory requirements including requirements in the ISO/IEC 17025:2005 standards.
- Communicate resource needs to Executive Management.
- Laboratory approved results signatory.

The **Laboratory Director** reports to the Group Officer and is responsible for all aspects of laboratory operation to ensure timely completion of all contractual obligations. Responsibilities include:

- Provide overall leadership and management of laboratory.
- Assist in development of overall CTS-VT Policies.
- Ensure that laboratory staff follows CTS-VT policies.
- Provide general supervision and support for laboratory staff.
- Propose project assignments and staff scheduling.
- Monitor and manage workload.
- Evaluate training requests and make recommendation to Group Officer, including requirements in the ISO/IEC 17025:2005 standards.

- Communicate resource needs to Group Officer or Executive Management.
- Laboratory approved results signatory.

The **Laboratory QA Manager** reports to the Laboratory Director and is responsible for the preparation, maintenance and implementation of the QSM. Responsibilities include:

- Maintain quality system under the ISO/IEC 17025:2005 and TNI/NELAC and TNI/NEFAP Standards.
- Authority for stopping, accepting or rejecting analytical data, method modifications, QA programs and QC criteria.
- Conduct internal system and data audits to monitor laboratory compliance with the QSM and SOPs.
- Provide assistance in the development of laboratory management documents including SOPs as well as control, revision and distribution thereof.
- Identify areas where corrective action is required and then ensure implementation and completion of the resulting action.
- Oversee laboratory participation in performance evaluation programs.
- Act as point of contact regarding QA matters for the laboratory and Management.
- Laboratory approved results signatory.

Project Scientists and/or Project Manager (PMs) are instrumental in assisting both the laboratory and the client during the course of a project and often fulfill the role of Project Manager or Analytical Chemist. Responsibilities include:

- Leadership role in project work and development.
- Coordination of laboratory services directly with clients.
- Understanding contractual requirements and effectively communicating client needs to laboratory personnel including requirements in the ISO/IEC 17025:2005 standards.
- Notification of clients regarding specific non-conformance, changes or difficulties encountered within the laboratory.
- Investigation of problems with samples and shipping containers received from the field.
- Monitoring of analytical work progress.
- Lead report writing for projects managed.
- Laboratory results signatory.

Analytical Chemists/Technical Directors are responsible for the generation of data by analyzing samples according to written SOPs and state regulations. Responsibilities include but may not be limited to:

- Manage and perform analytical analysis as coordinated with the client and the project scientist or manager.
- Maintain a thorough understanding of the QSM and the SOPs associated with their

specific function including requirements in the ISO/IEC 17025:2005 standards.

- Sample Login / Sample Custodian
- Ensure that all steps related to sample analysis are documented completely and accurately.
- Perform initial review of raw data with the authority to stop, accept or reject data based on compliance with well-defined QC criteria.
- Provide prompt notification to the Director or Laboratory QA Manager of problems or anomalies detected.
- Monitor and maintain standard laboratory equipment such as refrigerators, ovens, water systems as necessary.
- Report writing and statistical analysis of data.
- Implementation of proper sample receipt procedures and sample preservation.
- Implements, completes and/or reviews external and internal chain-of-custody, as appropriate.
- Communicates and records anomalies associated with condition upon receipt of samples to the Project Scientist or Manager.
- Assigns laboratory identification number (if applicable) to a sample and logs the sample into the Laboratory Information Management System (LIMS).
- Secures sample storage and preservation.
- Assists Health and Safety Site Officer with sample disposal.
- Reviews storage monitoring records.
- Compiles analytical reports and provides data package and electronic deliverables according to the client request.
- Ensures that all aspects of data deliverable production, organization, contract compliance screening, archival storage, packaging and data delivery operations are performed according to the client requirements.
- With proper data review and secondary review signature, laboratory results signatory (as secondary reviewer).

Health & Safety Officer is responsible for administering the Corporate Health &Safety (H&S) program in order to provide a safe, healthy working environment for all employees. The H&S Officer responsibilities include the monitoring of all work areas to detect unsafe conditions, acts, and potential hazards, enforcement of environmental, health, and safety policies and procedures and ensuring regulatory compliance with local, state, and federal laws. The H& S Officer provides safety and health recommendations to laboratory management in conjunction with the facility safety committee, develops the facility Contingency Plan, Site Specific Health and Safety Plans and task hazard forms.

5.0 Quality System

5.1 Quality System Objective

The objective of this manual is to establish the framework and assign responsibilities to ensure that the staff conforms to this quality system. The goal of the laboratory's quality system is to ensure that business and technical operations are conducted with the highest standards of professionalism and ethics in the industry. To achieve this goal, it is necessary to provide our clients with the highest quality of service available in the industry as well as scientifically sound, documented, regulatory compliant data. The laboratory's quality system is designed to minimize systematic error, encourage constructive, documented problem solving, and to provide a framework for continuous improvement within the organization.

5.2 Quality Assurance Policy

CTS-VT's Policy Statement:

It is CTS-VT's policy that environmental data operations will result in the collection of data of known and documented quality, suitable for its intended use, and the environmental technology field activities will perform as specified. This quality policy applies to all data collected and environmental technology field activities performed by and for CTS-VT.

Continuous efforts toward improvement are built into every activity of the company including the laboratory. These improvements ensure that CTS-VT maintains a high-quality, efficient mobile testing facility.

5.3 Commitment to Quality Assurance

CTS-VT Management is committed to providing the highest quality environmental services in the industry. To ensure that the data produced and reported by CTS-VT meet the requirements of its clients and comply with applicable municipal, state and federal regulations, CTS-VT maintains a Quality System that is clear, effective, well communicated and supported at all levels in the company.

5.4 Ethics and Data Integrity

One of the most important aspects in assuring the highest level of data quality is a highly qualified, ethical and professional staff. Establishing and maintaining a high ethical standard is an important element of a Quality System. Each employee is trained in the prevention and detection of improper, unethical, or illegal actions in their initial orientation training program that includes a review of the ethics statement, and discussions about data integrity and repercussions that result from data misrepresentation. CTS-VT has developed a Data Integrity Training Module which outlines all data integrity procedures, training, and documentation, as well as in-depth data monitoring. Employees are required to understand that any infractions of the laboratory data integrity procedures will result in a detailed investigation that could lead to very serious consequences including immediate termination, debarment or civil/criminal prosecution. The initial data integrity training and the annual refresher training has a signature page which is signed and filed along with an ethics agreement, which demonstrates they have participated and that they understand their obligations related to data integrity. Specific examples of breaches of ethical behavior are discussed in the training module, including improper data manipulations, adjustments of instrument time clocks, and inappropriate changes in concentrations of standards. Data integrity training emphasizes the importance of proper documentation by the analyst in cases where analytical data are partially deficient, but may still be useful. Additionally, each employee is encouraged to discuss any fraud or unethical behavior with their Management and/or the Laboratory Director or Laboratory QA Manager.

Data integrity is monitored by various measures that include but are not limited to; secondary and tertiary data review, internal audits including data authenticity audits, electronic data audits and other special audits. A data integrity review is performed on all Level IV data packages during the secondary data review process. At the completion of the Level IV data review and data integrity audit, the data integrity checklist will be completed along with the secondary data review checklist. See Appendix H.

Violations of the ethics policy will not be tolerated. All suspected violations will be investigated by the Laboratory QA Manager or a designee. Employees who violate the policy will be subject to disciplinary action up to and including termination. Criminal violations may also be referred to the government for prosecution.

In the event that a data integrity or ethics violation casts doubt on the validity of results submitted to a client, CTS-VT will notify the client in writing within 15 days of discovery of any resulting invalid results. This communication will include an explanation of how their data were affected and a corrective action plan and timeframe for completion. Revised final deliverables, if necessary, will typically be submitted to the client within 30 days from the time of discovery; however, in situations where data reprocessing may be extensive, CTS-VT may work with the client to establish a longer timeframe for delivery of revised data deliverables.

5.5 Ethics Policy

In order to ensure that all personnel understand the importance the company places on maintaining high ethical standards at all times, CTS-VT has an Ethics Agreement (Appendix H-Forms). Each employee signs the Ethics Agreement upon initial training and annually thereafter, signifying agreed compliance with its stated purpose. Ethics is also a component of the training program.

5.6 Personnel and Training

It is the policy of the company to employ permanent and part time staff that are appropriately qualified and/or trained to perform their respective duties. Where, for commercial reasons, it is necessary to employ temporary staff, the laboratory ensures that the same criteria as those governing permanent staff apply with respect to training and qualifications. In order to ensure that employees have sufficient education and experience to perform a particular task, job descriptions are developed for all personnel.

Personnel training procedures begin with an established initial orientation program designed to familiarize the new staff with health, safety and chemical hygiene issues, the importance of quality assurance/quality control in the analytical laboratory, ISO/IEC 17025:2005 standards and company policies and benefits. The basic elements of the orientation and training program are outlined in the Orientation and Training of SEI Staff Standard Operating Procedure (SEI-1.1.n).

The level of training necessary to perform analytical tasks and sampling is determined from employee's academic background and past experience, technical courses, and on-the-job training with specific methods or instrumentation. The responsibility for formal academic training lies foremost with the individual. The responsibility for the additional specialized skills obtained through in-house training or external workshops is a shared obligation of the individual, their Group Leader, and the laboratory. An individual's academic and professional experience is kept on file including an initial statement of qualifications or resume and any additional documentation concerning subsequent training. Copies of certificates of completion, transcripts, diplomas, or other documentation may be included in the training files as appropriate.

In order to ensure that the policies and objectives of this QSM are communicated to all new personnel, the staff is required to read this QSM during the training process. This training is documented on the Procedure Specific Training Log (Appendix H: Forms) and included in the training files of each staff. Training records are available for inspection at the fixed facility in Montpelier, VT.

Trainees are under the supervision of experienced analysts who are responsible for showing them the analytical procedures including applicable QA/QC measures. A new analyst is not permitted to perform an analysis until the Laboratory Manager is confident that the analytical and QA/QC procedures can be carried out correctly and method proficiency is documented. Each technical employee shall also have documentation of demonstration of capability (DOC) and continued proficiency for each test method performed.

Each technical employee must complete the DOC prior to independent analysis on client samples. The DOC study may be performed by analysis of four replicate QC (Laboratory Control) samples with acceptable results for precision and accuracy. Additionally, each technical employee must demonstrate continued proficiency at least once per year by one of the following:

- Acceptable performance of a blind sample;
- Another demonstration of capability:
- Successful analysis of a blind performance sample on a similar test method using the same technology.
- Analysis of at least four consecutive laboratory control samples with acceptable levels of precision and accuracy.

If the above options cannot be performed (i.e. spiking is not an option), analysis of field samples with results that are statistically indistinguishable from those obtained by another analyst may be used to satisfy the requirement for ongoing proficiency. A DOC Certification Statement is recorded and maintained in the employee's training file. Appendix H - Forms shows an example of a DOC Certification Statement.

CTS-VT's Vermont facility is equipped with many structural safety features. Each staff is familiar with the location, use, and capabilities of general and specialized safety features within their workplace. To protect staff from potential workplace hazards, CTS-VT provides and requires the use of certain items of protective equipment. These include safety glasses, protective clothing, gloves, respirators, etc. For a complete description of the types of personal safety equipment available and applicable to a particular workspace, refer to the Health and Safety Manual.

CTS-VT has a firm commitment to make sure that all analysts remain proficient in the tests that they perform. SOP's are reviewed at least every two years and analysts are required to read the latest version of the SOP and/or amendments.

5.7 Document Control

Security and control of documents is necessary to ensure that confidential information is not distributed and that all current copies of a given document are from the latest applicable revision. Unambiguous identification of a document is through a header placed on the top of each page. The header may contain the document name, revision number, revision date and number of pages.

The Laboratory QA Manager controls the following documents: Laboratory and Field Sampling Quality System Manual (QSM) and Standard Operating Procedures (SOP's). These documents require written approval by appropriate management prior to release in the company.

As approved revisions to controlled documents are prepared and distributed, outdated versions are removed and destroyed. The original copy of each revision is archived by the Laboratory QA Manager for reference purposes. Documents distributed externally (to clients, etc.) are not controlled unless specifically requested.

SOP's are written procedures for standardized methods (e.g., SW-846) and are supplied primarily to document specific laboratory procedures used to satisfy the general requirements specified in the individual methods and to explain any differences between the application of the established method and the published procedure. If any difference exists between CTS-VT's SOP and a standard method's specific procedures, method validation studies are performed to document the fact that the change does not adversely affect the applicability of the method. In general, every effort is made to adhere to the protocols of the standard method.

Standard Operating Procedures (SOP's) contain the basic procedures and practices the laboratory uses to analyze a method. These procedures provide a basis for training new associates and for showing customers how analyses are performed. The master list of all Stone SOP’s is found in Appendix D.

5.8 Request, Tender, and Contract Review

Many environmental sampling and analysis programs do not necessarily “fit” into standard laboratory service or product as noted in the TRIAD approach to environmental planning. It is CTS-VT’s intent to provide standard and customized environmental testing and field services to our clients. To ensure project success, a thorough review is conducted by the technical staff of technical and QC requirements contained in contracts and scope of services. Contracts are reviewed for adequately defined requirements and the laboratory’s capability to meet those services. The Group Officer or his designee, with input from the Laboratory Director, considers available resources and both current and pending workload prior to accepting new work. If the laboratory determines it has the ability to perform the work, a Project Scientist is assigned and a quotation is prepared.

Contract review or scope of services shall include a review of the client’s requirements in terms of compound lists, test methodology requested, sensitivity, accuracy, and precision requirements. The Project Scientist or Project Manager ensures that the laboratory’s test methods and field services are suitable to achieve these requirements and must ensure that the laboratory holds the appropriate accreditations and approvals to perform the work. The review also includes the laboratory’s capabilities in terms of turnaround time, capacity, and resources to perform the work, including documentation capabilities both hardcopy and electronic.

All contracts and scopes of service entered into by CTS-VT shall be reviewed and approved by the Group Officer or Executive Management. Any contract requirement or amendment to a contract or scope of services communicated to the laboratory verbally must be documented and confirmed with the client in writing. Any discrepancy between the client’s requirements and the laboratory’s capability to meet those requirements is resolved in writing before acceptance of the contract. Contract amendments and scope of services adjustments initiated by the client and/or CTS-VT, are documented in writing or in an e-mail for the benefit of both the client and the laboratory. CTS-VT also completes an on-site laboratory startup form documenting specific project requirements such as frequency of QC and other variables such as required deliverables (See Appendix H-forms)

Any documentation between the client and CTS-VT pertaining to the scope of services such as Quality Assurance Plans, Sampling and Analysis Plans, contract amendments, and documented communications shall become part of the permanent project record.

5.9 Subcontracting

CTS-VT's mobile laboratories do not subcontract on-site analytical services. CTS-VT's laboratory has backup systems in place to ensure that samples for CTS-VT's analytical methodologies are not subcontracted. If while on site, other analytical parameters are required, then the samplers will ship the samples directly to the fixed laboratory. CTS-VT's mobile laboratory does not take other samples into their facility and package them up for other parameters. CTS-VT's other service groups and field samplers contract laboratory services and those services are contracted directly with the environmental laboratory. It is the responsibility of the project manager and client contracting with an environmental laboratory that the laboratory is competent to perform the tests requested at a level equivalent to the requirements of NELAP and DOD ELAP / ISO/IEC 17025:2005. All contracting and subcontracting (if requested) is arranged with the documented consent of the client. The QC guidelines specific to the client's analytical program must be transmitted to the contractor and agreed upon before shipment of samples to the contract facility. Details regarding the laboratory agreement and their SOPs are typically outlined in the site specific Quality Assurance Project Plan. Where feasible, a contractor or sub-contractor may be assessed by CTS-VT's Laboratory QA Manager either through an on-site visit or by the submission of sufficient documentation to determine the subcontractor's capabilities and qualifications. This documentation may include, but is not limited to: laboratory QSM, SOPs, recent proficiency test sample results and relevant certifications. Such documentation is filed with the project files or as with certain programs filed with the Laboratory QA Manager and/or his or her designee.

In an emergency if CTS-VT had to contract on-site analyses, CTS-VT would not subcontract any samples without permission from the client. When permission is granted, samples are shipped to a subcontracting firm and the results of the analyses are transmitted back to CTS-VT for review. These results are synthesized into a final report, documented as subcontracted and presented to the client.

5.10 Procedures for Addressing Client Complaints

This procedure provides guidance for investigation of any client or regulatory agency's technical complaint. That is, complaints concerning the validity of the laboratory's test result or test methods or the interpretation of a client's technical specification. Complaints may originate in written form or verbally. All complaints are documented and investigated by the Project Manager. The Laboratory Director is responsible for working together with the Project Manager to investigate and resolve the complaint. Depending on the complexity and severity of the complaint, the QA Manager and Project Officers may be called upon to resolve the issue. In cases where the complaint relates to data quality or the quality system, an internal audit is conducted by the Laboratory QA Manager. The SOP titled "Client Inquiries, Data Revision Requests & Complaint Resolution" (SEI-8.4.n) provides approved detailed procedures to CTS-VT's staff. In addition, all complaints and non-conformances are logged into our corrective action program and assigned a NCR number for follow-up.

5.11 Client Confidentiality and Proprietary Rights

It is CTS-VT's policy not to release any information pertaining to projects, except to the client who submitted the samples or who is responsible for payment without the consent of the client. Data and sample materials provided by the client or at the client's request, and the results obtained by the laboratory are held in confidence (unless such information is generally available to the public or is in the public domain or client has failed to pay CTS-VT for all services rendered or is otherwise in breach of the terms and conditions set forth in the CTS-VT and client contract) subject to any disclosure required by law or legal process. Laboratory reports and the data and information provided therein, are for the exclusive use and benefit of client, and are not released to a third party without written client consent. Prior to release of any information to a third party, CTS-VT staff must obtain written consent from the original client. This release may be transmitted via facsimile, but must be on the client company letterhead.

5.12 Service to Client

CTS-VT assigns a Project Manager (PM) to each client to ensure that the project specific and technical requirements are effectively communicated to laboratory personnel during all project phases. The PMs are available to assist any client with the project planning process in order to develop a customized analytical program. The laboratory also encourages clients to visit the facility and hold formal or informal meetings in order to become acquainted with laboratory staff and to provide an open forum for effective communication of project specific details. In order for the laboratory to produce data of known quality suitable for the intended use; communication and understanding of the project data quality objectives (DQOs) is essential.

5.12.1 Project Specific Quality Planning

Communication of contract-specific technical and QC criteria is an essential activity in ensuring the success of site-specific testing programs. The PM is the first point of contact for the client. It is the PM's responsibility to ensure that project specific technical and QC requirements are effectively communicated to the analytical chemist at the bench level before and during the project. CTS-VT employs its Project Planning Tool and its LIMS-based Laboratory Project Startup Information Form (See Appendix H) to communicate client- and/or project-specific requirements.

5.12.2 Data Quality Objectives

The data quality objectives discussed below ensure that data are gathered and presented in accordance with procedures appropriate for the intended use, and that the data are of known and documented quality able to withstand scientific and legal scrutiny. The quality of the measurement data is defined in terms of precision, accuracy, representativeness, completeness, comparability, and traceability.

Precision measures the reproducibility of measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Total precision is the measurement of the variability with the entire sampling and analysis process. It is determined by analysis of duplicate or replicate field samples and measures variability introduced by both the laboratory and field operations. Duplicate samples and matrix spiked duplicate samples are analyzed to assess field and analytical precision, and the precision measurement is determined using the relative percent difference (RPD) between the duplicate sample results.

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error. It therefore reflects the total uncertainty with a measurement. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike or standard. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into a laboratory control sample (LCS) to a control limit. For volatile and semivolatile organic compounds, surrogate compound recoveries are also used to assess accuracy and method performance for each sample analyzed.

Representativeness is defined as the degree to which a single measurement is indicative of the characteristics of a larger sample or area. More specifically, it is the degree to which the data gathered by the project accurately and precisely represents the actual field conditions. The laboratory makes every effort to ensure a representative aliquot is removed from the sample container. Homogenization of the sample is carried out when appropriate.

Completeness is defined as the percentage of measurements that are judged to be valid measurements. Factors negatively affecting completeness include sample leakage or breakage in transit or handling and failure to meet specified holding times. Completeness can be compromised by improper handling, by improper documentation such that traceability is compromised, or by rejection of sample results due to a failure to conform to QC criteria specifications. Typically, a completeness objective of at least 90% of the data for on-site analyses or as specified by the statement of work is the goal established for most projects.

Comparability of results between current and past sampling events, and between analytical sequences of a method is achieved through Quality Assurance Project Plans (QAPP), controlled SOP’s, and experienced, well trained analysts.

Traceability is the extent to which reported analytical results can be substantiated by supporting documentation. Traceability documentation exists in two essential forms: those, which link the quantitation process to authoritative standards, and those, which explicitly describe the history of each sample from collection to analysis and disposal. The traceability goal for the laboratory is 100%.

5.12.3 Estimation of Uncertainty of Measurements

The components of analytical variability (uncertainty) can be estimated when QC samples of the right type and at the appropriate frequency are incorporated into the measurement process. CTS-VT uses numerous QC samples to obtain data for comparison to analytical DQOs and to ensure that the measurement system is working properly. The QC samples and their application as mentioned above are based on regulatory, method or client specific requirements. As outlined in Section 12.1 QC samples for inorganic and organic analyses may include calibration blanks, instrument blanks, method blanks, laboratory control samples, calibration standards, matrix spikes and surrogate spikes.

The methods that CTS-VT typically performs are well established and works within the published acceptance limits of the methods as recorded in the standard operating procedures. If necessary to establish uncertainty limits on non-routine methods, CTS-VT would employ the use of statistical control charts which provide a means for long-term trend analysis as well as a tool for real time data assessment. Statistical control charts may be prepared for most routine methods and matrices analyzed by the laboratory after accumulation of at least 20 data points (at least 30 data points for DoD ELAP accredited methods). The % recovery of laboratory control samples, matrix spikes and surrogates are monitored and charted only if necessary and as required by the client. The relative % difference (RPD) of laboratory duplicates is also monitored and charted as necessary.

Control limits derived from laboratory data are calculated in terms of multiple standard deviations from a mean or other reference point. Warning limits are set at ± 2 standard deviations and control limits are set at ± 3 standard deviations. Initial limits are established after a minimum of twenty data points is available. Once established, the control limits are updated at least annually. If method specified limits are available, the calculated control limits are compared to them. The laboratory adopts method-specified limits whenever available rather than use laboratory generated limits for actual evaluation of data as the laboratory limits may be too narrow for the overall site data quality objectives. This provides consistency over time, particularly for ongoing projects. In cases where acceptance limits are not specified in methodology, laboratory generated control limits are used for data evaluation if requested by the client.

In addition to control limits, control charts are used to determine if trends are occurring. Data points consistently above or below the mean or points becoming steadily high or low over time indicate the occurrences of trending or bias in the procedure. Investigation and corrective action is taken if these situations are observed.

5.13 Nonconformance and Corrective Actions

A nonconformance is typically defined as an unplanned deviation from an established protocol. An occurrence of a nonconformance may be the result of CTS-VT's actions, which would be rendered as a deficiency, or the result of events beyond CTS-VT's control, which would be termed an anomaly. All nonconformances or deviations are documented in an access database and numbered.

Deviations from the QSM or SOPs, deficiencies, errors, or out-of-control situations require corrective action. Documentation of the problem, identification of the cause and follow-up action to prevent recurrence is accomplished through the use of this documentation.

Any individual who detects the need for corrective action is responsible for initiating the report using the NCR Form found in Appendix H. Corrective action procedures or deviations may be initiated and are often completed at all levels of the laboratory. If the person initiating the report is uncertain as to what would constitute appropriate corrective action or is unable to resolve the situation, they identify the problem and submit the incomplete report to their Laboratory Manager, the Project Scientist/Manager or the Laboratory QA Manager who is then responsible for resolution. The procedure for the corrective action at this level starts with an investigation to determine the root cause(s) of the problem.

All completed corrective action reports and/or deviations are submitted to the Laboratory QA Manager within 30 days. The Laboratory QA manager is responsible for review and follow up to determine if the corrective action is sufficient, effective and fully implemented with the completed corrective action performed within 90 days. Completed reports are maintained on file in the QA department. Copies of corrective action reports or deviations that are specific to a sample or set of samples will also be filed with the supportive documentation and discussed in each appropriate case narrative.

5.13.1 Correction of Erroneous Reports

The discovery of an erroneous report or of an event that casts doubt on the validity of results submitted to a client elicits immediate corrective action to rectify any errors. If the error is discovered internally, then the client is notified in writing within 15 days by the Project Manager or Laboratory QA Manager. This communication will include an explanation of the error and a corrective action plan and timeframe for completion. If a client or validator has a question or finds a deficiency concerning a data submittal, the Project Manager is responsible for communicating and implementing the corrective action in the laboratory within 30 days. The analytical results and all supportive documentation in question are submitted to the appropriate section for evaluation.

When necessary, revision of the case narrative and/or other data deliverables is the responsibility of the Project Manager or Laboratory QA Manager. Should reanalysis be necessary, it is initiated in writing. Revised final deliverables are typically submitted to the client or validator by the Project Manager or Laboratory QA Manager within 30 days from the time of discovery of the error. However, in situations where data reprocessing may be extensive, CTS-VT may work with the client to establish a longer timeframe for delivery of revised data deliverables.

In some instances, clients request that sample handling information; recalculations or qualitative judgments are re-checked in order to ensure data integrity. In this case, resubmission of the data may not be necessary unless a problem is detected. The Project Manager brings customer problems that persist in the laboratory to the attention of the Laboratory Director and/or Laboratory QA Manager.

5.14 Preventive Action

In order to prevent system down time, minimize corrective maintenance costs and ensure data validity, the laboratory employs a system of preventive maintenance. General preventive maintenance procedures, many of which are unique to particular instruments, are outlined in each instrument’s operation manual. All routine maintenance is performed as recommended by the manufacturer. The manuals also assist in the identification of commonly needed replacement parts, so that an inventory of these parts can be maintained at the laboratory. It is the Laboratory Director’s responsibility to make sure that the most current version of the operator’s manual is available in the laboratory. The on-site analytical chemist performs routine maintenance while external technicians may be called in for major repairs.

A bound maintenance and repair log notebook is kept with each instrument to record all routine and non-routine maintenance. Notation of the date and maintenance activity is recorded every time service procedures are performed. This includes routine service checks by laboratory personnel as well as factory service calls. The return to analytical control following instrument repair is also noted in laboratory maintenance logbooks. If a non-conformance resolution results in a preventive action then an NCR form is completed, logged into the access database and followed up with a preventive action.

5.15 Quality System Review by Management

A review of the quality system is conducted annually. Management, including but not limited to the Executive Management, Laboratory Managers and QA Manager, review all aspects of the quality system. The purpose of this review is to ensure the suitability and effectiveness of CTS-VT’s program as well as provide opportunity for improvements. The review includes the following topics:

- Reports from audits by clients and regulatory agencies
- Reports from internal audits
- Results of proficiency studies
- Corrective actions from the past year and a review of their implementation
- Details of complaints from clients and their resolution
- Training goals and objectives
- Staff, facility and equipment resources
- Future plans and goals
- Monthly Operations Report to Management

In addition to this annual review, a monthly report and staff meetings occur to communicate issues and needs which arise during the course of operations.

5.16 Audits Types and Frequency

There are several different types of audits performed at CTS-VT. Technical system audits are designed to assess the adequacy of a selected system in meeting CTS-VT objectives.

5.16.1 System audits

System audits are technical in nature and may be performed by the Laboratory QA Manager as an internal audit or by a client or regulatory agency for certification or approval. System audits cover all aspects of the laboratory, both operational and support. These audits are performed annually.

The Laboratory QA Manager shall issue the audit report within 60 days of the audit. The audit report is addressed to the Laboratory Director and Group Officer.

Written responses are required by the Laboratory Director within 60 days of receiving the audit report and the audit response should follow the format of the audit report, and corrective actions and time frames for their implementation are included for each deficiency. If a corrective action requires longer than sixty days to complete, the target date for the corrective action implementation is stated and evidence of the corrective action is submitted to the Laboratory QA Manager in the agreed upon time frame.

5.16.2 Data Audits

Data audits are performed to assess the quality of results reported to clients. If the results of an audit (either internal or external) indicate that a client’s analytical results are questionable the client is notified in writing by either the Project Scientist/Manager or the Laboratory QA Manager. The laboratory then works with the client and makes every attempt to resolve the issue (i.e., by revising a report, reanalysis of the sample, etc.). Typically, the data audits are performed quarterly.

Records of the data audits are kept, and the frequency of the data audits shall be included in the QA Binder found in the QA Department or electronically on the CTS-VT server.

5.16.3 Special Audits

Special Audits are conducted on an as needed basis, generally as a follow up to a specific issue such as client complaints, corrective actions, proficiency testing results, data audits, system audits, third party assessments and/or regulatory audits. Special audits are performed for a specific issue and report format distribution and timeframes are designed to address the nature of the issue.

5.16.4 External Audits

To become a participant in state and federal accreditation programs, the laboratory may be audited by representatives of regulatory agencies or an accreditation body such as PJLA. Any audit findings or non-conformances are formally documented by the Laboratory QA Manager and submitted to the laboratory for corrective action. The laboratory is required to respond with corrective action to the audit findings and recommendations of the regulatory agencies before accreditation for a particular program can be granted. The Laboratory QA Manager conducts follow up audits to verify that corrective actions have been implemented. Observations made during these follow up audits are submitted to the appropriate representatives of the regulatory agency.

5.17 Proficiency Testing (PT)

The laboratory participates in internal and external laboratory check sample programs as a means for examining overall laboratory performance as well as to qualify for various federal and state certification programs. Internal or intra-laboratory check sample programs include the submission of blind samples that are carried through normal procedures. The following external or inter-laboratory check sample programs are the typical ones employed to demonstrate analytical proficiency for purposes of monitoring overall laboratory proficiency or to provide proof of acceptable performance for certification or accreditation programs by outside agencies or regulatory bodies:

National Environmental Laboratory Accreditation Program (NELAP) and Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) Semi-annual Proficiency Testing Programs.

The NELAP proficiency-testing program is an extensive and comprehensive check sample program. Private approved vendors administer the program under the direction of the EPA (WP or WS or HW designations). Participating laboratories receive reports detailing acceptability of their reported results and must provide corrective action responses to State Agencies regarding any results that are outside of the control limits. CTS-VT participates in both the WP and HW programs and performs at least two PTs a year for the WP and HW programs. CTS-VT must pass two PTs out of three within an eighteen month period. When PT samples for a given analyte-matrix-method combination cannot be obtained from any PT provider and the analyte-matrix-method combination is required for a scope of accreditation, inter-laboratory comparison studies may suffice.

5.18 Records

The laboratory retains all records related to sample analysis including raw data, calculations, derived data, calibrations and test reports. These records are maintained in a systematic manner for a minimum of seven (7) years unless other noted and outlined in the SOP, *Document Control, Record System and Archiving (SEI-7.2.n)*. Longer periods of storage may be arranged at the time of project initiation.

Mistakes are never erased, deleted or written over. They are corrected by drawing a single line through the error and entering the correction alongside. The correction is then initialed and dated by the responsible person and if applicable the reason for the change is documented as a footnote as outlined in the SOP *Data Handling, Storage, Retrieval and Error Coding (SEI-4.3.n)*.

Each log book page or, as required, each entry is dated and initialed by the analyst at the time the record is made. Pages inserted into logbooks are stapled to a clean, bound page (if using a bound notebook). Specific information on the types of logbooks, format of entry, and other pertinent information are contained in the appropriate sectional SOPs.

The Laboratory Director or his/her designee periodically reviews laboratory notebooks for accuracy, completeness, and compliance. If all entries on the pages are correct, then the Laboratory Director or his/her designee initials and dates the reviewed pages. Corrective action is taken for erroneous entries before the Laboratory Director or his/her designee signs off with their approval.

5.19 Computer, Electronic Data Security and Traceability

Access to computer systems that collect, analyze, and process raw instrumental data, and those that manage and report data must be both controlled and recorded. There are various systems at the laboratory to which this applies, which include the Laboratory Information Management System (LIMS), as well as specific systems such as a chromatography data system.
System users are granted privileges that are commensurate with their experience and responsibilities. Computer access must be tracked by using unique login names and passwords for all employees that have access to the computer system. “General” or “multi-user” account access to computer systems that collect, analyze and process raw instrumental data, and those that manage and report data should not be permitted. Entries and changes are documented with

the identity of the individual making the entry, and the time and date. Where a computer system is processing raw instrumental data, the instrument identification number is recorded. Many of these systems, such as the ChemStation has the capability of maintaining audit trails to track entries and changes to the data. This function shall be activated on any computer system that has that capability.

All commercially obtained software shall be verified prior to use and after version upgrade. Verification involves assessing whether the computer system accurately performs its intended function. Verification generally is accomplished by comparing the output of the program with the output of the raw data manually processed, or processed by the software being replaced. The records of the verification are required to contain the following information: software vendor, name of product, version, comparison of program output and manual output, raw data used to verify the program, date, and name of the individual performing the verification. Records of verification are retained.

Whenever possible the laboratory establishes standards for computer systems and peripheral equipment. In instances, where a vendor-provided solution is bundled with hardware and software, the vendor certifies that the proposed hardware is readily operable with existing hardware platforms, and will provide operating and maintenance instructions. CTS-VT staff or trained vendor technicians configure computer system hardware. Major hardware items include systems used for data collection, multi-user file servers, and multi-user printers.

Prior to release for production, use of any in-house developed software is considered under development. Software is validated prior to release. Validation of software consists of testing the output of the software based on sample input data, and comparing the output with independently calculated results.

CTS-VT employs the use of anti-virus software to detect and remove viruses from software.

5.19.1 Archives and Record Transfer upon Facility Change or Ownership Transfer

Archives are indexed such that records are accessible on either a project or temporal basis. Archives are protected to the degree possible against fire, theft, loss, deterioration, and vermin. Electronic records are protected from deterioration caused by magnetic fields and/or electronic deterioration. Access to archives is controlled and documented by the archivist.

CTS-VT ensures that all records are maintained as required by the regulatory guidelines and per the SOP (SEI-7.2.n) upon facility location change or ownership transfer. CTS-VT location change, all archives are retained by CTS-VT in accordance with the SOP. Upon ownership transfer, record retention requirements are addressed in ownership transfer agreement and the responsibility for maintaining archives for maintaining archives is clearly established.

5.19.2 Departures from Policies

Departures from laboratory standard operating procedures are not permitted unless the approval of the Laboratory Director or the Laboratory QA Manager is obtained prior to implementation of the departure. These exceptions must be documented with a SOP deviation and/or highlighted in the analytical logbook, which accompanies the analytical results. If a client requests a departure from the laboratory's policies or procedures, the Project Scientist/Manager notifies the Laboratory QA Manager who then discusses the steps necessary to implement such a departure with the Laboratory Director and appropriate laboratory analytical chemists. If necessary and appropriate method validation studies and method detection limit studies are performed as applicable.

5.19.3 Security

Because of the nature of CTS-VT's work, adequate security of the facilities, equipment, and project files is necessary. Access to the fixed facility and typically the on-site facility is controlled through a key system. Visitors register upon entering the building and are accompanied by a staff member while visiting. The Laboratory Director ensures that personnel are familiar with CTS-VT's security policies.

CTS-VT staff are familiar with and adhere to standards of confidentiality mandated by individual contracts and common sense business practices.

In addition, all of the CTS-VT staff has been instructed on ethics reflecting our belief that the cornerstone of any business relationship is ethical behavior and data integrity. This policy is a vehicle to reinforce our commitment to quality.

6.0 Facilities

6.1 CTS-VT Fixed Facility, On-Site Facility and Equipment

CTS-VT has a fundamental responsibility to provide facilities, equipment, maintenance, and an organized program to make necessary improvements to ensure a safe working environment.

The fixed physical layout of CTS-VT and a typical mobile laboratory layout are provided in Appendix A. The on-site laboratory will typically be approximately 250 square feet of floor space to house the equipment and two analytical chemists. Based on the size and scope of the on-site work plan, the size of the on-site laboratory will vary. The fixed facility and the mobile laboratory is compliant with all Occupational Safety and Health Administration regulations and are equipped with unique environmental controls including air flow monitoring, waste heat utilization, and security. In addition, the laboratory is outfitted with instrumentation exhibiting advanced technology and automation.

The fixed facility and the on-site laboratory facility have computer networking and centralized gas distribution to support its analytical services.

7.0 Laboratory Scope of Tests

The on-site or mobile laboratory performs USEPA standard field inorganic and USEPA standard organic analyses on various matrices including air, water, soil, and waste. Analyses follow acceptable protocols approved under applicable state and federal programs. Detailed descriptions of method procedures and reporting limits are maintained in the individual method SOP's. Appendix B of this QSM presents a summary of the laboratory and sampling methods performed by CTS-VT's on-site facility.

7.1 Reference to Test Procedures Used

The following list includes the sources for the majority of analytical methods referenced by the laboratory:

EPA SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, 3rd Edition, with Update I, Update II, Update IIA and Update III, December 1996.

APHA/AWWA/WPCF, Standard Methods for the Examination of Water and Wastewater, 19th Edition.

ASTM, American Society for Testing & Materials; Annual Book of Standards, 1986 through 1993 editions.

Plumb, Russell, USEPA Corps of Engineers, Procedures for Handling and Chemical Analysis of Sediment and Water Samples, May 1991.

7.2 Method Validation and Verification Activities

Methods performed at the laboratory are validated prior to sample analysis. Method validation may involve the determination of sensitivity and linearity and reproducibility studies. This would include but are not limited to: writing appropriate method SOPs and performing method detection limit studies.

Determination of Method Selectivity
Method selectivity should be demonstrated for the analyte(s) in the specific matrix or matrices. In some cases, to achieve the required selectivity for an analyte, a confirmation analysis may be required as part of the method.

Determination of Method Sensitivity
Method sensitivity is determined by method or instrument detection limit studies. The procedure

to determine the method detection limit (MDL) may follow 40CFR Part 136 Appendix B (revision 2.0). The reporting limit for a given analyte may be derived from the MDL. The MDL is used to determine the limit of detection (LOD) for each analyte and matrix as well as for all preparatory and cleanup methods routinely used on samples. After each MDL determination, the LOD is established by spiking a quality system matrix at a concentration of one to four times the MDL. This spike concentration establishes the LOD and the concentration at which the LOD shall be verified. It is specific to each suite of analyte, matrix, and method (including sample preparation).The MDL is verified for the method for each target analyte of concern in the quality system matrices. The validity of the MDL is verified by detection (a value above zero) of the analyte(s) in a QC sample in each quality system matrix. The validity of the MDL is verified as part of the LOD determination process. This verification shall be done prior to the use of the LOD for the sample analysis and then verified on an annual basis (on a quarterly basis for DoD ELAP accredited methods). For successful LOD verification, each analyte must meet all method requirements for analyte identification (e.g., signal to noise (S/N) ratio, ion abundance, retention time).

Determination of Limit of Quantitation (LOQ) or Reporting Limit (RL)

The MDL is the approximate limit at which an analyte can be qualitatively detected using a specific method at a 99% confidence interval. The MDL is a statistically calculated value and measures the sensitivity of an entire method and is independent of device. The Reporting Limit (RL) or Limit of Quantitation is the limit at which a compound can be qualitatively detected and quantified at a 99% confidence interval. The RLs or LOQ are also set based on specific knowledge about the analyte, project specific requirements and/or regulatory requirements. The RL is always greater than the MDL and is typically set based on 3-5 times the MDL or LOD.

The validity of the LOQ is verified by successful analysis of a QC sample containing the analytes of concern in each quality system matrix at 1 to 2 times the claimed LOQ. A successful analysis is one where the recovery of each analyte is within the laboratory established method acceptance criteria or client data quality objectives for accuracy. The LOQ is verified annually for each quality system matrix, technology, and analyte (verified quarterly for DoD ELAP accredited methods).

CTS-VT reports results to the sample specific RL's for a set of compounds as defined in the published methods. For most methods the low calibration standard is set at the laboratory RL to monitor method sensitivity per instrument per calibration. Sample specific RL's are derived by taking into account various sample specific data, which can include the amount of the sample subject to testing, percent moisture, dilution factors, interferences and the base RL's for the analysis.

In some cases, it is appropriate to report values between the MDL and the RL. In this region, an analyte can be qualitatively detected, but not accurately quantified. Any data point reported in this region is flagged with a “J” to indicate that it is an estimated value.

Determination of Range
Where appropriate, a determination of the applicable range of the method is performed. In most cases, range is determined and demonstrated by comparison of the response of an analyte in a curve to established and targeted criteria. The curve is used to establish the range of quantitation and the lower and upper values of the curve represent upper and lower quantitation limits. Curves are limited to linear relationships.

Determination of Interferences
A determination that the method is free from interferences in a blank matrix should be performed.

Determination of Capability
DOCs should be performed prior to method performance.

Determination of Accuracy and Precision
Accuracy and precision studies may be required as a separate determination from the DOC. Accuracy and precision studies are generally performed using four replicate analyses with the resulting percent recover and measures of reproducibility (standard deviation, relative standard deviation) calculated and measured against a set of target criteria.

Documentation of Method
The method should be formally documented in an SOP. If the method is a minor modification of a standard laboratory method that is already documented in an SOP, an SOP attachment describing the specific differences in the new method is acceptable in place of a separate SOP.

Continued Demonstration of Method Performance
Continued demonstration of method performance is addressed in the SOP by batch specific QA samples such as Laboratory control samples and method blanks.

7.3 Standard Operating Procedures (SOPs)

SOPs shall be written for all routine technical and administrative activities performed at CTS-VT. SOPs shall describe as necessary the analytical, QA/QC and operational protocol to be followed for each activity performed to reflect traceability of measurements. Employees must follow the procedures written in the SOP. Temporary deviations from an SOP may be necessary in order to meet the data quality objectives for a specific client or regulatory agency's request. Any department from the SOP will be documented in the project file.

CTS-VT maintains two types of SOPs: method and procedural SOPs. Method SOPs describe a specific test method. Procedural SOPs describe function and procedures not related to a specific analytical method. SOPs, at a minimum shall undergo review every 2 years. Where a SOP is based on a published method, the laboratory shall maintain a copy of the referenced method as well. SOPs are maintained on file at the fixed facility, electronically, and pertinent laboratory

SOPs are provided in each mobile laboratory and are available upon request.

Note: CTS-VT staff will continue to work under applicable Stone SOPs during the transition to Cascade. Applicable Stone SOPs will be converted to Cascade format in future revisions.

8.0 Equipment Inventory

A comprehensive list of major instrumentation available, Waterloo Profiling and Membrane Interface Probe (MIP) field equipment, along with supporting and miscellaneous equipment can also be found in Appendix A.

8.1 Support Equipment

Equipment that is necessary to support laboratory operations but that is not the actual test instrument is maintained in proper working order and verified annually against a NIST traceable reference standard of measurement, when available, bracketing the range of use:

- Refrigerator/Freezer Temperatures - Monitored daily when in operation using maximum/minimum digital thermometers
- Thermometer Calibration – Thermometer calibrations are verified annually against a currently certified (based on the manufacturer's expiration date), NIST-traceable thermometer.
- Balance Calibration – Balance calibration is checked daily or before use with two certified weights that bracket the range of use. Balance calibration is verified annually against certified weights that are calibrated on an annual basis by an outside vendor.
- Mechanic Volumetric Pipettes and Dispensers – Checked daily or prior to use bracketing the range of use and verified annually using a calibrated balance to verify mass of the dispensed volume.

The performance criteria used to determine acceptability of use will vary based on the needs of the application for which the equipment is being used. In general, the laboratory has established tolerance ranges for analytical support equipment in accordance with the criteria established by the American Society for Testing and Materials (ASTM). Records of calibration checks and verification of support equipment are retained along with records of repair or maintenance in the equipment maintenance log.

8.2 Procedures for Calibration and Verification

Calibration of instrumentation is required to ensure that the analytical system is operating correctly and functioning at the proper sensitivity to meet established reporting limits. Each instrument is calibrated with standard solutions appropriate to the type of instrument and the linear range established for the analytical method.

Method specific SOP's discuss in detail how each instrument is calibrated, including frequency for calibration and re-calibration, and the source or grade of the calibration materials. The range of analyses performed and instrumentation utilized is extensive and the calibration procedures are instrument specific, varying from analysis to analysis. The calibration procedures for organics usually include an initial system performance check and some type of initial calibration (with a minimum of five calibration standards for most methods) with each analytical series. On-going and closing calibration checks are also included in most analytical series. For each type of calibration standard or performance check there are specific criteria to meet before sample analyses begin. These criteria are established in the methodologies as they are written in the referenced texts or by contract specifications.

Gas Chromatography/Mass Spectrometry (GC/MS) - Prior to analysis of samples, the instrument is tuned with bromofluorobenzene (BFB) for volatile compounds and decafluorotriphenyl-phosphine (DFTPP) for semivolatile compounds or other tune criteria as specified by the method used. No samples are analyzed until the instrument has met the tuning criteria of the method.

In general, the instrument is then calibrated for target compounds. An initial calibration curve is produced to define the working range to establish criteria for identification. This initial calibration is evaluated on a daily basis to ensure that the system is within calibration. If the daily standard does not meet the established criteria, the system is recalibrated.

Gas Chromatography- Each chromatographic system is calibrated prior to performance of analyses. Initial calibration consists of determining the working range, establishing limits of detection, and establishing retention time windows. The calibration is checked as required to ensure that the system remains within specifications. In addition, continuing calibrations are performed at frequencies required by the method used. If the calibration checks do not meet established criteria, corrective action, which may include recalibration and reanalysis of samples, is taken.

Metals- Are typically performed in the field using HACH Kits. All applicable calibration requirements are defined in the instrument manual and as specified in the client's work plan.

Wet Chemistry - The field of classical (wet) chemistry involves a variety of instrumental and wet chemical techniques, for on-site measurements these tests are typically performed using designated kits. Calibration and standardization procedures vary depending on the system and analytical methodology required for a specific analysis. The calibration is checked on an ongoing basis to ensure that the system remains within specifications. If the ongoing calibration check does not meet established criteria, analysis is halted and corrective action is taken. The procedures include examination of instrument performance and recalibration and reanalysis of samples back to the previous acceptable calibration check.

9.0 Purchasing Services and Supplies

Evaluation and selection of suppliers and vendors is done, in part, on the basis of the quality of their products, their ability to meet the demand for their products on continuous and short term basis, the overall quality of their services, their past history, and competitive pricing. This is achieved through evaluation of objective evidence of quality furnished by the supplier, which can include certificates of analysis, recommendations and proof of historical compliance with the similar programs for other clients. To ensure that quality critical consumables and equipment conform to specified requirements, all purchases from specific vendors are approved by a member of the management staff.

Chemical reagents, solvents, gases, glassware and general supplies are ordered as needed to maintain sufficient quantities on hand. Purchasing guidelines for all equipment and reagents affecting data quality shall meet the requirements of the specific method and testing procedure and be well documented. Similarly, performance specifications are documented for all items of equipment having an effect on data quality. This includes type, age, and acceptance status of the item. Reagents are dated upon receipt and upon opening to establish their order of use and to minimize the possibility of exceeding their shelf life. Specifications for labeling reagents, solutions and standards are outlined in SOP SEI-4.7.n Labeling Reagents, Solutions and Standards.

Requests for equipment affecting the quality of analytical data are submitted in writing to the Division and Laboratory Director and/or Executive Management for technical approval. After approval, the requisition is submitted to the Executive Management for purchase approval.

10.0 Procedures for Traceability of Measurements

Balance calibrations are verified annually against a set of certified weights that is calibrated annually by an outside vendor. This verification is recorded in the Laboratory Support Equipment Log as well as on a label affixed to the balance. Balance calibrations are also verified on a daily basis prior to use using two traceable certified weights that bracket the range of use; the measured weight is recorded in a bound logbook specific to each balance. Any discrepancies are brought to the immediate attention of the Laboratory QA Manager. As necessary (when demonstrated by failure to calibrate), a technician services the balances. This service is documented on each balance with a signed and dated calibration stamp.

All thermometers and temperature probes are purchased with traceable calibration certificates. The Laboratory QA Manager maintains all thermometer calibrations. On a daily basis when in use, the temperature readings of the refrigerators and other temperature-controlled equipment are recorded in the monitoring logbook by lab staff. Each thermometer's calibration is verified annually at two temperature points against a thermometer with a current calibration certificate. Sample storage refrigerators are typically maintained at <10 and >0°C.

Traceability of measurements is assured through the use of a system of documentation and analysis of testing materials. The supplier as to their accuracy certifies all standards used in the calibration of instrumentation. The laboratory maintains these certificates of analysis. The preparation of all standards is recorded in Standard Preparation Logbooks. Information to facilitate traceability is included in this documentation. All standard and reagent labels must contain the following information: solution ID, concentration, date of preparation, initials of preparer and expiration date.

The elements of the laboratories standards and reagents traceability program are outlined in the following SOP: *Labeling Reagents, Solutions and Standards (SEI-4.7.n).*

11.0 Sampling - Procedures for Handling Test Items – Sample Custody

Sample representativeness and integrity are the foundations upon which meaningful analytical results rely. A documented and approved sampling plan reflecting data quality objectives should be in place at the sampling site. To prevent the deterioration of sample integrity, the samples should be maintained through the use of preservation techniques specified in Section 8.2 of SOP *The Determination of Volatile Organic Compounds by Gas Chromatography / Mass Spectrometry (GC/MS) (SW846 USEPA Method 8260C) (*SEI-10.15.n). If necessary, samples should be submitted to the laboratory under standard chain-of-custody procedures as outlined in the SOP *Chain of Custody Records (SEI-4.2.n)*. Typically, for on-site laboratory work the samples are submitted directly from the field to the lab and documented in the laboratory upon receipt.

A designated analytical chemist receives samples at the laboratory. The analytical chemist removes the samples from the cooler (if applicable) and compares the sample labels with the information provided on the chain of custody form. If applicable, sample preservation, including temperature, is checked at the time of sample receipt.

Sample Acceptance Policy

Samples are considered “compromised” if the following conditions are observed upon receipt:
- Cooler and/or samples are received outside of temperature specification.
- Samples are received broken and leaking.
- Samples are received beyond holding time.
- Samples are received without appropriate preservative.
- Samples are received in inappropriate containers.
- COC does not match samples received
- COC is not properly completed or not received.
- Breakage of any Custody Seal.
- Apparent tampering with cooler and/or samples.
- Inadequate sample volume.
- Illegible, impermanent, or non-unique sample Labeling.

Any non-conformance or irregularity is noted and brought to the immediate attention of the Project Manager, and if appropriate, a Corrective Action is taken. The Project Manager takes appropriate action and documents the resolution with a phone log and attaches it to the client’s chain-of-custody.

The laboratory utilizes a custom designed database or laboratory information system to uniquely identify and track samples and analytical data throughout the mobile facility. The following information is entered into the computer: sample number (unique to this sample), client identification, date prepared (if applicable), date received, sample description (if applicable), additional comments, and notation of special handling instructions. Once logged in the samples are placed in the appropriate storage area pending analysis. Typically, all samples are analyzed on the same day that they are received so long term storage is typically not required.

11.1.1 Field Sampling Procedures

11.1.1.1 **Membrane Interface Probe (MIP) Explorations**

The MIP provides VOC data in the form of detector response (microvolts) for each of the detectors in a continuous vertical record at each location that it is advanced. The MIP system will be housed in a data acquisition truck equipped with a 10-kW diesel generator and lights, heat, air conditioning, water, GC, computers, printers and all the other equipment and tools necessary for efficient operation of the system. The truck will be equipped with two complete systems (MIP probe and trunkline) ready for deployment. The uphole detection system consists of a Hewlett Packard 5890 Series II gas chromatograph (GC) equipped with halogen specific, electron capture, photoionization and flame ionization detectors (XSD, ECD, PID and FID).

Prior to each hole, a response test will be performed. The primary purpose of the response test is to determine the travel time of the contaminant molecules from the membrane to the detectors at the surface. The response test also provides valuable information on the condition of the membrane (and whether it needs to be replaced) as well as how well the detectors are operating. Following a successful response test, the MIP will be advanced at a rate of 1-ft/minute by pushing/hammering the probe into the ground using a GeoProbe rig. The MIP system, if continually advanced at 1-ft/minute results in "apparent drag down" or apparent smearing downward of the contamination relative to the actual concentrations in the ground after passing through highly contaminated zones. If very high detector responses are observed, driving is stopped to allow the system to "burn off" or flush out the contamination in the membrane and the carrier gas tubing. The probe temperature will be set at 121 degrees Celsius and the drive rate of 1-ft/minute ensures that the temperature does not fall significantly. Gas flow rate, pressure, temperature are monitored as the probe is advanced, along with the electrical conductivity of the soil and the response of the detectors to the gas stream.

MIP data are observed in real-time on the computer monitor. At the completion of each hole, a data plot is typically printed out for the use of the field team. The data files are emailed to the client as well as to the CTS-VT data management team in Montpelier, VT upon completion of each hole or at the end of each field day for review and for creation of final data plots.

11.1.2 Groundwater Investigation—Waterloo$^{\text{APS-TM}}$

CTS-VT performs vertical groundwater profiling using the Waterloo$^{\text{APS TM}}$ (Advanced Profiling System) typically at the same locations as the MIP investigations or at pre-planned investigative areas and in accordance with the Waterloo$^{\text{APS TM}}$ standard operating procedure (SEI-10.5.n).

The Waterloo$^{\text{APS-TM}}$ provides high quality, discrete depth samples for groundwater analysis. The system also provides a real-time, continuous record of the Index of Hydraulic Conductivity (IK) with which to assess the hydrostratigraphy at each location. The IK data are used to identify low permeability units within the flow system and sample at the interfaces of these units.

The profiler is driven below the water table and used to collect groundwater samples. In addition to the collection of groundwater samples for onsite analysis for VOCs, the system will be used to:

1. Measure a vertically continuous record of the hydrostratigraphy in the form of the Index of Hydraulic Conductivity (IK);
2. Measure the depth to the potentiometric surface at each sample depth; and
3. Measure physiochemical properties such as pH, specific conductance, dissolved oxygen, oxidation/ reduction potential, and temperature.

The profiling equipment will be calibrated prior to beginning work and at a minimum of once per week during the field program.

The Waterloo$^{APS\text{-}TM}$ profiling tip is equipped with 16 ports, each with a 0.64 cm diameter. The ports are arranged in four recessed rows, resulting in an open interval approximately 6 cm (2.4 inches) in length. This configuration increases the speed of sampling and minimizes the potential for the ports to become plugged while transiting hydrostratigraphic units with a high content of fines. To further minimize the potential for plugging, the screens are flush with the outer surface of the profiling tip. This prevents high plasticity soils from entering the recessed ports and blocking inflow. In addition, each port is fitted with a double screen: a coarse outer screen and a finer inner screen.

The stainless steel profiler tip is fitted with 1/8-inch outside diameter stainless steel tubing. The tubing is added in 20-foot lengths using SwageLok couplings as the profiler is driven. The drive rod coupled to the profiling tip is custom-made heavy-duty direct push rod that has an outside diameter of 1¾ inch. This diameter is uniform along the length of the rod and profiling tip to minimize the potential for fluid movement along the rod to the tip.

The Waterloo$^{APS\text{-}TM}$ data acquisition system and all necessary tools and supplies are housed in a data acquisition vehicle which provides a safe, weather insulated, high productivity work place for the field team.

Groundwater samples are collected using the Waterloo$^{APS\text{-}TM}$ nitrogen gas-drive/positive displacement pump located downhole. All data are collected in a single, continuous push.

11.1.3 Index of Hydraulic Conductivity

The Index of Hydraulic Conductivity (IK) is determined by pushing analyte-free water into the formation from the profiler tip as the tool is advanced. Compressed nitrogen is used to pressurize a stainless steel vessel containing water at a fixed pressure. The flow rate and back pressure are measured using in line electronic flow meter and pressure transducer. The IK is a unique and powerful metric for assessing hydrostratigraphy in real-time. An example of Index of Hydraulic Conductivity data is shown in figure below.

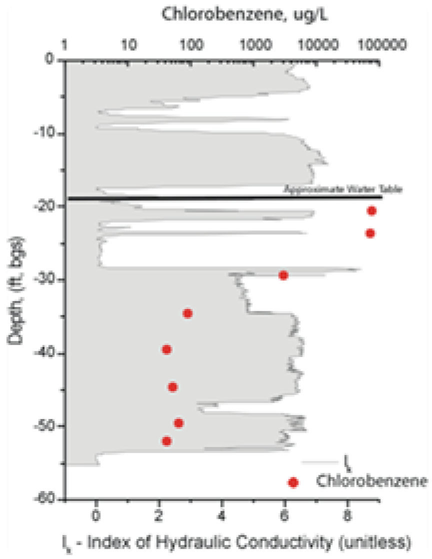


Figure 1. Example Index of Hydraulic Conductivity Data

The Index of Hydraulic Conductivity reveals five low hydraulic conductivity (K) layers (in this case, clay) with relatively high hydraulic conductivity sand between them. This is actually an extensive clay aquitard known as the Yellow Clay which happens to have significant and laterally extensive sand layers within it. These data were used in real-time to stop the advance of the Profiler and collect a groundwater sample. The plot shows that the ability to detect and sample the high-K zones allowed identification of concentrations several orders of magnitude higher than those in the rest of the profile.

The IK record allows for the identification of high-K zones during the same push in which samples are collected. As a result, no time is lost to multiple tool advances or in attempting to sample low-K, non-productive zones. Field personnel view the data in real-time and use it to target sampling to maximize the value of each profile location. The data can also be correlated between profiles and used to determine the 2 and 3-D geometry of low-K zones across the site. The solute distributions obtained from MobiLab analysis of the samples were superimposed on the stratigraphy in the lower half of the figure above. The results showed that the highest concentration zones were either in sandy interbeds within the clay unit or immediately under the clay unit.

11.1.4 Rate of Penetration

Rate of penetration (ROP) is measured using a string potentiometer on the direct push rig. The ROP data may show stratigraphic changes that may affect contaminant transport or design basis data used for remedial design.

11.1.5 Geochemical Properties

Using flow cell parameters rather than a predetermined purge volume ensures that formation water is sampled. In addition, the diversity of the flow cell parameters provides insight into the geochemical environment. A series of water quality probes in a sonde, equipped with a small-volume flow cell, is placed in-line on the discharge side of the pump. This custom flow cell minimizes the volume of water that must be pumped to achieve equilibration of parameters. The sonde and flow cell are integrated into the data acquisition system. These data are displayed on the notebook computer screen inside the data acquisition support vehicle, protected from the weather. The sonde monitors pH, specific conductance, temperature, dissolved oxygen, and oxidation/reduction potential. These data are used to determine when sufficient purging has occurred prior to sampling. In addition, the equilibrium data can be used in assessments of fate and transport.

Data generated at each location include:

- Index of Hydraulic Conductivity with depth
- Depth to the potentiometric surface at each sample depth
- Rate of penetration
- Specific conductance at each sample depth
- pH at each sample depth
- Dissolved oxygen concentration at each sample depth
- Oxidation/reduction potential at each sample depth

The Waterloo$^{\text{APS-TM}}$ provides detailed information on the hydrostratigraphy as well as samples for onsite analysis for VOCs. Concentrations near the effective solubility limit are indicative of nearby DNAPL. In some situations the profiler has recovered DNAPL from the subsurface for direct confirmation of DNAPL accumulations.

11.1.6 Collection of Water Samples for Analysis

Once the sampling depth is reached, driving ceases and the outflow of water is shut off and the sampling process begins as water is purged through the sample vials and the water quality flow cell. Flow cell parameters are monitored and purging continues until the water quality parameters equilibrate. The equilibration values are recorded and the sample is collected by removing the VOA vials for the sampling jig, capping them and taking them to the onsite laboratory for analysis by Method 8260C or other methods. Typical purge volumes for the peristaltic pump approach range from 500 mL to 1000 mL.

11.2 Holding Times, Preparation and Sample Screening

Holding times for every analysis are established in the method SOPs or on a project specific basis. Typically, all samples are analyzed on the same day that they are received so holding times are not a concern. The Laboratory Director and the client schedule the workload to expedite the field investigations. If any holding times are not met the laboratory informs the Project Manager as soon as possible and the Project Manager notifies the client.

Samples are prepared according to performance base standardized methods. Batches are generated in the lab according to preparation method, analytical method, matrix and reporting turnaround time. In general, if necessary batches do not exceed 20 field samples of the same matrix and are defined as samples prepared at the same time.

Inorganics (Metals and Wet Chemistry) - Samples for analyses are prepared in batches containing a maximum of 20 samples of the same or similar matrix. A laboratory blank and laboratory control sample are digested with each batch. A matrix spike and replicate analyses are performed for every 20 samples of the same matrix as requested by the analytical program and available.

Organics - Samples for organics analyses are prepared in batches containing a maximum of twenty samples of the same or similar matrix and reporting turnaround time. A method blank is performed with each batch. Lab control samples are extracted with each batch for applicable methods. Matrix spike and matrix spike duplicate analyses are performed for every 20 samples of the same matrix.

Re-preparation - Re-preparation or re-analysis of a sample may be required in cases of contamination, missed dilution, low surrogate recovery, etc. If the need for reanalysis/re-preparation has been determined, the request is forwarded to the appropriate analytical chemist

Screening – If necessary and appropriate, samples for organics analyses are screened prior to analysis and/or extraction. Screening helps to prevent unnecessary re-runs and lower instrument re-calibration, re-tune and analyst labor time and may be done on the instrument and the use of a PID.

11.2.1 Sample Disposal

CTS-VT retains samples for up to 30 days after the project report is sent unless prior written arrangements have been made with the client or as in some cases samples require disposal on-site. Samples shall be disposed of in accordance with federal, state and local regulations. The laboratory procedures for sample disposal are further described in the laboratory SOP *On-Site Laboratory Waste Handling, Storage and Disposal* (SEI-10.14.*n*)

12.0 Assuring the Quality of Test Results

The quality control program implemented in the laboratory includes the analysis of method blanks, check standards, laboratory control samples, analytical spikes, and surrogate spikes. Depending upon the analysis, every analytical series includes one or more of these controls. The combination of controls used in an analysis must be completely representative of the analytical task including all aspects of sample preparation and sample analysis. This section describes routine procedures used to monitor laboratory method performance and substantiate validation of data. Controls analyzed in conjunction with samples are essential in the evaluation of the quality of the generated data. These programs may include any of the following quality controls in addition to other project specific obligations.

12.1 Quality Control Samples

Method blanks are prepared and analyzed with each analytical batch to identify possible contamination within the analytical process. Method blanks are treated as samples (i.e., they go through each stage of the analytical process including glassware, reagents, instrumentation, and any other source of possible contamination that may affect sample results). Surrogate recoveries, and elevated levels of compounds must be evaluated for method blanks. The control limits and corrective actions for method blanks are defined in the method SOP's.

Instrument Blanks and/or Fiber Blanks are analytical runs prepared with no reagent introduced. They are used to monitor potential contamination of the analytical system. An instrument blank is analyzed at the start of the analytical sequence and after highly contaminated samples to confirm that the instrument is free of contaminants before continuing with sample analyses. Instrument blanks are also commonly known as *continuing calibration blanks* in inorganic analyses.

Equipment Blanks/Field Blanks are prepared as an unprocessed aliquot of reagent used to monitor the contamination of the field sampling system. An equipment blank is analyzed at the start of a boring hole and after highly contaminated samples to confirm that the field equipment is contaminant-free before continuing with the boring hole.

Laboratory Control Samples (LCS) are prepared and analyzed with each batch of samples. Laboratory control samples are fortified with all compounds of interest at documented levels and when applicable with the same spiking solution as the matrix spike (MS) sample. Aqueous and solid laboratory control samples are analyzed using the same sample preparation, reagents, and analytical methods employed for the samples received. Method performance is monitored by the measure of accuracy of the results. The results of the LCS, used in conjunction with the MS samples provide an indication of whether the laboratory performed the method correctly or the sample matrix affected the results. When a laboratory control sample duplicate (LCSD) is required, a percent recovery may be calculated, as well as a relative percent difference (RPD) between the LCS and the LCSD. The control limits and corrective actions for LCS's are defined in the method SOP's. LCS samples are also commonly known as method blank spikes.

Surrogates are non-target analyte compounds that are similar in composition and behavior to the target analytes but are not expected to be found in environmental media (often, isotopically labeled target analyses are used). Surrogates are spiked into every sample, quality control sample and method blank for organic analyses. Extractable organic analyses are spiked with surrogates at the time of extraction; and volatiles prior to analysis. Surrogates responses are used to evaluate the accuracy of the laboratory performance of the analytical method in a specific sample matrix and are expressed as percent recoveries. The control limits and corrective action for surrogate spikes are specified in the method SOP's.

Internal Standards (IS) are non-target analyte compounds that are similar to the target analytes but are not expected to be found in environmental media (generally, isotopically labeled target analytes are used) and are added to every standard, quality control sample and field sample at a known concentration prior to analysis. Internal standard area responses and retention times are evaluated in all samples and blanks according to the method of analysis. IS responses are used as the basis for quantitation of target analytes. The control limits and corrective action for internal standards are specified in the method SOP's.

Matrix Spikes/Matrix Spike Duplicates (MS/MSD) are prepared and analyzed with each batch of 20 samples or less (if specified by the client) of the same matrix for organic analyses and a MS is prepared and analyzed with each batch of 20 samples of the same matrix for inorganic analyses. The MS/MSD samples are prepared by taking an aliquot of an actual site sample and fortifying it with the selected target analytes of interest. The MS/MSD samples are analyzed using the same sample preparation, reagents, and analytical methods employed as the field samples. MS and MSD responses are used to evaluate the accuracy and precision of the laboratory performance of the analytical method in a specific sample matrix. Results from site samples other than those belonging to the client will not be reported with the data package. Control limits for recoveries of the matrix spike/matrix spike duplicate compounds are listed in the method SOP's.

Replicate analyses are prepared and analyzed for inorganic samples and for certain organic drinking water analyses with each batch of 20 samples of the same matrix. Control limits for replicate analyses are listed in the method SOPs.

Calibration Check Standards are analyzed with each analytical series at the frequencies stated in the methods. For metals, GC, and Wet Chemistry analyses calibration check standards are analyzed at a typical frequency of 10%, or after every ten samples unless otherwise noted in the site work plan. For GC/MS analyses, the frequency of the calibration check standard is every 12 hours. The tuning criteria must be met prior to analyzing blanks, standards or samples. Control limits for calibration check standards are listed in the method SOP's.

Parameter	QC type	Frequency	Control Limits	Corrective Action
Volatile/Semi-volatile Organics	method blank	1 per batch	Target analytes below RL, 10x exception for lab solvents, DOD < ½ RL	System check, reanalysis of affected samples
	surrogate spike	each sample, standard, blank	Limits listed in method	Review, reanalyze based on technical judgment
	MS/MSD	set per 20 samples per matrix	Limits listed in method	Report results
	LCS/	1 per batch	Limits listed in method	Review, reanalyze LCS and associated samples, based on technical judgment.
	ICV (independent)	After initial calibration	%Recovery 70-130, unless otherwise listed in method	Review, reanalyze ICV, check standards, recalibrate if appropriate.
Metals	lab reagent/prep blank	1 per 20 samples or batch	analyte below RL	redigest batch
	LCS	1 per batch	Soils- Limits provided by vendor; Waters - ± 20%	redigest batch
	replicates	1 per 20 samples per matrix	± 20%	flag results
	matrix spikes	1 per 20 samples per matrix	75-125%	flag results
Wet Chemistry	lab reagent/prep blank	1 per 20 samples or batch	analyte RL	system check, reanalysis of batch
	LCS	1 per batch	80-120% recovery	system check, reanalysis of batch
	replicates	1 per 20 samples per matrix	± 20%	flag results
	matrix spike	1 per 20 samples per matrix	75-125%	flag results

RL = Reporting Limit

12.2 Data Reduction

The Laboratory provides extensive data review prior to reporting results to the client. In general an analyst will process data in one of the following ways:

- Manual computation of results with manual reporting
- Computer computation of results with manual reporting
- Computer computation and reporting of results

If the analyst manually processes the data, all steps in the computation are provided for review including the source of the input parameters such as response factors, dilution factors, and calibration constants. All calculations of manually processed data are checked during secondary review.

For data that are processed using a computer and then entered into the Laboratory Information System by an analyst or data entry personnel, a hard copy of the computer-generated results is kept and uniquely identified with the sample number and any other preparation or dilution information as may be needed. The hard copy results are used for data validation and secondary review.

If computer processed data are directly acquired from the instrumentation, hard copies of the actual data are made and the analyst verifies that the following are correct before releasing instrumental data to the reporting system:

- Sample numbers
- Calibration constants/ response factors
- Output parameters such as units and compound names
- Numerical values used for detection limits
- Dilution and preparation factors

The hard copy of the results is used for data validation and review. After initial demonstration of proficiency of computerized programs computer calculations are randomly spot checked while the manual entry of every result is verified.

12.3 Data Review

The analyst is responsible for primary review of data generated from sample analysis. If the instrument calibration and recoveries of all quality control samples are within specified tolerances, then the data are presented for secondary review. The data package should be accompanied by a completed Analyst Checklist, wherein the analyst indicates the components they have included in the data package for secondary review (see Appendix H). If instrument calibration or the recoveries of any quality control samples exceed specified tolerances, then affected sample results are evaluated and generally the samples are submitted for re-analysis. Any manual integrations that occur are signed on the quantitation reports.

Secondary review (a complete technical review) is typically conducted by designated data review personnel to determine if analytical results are acceptable. All sample records, transcriptions, calibrations, manual calculations and manual integrations are checked for accuracy and quality control sample results are evaluated against specified tolerances. If discrepancies or deficiencies exist in the analytical results, then corrective action is taken and deficiencies or SOP deviations are indicated in the case narrative. Once final secondary review is completed, the analytical results are presented along with a case narrative and QC sample summaries (depending on requested level of reporting) in a final analytical data report, which is submitted to the client. A Secondary Data Reviewer Checklist (see Appendix H) is completed by the secondary data reviewer for each sample delivery group (SDG) reviewed and reported. Completed Analyst Checklists and Secondary Data Reviewer Checklists are retained in the appropriate project file and can be made available for external review.

Periodically, during a Level IV reporting project, a complete data integrity audit will be performed during the secondary review and documented on the data integrity audit checklist. Periodic data audits of final reports by the Laboratory QA Manager are conducted to determine that precision, accuracy, completeness and traceability goals of the sample analysis are being conducted.

13.0 Reporting Results - Data Reports

After all analytical data have been reviewed; the final analytical report is assembled for submission to the client. The on-site laboratory can currently offer five levels for reporting analytical results.

Level I data consist of measurements taken during field analysis with the report consisting of results only.

Level II reporting consists of an analytical report with results only. Internal quality control results are retained on file at the laboratory.

Level III reporting consists of an analytical report with internal quality control results reported; these include laboratory control standards, surrogate spike recoveries, and method blank results.

Level IV data refers to data submitted in CLP-like format. Level IV is defined by the submission of QA/QC supporting material including the raw laboratory data similar to that provided with CLP Statements of Work (SOW). Submission of data in this format results in an independently validatable package. Level IV reporting includes narrative or comments of concern, analytical results, supportive documentation including all raw data and preparation sheets, and all documentation related to chain of custody. Once the document is assembled, the sections may be distinguished with colored paper with their respective titles. Copy(s) of the documentation are sent to the client, and the original document is retained in storage for a minimum of seven (7) years.

Level V data have unique requirements in compound identification, quantitation, detection limits, cleanup, or QA/QC requirements. Level V analytical procedures are generally defined as Special Analytical Services. The procedures and QA/QC are specified through these requests. The QA/QC for Level V data usually requires frequent standardization, spikes, duplicates, blanks, and strict compound identification criteria.

13.1 Project Reports

The criteria described in Section 13.1.1 apply to all Project Reports that are generated under NELAP requirements and DOD ELAP / ISO/IEC 17025:2005 requirements. The criteria described in Section 13.1.2 and 13.1.3 applies to all client reports.

13.1.1 Project Report Content

- Title
- Laboratory Name, address, telephone number, contact person and location where the test was carried out if different from the fixed laboratory address.
- Unique Laboratory Project Number
- Total number of pages (report must be paginated)
- Client Project Number (if applicable)
- Laboratory Sample Identification (if applicable)
- Client Sample Identification
- Test Method
- Matrix and/or description of sample
- Dates: sample collection, collection time, sample receipt, preparation and/or analysis date.
- Definition of data qualifiers
- Reporting units
- Solid samples: indicate dry or wet weight
- Indication by flagging where results are reported below the quantitation limit.

13.1.2 Project Narrative/Cover Letter

A Project Narrative and/or Cover Letter is included with each project report and at a minimum includes an explanation of any and all of the following occurrences:

- Non-conformances that apply to project contracts and under NELAP requirements.
- “Compromised” sample receipt
- Method Deviations
- QC criteria failures

In addition, each report will include the following statement: The analytical procedures and test results in this report are in accordance with the NELAP standards and meet all NELAP requirements for parameters for which accreditation is required or available. The reports were completed according to contract-specific reporting requirements. Any exceptions to the NELAP standard requirements are noted here or in the case narrative and all data has been flagged accordingly.

APPENDIX A
Facilities (Floor Plans) and Capabilities (Equipment)

Figure 2: Typical Mobile Laboratory Layout

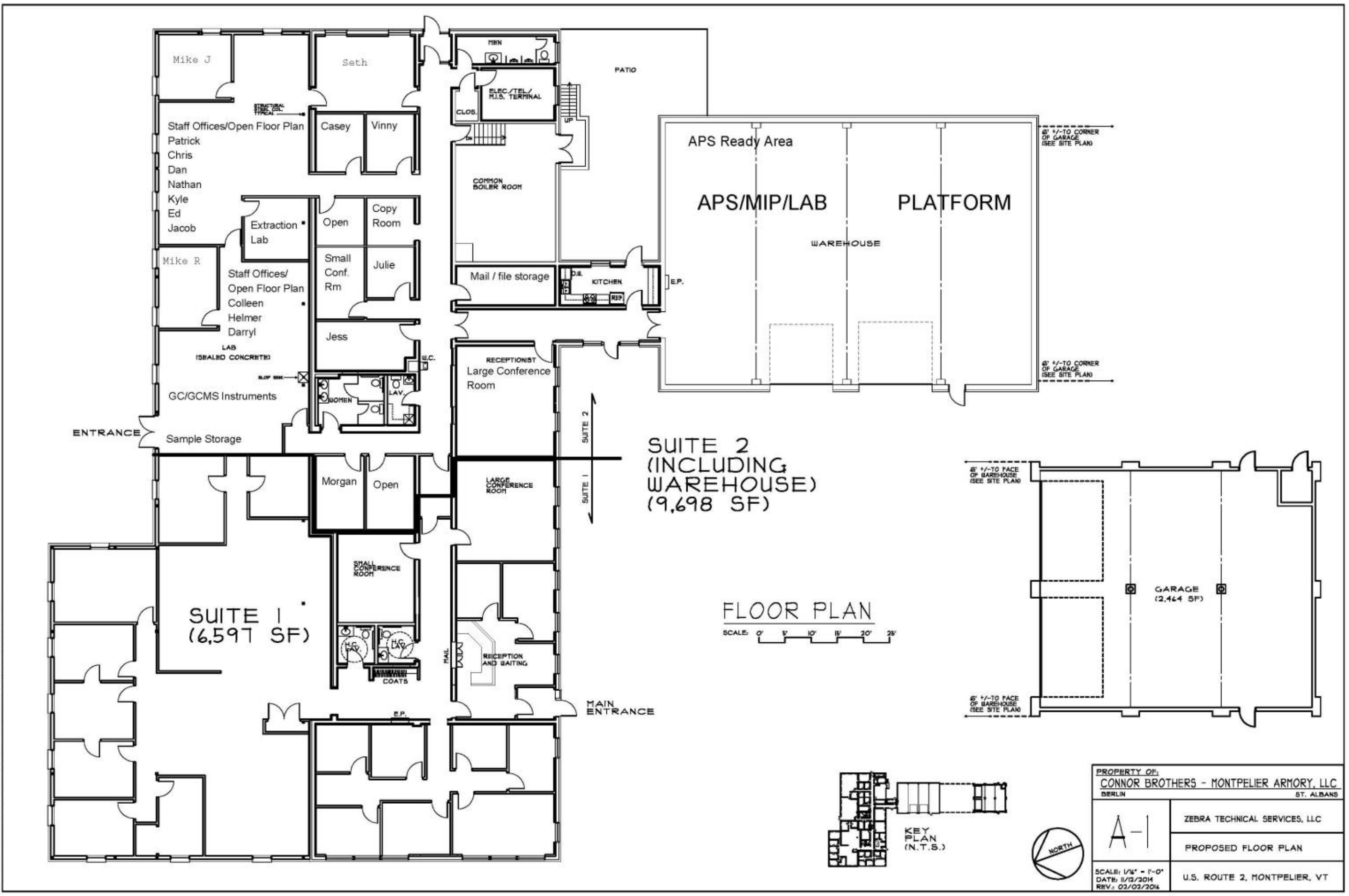


Figure 3: Floor Plan – Main Facility, Montpelier, Vermont

Mobile Laboratory Equipment Inventory

The following is a comprehensive list of major instrumentation available along with supporting and miscellaneous equipment.

Mobile/Fixed Laboratory Set-Up (may include)			
Make and Model	*Description*	*Quantity*	*Date Acquired*
HP6890	Gas Chromatograph equipped with dual heated injection ports (split/splitless and cool-on-column) and dual micro-Electron Capture Detectors. Data are collected on HP G2070AA ChemStation, Rev A.10	1	02/08
HP6890 GC / HP5973 MSD	GC/MS System with HP6890 GC and HP5973 MSD. Equipped with dual heated injection ports and capillary inlets for split/splitless and equipped with MS detector. Data are collected on HP G1701DA MS ChemStation.	1	03/17
Agilent 7890A	Gas Chromatograph equipped with dual heated injection ports and capillary inlets for split/splitless. Data are collected and analyzed on MSD ChemStation, G1701EA, revision E.02.02.1431	1	01/14
Agilent 5975C MSD	GC/MS System with Agilent 7890A GC. Equipped with MS detector. Data are collected and analyzed on MSD ChemStation, G1701EA, revision E.02.02.1431. NIST Spectral Library, revision 11.L	1	01/14
Agilent 5975T MSD	GC/MS System with Agilent 7890A GC. Equipped with MS detector. Data are collected and analyzed on MSD ChemStation, G1701EA, revision E.02.02.1431. NIST Spectral Library, revision 11.L	1	03/15
Milestone Ethos Series	Microwave oven equipped with temperature and energy control and a 12-place extraction vessel rotor.	1	02/08
CEM Mars 6	Microwave oven equipped with temperature and energy control and a 24-place extraction vessel rotor.	1	09/16
CTC CombiPal	Autosampler for SPME	3	2/12, 2/13, 3/15
Supelco	Solid Phase Micro-Extraction (SPME) preparation of Volatile and Semi-volatile analytes	4	Various
Various	Miscellaneous equipment: Refrigerators, freezers, ovens, pH meter, balances, syringes, dispensers, pressure regulators, and other laboratory support equipment		Various
Trailer/ Truck/Vehicle	Mobile Lab 2 = VIN# 1UK500F2541047129 Mobile Lab 1/T6 = VIN# JALE5B16067901082		Various
Shimadzu QP2020GC/MS	GC/MS System	1	11/16
Shimadzu 8050 MSMS	Triple Quad MS/MS	1	11/16
Shimadzu Controller	Pump Controller	1	11/16

Mobile/Fixed Laboratory Set-Up (may include)			
CBM 20A			
Shimadzu Lab Solutions solftware	LC/MSMS data system Version # 5.86	1	11/16
Gerstel MPS	Autosampler and SPE Unit	1	12/16

Information Systems: All terminals, PCs and printers are connected on an integrated Local Area Network (LAN) via network switches, routers and wide area links. Extensive variety of software to aid in data analysis and presentation, including Microsoft Office Products (Excel, Word, Access, etc.). All lab personnel have access to the internet for additional resources. Additional equipment in the laboratories includes printers and personal computers.

Waterloo Advanced Profiling System Equipment Inventory

The following is a comprehensive list of major instrumentation available along with supporting and miscellaneous equipment.

Waterloo Advanced Profiling System Set-Up (may include)			
Make and Model	*Description*	*Quantity*	*Date Acquired*
Waterloo Profiler	System comprised of a 1.5”, 1.75”, or 2.25” diameter tip attached to GeoProbe style rod and stainless steel sample line	>25	Various
CTS KPRO Box	System comprised of the zero head space sample jig, valves, electronic enclosure, and peristaltic pump.	10	2002, 2003
Sonde Water Quality Monitoring Systems	Several models are used including Troll 9000, Troll 9500, YSI 600XL, HydroLab MS-5, and Hach HQ30.	10	Various
Various	Miscellaneous equipment: string potentiometers, pressure regulators, pressure vessels		Various

Information Systems: Ruggedized laptops have an extensive variety of software to aid in data analysis and presentation, including Microsoft Office Products (Excel, Word, etc), programming environments, LabView and Kpro Data logging software. All sampling personnel have access to the internet for additional resources.

Membrane Interface Probe Equipment Inventory

The following is a comprehensive list of major instrumentation available along with supporting and miscellaneous equipment.

Membrane Interface Probe Set-Up (may include)			
Make and Model	*Description*	*Quantity*	*Date Acquired*
Geoprobe FI6000	Data Acquisition Field Instrument	1	1/11
Geoprobe MP6505	Flow Controller	1	1/11
Geoprobe MP7000	HTL Controller	1	10/11
Geoprobe K6300	HPT Flow Module	1	9/12
Hewlett Packard HP5890II	Gas Chromatograph equipped with Photoionization (PID), Electron Capture (ECD) and Flame Ionization (FID) detectors.	1	1/05
Various	Miscellaneous support equipment: flow meters, multi meters, syringes, pressure regulators, MIP probes		Various
Trailer/ Truck/Vehicle	Truck 5 = VIN#JALE5B16167901916		Various

Information Systems: Extensive variety of software to aid in data analysis and presentation, including Microsoft Office Products (Excel, Word, etc), Origin™, and DI Viewer. All MIP personnel have access to the internet for additional resources. Additional equipment in the MIP laboratory includes printers and personal computers.

APPENDIX B
Analytical Capabilities

Cascade Technical Services - Vermont
Mobile Laboratory
Analytical Methodologies

Reference	Method	Description
ASTM	D6520	Solid Phase Micro-extraction of water and its headspace for analysis of Volatile and Semi-volatile Organic Compounds
ASTM	D6520	Methanol extraction of soils (EPA 5035H, MeOH preservative) and Solid Phase Micro-extraction of soil extract and its headspace for analysis of Volatile and Semi-volatile Organic Compounds
EPA SW846	8260C	Volatile Organic Compounds by Gas Chromatography (GC)/Mass Spectrometry (GCMS) for Waters and Soils using Solid Phase Micro-extraction.
EPA SW846	8270	Semi-Volatile Organic Compounds by Gas Chromatography (GC)/Mass Spectrometry (GCMS) for Waters and Soils using Microwave Assisted Extraction.
40CFR Part 136	Method 537 (modified), ASTM Method D7979	Per- and Polyfluorylalkyl Compounds by Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)
SOP SEI-10.17.n		Microwave Assisted Extraction of Volatile Organic Compounds From Rock Samples
SOP SEI-10.18.n		The Determination of Volatile Organic Compounds By Gas Chromatography/Dual ECD Detectors in Rock Samples (Using Cool On-Column Injection and Split Method Injection)
SOP SEI-10.19.n		The Determination of Volatile Organic Compounds By Gas Chromatography/Dual ECD Detectors in Rock Samples (Using Cool On-Column Injection and Split Method Injection)
EPA SW-846	Modified 8015	Field TPH- Gasoline and Diesel
EPA SW-846	Modified 8021	Field GC Aromatic and Halogenated Volatile Organics
EPA SW-846	Modified 8082	Field Determination of Polychlorinated Biphenyls (PCBs) by Gas Chromatography with an Electron Capture Detector (ECD)
EPA SW8015	Modified 8015	Field Direct injection of Gas Chromatograph – Select Compounds
EPA SW-846	6200	Field Portable XRF Spectroscopy for the Determination of Elemental Concentrations in Soil and Sediment
EPA SW-846	4020	Screening for PCBs by Immunoassay
EPA SW-846	4035	Screening for PAHs by Immunoassay
Standard Methods	3500FE	Ferrous Iron (Phenanthroline Method)
Standard Methods	4500 CIG	Chlorine
HACH Kit	Various	Nitrate, Hexavalent Chromium

APPENDIX C
Laboratory Accreditation

State of New Jersey
Department of Environmental Protection
Certifies That

Cascade Technical Services - Vermont

Laboratory Certification ID # VT002

is hereby approved as a

Nationally Accredited Environmental Laboratory

to perform the analyses as indicated on the Annual Certified Parameter List
which must accompany this certificate to be valid

having duly met the requirements of the

Regulations Governing the Certification of
Laboratories and Environmental Measurements N.J.A.C. 7:18 et. seq.

and

having been found compliant with the 2009 TNI Standard approved by the

The NELAC Institute

Expires June 30, 2017

Michele M. Potter

Michele M. Potter
Interim Manager

NJDEP is a NELAP Recognized Accreditation Body

This certificate is to be conspicuously displayed at the laboratory with the annual certified parameter list in a location on the premises visible to the public. Consumers are urged to verify the laboratory's current accreditation status with the State of NJ, NELAP.

New Jersey Department of Environmental Protection

National Environmental Laboratory Accreditation Program

ANNUAL CERTIFIED PARAMETER LIST AND CURRENT STATUS

Effective as of 07/01/2016 until 06/30/2017

Laboratory Name: CASCADE TECHNICAL SERVICES - VERMONT Laboratory Number: VT002 Activity ID: NLC160001
1 HOME FARM WAY
MONTPELIER, VT 05602

Category: NPW09 -- Organics - NPW Preparation Methods

Status	Eligible to Report NJ Data	State	Code	Matrix	Technique Description	Approved Method	Parameter Description
Certified	Yes	NJ	NPW09.00010	NPW	Solid Phase Microextraction	[ASTM D6520]	Organics

Category: NPW11 -- Organic Parameters - Chromatography/MS

Status	Eligible to Report NJ Data	State	Code	Matrix	Technique Description	Approved Method	Parameter Description
Certified	Yes	NJ	NPW11.14390	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Benzene
Certified	Yes	NJ	NPW11.14430	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Bromodichloromethane
Certified	Yes	NJ	NPW11.14450	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Bromoform
Certified	Yes	NJ	NPW11.14550	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Carbon disulfide
Certified	Yes	NJ	NPW11.14560	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Carbon tetrachloride
Certified	Yes	NJ	NPW11.14570	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chlorobenzene
Certified	Yes	NJ	NPW11.14580	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chloroethane
Certified	Yes	NJ	NPW11.14600	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chloroform
Certified	Yes	NJ	NPW11.14610	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chloromethane
Certified	Yes	NJ	NPW11.14670	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dibromo-3-chloropropane (1,2-)
Certified	Yes	NJ	NPW11.14680	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dibromochloromethane
Certified	Yes	NJ	NPW11.14690	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dibromoethane (1,2-) (EDB)
Certified	Yes	NJ	NPW11.14730	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichlorobenzene (1,2-)
Certified	Yes	NJ	NPW11.14740	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichlorobenzene (1,3-)
Certified	Yes	NJ	NPW11.14750	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichlorobenzene (1,4-)
Certified	Yes	NJ	NPW11.14770	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethane (1,1-)
Certified	Yes	NJ	NPW11.14780	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethane (1,2-)
Certified	Yes	NJ	NPW11.14790	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethene (1,1-)
Certified	Yes	NJ	NPW11.14800	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethene (cis-1,2-)
Certified	Yes	NJ	NPW11.14810	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethene (trans-1,2-)
Certified	Yes	NJ	NPW11.14820	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloropropane (1,2-)
Certified	Yes	NJ	NPW11.14860	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloropropene (cis-1,3-)
Certified	Yes	NJ	NPW11.14870	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloropropene (trans-1,3-)
Certified	Yes	NJ	NPW11.14900	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dioxane (1,4-)
Certified	Yes	NJ	NPW11.14940	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Ethylbenzene

KEY: AE = Air and Emissions, BT = Biological Tissues, DW = Drinking Water, NPW = Non-Potable Water, SCM = Solid and Chemical Materials

New Jersey Department of Environmental Protection

National Environmental Laboratory Accreditation Program

ANNUAL CERTIFIED PARAMETER LIST AND CURRENT STATUS

Effective as of 07/01/2016 until 06/30/2017

Laboratory Name: CASCADE TECHNICAL SERVICES - VERMONT Laboratory Number: VT002 Activity ID: NLC160001
1 HOME FARM WAY
MONTPELIER, VT 05602

Category: NPW11 -- Organic Parameters - Chromatography/MS

Status	Eligible to Report NJ Data	State	Code	Matrix	Technique Description	Approved Method	Parameter Description
Certified	Yes	NJ	NPW11.15040	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Isopropylbenzene
Certified	Yes	NJ	NPW11.15110	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Methyl tert-butyl ether
Certified	Yes	NJ	NPW11.15130	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Methylene chloride (Dichloromethane)
Certified	Yes	NJ	NPW11.15160	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Naphthalene
Certified	Yes	NJ	NPW11.15270	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Styrene
Certified	Yes	NJ	NPW11.15330	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Tetrachloroethane (1,1,2,2-)
Certified	Yes	NJ	NPW11.15340	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Tetrachloroethene
Certified	Yes	NJ	NPW11.15360	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Toluene
Certified	Yes	NJ	NPW11.15380	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloro (1,1,2-) trifluoroethane (1,2,2-)
Certified	Yes	NJ	NPW11.15400	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichlorobenzene (1,2,4-)
Certified	Yes	NJ	NPW11.15410	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloroethane (1,1,1-)
Certified	Yes	NJ	NPW11.15420	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloroethane (1,1,2-)
Certified	Yes	NJ	NPW11.15430	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloroethene
Certified	Yes	NJ	NPW11.15470	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trimethylbenzene (1,2,4-)
Certified	Yes	NJ	NPW11.15480	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trimethylbenzene (1,3,5-)
Certified	Yes	NJ	NPW11.15500	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Vinyl chloride
Certified	Yes	NJ	NPW11.15510	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylene (m-)
Certified	Yes	NJ	NPW11.15520	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylene (o-)
Certified	Yes	NJ	NPW11.15530	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylene (p-)
Certified	Yes	NJ	NPW11.15540	NPW	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylenes (total)

Category: SCM08 -- Organics - SCM Prep. / Screening Methods

Status	Eligible to Report NJ Data	State	Code	Matrix	Technique Description	Approved Method	Parameter Description
Certified	Yes	NJ	SCM08.00070	SCM	Solid Phase Microextraction	[ASTM D6520]	Organics

KEY: AE = Air and Emissions, BT = Biological Tissues, DW = Drinking Water, NPW = Non-Potable Water, SCM = Solid and Chemical Materials

New Jersey Department of Environmental Protection
National Environmental Laboratory Accreditation Program
ANNUAL CERTIFIED PARAMETER LIST AND CURRENT STATUS
Effective as of 07/01/2016 until 06/30/2017

Laboratory Name: CASCADE TECHNICAL SERVICES - VERMONT **Laboratory Number:** VT002 **Activity ID:** NLC160001
1 HOME FARM WAY
MONTPELIER, VT 05602

Category: SCM10 -- Organic Parameters - Chromatography/MS

Status	Eligible to Report NJ Data	State	Code	Matrix	Technique Description	Approved Method	Parameter Description
Certified	Yes	NJ	SCM10.06840	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Toluene
Certified	Yes	NJ	SCM10.06860	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloro (1,1,2-) trifluoroethane (1,2,2-)
Certified	Yes	NJ	SCM10.06880	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichlorobenzene (1,2,4-)
Certified	Yes	NJ	SCM10.06890	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloroethane (1,1,1-)
Certified	Yes	NJ	SCM10.06900	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloroethane (1,1,2-)
Certified	Yes	NJ	SCM10.06910	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trichloroethene
Certified	Yes	NJ	SCM10.06950	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trimethylbenzene (1,2,4-)
Certified	Yes	NJ	SCM10.06960	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Trimethylbenzene (1,3,5-)
Certified	Yes	NJ	SCM10.06990	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Vinyl chloride
Certified	Yes	NJ	SCM10.07000	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylene (m-)
Certified	Yes	NJ	SCM10.07010	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylene (o-)
Certified	Yes	NJ	SCM10.07020	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylene (p-)
Certified	Yes	NJ	SCM10.07030	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Xylenes (total)

Michele M. Potter

Michele M Potter, Interim Manager

KEY: AE = Air and Emissions, BT = Biological Tissues, DW = Drinking Water, NPW = Non-Potable Water, SCM = Solid and Chemical Materials

New Jersey Department of Environmental Protection

National Environmental Laboratory Accreditation Program

ANNUAL CERTIFIED PARAMETER LIST AND CURRENT STATUS

Effective as of 07/01/2016 until 06/30/2017

Laboratory Name: CASCADE TECHNICAL SERVICES - VERMONT Laboratory Number: VT002 Activity ID: NLC160001
1 HOME FARM WAY
MONTPELIER, VT 05602

Category: SCM10 -- Organic Parameters - Chromatography/MS

Status	Eligible to Report NJ Data	State	Code	Matrix	Technique Description	Approved Method	Parameter Description
Certified	Yes	NJ	SCM10.05870	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Benzene
Certified	Yes	NJ	SCM10.05910	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Bromodichloromethane
Certified	Yes	NJ	SCM10.05930	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Bromoform
Certified	Yes	NJ	SCM10.06030	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Carbon disulfide
Certified	Yes	NJ	SCM10.06040	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Carbon tetrachloride
Certified	Yes	NJ	SCM10.06050	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chlorobenzene
Certified	Yes	NJ	SCM10.06060	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chloroethane
Certified	Yes	NJ	SCM10.06080	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chloroform
Certified	Yes	NJ	SCM10.06090	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Chloromethane
Certified	Yes	NJ	SCM10.06150	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dibromo-3-chloropropane (1,2-)
Certified	Yes	NJ	SCM10.06160	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dibromochloromethane
Certified	Yes	NJ	SCM10.06170	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dibromoethane (1,2-) (EDB)
Certified	Yes	NJ	SCM10.06210	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichlorobenzene (1,2-)
Certified	Yes	NJ	SCM10.06220	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichlorobenzene (1,3-)
Certified	Yes	NJ	SCM10.06230	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichlorobenzene (1,4-)
Certified	Yes	NJ	SCM10.06250	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethane (1,1-)
Certified	Yes	NJ	SCM10.06260	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethane (1,2-)
Certified	Yes	NJ	SCM10.06270	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethene (1,1-)
Certified	Yes	NJ	SCM10.06280	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethene (cis-1,2-)
Certified	Yes	NJ	SCM10.06290	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloroethene (trans-1,2-)
Certified	Yes	NJ	SCM10.06300	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloropropane (1,2-)
Certified	Yes	NJ	SCM10.06340	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloropropene (cis-1,3-)
Certified	Yes	NJ	SCM10.06350	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dichloropropene (trans-1,3-)
Certified	Yes	NJ	SCM10.06380	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Dioxane (1,4-)
Certified	Yes	NJ	SCM10.06420	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Ethylbenzene
Certified	Yes	NJ	SCM10.06520	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Isopropylbenzene
Certified	Yes	NJ	SCM10.06590	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Methyl tert-butyl ether
Certified	Yes	NJ	SCM10.06610	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Methylene chloride (Dichloromethane)
Certified	Yes	NJ	SCM10.06640	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Naphthalene
Certified	Yes	NJ	SCM10.06750	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Styrene
Certified	Yes	NJ	SCM10.06810	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Tetrachloroethane (1,1,2,2-)
Certified	Yes	NJ	SCM10.06820	SCM	GC/MS, P & T or Direct Injection, Capillary	[SW-846 8260C]	Tetrachloroethene

KEY: AE = Air and Emissions, BT = Biological Tissues, DW = Drinking Water, NPW = Non-Potable Water, SCM = Solid and Chemical Materials

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

NY Lab Id No: 12004

MR. MICHAEL ROSSI
CASCADE TECHNICAL SERVICES VERMONT. - MOBILE
UNIT #2
1 HOME FARM WAY
MONTPELIER, VT 05602

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved analytes are listed below:

Fuel Oxygenates

Methyl tert-butyl ether	EPA 8260C

Volatile Aromatics

1,2,4-Trichlorobenzene, Volatile	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
Benzene	EPA 8260C
Chlorobenzene	EPA 8260C
Ethyl benzene	EPA 8260C
Isopropylbenzene	EPA 8260C
Naphthalene, Volatile	EPA 8260C
Styrene	EPA 8260C
Toluene	EPA 8260C
Total Xylenes	EPA 8260C

Volatile Halocarbons

1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C

Volatile Halocarbons

1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C
Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Carbon tetrachloride	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
Dibromochloromethane	EPA 8260C
Methylene chloride	EPA 8260C
Tetrachloroethene	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260C
Trichloroethene	EPA 8260C
Vinyl chloride	EPA 8260C

Volatiles Organics

1,4-Dioxane	EPA 8260C
Carbon Disulfide	EPA 8260C

Sample Preparation Methods

	ASTM D6520-00

Serial No.: 56327

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to cal (518) 485-5570 to verify the laboratory's accreditation status.

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. MICHAEL ROSSI
CASCADE TECHNICAL SERVICES VERMONT. - MOBILE
UNIT #2
1 HOME FARM WAY
MONTPELIER, VT 05602

NY Lab Id No: 12004

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES SOLID AND HAZARDOUS WASTE All approved analytes are listed below:

Volatile Aromatics

1,2,4-Trichlorobenzene, Volatile	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
Benzene	EPA 8260C
Chlorobenzene	EPA 8260C
Ethyl benzene	EPA 8260C
Isopropylbenzene	EPA 8260C
Naphthalene, Volatile	EPA 8260C
Styrene	EPA 8260C
Toluene	EPA 8260C
Total Xylenes	EPA 8260C

Volatile Halocarbons

1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C
1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C

Volatile Halocarbons

Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Carbon tetrachloride	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
Dibromochloromethane	EPA 8260C
Methylene chloride	EPA 8260C
Tetrachloroethene	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260C
Trichloroethene	EPA 8260C
Vinyl chloride	EPA 8260C

Volatile Organics

1,4-Dioxane	EPA 8260C
Carbon Disulfide	EPA 8260C
Methyl tert-butyl ether	EPA 8260C

Sample Preparation Methods

EPA 5035A-H/ASTM D6520-00

Serial No.: 56328

Property of the New York State Department of Health. Certificates are valid only at the address shown, must be conspicuously posted, and are printed on secure paper. Continued accreditation depends on successful ongoing participation in the Program. Consumers are urged to call (518) 485-5570 to verify the laboratory's accreditation status.

State of Florida
Department of Health, Bureau of Public Health Laboratories
This is to certify that

E97999

CASCADE TECHNICAL SERVICES - VERMONT
1 HOME FARM WAY
MONTPELIER, VT 05602

has complied with Florida Administrative Code 64E-1,
for the examination of environmental samples in the following categories

NON-POTABLE WATER - VOLATILE ORGANICS, SOLID AND CHEMICAL MATERIALS - VOLATILE ORGANICS

Continued certification is contingent upon successful on-going compliance with the NELAC Standards and FAC Rule 64E-1 regulations. Specific methods and analytes certified are cited on the Laboratory Scope of Accreditation for this laboratory and are on file at the Bureau of Public Health Laboratories, P. O. Box 210, Jacksonville, Florida 32231. Clients and customers are urged to verify with this agency the laboratory's certification status in Florida for particular methods and analytes.

Date Issued: July 01, 2016   Expiration Date: June 30, 2017

Susanne Crowe

Susanne Crowe, MHA
Acting Chief, Bureau of Public Health Laboratories
DH Form 1697, 7/04
NON-TRANSFERABLE   E97999-11-07/01/2016
Supersedes all previously issued certificates

Rick Scott
Governor

Celeste Philip, MD, MPH
Interim State Surgeon General

Laboratory Scope of Accreditation

Attachment to Certificate #: E97999-11, expiration date June 30, 2017. This listing of accredited analytes should be used only when associated with a valid certificate.

State Laboratory ID: **E97999** EPA Lab Code: **VT00981** **(802) 229-2194**

E97999
Cascade Technical Services - Vermont
1 Home Farm Way
Montpelier, VT 05602

Matrix: **Non-Potable Water**

Analyte	Method/Tech	Category	Certification Type	Effective Date
1,1,1-Trichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1,2,2-Tetrachloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1,2-Trichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1-Dichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1-Dichloroethylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2,4-Trichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2,4-Trimethylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dibromo-3-chloropropane (DBCP)	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dibromoethane (EDB, Ethylene dibromide)	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dichloropropane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,3,5-Trimethylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,3-Dichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,4-Dichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,4-Dioxane (1,4-Diethyleneoxide)	EPA 8260	Volatile Organics	NELAP	5/23/2016
Benzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Bromodichloromethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
Bromoform	EPA 8260	Volatile Organics	NELAP	2/16/2016
Carbon disulfide	EPA 8260	Volatile Organics	NELAP	2/16/2016
Carbon tetrachloride	EPA 8260	Volatile Organics	NELAP	2/16/2016
Chlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Chloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
Chloroform	EPA 8260	Volatile Organics	NELAP	2/16/2016
cis-1,2-Dichloroethylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
cis-1,3-Dichloropropene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Dibromochloromethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
Ethylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Isopropylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Methyl chloride (Chloromethane)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Methyl tert-butyl ether (MTBE)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Methylene chloride	EPA 8260	Volatile Organics	NELAP	2/16/2016
m-Xylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Naphthalene	EPA 8260	Volatile Organics	NELAP	2/16/2016
o-Xylene	EPA 8260	Volatile Organics	NELAP	2/16/2016

Clients and Customers are urged to verify the laboratory's current certification status with the Environmental Laboratory Certification Program.

Issue Date: 7/1/2016 **Expiration Date: 6/30/2017**

Laboratory Scope of Accreditation

Attachment to Certificate #: E97999-11, expiration date June 30, 2017. This listing of accredited analytes should be used only when associated with a valid certificate.

State Laboratory ID: **E97999** EPA Lab Code: **VT00981** **(802) 229-2194**

E97999
Cascade Technical Services - Vermont
1 Home Farm Way
Montpelier, VT 05602

Matrix: **Non-Potable Water**

Analyte	Method/Tech	Category	Certification Type	Effective Date
p-Xylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Styrene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Tetrachloroethylene (Perchloroethylene)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Toluene	EPA 8260	Volatile Organics	NELAP	2/16/2016
trans-1,2-Dichloroethylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
trans-1,3-Dichloropropene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Trichloroethene (Trichloroethylene)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Vinyl chloride	EPA 8260	Volatile Organics	NELAP	2/16/2016
Xylene (total)	EPA 8260	Volatile Organics	NELAP	2/16/2016

Laboratory Scope of Accreditation

Attachment to Certificate #: E97999-11, expiration date June 30, 2017. This listing of accredited analytes should be used only when associated with a valid certificate.

State Laboratory ID: **E97999** EPA Lab Code: **VT00981** **(802) 229-2194**

E97999
Cascade Technical Services - Vermont
1 Home Farm Way
Montpelier, VT 05602

Matrix: **Solid and Chemical Materials**

Analyte	Method/Tech	Category	Certification Type	Effective Date
1,1,1-Trichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1,2,2-Tetrachloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1,2-Trichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1-Dichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,1-Dichloroethylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2,4-Trichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2,4-Trimethylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dibromo-3-chloropropane (DBCP)	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dibromoethane (EDB, Ethylene dibromide)	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dichloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,2-Dichloropropane	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,3,5-Trimethylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,3-Dichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,4-Dichlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
1,4-Dioxane (1,4-Diethyleneoxide)	EPA 8260	Volatile Organics	NELAP	5/23/2016
Benzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Bromodichloromethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
Bromoform	EPA 8260	Volatile Organics	NELAP	2/16/2016
Carbon disulfide	EPA 8260	Volatile Organics	NELAP	2/16/2016
Carbon tetrachloride	EPA 8260	Volatile Organics	NELAP	2/16/2016
Chlorobenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Chloroethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
Chloroform	EPA 8260	Volatile Organics	NELAP	2/16/2016
cis-1,2-Dichloroethylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
cis-1,3-Dichloropropene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Dibromochloromethane	EPA 8260	Volatile Organics	NELAP	2/16/2016
Ethylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Isopropylbenzene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Methyl chloride (Chloromethane)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Methyl tert-butyl ether (MTBE)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Methylene chloride	EPA 8260	Volatile Organics	NELAP	2/16/2016
Naphthalene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Styrene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Tetrachloroethylene (Perchloroethylene)	EPA 8260	Volatile Organics	NELAP	2/16/2016

Laboratory Scope of Accreditation

Attachment to Certificate #: E97999-11, expiration date June 30, 2017. This listing of accredited analytes should be used only when associated with a valid certificate.

State Laboratory ID: **E97999** EPA Lab Code: **VT00981** **(802) 229-2194**

E97999
Cascade Technical Services - Vermont
1 Home Farm Way
Montpelier, VT 05602

Matrix: **Solid and Chemical Materials**

Analyte	Method/Tech	Category	Certification Type	Effective Date
Toluene	EPA 8260	Volatile Organics	NELAP	2/16/2016
trans-1,2-Dichloroethylene	EPA 8260	Volatile Organics	NELAP	2/16/2016
trans-1,3-Dichloropropene	EPA 8260	Volatile Organics	NELAP	2/16/2016
Trichloroethene (Trichloroethylene)	EPA 8260	Volatile Organics	NELAP	2/16/2016
Vinyl chloride	EPA 8260	Volatile Organics	NELAP	2/16/2016
Xylene (total)	EPA 8260	Volatile Organics	NELAP	2/16/2016

Bryan W. Shaw, Ph.D., P.E., *Chairman*
Toby Baker, *Commissioner*
Jon Niermann, *Commissioner*
Richard A. Hyde, P.E., *Executive Director*

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

December 09, 2016

CERTIFIED MAIL

Ms. Morgan Greenwald
Cascade Technical Services
1 Home Farm Way
Montpelier, VT 05602-8243

Dear Ms. Greenwald:

I am writing to congratulate you and the staff of Cascade Technical Services. Based on your application and primary NELAP accreditation from the state of New York, pursuant to authorization from the Executive Director of the Texas Commission on Environmental Quality, the Program Manager of the Quality Assurance Section has issued your laboratory secondary NELAP accreditation according to the attached Fields of Accreditation.

I am enclosing the accreditation certificate and Fields of Accreditation listing. Please review the enclosures for accuracy and completeness. Your laboratory's accreditation is valid until the expiration date on the certificate and scope, contingent on continued compliance with the requirements of the state of Texas as well as those of your primary accreditation body.

In the meantime, please contact Mr. Frank Jamison at (512) 239-3754 or frank.jamison@tceq.texas.gov if we can provide any additional information or assistance.

Sincerely,

Ken Lancaster

Ken Lancaster
Manager, Laboratory & Quality Assurance Section

Enclosures

Texas Commission on Environmental Quality

NELAP-Recognized Laboratory Accreditation is hereby awarded to

Cascade Technical Services

1 Home Farm Way
Montpelier, VT 05602-8243

in accordance with Texas Water Code Chapter 5, Subchapter R, Title 30 Texas Administrative Code Chapter 25, and the National Environmental Laboratory Accreditation Program.

The laboratory's scope of accreditation includes the fields of accreditation that accompany this certificate. Continued accreditation depends upon successful ongoing participation in the program. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current location(s) and accreditation status for particular methods and analyses (www.tceq.texas.gov/goto/lab). Accreditation does not imply that a product, process, system or person is approved by the Texas Commission on Environmental Quality.

Certificate Number: **T104704543-16-1**
Effective Date: **12/9/2016**
Expiration Date: **12/31/2017**

Executive Director Texas Commission on Environmental Quality

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate:	**T104704543-16-1**
Expiration Date:	**12/31/2017**
Issue Date:	**12/9/2016**

Cascade Technical Services

1 Home Farm Way
Montpelier, VT 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Non-Potable Water***

Method EPA 8260

Analyte	**AB**	**Analyte ID**	**Method ID**
1,1,1-Trichloroethane	NY	5160	10184802
1,1,2,2-Tetrachloroethane	NY	5110	10184802
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	NY	5195	10184802
1,1,2-Trichloroethane	NY	5165	10184802
1,1-Dichloroethane	NY	4630	10184802
1,1-Dichloroethylene	NY	4640	10184802
1,2,4-Trichlorobenzene	NY	5155	10184802
1,2,4-Trimethylbenzene	NY	5210	10184802
1,2-Dibromo-3-chloropropane (DBCP)	NY	4570	10184802
1,2-Dibromoethane (EDB, Ethylene dibromide)	NY	4585	10184802
1,2-Dichlorobenzene	NY	4610	10184802
1,2-Dichloroethane (Ethylene dichloride)	NY	4635	10184802
1,2-Dichloropropane	NY	4655	10184802
1,3,5-Trimethylbenzene	NY	5215	10184802
1,3-Dichlorobenzene	NY	4615	10184802
1,4-Dichlorobenzene	NY	4620	10184802
1,4-Dioxane (1,4-Diethyleneoxide)	NY	4735	10184802
Benzene	NY	4375	10184802
Bromodichloromethane	NY	4395	10184802
Bromoform	NY	4400	10184802
Carbon disulfide	NY	4450	10184802
Carbon tetrachloride	NY	4455	10184802
Chlorobenzene	NY	4475	10184802
Chlorodibromomethane	NY	4575	10184802
Chloroethane (Ethyl chloride)	NY	4485	10184802
Chloroform	NY	4505	10184802
cis-1,2-Dichloroethylene	NY	4645	10184802
cis-1,3-Dichloropropene	NY	4680	10184802

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Cascade Technical Services	**Certificate:**	**T104704543-16-1**
	Expiration Date:	**12/31/2017**
	Issue Date:	**12/9/2016**

1 Home Farm Way
Montpelier, VT 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Non-Potable Water***

Ethylbenzene	NY	4765	10184802
Isopropylbenzene (Cumene)	NY	4900	10184802
Methyl chloride (Chloromethane)	NY	4960	10184802
Methyl tert-butyl ether (MTBE)	NY	5000	10184802
Methylene chloride (Dichloromethane)	NY	4975	10184802
Naphthalene	NY	5005	10184802
Styrene	NY	5100	10184802
Tetrachloroethylene (Perchloroethylene)	NY	5115	10184802
Toluene	NY	5140	10184802
trans-1,2-Dichloroethylene	NY	4700	10184802
trans-1,3-Dichloropropylene	NY	4685	10184802
Trichloroethene (Trichloroethylene)	NY	5170	10184802
Vinyl chloride	NY	5235	10184802
Xylene (total)	NY	5260	10184802

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate: T104704543-16-1
Expiration Date: 12/31/2017
Issue Date: 12/9/2016

Cascade Technical Services

1 Home Farm Way
Montpelier, VT 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Solid & Chemical Materials***

Method EPA 8260

Analyte	AB	Analyte ID	Method ID
1,1,1-Trichloroethane	NY	5160	10184802
1,1,2,2-Tetrachloroethane	NY	5110	10184802
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	NY	5195	10184802
1,1,2-Trichloroethane	NY	5165	10184802
1,1-Dichloroethane	NY	4630	10184802
1,1-Dichloroethylene	NY	4640	10184802
1,2,4-Trichlorobenzene	NY	5155	10184802
1,2,4-Trimethylbenzene	NY	5210	10184802
1,2-Dibromo-3-chloropropane (DBCP)	NY	4570	10184802
1,2-Dibromoethane (EDB, Ethylene dibromide)	NY	4585	10184802
1,2-Dichlorobenzene	NY	4610	10184802
1,2-Dichloroethane (Ethylene dichloride)	NY	4635	10184802
1,2-Dichloropropane	NY	4655	10184802
1,3,5-Trimethylbenzene	NY	5215	10184802
1,3-Dichlorobenzene	NY	4615	10184802
1,4-Dichlorobenzene	NY	4620	10184802
1,4-Dioxane (1,4-Diethyleneoxide)	NY	4735	10184802
Benzene	NY	4375	10184802
Bromodichloromethane	NY	4395	10184802
Bromoform	NY	4400	10184802
Carbon disulfide	NY	4450	10184802
Carbon tetrachloride	NY	4455	10184802
Chlorobenzene	NY	4475	10184802
Chlorodibromomethane	NY	4575	10184802
Chloroethane (Ethyl chloride)	NY	4485	10184802
Chloroform	NY	4505	10184802
cis-1,2-Dichloroethylene	NY	4645	10184802
cis-1,3-Dichloropropene	NY	4680	10184802

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate:	**T104704543-16-1**
Expiration Date:	**12/31/2017**
Issue Date:	**12/9/2016**

Cascade Technical Services

1 Home Farm Way
Montpelier, VT 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Solid & Chemical Materials***

Ethylbenzene	NY	4765	10184802
Isopropylbenzene (Cumene)	NY	4900	10184802
Methyl chloride (Chloromethane)	NY	4960	10184802
Methyl tert-butyl ether (MTBE)	NY	5000	10184802
Methylene chloride (Dichloromethane)	NY	4975	10184802
Naphthalene	NY	5005	10184802
Styrene	NY	5100	10184802
Tetrachloroethylene (Perchloroethylene)	NY	5115	10184802
Toluene	NY	5140	10184802
trans-1,2-Dichloroethylene	NY	4700	10184802
trans-1,3-Dichloropropylene	NY	4685	10184802
Trichloroethene (Trichloroethylene)	NY	5170	10184802
Vinyl chloride	NY	5235	10184802
Xylene (total)	NY	5260	10184802

Texas Commission on Environmental Quality

NELAP-Recognized Laboratory Accreditation is hereby awarded to

Cascade Technical Services - Mobile Lab (VT ARR 398)

1 Home Farm Way
Montpelier, Vt 05602-8243

in accordance with Texas Water Code Chapter 5, Subchapter R, Title 30 Texas Administrative Code Chapter 25, and the National Environmental Laboratory Accreditation Program.

The laboratory's scope of accreditation includes the fields of accreditation that accompany this certificate. Continued accreditation depends upon successful ongoing participation in the program. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current location(s) and accreditation status for particular methods and analyses (www.tceq.texas.gov/goto/lab). Accreditation does not imply that a product, process, system or person is approved by the Texas Commission on Environmental Quality.

Certificate Number: 1M104704543-16-1
Effective Date: 12/9/2016
Expiration Date: 12/31/2017

Executive Director Texas Commission on Environmental Quality

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate:	**1M104704543-16-1**
Expiration Date:	**12/31/2017**
Issue Date:	**12/9/2016**

Cascade Technical Services - Mobile Lab (VT ARR 398)

1 Home Farm Way
Montpelier, Vt 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Non-Potable Water***

Method EPA 8260

Analyte	AB	Analyte ID	Method ID
1,1,1-Trichloroethane	NY	5160	10184802
1,1,2,2-Tetrachloroethane	NY	5110	10184802
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	NY	5195	10184802
1,1,2-Trichloroethane	NY	5165	10184802
1,1-Dichloroethane	NY	4630	10184802
1,1-Dichloroethylene	NY	4640	10184802
1,2,4-Trichlorobenzene	NY	5155	10184802
1,2,4-Trimethylbenzene	NY	5210	10184802
1,2-Dibromo-3-chloropropane (DBCP)	NY	4570	10184802
1,2-Dibromoethane (EDB, Ethylene dibromide)	NY	4585	10184802
1,2-Dichlorobenzene	NY	4610	10184802
1,2-Dichloroethane (Ethylene dichloride)	NY	4635	10184802
1,2-Dichloropropane	NY	4655	10184802
1,3,5-Trimethylbenzene	NY	5215	10184802
1,3-Dichlorobenzene	NY	4615	10184802
1,4-Dichlorobenzene	NY	4620	10184802
1,4-Dioxane (1,4-Diethyleneoxide)	NY	4735	10184802
Benzene	NY	4375	10184802
Bromodichloromethane	NY	4395	10184802
Bromoform	NY	4400	10184802
Carbon disulfide	NY	4450	10184802
Carbon tetrachloride	NY	4455	10184802
Chlorobenzene	NY	4475	10184802
Chlorodibromomethane	NY	4575	10184802
Chloroethane (Ethyl chloride)	NY	4485	10184802
Chloroform	NY	4505	10184802
cis-1,2-Dichloroethylene	NY	4645	10184802
cis-1,3-Dichloropropene	NY	4680	10184802

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate: 1M104704543-16-1
Expiration Date: 12/31/2017
Issue Date: 12/9/2016

Cascade Technical Services - Mobile Lab (VT ARR 398)

1 Home Farm Way
Montpelier, Vt 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Non-Potable Water***

Ethylbenzene	NY	4765	10184802
Isopropylbenzene (Cumene)	NY	4900	10184802
Methyl chloride (Chloromethane)	NY	4960	10184802
Methyl tert-butyl ether (MTBE)	NY	5000	10184802
Methylene chloride (Dichloromethane)	NY	4975	10184802
Naphthalene	NY	5005	10184802
Styrene	NY	5100	10184802
Tetrachloroethylene (Perchloroethylene)	NY	5115	10184802
Toluene	NY	5140	10184802
trans-1,2-Dichloroethylene	NY	4700	10184802
trans-1,3-Dichloropropylene	NY	4685	10184802
Trichloroethene (Trichloroethylene)	NY	5170	10184802
Vinyl chloride	NY	5235	10184802
Xylene (total)	NY	5260	10184802

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate: 1M104704543-16-1
Expiration Date: 12/31/2017
Issue Date: 12/9/2016

Cascade Technical Services - Mobile Lab (VT ARR 398)

1 Home Farm Way
Montpelier, Vt 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Solid & Chemical Materials***

Method EPA 8260

Analyte	AB	Analyte ID	Method ID
1,1,1-Trichloroethane	NY	5160	10184802
1,1,2,2-Tetrachloroethane	NY	5110	10184802
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)	NY	5195	10184802
1,1,2-Trichloroethane	NY	5165	10184802
1,1-Dichloroethane	NY	4630	10184802
1,1-Dichloroethylene	NY	4640	10184802
1,2,4-Trichlorobenzene	NY	5155	10184802
1,2,4-Trimethylbenzene	NY	5210	10184802
1,2-Dibromo-3-chloropropane (DBCP)	NY	4570	10184802
1,2-Dibromoethane (EDB, Ethylene dibromide)	NY	4585	10184802
1,2-Dichlorobenzene	NY	4610	10184802
1,2-Dichloroethane (Ethylene dichloride)	NY	4635	10184802
1,2-Dichloropropane	NY	4655	10184802
1,3,5-Trimethylbenzene	NY	5215	10184802
1,3-Dichlorobenzene	NY	4615	10184802
1,4-Dichlorobenzene	NY	4620	10184802
1,4-Dioxane (1,4-Diethyleneoxide)	NY	4735	10184802
Benzene	NY	4375	10184802
Bromodichloromethane	NY	4395	10184802
Bromoform	NY	4400	10184802
Carbon disulfide	NY	4450	10184802
Carbon tetrachloride	NY	4455	10184802
Chlorobenzene	NY	4475	10184802
Chlorodibromomethane	NY	4575	10184802
Chloroethane (Ethyl chloride)	NY	4485	10184802
Chloroform	NY	4505	10184802
cis-1,2-Dichloroethylene	NY	4645	10184802
cis-1,3-Dichloropropene	NY	4680	10184802

Texas Commission on Environmental Quality

NELAP - Recognized Laboratory Fields of Accreditation

Certificate: 1M104704543-16-1
Expiration Date: 12/31/2017
Issue Date: 12/9/2016

Cascade Technical Services - Mobile Lab (VT ARR 398)

1 Home Farm Way
Montpelier, Vt 05602-8243

These fields of accreditation supercede all previous fields. The Texas Commission on Environmental Quality urges customers to verify the laboratory's current accreditation status for particular methods and analyses.

Matrix: ***Solid & Chemical Materials***

Ethylbenzene	NY	4765	10184802
Isopropylbenzene (Cumene)	NY	4900	10184802
Methyl chloride (Chloromethane)	NY	4960	10184802
Methyl tert-butyl ether (MTBE)	NY	5000	10184802
Methylene chloride (Dichloromethane)	NY	4975	10184802
Naphthalene	NY	5005	10184802
Styrene	NY	5100	10184802
Tetrachloroethylene (Perchloroethylene)	NY	5115	10184802
Toluene	NY	5140	10184802
trans-1,2-Dichloroethylene	NY	4700	10184802
trans-1,3-Dichloropropylene	NY	4685	10184802
Trichloroethene (Trichloroethylene)	NY	5170	10184802
Vinyl chloride	NY	5235	10184802
Xylene (total)	NY	5260	10184802

APPENDIX D
Standard Operating Procedures Master List

CASCADE
DRILLING | TECHNICAL SERVICES

CONTROLLED DOCUMENTS AND STANDARD OPERATING PROCEDURES MASTER INDEX

Cascade Technical Services (CTS) Controlled Documents and Standard Operating Procedures (SOPs) contain valuable confidential and proprietary information; disclosure, use, or reproduction of these materials without the written authorization of CTS is strictly prohibited.

Controlled Documents and PJLA Policies

		ISSUED	REVISED	REVIEWED	STATUS
QSM_CTS_ REV15	Laboratory and Field Sampling Quality Systems Manual	03/05/04	05/31/17	05/31/17	A
NCR Formv1	NCR Form 2016	09/07/12	01/18/16	01/18/16	A
PJLA PL-1	Perry Johnson Laboratory Accreditation, Inc. Proficiency Testing Requirements	12/00	11/16	1/17	A
PJLA PL-2	Perry Johnson Laboratory Accreditation, Inc. Measurement Traceability Policy	12/00	6/13	1/17	A
PJLA PL-3	Perry Johnson Laboratory Accreditation, Inc. Policy on Measurement Uncertainty	12/00	7/15	1/17	A
PJLA PL-4	Perry Johnson Laboratory Accreditation, Inc. Calibration Scopes of Accreditation	11/08	6/13	1/17	A
ISO 17025	General requirements for the competence of testing and calibration laboratories	05/15/05	NA	NA	A
TNI-NELAP	Management and Technical Requirements for Laboratories Performing Environmental Analysis	2009		1/17	A
TNI-NEFAP	Field Sampling and Measurement Organization Sector Volume 1 General Requirements For Field Sampling and Measurement Organizations	2014		1/17	A
DoD-QSM	DoD Quality Systems Manual Version 5.1	2017		1/17	A

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CONTROLLED DOCUMENTS AND STANDARD OPERATING PROCEDURES MASTER INDEX

Chapter 1 ADMINISTRATION

		ISSUED	REVISED	REVIEWED	STATUS
SEI-1.2.6	General Procedures For Regulatory Agency Inspections, Sponsors Audits, or Third Party Inspections	11/22/93	07/27/15	7/27/15	A
SEI-1.4.12	Curriculum Vitae	05/12/93	12/09/13	07/27/15	A

Chapter 2 PROTOCOLS AND REPORTS

		ISSUED	REVISED	REVIEWED	STATUS
SEI-2.2.6	Final Report Requirements	09/02/93	05/15/12	12/10/13	A

Chapter 3 STANDARD OPERATING PROCEDURES

		ISSUED	REVISED	REVIEWED	STATUS
SEI-3.1.9	Creating and Revising Standard Operating Procedures	04/09/93	05/15/12	12/10/13	A
SEI-3.2.8	Documentation, Revision, Distribution, Review and Retirement of Standard Operating Procedures	11/16/93	05/15/12	12/19/13	A

Chapter 4 DOCUMENTATION

		ISSUED	REVISED	REVIEWED	STATUS
SEI-4.2.7	Chain of Custody Records	04/09/93	07/05/12	12/11/13	A, L, F

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CONTROLLED DOCUMENTS AND STANDARD OPERATING PROCEDURES MASTER INDEX

		ISSUED	REVISED	REVIEWED	STATUS
SEI-4.4.6	Documenting and Filing all Project Specific Communications (emails, electronic correspondence, and phone logs).	09/02/93	01/15/15	01/15/15	A, L, F
SEI-4.5.11	Data Handling, Storage, Retrieval and Error Coding	09/02/93	05/10/12	12/11/13	A, L, F
SEI-4.6.7	Significant Figures, Rounding Procedures and Use of Conversion Factors	12/08/93	08/24/12	12/11/13	A, L, F
CTS-4.7.7	Labeling Reagents, Solutions and Standards	04/18/94	05/31/17	05/31/17	A, L, F
SEI-4.10.3	Computer Software Verification	04/21/94	04/04/03	12/11/13	A
SEI-4.14.2	Quality Control Check on Transcribed Data, Data Calculations, Figures, and Tables	07/29/99	03/06/03	12/11/13	A, L, F

Chapter 5 FIELD WORK AND EQUIPMENT

		ISSUED	REVISED	REVIEWED	STATUS
SEI-5.1.5	Maintenance and Decontamination of Field Equipment	04/09/93	02/20/04	12/20/13	A, F
SEI-5.3.4	Use of Borrowed and Rented Equipment	04/18/94	02/20/04	12/13/13	A, F
SEI-5.14.2	Use, Maintenance and Calibration of Electronic Balances Model GL1002R, OHAUS CT-200 Top Loading, Adam Equipment 2T200 and/or Other Similar Models	06/17/97	02/20/04	12/13/13	A, L, F
SEI-5.25.1	Use, Maintenance, and Calibration of the Multi-Parameter Troll 9000 and 9500	04/18/08	07/12/12	12/13/13	A, F

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CONTROLLED DOCUMENTS AND STANDARD OPERATING PROCEDURES MASTER INDEX

		ISSUED	REVISED	REVIEWED	STATUS
SEI-5.26.0	Use, Maintenance, and Calibration of the Lamotte Model 2020e Turbidity Meter	06/23/05	na	12/13/13	I
CTS-5.27.3	Use, Maintenance, and Calibration of the Hydrolab MS5 Water Quality Multiprobe	04/17/08	01/31/17	01/31/17	A, F
SEI-5.28.0	Use, Maintenance and Calibration of the HACH LDO Portable Dissolved Oxygen Meters (HACH Models HQ10 and HQ30d)	02/04/2011	na	12/13/13	A, F
SEI-5.29.0	Use, Maintenance, and Calibration of the MultiRAE IR Multi-Gas Monitor (PGM-54)	02/04/2011	na	12/13/13	I
CTS-5.30.3	Use, Calibration, and Maintenance of The YSI Model 699xl Multi-parameter Water Quality Monitoring System(Temperature, Specific Conductance, Ph, Redox Potential, Dissolved Oxygen)	08/13/02	01/31/17	01/31/17	A, F

Chapter 6 FIELD WORK AND PROFILING

		ISSUED	REVISED	REVIEWED	STATUS
SEI-6.1.6	Collection of Soil Samples for Preliminary Site Selection	10/26/92	11/18/05	04/2/08	I
SEI-6.2.6	Water Level measurement, Use, Maintenance and Calibration of Electronic Water Level Indicators	04/09/93	02/20/04	04/2/08	I
SEI-6.3.5	Surface Water Sampling	04/09/93	8/12/15	8/12/15	I
SEI-6.4.5	Installation, Development and Decommissioning of Monitoring Wells and Observation Wells	04/09/93	08/01/07	04/10/08	I

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		ISSUED	REVISED	REVIEWED	STATUS
SEI-6.6.9	Installation and Testing of Bladder Pumps for Sampling of Monitoring Wells	04/09/93	03/31/04	05/02/08	I
SEI-6.10.4	Soil Characterization Study	04/09/93	03/31/04	12/07/12	I
SEI-6.11.9	Slug Tests	04/12/93	04/11/13	04/22/13	I
SEI-6.14.3	Test System Preparation, Care and Observations	04/18/94	04/16/04	05/02/08	I
SEI-6.16.4	Handling, Collection and Transportation of Samples	11/22/93	04/16/04	05/02/08	A, L, F
SEI-6.17.4	Evaluation of Soil Texture, Moisture Content, and Mottling, Using the USDA Soil Classification Scheme	11/15/94	04/16/04	12/7/12	I
SEI-6.20.3	Undisturbed Soil Sample Collection Using a Thin Walled (Shelby) Tube	02/16/96	11/18/05	12/7/12	I
SEI-6.24.1	Locating Soil Sampling Points in a Sampling Area	07/19/99	11/18/05	12/7/12	I
SEI-6.27.3	Groundwater Sampling of Monitoring Wells	03/03/00	11/29/05	12/20/12	I
SEI-6.34.1	Procedure for Sampling Groundwater Monitoring Wells Using Low Stress (Low Flow) Technique	01/21/05	11/3/14	11/3/14	A, F
SEI-6.35.0	Passive Collection of Pore Water Samples Using Passive Diffusion Bags	06/22/07	na	12/20/12	I
SEI-6.36.2	Procedure For Collection of Soil Gas Samples for VOC Analysis	06/22/07	07/1/15	07/1015	I

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		ISSUED	REVISED	REVIEWED	STATUS
SEI-6.37.2	Field Methods for Retrieval, Collection, Handling, and Preservation of Rock Samples to be Analyzed for VOCs and Physical Properties	07/01/08	07/29/15	07/29/15	A, F
SEI-6.41.0	Hydrophobic Dye Testing for Light or Dense Non-Aqueous Phase Liquids (NAPL) Contamination	08/21/12	na	08/21/12	I
SEI-6.42.2	Geologic Description of Unconsolidated Deposits	01/18/02	10/16/12	10/16/12	I
CTS-6.43.7	Groundwater Profiling and K-Pro Testing	08/13/02	05/26/17	05/26/17	A, F
SEI-6.45.0	Collection, Handling, and Preservation of Discrete Soil Samples	10/15/12	na	10/15/12	I
SEI-6.46.0	Geologic Description of Unconsolidated Deposits Using the Unified Soil classification System (USCS)	10/15/12	na	10/15/12	I
SEI-6.47.0	Non-Aqueous Phase Liquid (NAPL) Sampling	10/16/12	na	10/16/12	I
SEI-6.49.0	Procedure For Collection of Indoor Air Samples for TO15 Analysis using Summa Canister	03/22/13	na	03/22/13	I

Chapter 7 ARCHIVES

		ISSUED	REVISED	REVIEWED	STATUS
SEI-7.2.6	Document Control, Record System and Archiving	11/16/93	03/04/03	12/13/13	A

Chapter 8 MANAGEMENT

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		ISSUED	REVISED	REVIEWED	STATUS
SEI-8.4.0	Client Inquiries, Data Revision Requests & Complaint Resolution	10/20/05	na	12/13/13	A

Chapter 10 ENVIRONMENTAL MOBILE LABORATORY

		ISSUED	REVISED	REVIEWED	STATUS
SEI-10.1.6	Determination of Aromatic and Chlorinated Volatile Organics and Light Weight Petroleum Hydrocarbon Compounds Using Solid Phase Microextraction (SPME) and A Gas Chromatograph in Soil and Water Samples (Modified SW846 Methods 8021/8015 & ASTM D6520)	02/21/03	05/26/09	05/26/09	I
SEI-10.2.0	Determination of Polychlorinated Biphenyl (PCB) by Gas Chromatography with an Electron Capture Detector (ECD) in Sediment and Soil Samples	08/17/04	na	02/15/08	I
SEI-10.12.3	Use, Calibration, and Maintenance of the Membrane Interface Probe (MIP)	08/4/04	08/12/15	08/12/15	A
CTS-10.13.2	Policy Requirements for Manual Integration of Chromatographic Peaks	08/05/04	11/27/16	11/27/16	A, L
CTS-10.14.2	On-Site Laboratory Waste Handling, Storage and Disposal	10/20/04	11/27/16	11/27/16	A, L
CTS-10.15.15	The Determination of Volatile Organic Compounds By GC/MS(SW846 USEPA METHOD 8260C) ASTMD6520	08/19/04	05/31/17	05/31/17	A, L
SEI-10.16.0	Determination of Selected Elements in Soil and Sediment Samples Using Field Portable X-Ray Fluorescence Spectrum Analyzers, SW846 6200	10/22/04	na	08/22/12	I
SEI-10.17.1	Microwave Assisted Extraction of Volatile Organic Compounds From Rock Samples	07/02/08	05/21/12	05/21/12	A, L

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		ISSUED	REVISED	REVIEWED	STATUS
SEI-10.1.6	Determination of Aromatic and Chlorinated Volatile Organics and Light Weight Petroleum Hydrocarbon Compounds Using Solid Phase Microextraction (SPME) and A Gas Chromatograph in Soil and Water Samples (Modified SW846 Methods 8021/8015 & ASTM D6520)	02/21/03	05/26/09	05/26/09	I
SEI-10.2.0	Determination of Polychlorinated Biphenyl (PCB) by Gas Chromatography with an Electron Capture Detector (ECD) in Sediment and Soil Samples	08/17/04	na	02/15/08	I
SEI-10.18.1	The Determination of Volatile Organic Compounds By Gas Chromatography/Dual ECD Detectors in Rock Samples (Using Cool On-Column Injection and Split Method Injection)	07/02/08	05/21/12	05/21/12	A, L
SEI-10.19.0	Determination of Polychlorinated Biphenyls (PCBs) by Gas Chromatography with an Electron Capture Detector (ECD)and Microwave Assisted Extraction in Sediment and Solid Samples	01/12/16	NA	01/12/16	A, L
CTS-10.20.0	The Determination of Selected Perfluorinated Compounds in Ground Water, Waste Water, Surface Water (Non-Drinking Water) by Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)	01/31/17	NA	01/31/17	A, L

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APPENDIX E
References

References

40 CFR Part 136 (Revision 2), Appendix A and Appendix B

National Environmental Laboratory Accreditation Conference, Constitution, Bylaws and Standards, EPA 600/R-98/151, U. S. Environmental Protection Agency's (EPA) Office of Research and Development, Approved June 5, 2003, Effective July 1, 2003.

2009 TNI Standard, Volume 1: Management and Technical Requirements for Laboratories Performing Environmental Analysis, TNI, 9/8/2009

TNI-National Environmental Field Activities Program (NEFAP) Field Sampling and Measurement Organization Sector Volume 1 General Requirements For Field Sampling and Measurement Organizations, 1/29/2014

General Requirements for Competence of Testing and Calibration Laboratories, ISO/IEC 17025, May 2005.

Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories v.5.1, December 2016.

PJLA PL-1 Perry Johnson Laboratory Accreditation, Inc. Proficiency Testing Requirements, 11/16

PJLA PL-2 Perry Johnson Laboratory Accreditation, Inc. Measurement Traceability Policy, 06/13

PJLA PL-3 Perry Johnson Laboratory Accreditation, Inc. Policy on Measurement Uncertainty, 07/15

PJLA PL-4 Perry Johnson Laboratory Accreditation, Inc. Calibration Scopes of Accreditation, 06/13

APPENDIX F
Terms and Definitions

Terms and Definitions

Accuracy: the degree of agreement between a measurement and true or expected value, or between the average of a number of measurements and the true or expected value.

Audit: a systemic evaluation to determine the conformance to specifications of an operational function or activity.

Batch: environmental samples, which are prepared and/or analyzed together with the same process, using the same lot(s) of reagents. A preparation batch is composed of one to 20 environmental samples of a similar matrix, meeting the above mentioned criteria. Where no preparation method exists (example, volatile organics, water) the batch is defined as environmental samples that are analyzed together with the same process and personnel, using the same lots of reagents, not to exceed 20 environmental samples. An analytical batch is composed of prepared environmental samples, extracts, digestates or concentrates that are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples.

Chain of Custody (COC): an unbroken trail of accountability that ensures the physical security of samples, data and records.

Clean Air Act: legislation in 42 U.S.C. 7401 et seq., Public Law 91-604, 84 Stat. 1676 Pub. L. 95-95, 91 Stat., 685 and Pub. L. 95-190, 91 Stat., 1399, as amended.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA/Superfund): legislation (42 U.S.C. 9601-9675 et seq., as amended by the Superfund Amendments and reauthorization Act of 1986 (SARA), 42 U.S.C. 9601et seq.

Compromised Sample: a sample received in a condition that jeopardizes the integrity of the results. See Section 18.0 for a description of these conditions.

Confidential Business Information (CBI): information that an organization designates as having the potential of providing a competitor with inappropriate insight into its management, operation or products.

Confirmation: verification of the presence of a component using an additional analytical technique. These may include second column confirmation, alternate wavelength, derivatization, mass spectral interpretation, alternative detectors, or additional cleanup procedures.

Corrective Action: action taken to eliminate the causes of an existing non-conformance, defect or other undesirable situation in order to prevent recurrence.

Data Audit: a qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality.

Demonstration of Capability (DOC): procedure to establish the ability to generate acceptable accuracy and precision.

Equipment Blank: a portion of the final rinse water used after decontamination of field equipment; also referred to as Rinsate Blank and Equipment Rinsate.

Document Control: the act of ensuring that documents (electronic or hardcopy and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Environmental Data: Any measurement or information that describes environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology. DoDI 4715.15, December 11, 2006.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA): legislation under 7 U.S.C. 135 et seq., as amended.

Federal Water Pollution Control Act (Clean Water Act, CWA): legislation under 33 U.S.C. 1251 et seq., Public Law 92-50086 Stat. 816.

Field Blank: a blank matrix brought to the field and exposed to field environmental conditions.
Field of Testing (FOT): a field of testing is based on NELAC’s categorization of accreditation based on program, matrix, analyte.

Good Laboratory Practices (GLP): formal regulations for performing basic laboratory operations outlined in 40 CFR Part 160 and 40 CFR Part 729 and required for activities performed under FIFRA and TSCA.

Holding Time: the maximum time that a sample may be held before preparation and/or analysis as promulgated by regulation or as specified in a test method.

Instrument Blank: a blank matrix that is the same as the processed sample matrix (i.e. extract, digestate, condensate) and introduced onto the instrument for analysis.

Instrument Detection Limit (IDL): the minimum amount of a substance that can be measured with a specified degree of confidence that the amount is greater than zero using a specific instrument. The IDL is associated with the instrumental portion of a specific method only sample preparation steps are not considered in its derivation. The IDL is a statistical estimation at a specified confidence interval of the concentration at which the relative uncertainty is +100%.

The IDL represents a range where qualitative detection occurs on a specific instrument. Quantitative results are not produced in this range.

Laboratory Control Sample (LCS): a blank matrix spiked with a known amount of analyte(s), processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

Laboratory Quality Manual (QSM): a document stating the quality policy, quality system and quality practices of the laboratory. The QSM may include by reference other documentation relating to the laboratory's quality system.

Limit of Detection (LOD): the minimum amount of a substance that an analytical process can reliably detect.

Limit of Quantitation (LOQ): the minimum concentration of an analyte or category of analytes in a specific matrix that can be identified and quantified above the method detection limit and within the limits of precision and bias during routine analytical operating conditions.

Matrix: the substrate of a test sample. Common matrix descriptions are Air (air samples as analyzed or as adsorbed into a solution or absorption matrix and desorbed), Aqueous includes surface water, groundwater and effluents, Drinking Water Aqueous sample that has been designated a potable water source, Saline Aqueous sample from an ocean or estuary, or other salt-water source, Liquid: Liquid with <15% settleable solids, Solid: Soil, sediment, sludge or other matrices with >15% settleable solids, Waste (a product or by-product of an industrial process that results in a matrix not previously defined), Tissue Sample of a biological origin such as fish tissue, shellfish, or plant material.

Matrix Duplicate (MD): duplicate aliquot of a sample processed and analyzed independently; under the same laboratory conditions; also referred to as Sample Duplicate; Laboratory Duplicate.

Matrix Spike (MS): field sample to which a known amount of target analyte(s) is added.

Matrix Spike Duplicate (MSD): a replicate matrix spike.

Method Blank: a blank matrix processed simultaneously with, and under the same conditions as, samples through all steps of the analytical procedure.

Method Detection Limit (MDL): the minimum amount of a substance that can be measured with a specified degree of confidence that the amount is greater than zero using a specific measurement system. The MDL is a statistical estimation at a specified confidence interval of the concentration at which the relative uncertainty is ±100%. The MDL represents a range where qualitative detection occurs using a specific method. Quantitative results are not produced in this range.

Non-conformance: an indication, judgment, or state of not having met the requirements of the relevant specifications, contract, or regulation.

Precision: an estimate of variability. It is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions.

Preservation: refrigeration and/or reagents added at the time of sample collection to maintain the chemical, physical and/or biological integrity of the sample.

Proficiency Testing: determination of the laboratory calibration or testing performance by means of inter-laboratory comparisons.

Proficiency Test (PT) Sample: a sample, the composition of which is unknown to the analyst that is provided to test whether the analyst/laboratory can produce analytical results within specified performance limits. Also referred to as Performance Evaluation (PE) Sample.

Proprietary: belonging to a private person or company.

Quality Assurance (QA): an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

Quality Assurance Project Plan (QAPP): a formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved.

Quality Control (QC): the overall system of technical activities, the purpose of which is to measure and control the quality of a product or service.

Quality Control Sample: a control sample, generated at the laboratory or in the field, or obtained from an independent source, used to monitor a specific element in the sampling and/or testing process.

Quality Management Plan (QMP): a formal document describing the management policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an agency, organization or laboratory to ensure the quality of its product and the utility of the product to its users.

Quality System: a structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA/QC.

Quantitation Limit (QL): the minimum amount of a substance that can be quantitatively measured with a specified degree of confidence and within the accuracy and precision guidelines of a specific measurement system. The QL can be based on the MDL, and is generally calculated as 3-5 times the MDL, however, there are analytical techniques and methods where this relationship is not applicable. Also referred to as Practical Quantitation Level (PQL), Estimated Quantitation Level (EQL), Limit of Quantitation (LOQ).

Raw Data: any original information from a measurement activity or study recorded in laboratory notebooks, worksheets, records, memoranda, notes, or exact copies thereof and that are necessary for the reconstruction and evaluation of the report of the activity or study. Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic/optical media, including dictated observations, and recorded data from automated instruments. Reports specifying inclusion of “raw data” do not need all of the above included, but sufficient information to create the reported data.

Record Retention: the systematic collection, indexing and storing of documented information under secure conditions.

Reference Standard: a standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.

Reporting Limit (RL): The level to which data is reported for a specific test method and/or sample. The RL is generally related to the QL. The RL must be minimally at or above the MDL.

Resource Conservation and Recovery Act (RCRA): legislation under 42 USC 321 et seq. (1976).

Safe Drinking Water Act (SDWA): legislation under 42 USC 300f et seq. (1974), (Public Law 93-523).

Sampling and Analysis Plan (SAP): a formal document describing the detailed sampling and analysis procedures for a specific project.

Selectivity: the capability of a measurement system to respond to a target substance or constituent.

Sensitivity: the difference in the amount or concentration of a substance that corresponds to the smallest difference in a response in a measurement system using a certain probability level.

Spike: a known amount of an analyte added to a blank, sample or sub-sample.

Standard Operating Procedure (SOP): a written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks.

Storage Blank: a blank matrix stored with field samples of a similar matrix.

Systems Audit: a thorough, systematic, on-site, qualitative review of the facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of a total measurement system.

Test Method: defined technical procedure for performing a test.

Toxic Substances Control Act (TSCA): legislation under 15 USC 2601 et seq., (1976).
Traceability: the property of a result of a measurement that can be related to appropriate international or national standards through an unbroken chain of comparisons.

Trip Blank: a blank matrix placed in a sealed container at the laboratory that is shipped, held unopened in the field, and returned to the laboratory in the shipping container with the field samples.

Verification: confirmation by examination and provision of evidence against specified requirements.

APPENDIX G
Organizational Chart

Figure 4. Cascade Technical Services – Vermont Organizational Chart

APPENDIX H

Forms:

Procedure Specific Training Log
Laboratory Project Startup Information Form
Project Planning Tool
Demonstration of Capability Certification Statement
Non-Conformance Form (NCR) Form
Ethics Agreement
Data Integrity Audit Checklist
Data Package Requirements – Analyst Checklist
Secondary Data Reviewer Checklist

Cascade Technical Services
Procedure-Specific Laboratory Training Documentation Sheet

Staff Name: ______________________________

General Procedure	Steps	Tier 1	Tier 1	Tier 2	Tier 2	Tier 3	Tier 3	Tier 4	Tier 4	
		understands basics and SOP	Training date	on the job training	Training date	demonstrated competence; able to perform unsupervised	Date	authorized to provide training to other staff	Date	Comments
		trainee int./date		*trainee and trainer int./date*		*trainee and trainer int./date*		*trainee and trainer int./date*		
Misc. Procedures	MeOH Vial Prep									
	Balance checking									
	MeOH Pipettor checking									
	Soil Extractions									
	% Moisture analyses									
	Thermometer checking									
	SPME Ext Vial Cleaning									
Sample Administration	Sample Login									
	Sample Storage									
Hazardous Waste	Overview of Lab Waste Streams									
	Waste Disposal									
	Sampling and Analyses for Disposal									
GC/MS Operation	Standard Preparation									
	Calibration Curve									
	Sample prep - Soil/Water									
	Populating Run Log									
	Pal Sequencing									
	GC/MS Sequencing									
	MS/MSD Prep - soils and waters									
	Reviewing runs in HP Chemstation									
GC/MS Reporting	Level 2 Reporting									
	Level 3 Reporting									
	Level 4 Reporting									
MAE Extractions	Extractions									
	Decontamination									
	Standard Preparation & Spiking									
LIMS	Sample Login									
	Batch Login									
	Importing Data									
	Reviewing Data									
	Reporting Sample Data									
	External Check Procedure									
	Reporting QC Data									
	Work Order									
	EDD Generation and checking									
GC/MS Maintenance	source cleaning/filaments									
	ip cleaning									
	replacing columns									
PAL Maintenance	changing out bands									
	changing fuses									
	alignment of items									
	cleaning of trays and incubator									

CASCADE TECHNICAL SERVICES MOBILAB - LIMS PROJECT INFORMATION SUMMARY

Project #:	[redacted]	**Client**	[redacted]
ProjectID:	[redacted]	**Location:**	[redacted]
		Lab Name	ML1

Site Details

Site Access Logistics Quote also assumes site power (240V, single phase, 50Amp) is NOT available for laboratory - plug required for lab is NEMA 14-50R.
Backup Power:
[redacted]

Site Address [redacted]

City [redacted] **State** [redacted] **Zip**

Contact Name [redacted] **Affiliation** [redacted]

Email Address [redacted] **Phone** [redacted]

Site Power ☐

Staffing and Schedule

Staffing		**Scheduling**	
PrimaryAnalyst:	HJK	**OnSite Arrival Date (on-site)**	5/23/2016
Extraction Chemist:		**Expected Sample Arrival (in-house)**	
Secondary Reviewer:	MJG	**Complete extractions by**	
Cascade PM:	MDR	**Complete analyses by**	
Lab PM:	MDR	**Preliminary results due**	
Sample Team Rep:		**Final report due**	6/10/2016
		Preliminary Reporting Frequency:	2x Daily
Staffing Notes:	DBJ is second chemist for project	**Scheduling Notes:**	

Instrument	Detector	System	Method	Filename	Include
MS3	MS	System A	8260C	details.txt	☑

Matrix	SS Amount (ug/L)	Default Dilution	Check to Include	Check ONE Default	Num Samples Expected	Vial Prep Required	Vials By Date	Vials To Whom
Soil	20	40	☑	☑	200	☑	5/20/2016	Livia

Vial Prep Instructions/ Sample Info: %M required - please weigh %M vials at receipt without caps. enter "enter soil mass for % moisture" button on main LIMS startup page. After weighing, recap and bring back to VT for drying and post weights (Note: empty %M vial w/o cap 25.09 g)

Specify Methanol Volume (mL) 10 For soils: 10ml, For rock: 20ml

Specify Default Soil/Rock Mass (g): 10 For soils: 10g, For rock: 15g

Analysis

SDG Batching Notes:

Field Duplicates		**MS/MSD**		**Lab Duplicates**		**LCSD**	
Frequency	1 in 20	**Frequency**	1 in 40	**Lab Dup Required? (beyond MSD)**	☐	**LCSD Required?**	☐
Selectedby		**Selectedby**					
Field Dup Report?	☐	**MS/MSD Report?**	☐	**Frequency**		**Frequency**	

Project Specific QAPP?: ☐

Project-Specific Analytical Details: [redacted]

CASCADE TECHNICAL SERVICES MOBILAB - LIMS PROJECT INFORMATION SUMMARY

Compound List

Compound	Soil Mdl	Water Mdl	Cal Lower	Cal Upper	Lower Control Limit	Upper Control Limit	Compound Multiplier
Vinyl Chloride	0.76	0.61	1	200	70	130	1
trans-1,2-Dichloroe	0.29	0.16	1	200	70	130	1
cis-1,2-Dichloroeth	0.96	0.57	1	200	70	130	1
Trichloroethene	0.18	0.22	1	200	70	130	1
Tetrachloroethene	0.52	0.8	1	200	70	130	1
Bromofluorobenzen	0.25	0.24	1	200	70	130	1

Reporting

COC Format MobiLab Login Sheet

Reporting Notes:

Reporting Level II

DODProject ☐

EDD Format EQUIS EZ Basic

Please see "Staffing and Schedule" for Reporting Due Dates and "Client Contact Info" for Reporting Distribution List.

Client Contact Info

Contact Name	Type	Affiliation	Primary Reporting Contact	On Distribution List for Reporting
[redacted]	Client Geologist	[redacted]	☑	☑

Address [redacted] [redacted]

phone [redacted]

Notes

City [redacted] **State** [redacted]

Zip [redacted]-[redacted]

email [redacted]

Contact Name	Type	Affiliation	Primary Reporting Contact	On Distribution List for Reporting
[redacted]	Client PM	[redacted]	☑	☑

Address

phone

Notes

City **State**

Zip

email [redacted]

[redacted] [redacted]

Project Planning (PP) Tool

[redacted]

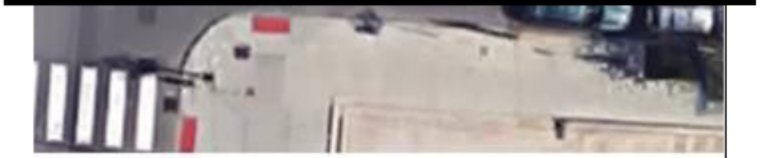
[redacted]

Project Planning Lead (who organized and led the PP): MDR

Other PP team members: HK, DJ and MG

Project Planning
Date: [redacted]
Project Information

Client: [redacted]	Stone Project Manager: MDR
Project Name: [redacted] [redacted]	Stone Project ID: [redacted]
Client Contact: [redacted]	Project Location: [redacted]

	See attached map for “parking lot” where we will park lab. [redacted] 
Subcontractors:	Special Procurement/Contracting Needs: Backup Power [redacted]

Objectives for Project:
To provide near real time analytical chemistry services for a soils investigation.

Scope of Work:
Mobilize/demobilize one GC/MS lab and two chemistsw from Montpelier, VT to [redacted] Mobilab will be onsite for four days and will conduct soil analyses via EPA SW846 Method 8260 (gas chromatography/mass spectrometry (GC/MS)) with solid phase microextration technique for PCE and its degradates. Cascade is NELAC certified for the methods to be used for this program. Laboratory productivity rate is approximately 50 samples per day with two chemists. Detection limits for soil analyses will be 40 ug/Kg. Results will be reported as wet weight results in the field. % moisture analyses will also be completed for this work and the final sample results will be reported as dry weight results. Quote also assumes site power (240V, single phase, 50Amp) is not available for laboratory - plug required for lab is NEMA 14-50R. If site power is available, Cascade will not charge a generator/fuel fee as shown below.

What are our client's expectations? Near-r*eal time VOC data for the soils.*

What are the deliverables and corresponding schedule:
See scope of work for lab deliverables. Schedule is to mobe [redacted]*. Project will not likely last full four days.*

Budget details for this project?
Budget is 4 hrs for one-way trip to site.
4 hours on site setup.
10 hour work days.
Hotels and car rental are being arranged by Helmer and Corrina

What, if any, challenges might we expect to see? How will we address these challenges?
High throughput. Will need fast method.

What are the project staff roles? *MDR is the PM. HK will be site lead with support from Daryl Jones. MG is data management/review lead for this project.*

Communication Plan: Discuss lines of communications with client, [redacted] Staff (field and office) and Subcontractors.
Communication with client is expected to occur primarily through emails with MDR, MG and HK copied at all times. Distribution list for data for [redacted]

Describe contingency for when trained resources are not available. *Staff selected for this position should be adequately trained for all aspects of this project.*

Project Specific or Corporate Health and Safety Plan needed? Provided by whom? We will be working under [redacted] HASP.

Under what quality standard [redacted] does this project fall? E.g. GLP; NEFAP; NELAP; USACE QSM; Project Specific Quality Assurance Project Plan; other? Do any of our quality assurance processes need to be modified in order to do this work? Our SOP for 8260 meets the standard that is required for this work. We have not yet received a firm number for frequency of QC samples that will be collected in the field.
Special notes – other comments, action items, travel details, etc: See below for more details.

DEMONSTRATION OF CAPABILITY

CERTIFICATION STATEMENT

Date:

Laboratory Name: **Cascade Technical Services - Mobilab**

Laboratory Address: 1 Home Farm Way, Montpelier, VT 05602

Analyst Name:

Matrix:

Method number: _______________SOP #:_____________

Analyte, or Class of Analytes or Measured Parameters:

We the undersigned CERTIFY that:

1. The analyst identified above, using the cited test method, which is in use at this facility for the analysis of samples under the National Environmental Laboratory Accreditation Program, has met the Demonstration of Capability.
2. The test method was performed by the analyst identified on this certification.
3. A copy of the test method and the laboratory-specified SOPs are available for all personnel on-site.
4. The data associated with the demonstration capability are true, complete and self-explanatory (1).
5. All raw data (including a copy of this certification form) necessary to reconstruct and validate these analyses have been retained at the facility, and that the associated information is available for review by authorized assessors.

______________________	_________________________	__________________
Laboratory Manager	Signature	Date
______________________	_________________________	__________________
Quality Assurance Manager	Signature	Date

(1) True: consistent with Supporting data. Accurate: Based on good laboratory practices consistent with sound scientific Principles/practices. Complete: Includes the results of all supporting performance testing. Self-Explanatory: Data property labeled and stored so that the results are clear and require no additional explanation.

CASCADE
DRILLING | TECHNICAL SERVICES

CASCADE TECHNICAL SERVICES - MOBILAB
LABORATORY QUALITY MANAGEMENT

NON-CONFORMANCE REPORT - (NCR) CORRECTIVE ACTIONS

To: ______________________ NCR Number: ________ *(YYYY-MM-DD-##)*

Issue Date: ____________ Due Date: ____________ Closing Date (by QAM): ____________

This Non-Conformance Report refers to the following:

Project Number: ________ NCR Category: Audit Finding

NCR Title (Brief statement of NCR): ______________________

Description of Deficient Condition: *(Include additional information, sketches, etc. as necessary)*

Signature: ______________________ Date: ____________
Quality Assurance Manager (QAM) or Designee

Corrective Action Taken:

Recommended by: ______________________ Date: ____________

Closeout of Corrective Action: *(Note: Preventive Actions taken here, use attached sheet if necessary)*

Corrective Action Approved: Timeframe:

Signature: ______________________ Signature: ______________________
Client/Other **Cascade Technical Services**
Title: ______________________ Title: ______________________

Followup Required? __________ Yes __________ No Copy to: ____________
Followup Performed on: Date: ____________ ____________
Acceptable: _________ Yes __________ No ____________
File: ____________

S:\Netdrv-I\GLP_NELAC\CORRECTIVE ACTIONS_NonConformances\NCR Form Template - Cascade\[FLB005.05.31.2017.01_NCR_CA_Form_Template.xls]Sheet1

CASCADE
DRILLING | TECHNICAL SERVICES

Ethics Agreement

It is the policy of Cascade Technical Services – Vermont (CTS-VT) to incorporate the highest standard of quality and confidentiality with all analytical and field programs by adhering to the following practices:

CTS-VT will only offer analytical procedures for which it can consistently demonstrate compliance with high quality, traceable and legally defensible performance standards. CTS-VT staff are committed to the practice of complete honesty in the production and reporting of data. Staff who may be aware of misrepresentation of facts or data manipulation to bypass established quality assurance (QA) and quality control (QC) requirements, are required to immediately inform their supervisor or any member of management. In addition, any and all information which is not in the public domain that an employee acquires through the course of his or her employment at CTS-VT, whether the information is owned by CTS-VT or a client or potential client, is to be held in strictest confidence and not disclosed orally or in writing to any person other than a CTS-VT employee or the client.

All employees are asked to sign a copy of the statement below upon their first day of employment.

I, ____ (print name) understand that high standards of integrity are required of me with regard to the duties I perform and the data I report in connection with my employment at CTS-VT. I agree that in the performance of my duties at CTS-VT:
I will not intentionally report data values that are not the actual values obtained;
I will not intentionally report dates, times, sample or QC identifications, or method citations of data analyses that are not the actual dates, times sample or QC identifications, or method citations;
I will not intentionally misrepresent another individual's work; and
If a supervisor or a member of CTS management requests me to engage in or perform an activity that I feel is compromising data validity or quality, I will not comply with the request and report this action immediately to a member of the upper management, up to and including the Senior Vice President of Technical Services.
I will not intentionally report data values that do not meet established quality control criteria as set forth in the Method and/or Standard Operation Procedures, or as defined by CTS-VT Policy.

I agree to inform my Supervisor of any accidental reporting of non-authentic data by me in a timely manner. I agree to inform my Supervisor of any accidental or intentional reporting of non-authentic data by other employees. I have read this Ethics Agreement and understand that failure to comply with the conditions as stated above will result in disciplinary action, up to and including termination from CTS.

Compliance with this agreement of business ethics and conduct is the responsibility of every CTS-VT employee. Disregard or failing to comply with this standard of business ethics and conduct could lead to disciplinary action up to and including possible termination of employment and criminal action.

Signature: ____________________________________ Date: _______________

Witnessed by: ____________________________________

DATA INTEGRITY AUDIT CHECKLIST

Date: ____________ **Conducted by:** __________________________ **Audit #:** ___________

Method/Sample ID(s): ____

Personnel/Section Audited: ____

Are all samples accounted for and are sample IDs recorded correctly?

Is the sample sub-sampled without bias?

Is the appropriate QC (duplicates, spikes, LCS, etc.) being analyzed and accurately recorded?

Are blank samples being analyzed and accurately recorded?

Are unusual sample characteristics or method deviations noted?

Is temperature accurately recorded? Are correct temperatures being adhered to?

Are instrument times (clocks) accurate? Are critical dates and times of analysis accurately recorded?

Are records of holding times accurate?

Are duration times correctly recorded and do they meet method requirements?

Are dilutions accurately recorded and correctly calculated?

Are all results recorded in ink onto authorized bench sheets?

Is the correct SOP being followed accurately?

Verify all spiking activities

Verify standard and reagent expiration dates and usage

Verify calibration accuracy and acceptability

Verify a manual integration

Verify a sample calculation

Is the analyst of record correct?

Select one result on a final report and trace back to raw data – record findings:

____

Record any necessary Corrective Actions and corresponding report numbers (NCR Form):

Are any of the findings due to a personnel integrity issue (were any of the findings more than 'mistakes')? If so, detail further actions (e.g. notification of laboratory management, further investigations, final resolution, etc.)

CASCADE
DRILLING | TECHNICAL SERVICES

Data Package Requirements - Analyst Checklist

Project ID: ___________________________ Lab #: __________________________________
SDG #: ___________________________ Analyst(s): ________________________________
Level of Reporting (II, III, IV?): _________ Date Range of Analyses: ___________________

Hard Copy Components (For All Projects)	**Included in Data Package?**	**Analyst Comments**
Copies of Run Logs		
Sample Login Sheets/COCs (make sure all req'd fields completed correctly for each sample, soil weights & Lab ID included)		
All applicable calibrations, including:		
• Response Factor (RF) Report, including:		
○ Specify cal ranges for each cpd and specify concentrations for cpds different from levels listed on RF (e.g., ketones, m+p-xylenes)		
○ Make sure RFs and datafile names are included for all points		
○ Plots printed for any linear or quadratic fits, with r^2 values recorded on plots		
○ CAL CHECK quant reports – the low and high points of the cal reprocessed back through the curve to demonstrate that the recovery is within 70-130% (representative fit).		
• "List Compounds" Report (shows cal fit types)		
• Quant reports for individual cal levels and ICV, signed and dated*		
QA/QC Coversheets for each analytical batch, indicating file IDs for each QC run and any deficiencies or other important details, signed and dated. Make sure to include any IS or SS outages and to include MS/MSD runs, where applicable.		
All Daily QC quant reports with QC Batch IDs designated, signed and dated*, including:		
• FBLK run(s)		
• BFB Tune check run(s) including spectra		
• CCV run(s)		
• MBLK run(s)		
• LCS run(s) –		
All sample quant reports, signed and dated*, including MS/MSD & FD runs, if applicable. Organize by hole & depth.		
Internal Standard & Surrogate Reports from ChemStation		

* Sign and date at bottom of quant report next to "m" for Manual Integration (MI) and include MI reason code next to each compound manually integrated.

Electronic Data Components (For All Projects)	Transferred?	Analyst Comments
LIMS (*FRONT* and *DATA* components) and any other misc. electronic project files copied to project folder on network		
All Data (.D) and Methods (.M) Files backed up to \\cdlp-file\Active Projects\Lab Data via SFFS		

Electronic Data Components (Additional Requirements for Level III Projects)	Transferred?	Analyst Comments
LIMS-generated QC Reports, including:		
• CCV Reports		
• MBLK Reports		
• LCS/D Reports		
• MS/MSD Reports (if applicable)		
• FD Reports (if applicable)		

Electronic Data Components (Additional Requirements for Level IV Projects)	Transferred?	Analyst Comments
Detailed pdf Reports, post-q-edit		

Analyst Signature: ____ Date:____________________

SECONDARY DATA REVIEWER CHECKLIST

Instrument:_________________________ Project Number:_________________________

SDG Date Range:_________________________ Project Name:___________________________

Sample Delivery Group (SDG):_____________

Action	**Completed?**
COCs: • Check that all COCs have been properly populated with all necessary information.	
Accuracy & Completeness: • Export and format LIMS tblSampleLogin for inclusion in lab data report, including a header that shows project and SDG info. • Check each sample on this Sample Login Summary against project COCs for accuracy and completeness. • Use LIMS Completeness check ("Samples Logged in/Count of Results" button) to make sure all samples have data in LIMS.	
Sample Weights & Percent Moisture: • If soil or rock samples are present in SDG, generate, export and format LIMS "Review Sample Weights" query for inclusion in lab data report, including a header that shows project and SDG info and a footer that shows page numbers. This is also a handy sheet to use when reviewing results and checking calculations – especially if a column is added for calculated Reporting Limit.	
QC Data Review: • ICAL - Check response factor calculations for ICAL (esp. one with manual integrations) and make sure all levels are represented correctly on RF Report – add 7th level RFs if applicable. Make sure that cal ranges are correct in LIMS. • Review all QC data from each analytical batch in the SDG, making sure that all QC Data meet the requirements described on QA/QC Batch Checklist. This review should include the following: FBLK, BFB Tune (including 12-h window), ICAL, CCV, MBLK, LCS, MS/MSD, FD, ISTD and SS recoveries. Sign Daily QA/QC Checklist. • Make sure that all QC outages are documented on QA/QC Batch Checklists. If any data qualifications are necessary based on QC outages, use qualification tool in LIMS to apply qualifiers (make sure to QC the batches assigned at runlog first)	

Sample Data Review: • Make sure all results in LIMS (or on LIMS-generated Form 1 Reports) match those on quant reports, including checking any sample weight and/or percent moisture calculations for soil/rock samples. • Make sure quant reports say "QT reviewed" and have been signed and dated by analyst. • Check that ISTD and SS are within acceptable range for all samples in window. • Check that all results have been reported from within cal range. • Check that qualifiers have been applied appropriately if necessary.	
Manual Integrations: • Check all manual integrations by looking at the "after" integrations on pdf files. • Verify that analyst has initialed and dated next to the "m" on the quant report and has included a reason code for each compound manually integrated.	
Lab Narrative Report: • Using the Daily QA/QC Checklists, summarize in narrative any QC outages from the batches within the SDG as well as any problems encountered with samples. • Compile all necessary attachments (dependent of level of reporting). At a minimum, this would include scanned COCs, LIMS Sample Login Summary, Sample weights and percent moisture data (for soil/rock data), and sample Form 1 Reports. • Send final report to another analyst or Lab or QA Manager for review.	
EDD: • Generate EQUIS EDD (or other appropriate format) in LIMS. • Make sure that all columns are properly populated. • Make sure that EDD contains the correct number of results • Spot check results in the EDD against verified Form 1 Reports.	

Secondary Reviewer Signature: ___________________________ Date: ________________________

Additional Notes:

Alpha Analytical Labs
Laboratory Control Plan
2017

Quality Systems Manual

Alpha Analytical, Inc.

D/B/A

Alpha Analytical
Eight Walkup Drive
Westborough, MA 01581-1019
Telephone: (508) 898-9220
Facsimile: (508) 898-9193

Alpha Analytical
Woods Hole Labs Facility
320 Forbes Blvd
Mansfield, MA 02048
Telephone: (508) 822-9300
Facsimile: (508) 822-3288

Email: info@alphalab.com
Web site: www.alphalab.com

President: Mark Woelfel, 508-439-5115
Quality Assurance Officer: James Todaro, Ext 508-439-5101
Laboratory Technical Manager (Director) Westboro: Joseph Watkins 508-439-5125
Laboratory Technical Manager (Director) Mansfield: Greg Yogis, 508-844-4141
Laboratory Technical Manager (Director) Air-Mansfield: Andy Rezendes, 508-844-4181

1 Mission Statement

The mission of Alpha Analytical is quite simply to provide our customers with the greatest value in analytical service available. For the ‘greatest value’ is not only found in the data that is delivered, it is also found in the services provided.

- Data must be of the highest integrity, accuracy and precision.
- Consultation and educational services must be provided to support the customer in establishing data quality objectives and interpretation of the final data package.
- Support services such as sample containers, courier service and electronic data deliverables must be available to the customer.

Alpha’s mission continues with an established commitment to our community and environment. We must ensure that we do not produce any additional contamination to our environment or harm our neighbors and community in any way.

The value of Alpha’s product is in the honesty and integrity with which each chemist, courier, login staff member, or office staff member performs their tasks. The customer or employee must always feel satisfied that they received the greatest value in their lab experience at Alpha.

Alpha Analytical will vigorously pursue its mission into the next millennium.

Mark Woelfel

President

2 Table of Contents

3 Introduction

The Quality Systems Manual, referred to as Corporate Quality Systems Manual (CQSM) of Alpha Analytical describes the quality program in use at the laboratory for both Westboro and Mansfield facilities. This Quality Systems Manual provides employees, customers and accrediting agencies with the necessary information to become familiar with how the quality system operates within Alpha Analytical. The quality program includes quality assurance, quality control, and the laboratory systems including feedback mechanisms for the automated continuous improvement of the laboratory operations to meet customer needs.

Implementation of the laboratory operations is by documenting procedures, training personnel and reviewing operations for improvement. Written procedures are maintained as Standard Operating Procedures (SOPs). The SOPs are available to the staff as a controlled, electronic, secure copy. The provisions of the QSM are binding on all temporary and permanent personnel assigned responsibilities. All laboratory personnel must adhere strictly to the QSM and SOPs.

All policies and procedures have been structured in accordance with the NELAC Institute (TNI) Standards), DOD QSM 5.1 and applicable EPA requirements and standards.

Twenty-five (25) sections comprise the QSM. Related quality documentation including the listing of SOPs, forms, floor plan, equipment, personnel and laboratory qualifications are available. The QSM sections provide overview descriptions of objectives, policies, services and operations.

3.1 Scope

The QSM describes the requirements of the Laboratory to demonstrate competency in the operations for performing environmental tests for inorganic, organic, air and microbiological testing. The basis for the environmental tests is the methods found in documents published by the United States Environmental Protection Agency (EPA), ASTM, AOAC, APHA/AWWA/WEF, Standard Methods, and other procedures and techniques supplied by customers.

The QSM includes requirements and information for assessing competence and determining compliance by the laboratory to the quality system. When more stringent standards or requirements are included in a mandated test method, by regulation, or specified in a project plan the laboratory demonstrates achievement of the customer specified requirements through its documented processes.

The QSM is for use by Alpha Analytical for developing and implementing the quality system. Accrediting authorities and customers use the QSM for assessing the competence of Alpha Analytical. Alpha Analytical is committed to continually improving the quality system. Meeting customer needs, operating within regulatory requirements and adhering to Alpha's Data Integrity and Ethics policy are several of the mechanism used to continually improve the quality system.

3.2 Policy Statement

This Quality Systems Manual summarizes the policies, responsibilities and operational procedures associated with Alpha Analytical. This manual applies to all associates of the laboratory and is intended for use in the on-going operations at Alpha Analytical. Specific protocols for sample handling and storage, chain-of-custody, laboratory analyses, data reduction, corrective action, and reporting are described. All policies and procedures have been structured in accordance with the NELAC Institute (TNI) Standards, DOD QSM(which includes 17025 standards), applicable EPA requirements, regulations, guidance, and technical standards. This Quality Systems Manual, laboratory Standard Operating Procedures (SOPs), and related documentation describe the quality systems, policies and procedures for Alpha Analytical.

Alpha Analytical performs chemical analyses for inorganic and organic constituents in water, seawater, soil, sediment, oil, tissue and air matrices. Alpha Analytical's goal is to produce data that is scientifically valid, technically defensible, and of known and documented quality in accordance with standards developed by The NELAC Institute (TNI) Standards and any applicable state or EPA regulations or requirements. It is the commitment of the President, Operations Director, Laboratory Technical Manager and Quality Assurance Officer to work towards continuous improvement of the operation, and towards meeting our customer's needs, requirements, and intended data usage. This continued commitment is built into every activity of the laboratory. It is the responsibility of Senior Management and the Department Managers to ensure that all associates familiarize themselves with, and comply at all times with, the quality systems, procedures and policies set forth in this manual, laboratory SOPs, and related documentation.

Alpha Analytical analyzes Proficiency Test (PT) samples, in accordance with the NELAC Institute (TNI) Standards and other regulatory programs, from a National Institute of Standards and Technology (NIST)-approved PT provider for the analytes established by EPA for water samples, and for other analytes and matrices. The specific analytes and matrices analyzed are based on the current scope of the laboratory services as documented in the laboratory SOPs and state certifications.

The technical and service requirements of all requests to provide analyses are thoroughly evaluated before commitments are made to accept the work. This includes a review of facilities and instrumentation, staffing, and any special QC or reporting requirements to ensure that analyses can be performed correctly and within the expected schedule. All measurements are made using published reference methods or methods developed by Alpha Analytical. Competence with all methods is demonstrated according to the procedure described in SOP/ 1739 prior to use.

Alpha Analytical has developed a proactive program for prevention and detection of improper, unethical or illegal actions. Components of this program include: internal proficiency testing, electronic data audits and post-analysis data review by the QA Officer; a program to improve employee vigilance and co-monitoring; and Ethics Training program identifying appropriate and inappropriate laboratory practices, instrument manipulation practices and consequences. Additionally, all associates are required to sign the Alpha Analytical *Ethics Agreement* form upon commencement of employment and each year following. This form clearly outlines the possible consequences of unethical or improper behavior, or data misrepresentation. All staff are required to report any suspected unethical conduct to management. Management will then investigate and determine if the situation was considered unethical and will take appropriate action as described in the Alpha Ethics policy.

It is the policy of the laboratory to discourage and reject all influence or inducements (whether commercial, financial or personal) offered either by customers or suppliers, which might adversely affect results or otherwise compromise the judgment or impartiality of the staff. It is the responsibility of the Operations Director and Laboratory Technical Manager to inform customers and suppliers of this policy when necessary.

In the event that any such influences or inducements are encountered, the staff is instructed to inform management immediately. It is the responsibility of the Operations Director and the Laboratory Technical Manager to take appropriate action to prevent recurrence.

3.3 References

External reference documents are available electronically in the Qualtrax system for staff to access the latest edition or version of the reference methods, regulations or national standards. The Quality Assurance Department maintains the electronic files in the Qualtrax system. Management purchases automated update services, where available, to provide the laboratory with the latest hardcopy edition, where electronic means is not available.

3.4 Definitions

Appendix A lists the definitions as adopted by the laboratory. The definitions are from the 2009 TNI standards.

4 Organization and Management

4.1 Legal Definition of Laboratory

Alpha Analytical is a full service analytical laboratory. Testing services include Drinking Water, Waste Water, Ground Water, Waste material and Air. Alpha Analytical is a privately held corporation incorporated in the state of Massachusetts. Alpha Analytical, Inc. does business as (D/B/A) Alpha Analytical.

Alpha Analytical has been in business since 1985. The types of businesses served include:

Consulting firms,
Engineering firms,
Waste Management Companies,
Industrial sites,
Municipal agencies
Department of Defense projects.

4.2 Organization

The laboratory operates a quality system approach to management in order to produce data of known quality. The laboratory organization provides effective communication and lines of authority to produce analytical data meeting customer specifications. The organizational design provides open communication while ensuring that pressures and day to day operating circumstances do not compromise the integrity of the reporting of the final data. See Appendix B for Organizational Chart.

The President is responsible for directing all areas of the company. The following job functions report to the President:

Operations Manager
Quality Assurance Officer
Marketing / Business Development / Sales
Financial Services
Human Resources

The Operations Manager is responsible for directing all laboratory operational areas of the company. The following job functions report to the Operations Manager:

Laboratory Technical Manager(s)
Customer Services Manager
Department Managers

The Laboratory Technical Manager(s) is(are) responsible for the laboratory data generated by the organics testing, inorganics testing and metals testing areas and the Air Technical Director is responsible for laboratory data generated by air analyses.

The Departmental Managers (Supervisors) have the following responsibilities:

The organics managers direct personnel in the organics extraction and instrumental laboratories.

The wet chemistry manager directs personnel and team leaders in the wet chemistry and/or microbiological testing areas.

The metals manager directs personnel and team leaders in the metals sample preparation and instrumental laboratories.

The Quality Assurance Officer is a member of the staff and reports directly to the President and has defined responsibility and authority for ensuring that the quality system is implemented and adhered to at all times. The Quality Assurance (QA) Officer is responsible for interacting and communicating certification requirements, implementing the Quality Systems Manual and reporting to the Laboratory Technical Manager and Senior Management the status of the quality program. The QAO oversees the Quality Systems Specialists and is responsible for oversight and/or review of quality control data and function independently from laboratory operations.

The Customer Services Manager is responsible for customer interactions, project coordination and laboratory personnel notification of project requirements.

The Marketing, Business Development and Sales personnel are responsible for increasing the volume of work from current customers and adding new customers to the base business of Alpha Analytical. The Marketing and Business Development personnel review all new work with the Laboratory Technical Manager, Operations Manager, President and/or Quality Assurance Officer before contractual commitment.

The CFO is responsible for maintaining and reporting on the financial status of the company. The CFO directs financial personnel on proper accounting procedures and maintaining the list of approved suppliers and subcontractors. The CFO reports directly to the President.

The Human Resource Director is responsible for personnel recruitment, hiring, performance reviews.

Personnel job descriptions define the operational function duties and responsibilities. Administration and Laboratory personnel assignments may include cross-functional training and work performance in multiple areas of the operations. Multiple function training ensures laboratory back up personnel during peak workloads.

During the absence of any staff member, assignment of alternative personnel occurs by memo or e-mail. The Manager or Supervisor authorizes the assignment. The naming of alternative personnel assures the continuing performance of critical tasks during the primary person’s absence and ensures that lines of communication remain open for continued decision making. The deputy for the Laboratory Technical Manager is the Quality Assurance (QA) Officer. The deputies for the Quality Assurance (QA) Officer are the Quality Systems Specialists.

For the purposes of the NELAC Institute (TNI) Standards the Lead Laboratory Technical Manager is the Laboratory Technical Manager. The deputies for the Lead Technical Manager are the Quality Assurance (QA) Officer, and the Departmental Managers. The Laboratory Technical Manager meets the requirements specified in the Section 4.1.7.2 Volume 1, Module 2 of the 2009 TNI standards. If the Laboratory Technical Manager is absent for a period of time exceeding 15 consecutive calendar days, a full-time staff member meeting the qualifications of Laboratory Technical Manager will be designated to temporarily perform this function. The primary Accrediting Body shall be notified in writing if the Technical Manager’s absence exceeds 35 consecutive calendar days.

4.3 Business Practices

Alpha maintains certification for the programs and analytes required by regulatory programs. The listing of qualifications from the various certifications, registrations and accreditation programs are available upon request. Alpha Analytical operates Monday to Friday from 7:30 a.m. to 5:30 p.m. Management prepares and posts the holiday schedule for the year indicating closed operations. Sample delivery occurs during normal operating hours unless arranged in advance.

Alpha's reputation depends upon timely reporting and quality data. The standard turnaround time for engineering and consulting firms is five business days from time of sample receipt. Standard turnaround for all other customers is ten business days from time of sample receipt. The time of sample receipt is when the verification of the chain of custody and samples meets the laboratory sample acceptance policy. Laboratory management must approve any special arrangements for rush or expedited turnaround time. The basis for data quality depends on customer, regulation and method performance criteria. Accuracy, precision, sensitivity and comparability are expressions of method performance criteria.

All work is performed in the strictest confidence. New and contract employees must review corporate policy and practice requirements for protecting customer confidentiality and proprietary rights. The review occurs during orientation and ethics training. It is the policy of the laboratory to release data to the customer authorized contact. Personnel assigned the duties of interacting with customers review project files and discuss data related only to the project. Personnel whose duties do not include routine customer contact must check with the customer service manager before discussing data with regulators or third parties

5 Quality System

Establishment, Audits, Essential Quality Controls and Data Verification

5.1 Establishment

The Mission Statement presents the policy and objectives for Alpha Analytical. The Quality Systems Manual provides the framework for the processes and operations to implement the Mission. The Quality Systems Manual and documentation controlled by the laboratory system detail the management authorized operations for achieving the objectives of the company.

The laboratory operates a quality system approach to management in order to produce data of known quality. Alpha Analytical is a full service laboratory designed to provide its customers with accurate, precise and reliable data within the best turn-around time and at the most reasonable prices. Alpha employs chemists of the highest training, ethics and caliber in the field of analytical chemistry. This and state-of-the-art instrumentation and automation combine to insure data of known and documented quality.

5.2 Quality Systems Manual

The QA Officer is responsible for the publication and distribution of the Quality Systems Manual and annual review. Management reviews and authorizes the manual. Implementation of major changes in the quality system occurs after revision of the appropriate Quality Systems Manual section and authorization by management.

The authorization of the Quality Systems Manual is documented electronically in Qualtrax. Updates of this manual occur at any time throughout the year. Document control procedures (SOP1729) apply to the distribution of the Quality Systems Manual. Controlled copies of the manual are maintained electronically within Qualtrax. Persons or organizations outside of Alpha Analytical may receive uncontrolled copies. Copies are distinctly indicated “Uncontrolled Documents” within the footer of each page.

5.3 Audits

Laboratory audits, both internal and external, review and examine the operations performed in the laboratory. Internal audits are conducted by qualified QA Specialists and external audits are reviews by external organizations to evaluate the ability of the laboratory to meet regulatory or project requirements. Internal audits are conducted on a frequency of bi-annually, method required and annually for DoD certified methods.

A QA designee schedules internal process audits to ensure the completion of the annual audit of each operational area. The process audits are a more detailed review of the operations. Personnel from areas other than the one audited perform process audits.

The internal system audit is a review of the implementation of the documented quality system. The system audit includes sample tracking from receipt to disposal, a data audit of a completed report, and all operations not audited during the process audit.

The purpose of the internal system audit is:

Verification that adequate written instructions are available for use;

Analytical practices performed in the laboratory are consistent with SOPs;

The quality control practices are applied during production;

Corrective actions are applied as necessary;

Deviations from approved protocols are occurring only with proper authorization and documentation;

Reported data is correct and acceptable for reporting;

SOPs, quality records, analytical records, electronic data files are maintained properly; and

Personnel training files and records are satisfactory and current.

Before a scheduled internal audit, the assigned auditor reviews checklists, if used, and/or the SOP specific to the area. The checklist may be from an external source or prepared by the auditor. . After the audit, the auditor submits a summary or notes from the audit to the Laboratory Technical Manager or QAO as part of the audit report. The summary identifies discrepancies found during the audit. Technical personnel are responsible for the inspection and monitoring of in-process and final data. Personnel independent of those having direct responsibility for the work performed audit the quality system and processes.

Representatives sent by customers and government or accrediting agencies often perform external audits. These audits are most often announced inspections, but sometimes are not announced. The Quality Assurance Officer, Laboratory Technical Manager or assigned deputy, and/or appropriate Department Manager accompany the external audit team through the laboratory. The auditors receive a brief overview of company objectives, activities, and facilities. Interviews with essential supervisory staff and technical staff are arranged, along with retrieval of any documentation pertinent to the audit. Auditors usually provide a report on their findings shortly after the audit. The QA Officer receives the audit report and copies are provided to laboratory personnel for review. Corrective actions are identified and distributed to responsible parties for implementation in response to any cited deficiencies.

5.4 Audit Review

Management reviews internal and external audit reports to evaluate system effectiveness at the annual management review meeting. Tracking of the audit findings occurs through the nonconformance action process. The management and staff work together to establish a time line for resolving the audit findings. The Quality Assurance team tracks the time line and reports to the Laboratory Technical Manager on any outstanding audit findings. Approved corrective actions for DoD that are not implemented or avoided may result in loss of DoD ELAP accreditation and may result in work being discontinued until implementation is verified by DOD ELAP AB.

5.5 Performance Audits

Alpha Analytical participates in inter-laboratory comparisons and proficiency test programs required by customers and certifying agencies. The performance audits provide information on the data comparability of results generated by the laboratory. Test samples received by the laboratory are handled following routine laboratory procedures. Proficiency test samples are unpacked, checked against the packing slip and examined for damage. Reporting requirements and deviations to routine practices are noted as would be required for any project.

Analysts demonstrate proficiency by analyzing either an external proficiency test sample, an internally prepared blind test sample or Initial Demonstration of Capability (IDC) before independent operation of a test method. The results of performance audits serve several purposes. The QA Officer may use performance audits for evaluating analyst proficiency, laboratory performance in a specified area to facilitate laboratory improvement efforts, and/or to provide information to an accrediting agency on correction of past performance of an external performance audit.

5.6 Corrective Actions/Preventative Actions (CAPA)

The corrective action process at Alpha Analytical is detailed in SOP 1736. The corrective action program at Alpha Analytical uses the Nonconformance workflow in Qualtrax to document and follow through the corrective action/preventative action process for three main areas: nonconformance's within the laboratory, customer complaints and failed PT studies. The process ensures continuous improvement of company performance by preventing the recurrence of quality problems.

Nonconformance reports are tracked for closure date and the type. Reports to management include the listing of open nonconformance reports and the frequency of the type of nonconformance occurring. A QA designee monitors the completeness of the forms, as well as verifies the actions are complete and acceptable.

Customers will be notified within 5 days of any question(s) regarding validity of results.

5.7 Managerial Review

The management review occurs at least once per year as part of the strategic planning process. Documentation of the management review meeting is by recording the meeting minutes and listing the attendees. The focus of the quality management review is the frequency of the type of nonconformance, closure status, audit progress and other quality assurance actions. Meetings include discussion and progress on quality system initiatives since the last meeting.

Prior to the meeting, an agenda is distributed to all personnel expected to be in attendance. The meeting is chaired by the President. Minutes are taken and distributed at the conclusion of the meeting by a QA designee. If action is necessary on any issue, a Summary Report is generated and distributed to responsible parties for implementation. Actions are monitored by the QAO or designee until completion.

5.8 Essential Quality Control Procedures

The following general quality control principles apply to all tests. The manner implemented is dependent on the type of test performed. The laboratory SOP presents the specific quality control checks undertaken to ensure precision, accuracy and sensitivity of each test method. Deviations from the existing SOP are allowed only upon approval of the deviation by the department manager and Quality Assurance Officer. This documentation must be either in form of written notice or email.

Alpha Analytical uses quality control samples to evaluate the following:

1. Adequate positive and negative controls to monitor blanks, spikes, reference toxicants, zero blanks;
2. Adequate tests to define the variability and/or reproducibility of laboratory results;
3. Measures to ensure the accuracy of the test data including sufficient calibration and/or continuing calibrations, use of certified reference materials, proficiency test samples;
4. Measures to evaluate test performance, such as detection limits and quantitation limits or range of applicability such as linearity;
5. Selection of appropriate formulae to reduce raw data to final results such as linear regression, internal standards, or statistical packages;
6. Selection and use of reagents and standards of appropriate quality;

7. Measures to assure the selectivity of the test for its intended purpose;
8. Measures to assure constant and consistent test conditions for the method such as temperature, humidity, light, or specific instrument conditions.

   Note: All quality control samples are treated in the same manner as field samples.

All quality control measures are assessed and evaluated on an on-going basis, and quality control acceptance limits are used to determine the usability of the data. Control charts and/or calculated control limits monitor the long-term method performance by analyte, by instrument for water matrices. Routine evaluation and reporting of the control chart performance provides supervisors and management with additional performance measures to ensure data comparability. Control limits are recalculated when trends are observed.

Where no reference method or regulatory criteria exist, the laboratory specifies the acceptance/rejection criteria in the SOP. The test SOP specifies the QC samples performed per batch of samples. The quality control samples are categorized into the following, as appropriate to the method

- Method Blank
- Laboratory Duplicate
- Laboratory Control Sample (LCS)
- Laboratory Control Sample Duplicate (LCSD)
- Matrix Spike (MS)
- Matrix Spike Duplicate (MSD)

Selection of samples for Duplicate, Matrix Spike (MS) & Matrix Spike Duplicate (MSD)

2. Duplicate samples
   a. Samples will be selected if identified and requested by customer
   b. If no samples are identified by the customer then random samples will be analyzed within the batch as defined by the method, program or at a minimum batch of 20 samples.

3. Matrix Spike (MS) / Matrix Spike Duplicate (MSD) samples
   a. Samples will be selected if identified and requested by customer
   b. If no samples are identified by the customer then random samples will be selected and analyzed within the batch as defined by the method, program or at a minimum batch of 20 samples.
   c. If MS/MSD is not required, LCS/LCSD may be substituted for

precision and accuracy evaluation.
All DOD projects require MS/MSD.

The frequency is dependent on the reference method and test protocol. The following is the default requirement for quality control checks in lieu of any other guidance. The frequency for each quality control sample is generally one (1) per every 20 samples.

5.9 Data Reduction

After completion of the test procedure, the data reduction process begins.

Chromatography data may require the manual integration of peak areas or heights before reporting of results. The analyst must perform manual integration when software does not properly integrate or identify the peak. Manual integration must not occur for the purpose of achieving acceptable quality control or calibration. The analyst and reviewer sign and date the hardcopy of all manual integration. The analyst notes the rationale for performing the manual integration on the hardcopy printout and ensures the “TIC” marks from the software represent the integration area used for reporting the results. The analyst must minimize and avoid manual integration. The establishment of the proper integration parameters in the software reduces the number of manual integration occurrences.

The SOP for each test presents the formulas used for the specific test method. The formulas for the data calculations used throughout the laboratory are the following:

% Recovery (LCS)

$$\frac{MV}{TV} * 100 = \%R_{LCS}$$

where:
MV = Measured Value
TV = True Value

% Recovery (MS or MSD)

$$\frac{MV - SV}{TV} * 100 = \%R_{MS}$$

where:
MV = Measured Value
TV = True Value
SV = Amount found in sample

Average ($\overline{X}$)

$$\sum_{i-1}^{n} X_i \Big/ n = \overline{X}$$

where: $\overline{X}$ = Average of all values
X = Result of each measurement
n = Number of values

Relative Percent Difference (% RPD)

$$\frac{R_1 - R_2}{(R_1 + R_2)/2} * 100 = \%RPD$$

where: R_1 = Larger of two observed values
R_2 = Smaller of two observed values

% Difference (%D)

$$\frac{X - \overline{X}}{\overline{X}} * 100 = \%D$$

where: $\overline{X}$ = Average of all values
X = Result of measurement

Standard Deviation of the sample (S_x)

$$\sqrt{\frac{\sum\left(X - \overline{X}\right)^2}{n-1}} = S_x$$

where: $\overline{X}$ = Average of all values
X = Result of each measurement
n = Number of values

Relative Standard Deviation (%RSD)

$$\frac{S_x}{\overline{X}} * 100 = \%RSD$$

where: $\overline{X}$ = Average of all values
Sx = Standard Deviation (n - 1)

Range of Logs (for microbiological enumeration analysis)

10% of routine samples are analyzed in duplicate and the range of logs is determined.

MDL (See 40CFR Part 136 for details)

$$\left[\sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2 \Big/ n}{n-1}}\right] * t_{0.99} = MDL$$

where: *MDL* = The method detection limit
X = Result of each measurement
n = Number of values
t(n-1,1 = .99) = The students' T value appropriate for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom. (See Students t Test Table)

Reporting Limit (RL)

Lowest calibration standard or greater

Control Limits

Upper Control Limit: $\overline{X} + 3 * S_x = UCL$
Lower Control Limit: $\overline{X} - 3 * S_x = LCL$

Warning Limits

Upper Warning Limit: $\overline{X} + 2 * S_x = UWL$
Lower Warning Limit: $\overline{X} - 2 * S_x = UWL$

Method of Standard Additions (MSA): (See EPA 7000A for details)

The simplest version of this technique is the single-addition method, in which two identical aliquots of the sample solution, each of volume Vx, are taken. To the first (labeled A) is added a known volume Vs of a standard analyte solution of concentration Cs. To the second aliquot (labeled B) is added the same volume Vs of the solvent. The analytical signals of A and B are measured and corrected for non-analyte signals. The unknown sample concentration Cx is calculated:

$$C_x = \frac{SB\ V_S\, C_s}{(SA - SB)\ V_X}$$

where SA and SB are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_S and C_s should be chosen so that SA is roughly twice SB on the average, avoiding excess dilution of the sample. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure.

Improved results can be obtained by employing a series of standard additions. To equal volumes of the sample are added a series of standard solutions containing different known quantities of the analyte, and all solutions are diluted to the same final volume.

For example, addition 1 should be prepared so that the resulting concentration is approximately 50 percent of the expected absorbance from the endogenous analyte in the sample. Additions 2 and 3 should be prepared so that the concentrations are approximately 100 and 150 percent of the expected endogenous sample absorbance.

The absorbance of each solution is determined and then plotted on the vertical axis of a graph, with the concentrations of the known standards plotted on the horizontal axis. When the resulting line is extrapolated to zero absorbance, the point of interception of the abscissa is the endogenous concentration of the analyte in the sample. The abscissa on the left of the ordinate is scaled the same as on the right side, but in the opposite direction from the ordinate. A linear regression program may be used to obtain the intercept concentration.

5.10 Document Control

The Document Control Procedure (SOP/1729) describes the process for controlled and uncontrolled documents. The use of the revision number allows for the retention of a previous document for historical information purposes.

Every document is assigned a unique identification number, which is present on each page of the document. A master list of documents includes the unique identification. Each controlled copy includes the revision number, published date and page number.

Full document control includes the status of each document: active, inactive or superseded/archived. Inactive documents are procedures not currently requested, but may be in the future. Archived documents are procedures replaced with a later revision. Authorized personnel must review and approve each document and any subsequent revisions before use in the laboratory. Personnel authorized to review and approve a document have access to all necessary information on which to base their review and approval. The history section of the document in Qualtrax includes a description of the nature of the document change.

Standard Operating Procedures (SOPs) are instructions for repetitive or standard operations performed by the laboratory. The SOP author is the person familiar with the topic. The standard format for writing SOPs is set-up as a template for administration and technical SOPs. Each SOP is peer reviewed, authorized by management, and QA before final publication and implementation. Authorized signatories for controlled documentation include one or more of the following personnel: Company President, Quality Assurance Officer, Laboratory Technical Manager, Department Manager, Department Team Leader. Personnel acknowledge approved documents as read, understood and agreed to through electronic attestation forms associated with each document as SOP Attestation Tests which reside in Qualtrax.

SOPs must receive evaluation and input by laboratory supervisors and key technical personnel. The content of each SOP must conform to applicable requirements of analytical methods and certification agencies. Within these constraints, the content of a SOP meets the needs of a particular area of the laboratory. A new or revised SOP is needed when regulatory programs update or add methods, the scope of the existing method is extended, or when activities are being performed without adequate documentation.

Updating, modifying and changing SOPs, forms and the contents of this QSM are prompt and part of the routine practices. The prompt modification of these documents ensures the documents reflect the current practices and operations of the laboratory. During annual review of a document, (including but not limited to: SOPs, Ethics Policy, Quality Systems Manual), requested changes are reviewed and the document reissued using the information and a new revision number is assigned and published in Qualtrax.

The laboratory maintains control over the possession and distribution of all documents that directly affect the quality of data. This includes, but is not limited to, documents such as the Quality Systems Manual, Standard Operating Procedures, customer instructions, Laboratory Work Instructions, data sheets, check lists and forms.

5.11 Detection Limits

Detection Limits (DLs), previously referred to as Method Detection Limits (MDLs), are determined for all analytes as specified in the Institute (TNI) Standards. DLs are determined for all new instrumentation, whenever there is a change in the test method or instrumentation that affects performance or sensitivity of the analysis. From these, detection limits, Reporting Limits (RLs), are established. The RL is the minimum concentration of an analyte that can be identified and quantified within specified limits of precision and bias during routine and analytical operating conditions.

Laboratory reporting limits lie within the calibration range, at or above the RL. For methods that require only one standard, the reporting limit is no lower than the low-level check standard, which is designed to verify the integrity of the curve at lower levels. If reporting limits are required below the lower level of the calibration curve, RL, or low-level check standard, method modifications are required. Refer to DL/LOD/LOQ SOP/1732. Note: ”J” Estimated value: Upon customer request, the Target analyte concentration can be reported below the quantitation limit (RL), but above the Detection Limit (DL) with a “J” qualifier as long as there is a LOD study on file.

5.12 LOD/LOQ Studies

A. LOD (Limit of Detection) Verification

1. LOD (Limit of Detection) verification is required annually for each target analyte in which test results are to be reported below the lowest calibration standard (“J” values) for each instrument, matrix and prep procedure. LOD is required quarterly for all DOD projects.

2. All sample-processing steps of the analytical method shall be included in the determination of the LOD.

3. The validity of the LOD shall be confirmed by ***qualitative*** identification of the analyte(s) in a QC sample in each quality system matrix containing the analyte at no more than 2-3X the LOD for single analyte tests, and 2X up to 4X the LOD for multiple analyte tests. This verification must be performed on every instrument that is to be used for analysis of samples and reporting of data.

4. An LOD study is not required for any component for which spiking solutions or quality control samples are not available such as temperature. Where an LOD study is not performed, the laboratory may not report a value below the limit of quantitation.

B. LOQ (Limit of Quantitation) Verification

1. LOQ (Limit of Quantitation) verification is required annually for each target analyte that is not reported below the lowest calibration standard for each matrix and prep procedure. LOQ is not required if an annual LOD verification is performed.
2. The validity of the LOQ shall be confirmed by successful analysis of a QC sample containing the analytes of concern in each quality system matrix 1-2 times the claimed LOQ. A successful analysis is one where the recovery of each analyte is within the established test method acceptance criteria for accuracy. LOQ are required quarterly for all DOD projects.

The LOQ study is not required for any component or property for which spiking solutions or quality control samples are not commercially available or otherwise inappropriate (e.g., pH).

The LOQ acceptance criteria are based on the established acceptance criteria for Laboratory Control Samples.

Refer to DL/LOD/LOQ SOP/1732

5.13 Range of Logs – Precision of Quantitative Methods - Microbiology

A. Precision of duplicate analyses is calculated for samples examined by enumerative microbiological methods according to the following procedure:

   a. Perform duplicate analyses on first 15 positive samples.

   b. Record duplicate analyses as D1 and D2 and calculate the logarithm of each result.

   c. If either of a set of duplicate results is <1, add 1 to both values before calculating the logarithms.

   d. Calculate the range (R) for each pair of transformed duplicates as the mean of these ranges.

6 Personnel

6.1 Laboratory Management Responsibilities

Management is responsible for communicating the requirements of the quality system, customer specifications and regulatory needs to all personnel. Management job descriptions detail the responsibilities of each position.

The H.R. Director has job descriptions for all positions in the laboratory defining the level of qualifications, training, and experience and laboratory skills. During initial training, management provides access to documented operations procedures, observes personnel performance, and evaluates personnel proficiency. Management documents technical laboratory staff's proficiency initially and on a continuing basis through use of laboratory control samples and purchased proficiency evaluation standards.

Management is responsible for verification of proper sample management and all aspects of data reporting. The communication of the operating practices of the laboratory is through the document control and attestation process.

Either the Quality Assurance Officer, Operations Director and/or Technical Managers have the authority to stop work due to non-conformances and have the authority to resume work after it has been stopped.

6.2 Laboratory Staff Requirements

Recruitment is the responsibility of the Operations Manager and HR Department, with input from other personnel as required. The Training Program procedure SOP/1565 details the process for completing requirements and training to ensure personnel have adequate skills and competence for the job function. Initial training includes ethics training, Qualtrax Training, QA Basics, IT/LIMs including computer security.

A job description details the necessary requirements for each job and includes position title, minimum educational requirements, skills, responsibilities and reporting relationships and any supervisory responsibility.

Initial training of new employees and contract staff includes laboratory ethics and quality policies, as well as execution of an Ethics Agreement. Any employee found to knowingly violate the Ethics Policy Agreement, report data values, that are not actual values obtained or improperly manipulated, or intentionally report dates and times of data analyses that are not the actual dates and times of analysis, will lead to disciplinary action, including termination, as outlined in Section V.K of the Employee Handbook. Each employee must report personally or anonymously to the Laboratory Technical Manager, QA Officer and/or Ethics Team Member any accidental or suspected intentional reporting of non-authentic data by others for follow up action. The review of the laboratory ethics and ethics training occurs annually with all personnel.

(DOD) All inappropriate and prohibited laboratory practices, as detailed in the DOD WSM 5.2.7, will be reported to the appropriate accrediting body within 15 business days of discovery. Records of corrective actions or proposed will be submitted within 30 business days. Failure to notify the AB within 15 business days will result in suspension of the DOD ELAP accreditation.

The Ethics program consists of the following key components:

- Ethics Policy /Agreement (Appendix F)

- Initial and annual ethics training
- Internal audits conducted annually
- Adherence to Manual Integration SOP/1731
- Ethical or Data Integrity issues reported to Lab Managers, QAO or HR Director
- Anonymous reporting to HR Director - This is accomplished by writing a detailed description of the suspected ethics breach and submitting the information, anonymously, to the Human Resource Director.
- “No-fault” policy encouraging reporting of incidences without fear of retribution
- Electronic tracking and audit trails through LIMs and instruments enabled where available.

6.3 Training

The Quality Systems Manual and related documentation is available to all employees. Cross training, supervisory training and other related training takes place on a scheduled and as-needed basis. Training ensures the communication and understanding of all personnel in the laboratory-documented procedures and practices.

All personnel undertake orientation-training sessions upon initial employment. Orientation training includes laboratory business practices, employment specifications, Ethics Policy, Quality Systems Manual, Chemical Hygiene Plan, and all SOPs required for the job function.

Managers ensure the training for new employees and review the continuing training for current employees. Training includes on-site and off-site programs presented by staff members, contractors, equipment manufacturers, and institutions of higher learning.

Training of new personnel to any job assignment takes place on-site according to the Training Program procedure. Laboratory personnel may perform their assigned methods/protocols without supervision only after documentation of acceptable proficiency. Training records lists the current training status.

On-the-job training includes demonstration of skills during job performance, initial demonstration of proficiency, and review of SOPs. Health and Safety training takes place on an annual basis with careful introduction to new principles. Personnel have access to the Chemical Hygiene Plan and Material Safety Data Sheets. On-site training includes side-by-side hands-on training, formal classroom type instruction on the SOP or a meeting to discuss procedural changes or to address questions related to the laboratory operation. All training is documented via the Training Attestation Form, which is signed by all in attendance that they understood and will implement what was presented to them.

Training is an on-going opportunity to evaluate the laboratory operations. The updating of SOPs, Quality Systems Manual and other related information documents all changes to the quality system. Training is documented via the Training Attestation Form or in Qualtrax with training test records.

Off-site training takes place on an as-needed basis. Recommendations and suggestions regarding educational programs come from all levels of staff. It is the employee’s responsibility to present a copy of any certificates or attendance information to the HR Director. The information is added to the individual's training record.

6.4 Records

The QA Department is responsible for maintaining training records. Certificates, demonstration of capability forms and other records of training are placed in the individual's training file.

Appropriate personnel are notified through email and/or Qualtrax or by the QA department when a revision is complete for the controlled version of a document. The manager of the area determines when a change is significant to require training.

Job descriptions are included in the training record files. The Human Resources Department reviews the job descriptions, Resumes and/or biosketches are kept on file with the Human Resources Department and the QA Department.

7 Physical Facilities – Accommodation and Environment

This laboratory facility has a total area of 25,000 square feet for each of the Westboro and Mansfield Facilities

The laboratory functional areas include:

Administration and offices
Sample receiving
Sample management
Air analysis (Mansfield Facility only)
Microbiological (Westboro Facility only)
General analytical chemistry
Metals sample preparation (Mansfield Facility only)
Organic sample preparation
Metals analysis (Mansfield Facility only)
Volatiles gas chromatography (GC)
Volatiles gas chromatography/mass spectrometry (GC/MS)
Volatiles air analysis (Mansfield Facility only)
Semivolatiles gas chromatography/mass spectrometry (GC/MS)
Semivolatiles gas chromatography (GC)
Miscellaneous facility mechanical and storage areas.

All chemicals are stored in appropriate cabinets and properly disposed of as required. All flammable solvents are stored in OSHA and NFPA approved cabinets. Acids are stored in OSHA acid cabinets. Separate waste areas houses the sample and chemical waste before pickup by a licensed waste hauler.

7.1 Environment

Lighting, noise, humidity, heating, ventilation and air conditioning satisfy the needs of the testing performed on the premises. The laboratory building design ensures regulated temperature control for analytical equipment. Air-handling systems minimize airborne contaminants that may jeopardize sample integrity or analytical performance.

The analytical instrumentation is in separate rooms from laboratory activities that involve the use of large quantities of organic solvents or inorganic acids. A separate room, in the Westboro facility, provides the facilities for the microbiological testing.

Standards and other materials requiring below 0°C storage temperatures are placed in freezers and separated from samples or potential contaminating materials. Refrigerators provide cooling needs for samples and materials with temperature requirements of below room temperature and greater than freezing. Sample and standard storage areas are monitored and controlled for temperature and recorded in the data logger system. Sample storage areas for volatiles are separated from other samples and monitored for any effects due to cross contamination.

Bulk hazardous waste containers are located away from the testing activities. Waste disposal uses lab pack procedures and those designated by the regulatory authorities. The Chemical Hygiene Plan and the Waste Management and Disposal SOPs (Westboro: SOP/1728 and Mansfield SOP/1797)) include the procedures for handling and disposing of chemicals used in the laboratory.

The working and storage environments are maintained in a safe and appropriate manner. A Chemical Hygiene Plan details the requirements for safety and chemical handling. Safety measures that protect property and personnel from injury or illness include: fume hoods, fire extinguishers, fire blankets, alarm systems, safety training, protective clothing, emergency showers, eyewashes, and spill control kits.

7.2 Work Areas

Good housekeeping is the responsibility of all personnel. Each person is responsible for assuring clean and uncluttered work areas. The job descriptions list specific housekeeping duties. Records, samples and waste materials are the common cause for clutter in the laboratory.

. Removal of administration and laboratory records to the record storage area occurs to reduce clutter and ensure traceability. The individual filling the laboratory record box, labels the box with a number, the contents, date and laboratory area. Authorized personnel assign and record into a permanent record the box number, discard date and box contents. Authorized personnel review the box label for number, discard date and contents. Boxes are stored onsite and off-site for the record retention period identified in the NELAC Institute (TNI) Standards and EPA regulations, whichever is more stringent.

Sample management personnel remove samples to the sample storage area after all data is correct and complete. Sample coolers are removed to a designated storage area for recycling. Samples are stored in the designated process storage areas until testing is complete. Sample removal from the process storage occurs after mailing of the final report. The sample management staff places the samples in the archive storage area for thirty days after report release. The archive sample storage area is not controlled or monitored. Based on customer specifications, samples are properly disposed or returned to the customer.

Waste materials, expired reagents, expired standards and materials are disposed of and not stored in the laboratory. Hazardous waste labeled accumulation containers in the laboratory collect designated waste streams for later bulk disposal. Laboratory personnel remove the less than five-gallon accumulation containers when full from the laboratory and place the containers in the bulk hazardous waste area. Refer to the Waste Management and Disposal SOPS for Westboro: SOP/1728 and Mansfield SOP/1797. Personnel identifying out of date reagents and standards remove the materials to the proper disposal area.

7.3 Security

Alpha Analytical provides a secure environment for our employees, guests, customers, samples and analytical data. Security procedures require that all exterior doors remain locked unless manned. Access to the laboratory is limited to employees and contractors. Visitors not under signed contract are required to sign the Visitors Log and must be accompanied by a laboratory employee at all times within the testing areas.

The defined high security area is the sample management area. Identification card locks on the internal doors control entry into the laboratory area.

All doors are locked after hours and require a key for entry. The security alarm continuously monitors for smoke and fire related heat. When the alarm is activated, the appropriate emergency response officers are notified. The local emergency offices have the emergency contact list for the laboratory.

8 Equipment and Reference Materials

8.1 Maintenance

The laboratory has a proactive equipment maintenance program. The laboratory maintains service contracts for most major equipment, which include routine preventative maintenance visits by the service provider. Technical personnel perform manufacturer's specified maintenance on a routine basis to ensure equipment operates at peak performance.

A brief summary of some common preventive maintenance procedures is provided in Appendix E. All instrument preventative and corrective maintenance is recorded in the maintenance logbook assigned to the equipment. After maintenance or repair, the instrument must successfully calibrate following the method SOP. Laboratory personnel must demonstrate quality control performance before sample analysis.

The laboratory maintains a stock of spare parts and consumables for analytical equipment. Backup instrumentation for some analytical equipment is available on site for use in case of major equipment failure. The person discovering or suspecting an equipment maintenance problem or failure tags the equipment with 'out of service' tag. If routine maintenance measures do not eliminate the problem, the Laboratory Technical Manager or Operations Director is notified and the appropriate equipment service provider is contacted.

All major laboratory equipment has individual and traceable maintenance logbooks in which to document manufacturer's recommended maintenance procedures, specific cleaning procedures, comments on calibration, replacement of small worn or damaged parts, and any work by outside contractors. The person performing routine or non-routine maintenance signs and dates the maintenance logbook. If an instrument is down for maintenance, a complete record of all steps taken to put it back into service is recorded including reference to the new calibration and quality control checks. Any equipment service providers working on the equipment are recorded in the logbook.

Record repetitive or on-going equipment problems other than normal maintenance requirements on nonconformance action forms. The nonconformance action form notifies management and the Quality Assurance Officer of a problem affecting the performance and data quality.

The laboratory groups some equipment into a single laboratory equipment maintenance logbook. Examples include: autopipets, thermometer calibration. The identity of each item is by serial number or a laboratory-designated item number. The same data recorded for major equipment applies to this documentation.

The maintenance records shall include:

Equipment name;
Manufacturer's name, type identification, serial number or other unique identification;
Date received, date put into service, condition when received;
Current location;
Details of past maintenance and future schedule;
A history of any damage, malfunction, modification or repair;
Dates and results of calibration or verification.

The maintenance logbook may include the reference to the location of the equipment operational and maintenance manuals. The logbook may include the reference to laboratory run logbook or data files for the calibration and quality checks of daily or frequent calibrations.

The Courier Supervisor ensures that maintenance and records for transportation vehicles are complete. The purchasing process is used for ordering garage maintenance, the garage work order is reviewed, and the vehicle checked for condition. The Controller receives all paperwork for completion of the maintenance process.

8.1.1 Microbiology General Equipment Maintenance

Optics of the Quebec colony counter and microscope are cleaned prior to each use. The stage of the microscope is also cleaned and the microscope is kept covered when not in use.

Glassware is checked for residual alkaline or acid residue utilizing bromothymol blue (BTB) on each day of media preparation.

8.2 Equipment Listing

A listing of the major equipment used for testing is available upon request. The equipment list details the unique identification number, equipment location, serial number, model number, and purchase date. The unique identification number is attached to the piece of equipment.

The laboratory performs analyses using state of the art equipment. In addition to the major equipment, the most common equipment used in the laboratory are: thermometers, balances, autopipets, water baths, hot plates, autoclaves, pH meters, conductivity meters and a variety of labware. The SOPs list the calibration and verification requirements for all laboratory equipment used in measurements.

8.3 Laboratory Water

Laboratory water is purified from central DI and RO water systems and piped to all laboratory areas. The QA Department samples the laboratory grade water and submits the samples for analysis by the lab to document the water meets the drinking water certification criteria. The Laboratory Water Logbook lists the daily conductivity checks and acceptance criteria for the laboratory water. The laboratory documents the daily, monthly and annual water quality checks. Please refer to Table 8-1 for tested parameters, monitoring frequency and control limits for each parameter (SOP/1738). Additional parameters may be tested for at the laboratory's discretion.

When additional treatment occurs in the test area, that test area records the water quality checks from the most frequently used tap. At a minimum the quality of the laboratory grade water is monitored daily by conductivity measurements. Records of the daily checks are found in the Laboratory Water Logbook. If out of specification results occur, a nonconformance action form is submitted.

TABLE 8-1

Parameter	Monitoring Frequency	Control Limits
Conductivity	Daily	<2 µmhos/cm @ 25°C
pH	Daily	5.5 - 7.5
Total Organic Carbon (Westboro only)	Monthly	< 1.0 mg/L
Total Residual Chlorine	Monthly	< detection limit
Ammonia Nitrogen (Westboro only)	Monthly	< 0.1 mg/L
Metals: Cd, Cr, Cu, Pb, Ni and Zn (Mansfield only)	Monthly (Required Annually)	< 0.05 mg/L
Total Metals (Mansfield only)	Monthly (Required Annually)	< 0.1 mg/L

Heterotrophic Plate Count (Westboro only)	Monthly	< 500 CFU/mL
Water Quality Test (Biosuitability) (Westboro only)	Annually	0.8 – 3.0 ratio

8.4 Reference Materials

Reference materials include: Class 1 weights, NIST thermometers and reference standards. Logbooks record the reference materials used for calibration and verification. The Department Manager or QA Department maintains any certificates received with the reference materials. Laboratory personnel record in the standards logbook the reference standards date received, unique identification number, expiration date and number of containers. Each laboratory area records the unique identifier on the reference standard certificate and the Department Manager maintains the certificate. The identifier allows traceability from the certificate to the analytical data.

9 Measurement Traceability and Calibration

9.1 General Requirements

All measuring operations and testing equipment having an effect on the accuracy or validity of tests are calibrated and/or verified before put into service and on a continuing basis. The results are recorded in the instrument specific logbook. The laboratory has a program for the calibration and verification of its measuring and test equipment. The program includes all major equipment and minor equipment such as balances, thermometers and control standards. The Quality Systems Manual and method SOP describe the calibration records, frequency and personnel responsibilities.

9.2 Traceability of Calibration

The program of calibration and/or verification and validation of equipment is such that measurements are traceable to national standards, where available. Calibration certificates indicate the traceability to national standards, provide the results, and associated uncertainty of measurement and/or a statement of compliance with identified metrological specifications. A body that provides traceability to a national standard calibrates reference standards. The laboratory maintains a permanent file of all such certifications.

9.3

9.4 Reference Standards and Materials

Alpha Analytical has a program for calibration and verification of reference standards. The results and program are recorded in the appropriate instrument logbook. Required in-service checks between calibrations and verifications are described in method SOPs and are recorded in the appropriate instrument logbook.

Calibration standards are maintained within the area of consumption. A logbook of use is maintained and use is limited strictly to method required calibrations. Each calibration standard is identified as to test method used, date received, date opened, and expiration date. Calibrations are verified by using a second source or lot number of the calibration standard. Calibration check procedures are stated in applicable test method SOPs.

Preparation of standards must be performed using Class A glassware. Class A glassware must be used for all processes involving quantitative analyses.

Reference standards of measurement in the laboratory’s possession (such as calibration weights or traceable thermometers) are used for calibration only and for no other purpose.

Standards and reagents are uniquely identified as outlined in Westboro SOP 1745 and Mansfield SOP 1816.

9.5 Calibration General Requirements

Each calibration record is dated and labeled with method, instrument, analysis date, analyst(s) and each analyte name, concentration and response. For electronic processing systems that compute the calibration curve, the equation for the curve and the correlation coefficient are recorded in the appropriate instrument logbook. This is also true for manually prepared curves. Calibrations are tagged to the specific instrument through use of the instrument logbook and or sequence file documentation.

Initial calibration requires a standard curve that brackets the expected sample concentration. Initial calibration generally uses three to five standards depending on the equipment and reference method specifications. Before the start of each analytical sequence, initial calibration is verified by using a continuing calibration standard. Calibration verification or continuing calibration uses the same standard as the ICAL unless method specifies otherwise. The ICV is from a second source or lot number than that used for initial calibration. The acceptance criteria for the continuing calibration standard must meet acceptance criteria before analysis of any samples. When the acceptance criteria is not within limits, review maintenance protocols and perform any necessary maintenance before starting the initial calibration sequence.

9.6 Equipment Calibration

The SOP used for the analysis defines the instrument and equipment calibration required. The following defines the general practices for equipment calibration of selected equipment.

9.6.1 Gas Chromatography/Mass Spectrometry (GC/MS)

The GC/MS is hardware tuned before performing the initial and continuing calibrations. Results must meet the peak ratio specifications of the analytical methods. For volatiles analyses, bromofluorobenzene (BFB) is used, and for semivolatiles analyses, decafluorotriphenylphosphine (DFTPP) is used for instrument tuning.

The mass spectrometer response is calibrated by analyzing a set of five or more initial calibration solutions, as appropriate, for each GC/MS method. Each solution is analyzed once, unless the method or the customer requires multiple analyses. The relative response factor for each analyte is calculated for internal standard calibration. The calibration factor for external standard calibration is calculated using the expressions found in the laboratory method SOP. Calibration is acceptable when all acceptance criteria are within method criteria.

The initial calibration is verified through the analysis of a continuing calibration standard every 12 hours. The concentration of the continuing calibration standard is dependent on the requirements of the specific method. The relative response factors for all analytes of interest are calculated and verified against the initial calibration mean relative response factors. The percent difference (%D) for each analyte is calculated and must be less than the acceptance criteria stated in the method.

An acceptable continuing calibration run must have measured percent differences for the analytes within method specified ranges. If any criteria for an acceptable calibration are not met, either instrument maintenance must be performed until the continuing calibration analysis meets all criteria or a new initial calibration is established before any samples are analyzed. No samples may be analyzed unless the acceptance criteria are met for the initial and continuing calibration.

Additional quality control samples are part of the GC/MS analysis. These include internal standards, surrogates, method blanks, instrument blanks, laboratory control samples, matrix spikes and matrix spike duplicates. The frequency and control criteria are defined in the laboratory SOP.

9.6.2 Gas Chromatography (GC)

Internal standard calibration or external standard calibration is utilized for analysis by GC. The method-specified number of calibration standards is used. Each solution is analyzed once and the analyte relative response factors or calibration factors are calculated. The mean relative response factor for each analyte is then obtained by using the expression in the formula listed in the SOP. Integrated areas are utilized for these expressions.

For multiple response pesticides, PCBs or hydrocarbons the quantitation consists of the average of selected peaks or the integration of the area defined by a reference standard. The SOP details the integration criteria for each compound.

The initial calibration is verified through the analysis of a continuing calibration standard every 12 hours or 20 samples. The concentration of the continuing calibration standard is dependent on the requirements of the specific method. The relative response factors for all analytes of interest are calculated and verified against the initial calibration mean relative response factors. The percent difference (%D) for each analyte is calculated. The percent drift (%d) may be calculated when calibration factors are used for quantitation.

An acceptable continuing calibration must have measured percent differences or percent drift for the analytes within method specified ranges. Should any criteria for an acceptable calibration not be met, either instrument maintenance is performed until the continuing calibration analysis meets all criteria, or a new calibration is established before any samples are analyzed. No samples may be analyzed unless the acceptance criteria are met for the initial and continuing calibration.

Other standard checks may be required for a specified reference method. Instrument performance checks specified in the reference method must be performed and be within the acceptance limits stated in the reference method. Additional quality control samples are part of the GC analysis. These include internal standards, surrogates, method blanks, instrument blanks, laboratory control samples, matrix spikes and matrix spike duplicates. The frequency and control criteria are defined in the laboratory SOP.

9.6.3 Cold Vapor Atomic Absorption Spectrophotometry (CVAA)

An initial calibration is performed daily with freshly prepared working standards that bracket the expected concentration range of the sample. A minimum of a three-point calibration curve is acquired which must have a correlation coefficient of 0.995 or better. The initial calibration is verified every 10 samples. The continuing calibration is required to be within method-defined criteria, depending on the analytical method employed. Continuing calibration blanks are run at the same frequency. Analysis of samples cannot begin until an initial calibration verification has been performed and is found to be within ± 10% of the true value.

9.6.4 Inductively Coupled Plasma Emission Spectrophotometry-Mass Spectrometry (ICP-MS)

Initial calibration and instrument tune is performed daily, not to exceed 24 hours, and continuing calibrations are performed every 10 samples. Initial calibration consists of a minimum of three standards and a Blank that bracket the expected concentration range of the samples. Analysis of samples cannot begin until an initial calibration verification has been performed and is found to be within method-defined criteria. The continuing calibration is required to be within method-defined criteria. Interference check standards are performed at the beginning of the sequence. Acceptance criteria are stated in the SOP.

9.6.5 Inductively Coupled Plasma Emission Spectrophotometry (ICP)

Initial calibration is performed daily, not to exceed 24 hours, and continuing calibrations are performed every 10 samples. Initial calibration consists of one standard and a Blank that bracket the expected concentration range of the samples. Analysis of samples cannot begin until an initial calibration verification has been performed and is found to be within 5% of the true value for EPA Method 200.7 and 10% for SW846 6010 methods. The continuing calibration is required to be within 10% of the true value. Interference check standards are performed at the beginning and end of the sequence. Acceptance criteria are stated in the SOP.

9.6.6 Thermometers

Laboratory thermometers are checked annually for accuracy against certified, NIST traceable thermometers. Correction factors derived from the annual calibrations are applied to temperature readings where applicable. The analyst records the corrected temperature for all observations.

NIST traceable thermometers are calibrated professionally and re-certified every year. Records of thermometer calibrations are retained by the QA Department. All thermometers are tagged with the ID number, correction factor to be applied and the expiration of the calibration check.

NOTE: Electronic-based thermometers are calibrated on an annual basis. Thermometers are tagged with calibration information by the vendor, including the ID number, correction factor to be applied and the expiration of the calibration check. Certificates are kept on file in the QA Department.

Thermometers are not used past the calibration expiration date or if the thermometer is not reading properly. Replacement thermometers are calibrated and the maintenance logbook is updated when a change in the thermometer is required due to breakage, damage or expired calibration.

9.6.7 Balances

Calibration checks are performed for each day of use, for each balance. The calibration consists of a minimum of two weights, which bracket the weight to be measured. Additional calibration check procedures are performed on balances utilized in Microbiology laboratory. This additional procedure consists of a deflection test, which is performed to ensure that 100mg is detectable at a weight of 150 grams.

The balance logbook lists the acceptance criteria and performance criteria for the various balances used in the laboratory. Calibration weight measurements must meet the acceptance criteria listed on the record form.

Each balance is serviced and calibrated by a professional semi-annually. Balances are labeled with the balance number, date of service and the expiration date for the annual service check. The balance number used for any measurements requiring traceability is recorded with measurement data. Balances are not used past the expiration date or when the weight check is not within acceptable criteria. The accuracy of the calibration weights used by Alpha Analytical is verified annually by an accredited calibration service.

9.6.8 Mechanical volumetric pipettes

Delivery volumes for the mechanical volumetric pipettes (i.e. Eppendorf) are checked and recorded gravimetrically before use and on a quarterly basis. The verification is performed at the volume of use or bracketing the volume range of use. The check must be within the criteria stated in the laboratory logbook. Pipettes failing acceptance criteria are tagged and removed from service until repaired and the criteria are met, or discarded and replaced. Automatic pipettes are labeled with a unique ID number, volumes verified and expiration date.

9.6.9 Ion Chromatography

The ion chromatograph calibration is by analyzing a set of five or more initial calibration solutions, with concentrations of analytes appropriate to the analytical methods. The concentrations must bracket the expected concentration range of the samples analyzed. Procedures for verifying the calibration curve are method specific. The initial calibration is performed at the start of each day. The calibration curve is verified at least after every 20 samples.

9.6.10 pH Meters

pH meters are calibrated prior to use for each day of use. The meter is calibrated following the procedure for pH analysis. The records of the calibration are recorded in an instrument logbook or in the raw data for the analysis being performed. At least two buffer solutions that bracket the measurement range for the analysis are used for calibration. A second source check standard is used at the end of a run to verify meter stability. Buffer solutions used for calibration are NIST certified. Standard buffer solutions are not retained or re-used. The lot number of the buffer solutions is recorded in the data record to ensure traceability of the measurement to NIST.

9.6.11 Conductivity Meters

Three calibration standards of potassium chloride (KCL) solutions are analyzed annually on each instrument range. The calibration standards are used to verify instrument performance. The acceptance criteria are defined in the test SOP. If unacceptable performance is found, the cell is cleaned and rechecked. The cell is not used until satisfactory performance is achieved.

A single KCL standard solution is used to calibrate each range of the instrument. A second standard is used to check the calibration each day the meter is used. The check standard is near the measurement range for the samples to be analyzed. The acceptance criterion is ± 20% of the true value. The meter is labeled with expiration date for the annual calibration. A check standard that is NIST traceable is used to allow traceability. The check standard is performed at the end of the analysis run or at least after every 20 samples.

9.6.12 Autoclave

The date, contents, sterilization time and temperature, total cycle time and analyst’s initials are recorded each time the autoclave is used. Autoclave cycles must be completed within 45 minutes when a 15 minute sterilization time is used. Autoclave timing mechanisms are checked quarterly with a stopwatch to verify timing controls. A maximum temperature thermometer is used with each cycle to ensure the sterilization temperature is reached.

Spore strips or ampoules are used weekly to confirm sterilization. BTSure ampoules are utilized as follows: An indicator ampoule is placed in most challenging area of sterilizer. Load is processed according to standard operating instructions. Remove from sterilizer and allow to cool for a minimum of 10 minutes. (Chemical indicator on label changes from green to black when processed.) Place the autoclaved indicator and un-autoclaved control indicator in an upright position in the plastic crusher provided. Gently squeeze crusher to break glass ampoules. Incubate both indicators at 55-60^{o}C for 24 hours. Examine appearance for color change. Yellow color indicates bacterial growth. No color change indicates adequate sterilization.

Calibration is conducted and certified annually by an outside service provider and recorded. Certificates are kept on file. Routine maintenance includes cleaning the autoclave seal to ensure freedom of caramelized media and cleaning drain screens to remove any debris buildup. For the efficient operation of the unit, overcrowding is avoided.

10 Test Methods and Standard Operating Procedures

10.1 Methods Documentation

Analysis consists of setting up proper instrument operating conditions, executing acceptable calibrations, monitoring instrument performance tests, analyzing prepared samples, and collecting data from the analyses. The test method SOP describes the instrumental analysis procedures, quality control frequencies and acceptance criteria. EPA accepted methods, national recognized methods or customer-specified methods are the basis for performance criteria, instrument conditions and the steps of the procedure. The method performance requirements of the published methods are followed unless otherwise specified by the customer.

The reference methods define the instrument operating conditions. In many of the reference methods, a range or general guidance on the operating conditions is defined. Documented modifications to the operating conditions clarify the reference methods or improve the quality of the results. In all cases where the method modifications are adopted, the performance criteria from the reference method must be met. Modifications to the operating conditions are stated in the SOP. Changes in the operating conditions made at the time of the analysis are documented in the appropriate laboratory or sequence log. A revision to the SOP takes place, when a day to day change in the operating condition improves performance for all matrices.

The laboratory SOPs include the operation of measurement equipment. The SOPs contain the -following information, as applicable:

The equipment used in the procedure, including equipment type

Equipment calibration and process for obtaining the measurement from the calibration

The step by step instructions to perform the measurement

Acceptance criteria for the calibrations

Corrective action for failed acceptance criteria, including assessment of previous calibration results

The basis used for the calibration standards such as traceability to NIST or EPA or demonstration of comparability

Frequency at which the equipment will be calibrated, adjusted and checked

The records maintained to document the calibration and use of measurement equipment

The calibration status for the equipment

The environmental conditions necessary before measurement equipment may be calibrated or used for measurement

Allowed adjustments to measurement equipment, including software, which will not invalidate the laboratory analysis

Maintenance of the equipment and record keeping to track performance before and after maintenance is completed

Define the standards, reagents and sample handling, interferences, preservation, and storage in order to assure measurement performance

10.2 Standard Operating Procedures (SOPs)

Alpha Analytical maintains SOPs that accurately reflect all phases of current laboratory activities such as assessing data integrity, nonconformance actions, handling customer complaints, sample receipt and storage, purchasing of all materials, and all test methods. These documents include equipment manuals provided by the manufacturer, internally written documents, and published methods with documented changes or modifications.

Copies of all SOPs are accessible to all personnel in electronic form through Qualtrax. Each SOP clearly indicates the published date of the document and the revision number.

10.3 Laboratory Method Manual (s)

All SOPs are posted as secure documents in the Alpha Qualtrax system. Directories are available for each laboratory area and administrative area in appropriate subfolders. Each SOP includes or references where applicable:

1) identification of the test method and where applicable;
2) applicable matrix or matrices;
3) method detection limit;
4) scope and application;
5) summary of method;
6) definitions;
7) interferences;
8) safety;
9) equipment and supplies
10) reagents and standards
11) sample collection, preservation, shipment and storage;
12) quality control;
13) calibration and standardization;
14) procedure;
15) calculations;
16) method performance;
17) pollution prevention;
18) data assessment and acceptance criteria for quality control measurements;
19) corrective actions for out-of-control data;
20) contingencies for handling out-of-control or unacceptable data;
21) waste management;
22) references; and
23) any tables, diagrams, flowcharts and validation data.

In cases where modifications to the published method have been made by the laboratory or where the referenced method is ambiguous or provides insufficient detail, these changes or clarifications are clearly described in the SOP.

10.4 Test Methods

The laboratory uses appropriate methods and procedures for all tests and related activities within its responsibility (including sampling, handling, transport and storage, preparation of items, estimation of uncertainty of measurement and analysis of test data). The method and procedures are consistent with the accuracy required, and with any standard specification relevant to the calibrations or tests concerned. When the use of mandated methods for a sample matrix is required, only those methods are used. Where methods are employed that are not required, the methods are fully documented and validated and are available to the customer and other recipients of the relevant reports.

The customer requests the reference method for sample analysis usually based on the regulatory program. The customer services staff may assist the customer with method selection when the customer specifies the regulatory program, but is unsure of the correct method required. The Laboratory Technical Manager or Quality Assurance Officer recommends methods for non-regulatory programs. In all cases, recommendation of methods is based on customer-defined method performance criteria. Customer services may recommend a procedure that meets the customer method performance criteria.

10.5 Method Validation/Initial Demonstration of Method Performance

Before acceptance and use of any method, satisfactory initial demonstration of method performance is required. In all cases, appropriate forms are completed and retained by the laboratory and made available upon request. All associated supporting data necessary to reproduce the analytical results is retained. Initial demonstration of method performance is completed each time there is a significant change in instrument type, personnel or method.

10.6 Sample Aliquots

The aliquot sampling process from a submitted sample is part of a test method. The laboratory uses documented and appropriate procedures and techniques to obtain representative sub-samples. Sample aliquots removed for analysis are homogenized and representative portions removed from the sample container. Personnel record observations made during aliquot sampling in the test method logbooks.

10.7 Data Verification

Calculations and data transfers are subject to appropriate checks which is a 3 tier approach. The initial analyst verifies all of his work, a secondary review of 100% of the initial is conducted by a an independent qualified analyst. A Customer Services representative reviews data for project and method performance requirements where applicable. A QA representative reviews data for project and method performance requirements when requested by a Customer. Final report review is performed by an authorized company signatory.

For drinking water suppliers, every effort is made to notify the Customer within 24-hours of obtaining valid data of any results that exceed any established maximum contaminant level or reportable concentration. Analyst or Department Supervisor notifies the Customer Services Department of the sample number(s), Customer name, analysis and sample results (preliminary or confirmed). The Customer Services Department notifies the customer.

The laboratory Report Generation and Approval SOP describes the practices to ensure that the reported data is free of transcription errors and calculation errors. Manually entered data into the LIMS is dual entered and checked by the LIMS to minimize transcription errors. The laboratory test method SOP describes the quality control measures used to assure method performance before reporting data.

10.8 Labeling of Standards and Reagents

The purchase, receipt and storage of consumable materials used for the technical operations of the laboratory include the following:

a) The laboratory retains records of manufacturer’s statement of purity, of the origin, purity and traceability of all chemical and physical standards.
b) Original reagent containers are labeled with the date opened and the expiration date.
c) Detailed records are maintained on reagent and standards preparation. These records indicate traceability to purchased stocks or neat compounds and include the date of preparation and preparer's initials.

d) Where calibrations do not include the generation of a calibration curve, records show the calibration date and type of calibration standard used.
e) All prepared reagents and standards are uniquely identified and the contents are clearly identified with preparation date, concentration and preparer's initials. These procedures are outlined in Westboro SOP/1745 and Mansfield SOP/1816.

10.9 Computers and Electronic Data Related Requirements

Computers or automated equipment are used for the capture, processing, manipulation, recording, reporting, storage or retrieval of test data. The laboratory ensures that computer software is documented and adequate. The goals of the software development methodology, existing system validations and the change control system are to ensure that:

the software systems perform the required functions accurately,

the users understand how to use the system, and

auditors can assure themselves of the validity of the analytical data.

The computer systems used at Alpha Analytical are purchased. A coordinated effort is made with the supplier to assure the computer operations meet the laboratory requirements for data integrity. Alpha Analytical has a formal validation program of its computer systems. The validation program is a comprehensive program to ensure data transmitted, reported or manipulated by electronic means is correct and free of errors. The validation and verification approach is separated into three areas.

1. New software is developed and validated using test data. Records of validation include the test data report, date and initials. Where formulas are part of the program, documentation includes manual verification of the final calculated values. New software includes the development of macros for spreadsheets and other tools using commercial software packages.
2. Reasons for changes to software are identified through flaws in existing documentation or the need to improve system processes and are documented on the Nonconformance Report. Final implementation of the change is documented on the nonconformance action form. The tracking and timelines of making the change is readily available. This process also provides the complete documentation of all software and electronic data reporting problems. All nonconformance identified with electronic data process result in corrective action that are reported to management before or at the bi-weekly executive meeting. Customers will be notified prior to any changes to software or hardware that will adversely affect customer electronic data. This information is provided by IT department to QA and Project Managers to be communicated to appropriate customers.

Verification of system integrity is through routine maintenance, protection from unauthorized access and electronic verification programs. Routine maintenance including system backups are performed on a scheduled basis. The backup process and password and access protections are defined in the Computer System Backup Control SOP/1562 and Computer Security SOP/1563. Electronic verification may be used to assure the commercially purchased software is performing at its original specifications. This includes virus checking of all network operation at least once per week. Documentation of all verification and maintenance operations is retained.

11 Sample Handling, Sample Acceptance Policy and Sample Receipt

The Sample Login and Custody procedures define the process for sample management from sample receipt through analysis and to disposal. These procedures detail the process for sample receipt, records and storage pending analysis.

Customers or Alpha's Couriers deliver samples to the laboratory during normal business hours. Sample receiving occurs in the sample management area.

Customer service personnel place bottle orders. The orders are filled following the bottle order instruction form. Blanks are prepared as needed with minimal storage. All glass containers are packed to minimize or prevent breakage. The containers are placed in plastic coolers or shipping packages and Chain-of Custody forms, seals (if requested) and labels enclosed. The bottle order is shipped by third party, picked up by the customer or customer representative or delivered by Alpha courier to the customer.

11.1 Sampling Supplies

11.1.1 Sample Containers

Sample containers provided by Alpha Analytical include labels, preservatives and a blank chain of custody form. Preservatives and containers are lot controlled and verified as appropriate for the indicated type of analysis.

Each lot of containers used for the collection of samples for microbiological analysis is checked for sterility prior to distribution. Sterility checks are performed by Microbiology staff and results recorded in Microbiology Sample Container Sterility Log.

Sample Containers for collecting Air samples (TO-15) are cleaned and prepared according to SOP 2190 "Cleaning and Preparation Procedures for Equipment used to collect Air sample for analytis of Volatile Organic Compounds".

11.1.2 Chain of Custody

Chain of custody forms must accompany all samples received by Alpha personnel. The chain of custody form indicates the sample origin and arrival at the laboratory and identifies the analyses requested.

11.1.3 Reagent Water

Alpha Analytical supplies laboratory pure water for field QC blanks. Water used for volatile organics must be free of volatile compounds below the method detection limit. The quality of the laboratory water is monitored for conductivity once per day. Additional water quality criteria may be monitored based on customer specific requests. The water quality in the laboratory is monitored for chemical parameters as required by the EPA certification manual for drinking water (Water Quality Monitoring SOP/1738).

11.2 Sample Tracking

Alpha Analytical uses an internal chain-of-custody in LIMs for sample tracking control purposes. When requested or required by regulation a legal custody program is used in addition to the routine laboratory practices. Legal custody practices must be arranged at the time of contractual commitment.

For legal custody the process must include complete and continuous records of the physical possession, storage, and disposal of sample containers, collected samples, sample aliquots, and sample extracts or digestates. For legal custody a sample is in someone's custody if:

1. It is in one's actual physical possession;
2. It is in one's view, after being in one's physical possession;
3. It is in one's physical possession and then locked up so that no one can tamper with it;
4. It is kept in a secured area, restricted to authorized personnel only.

The routine sample handling and tracking process includes unique identification of all sample containers, initials of the person removing the sample from the sample management area and documentation of the date of sample removal for disposal.

Samples are assigned a unique identification number from the LIMS program. Each sample container label includes a unique identifier for the container. The person handling the sample is recorded along with the unique identifier in the container tracking records in LIMS.

ALPHA ANALYTICAL utilizes a custom designed Laboratory Information Management System (LIMS) to uniquely identify and track samples and analytical data throughout the facility. The LIMS log-in, is initiated by the Sample Custodian when the following information is entered into the computer:

- Quote number (unique to the project if requested)
- Project name or description
- Analyses requested (per matrices received)
- Sample number (unique to this sample)
- Sample descriptions (customer ID, including number of received containers)
- Date received
- Date(s) and time(s) collected
- Date analytical results are due

11.2.1 Chain of Custody

Chain of custody forms must accompany all samples received by Alpha personnel. The chain of custody form indicates the sample origin and arrival at the laboratory and identifies the analyses requested.

- Customer's name and address
- Notation of special handling instructions
- Additional comments or instruction for the laboratory
- Purchase order number(s), if applicable

Alpha Job Numbers (Process for assigning numbers)

Alpha Job Numbers are unique #'s automatically designated by our LIMS computer system for every individual customer project.

There are 3 parts to this number:

- All numbers start with the letter “L”
- The next two numbers are the last two numbers of the current year.
- The last five numbers are pulled sequentially by the LIMS as each Login personnel requests a new number for a job.

For example…. L0904165 ---- Year 2009 and 4,165th job to be logged in this year.

The Alpha Job Number then may contain as many extensions as there are individual samples in a job. L0904165-01 is the first sample, L0904165-02 is the second and so on. Each sample may contain as many as 26 containers as the containers are designated with the letters of the Alphabet, and each container receives its own bar-coded label. For example, L0904165-09A is the first container of the 9th sample listed on a customer’s Chain of Custody.

Each container is labeled with a unique identifier, a label with a unique identifier number is placed on each sample container. Once labeled, the sample containers are placed in the appropriate storage area.

11.3 Sample Acceptance Policy

The sample management personnel check for proper sample labeling, preservation and handling at the time of arrival at the laboratory. The customer and customer services manager specifies the proper sample preservation, containers, cooling and other criteria on the project review form and in the LIMS. Sample management staff record all observations and immediate notify customer services of any discrepancies or questions arising during sample receipt.

It is possible for samples or sample containers to be lost, damaged, or determined to be unsuitable, for whatever reason, after initial receipt at Alpha Analytical. The problem is brought to the attention of a customer services manager who reports it to the customer. Plans for disposition of the affected samples or container are agreed upon with the customer, carried out, and recorded in the project records. Sample hold times and preservations are listed on the Alpha website (www.alphalab.com) under Support Services “Sampling Reference Guide”.

11.4 Sample Receipt Protocols

The sample management staff receives all samples. A unique job number is assigned to each shipment of samples received from a customer. The in-house records for the incoming job, including the internal Chain-of -Custody, are initiated with a Sample Delivery Group (SDG) form. The customer, and Alpha courier and/or the sample management personnel sign the sample custody form at the time of receipt at the laboratory. Samples received via overnight courier are signed on the bill of lading. The bill of lading, SDG form and the sample custody form are completed for external courier delivered samples.

The sample management staff examines the shipping containers, their contents, and accompanying customer documentation. Information about the sample identification, the location, date and time of collection, collector’s name, preservation type, sample type, presence and condition of custody seals, the state of preservation of the samples and other required information is noted on the SDG form. Any discrepancies in documentation or problems with sample condition such as appropriate sample containers, thermal preservation variation, holding times and adequate sample volumes are noted and brought to the attention of the customer via the nonconformance action form, The login staff or project manager contacts the client via email or or by phone. The Customer Services Manager provides clarification or further instruction to the sample management staff on the processing of the samples that are incomplete or missing required information.

The sample management staff logs the samples in the LIMs and a durable label for each container is printed. The custodian attaches each label to the appropriate sample container. The following information is recorded for tracking internal custody: laboratory sample ID, customer sample ID, sample matrix and storage location. Sample receipt and log-in specifically requires: date and time of laboratory receipt of sample(s); sample collection date; unique laboratory ID code; field ID code supplied by sample submitter; requested analyses; signature or initials of data logger; comments from inspection for sample acceptance or rejection and in some cases, sample bottle codes.

11.5 Storage Conditions

Alpha Analytical stores samples under proper environmental conditions to ensure their integrity and security. Samples are stored at temperatures that meet specifications of the methodology, regulatory agencies and customer directives. Refrigerators are monitored and controlled to be within 4 ± 2°C. Chemical, temperature, holding times and container storage requirements are listed in the LIMS project database.

Customer Quality Assurance Project Plans may list preservation requirements differing from the laboratory. The sample management staff reviews project information for projects specific handling. Addition of chemical preservative to sample containers normally is done in the field at the time of sampling. Chemical preservation and temperature preservation checks at the time of receipt are recorded except for volatile organic compounds, bacteria, sulfite, and dissolved oxygen preservation. Any differences from laboratory or customer specific requirements are recorded on nonconformance action forms and contact made with the customer by the Customer Services Manager or designee.

Sample storage facilities are located within the sample management area, walk-in custody refrigerator or in designated sample storage areas within the analytical departments. Internal chain-of-custody procedures and documentation pertaining to sample possession, removal from storage, and transfer are outlined in the sample custody procedure. Samples are returned to the sample storage area after the sample portion is removed for analysis. Extracts and digestates are tracked and follow the same internal custody operation. Extracts and digestates are removed to the waste disposal area after analysis for proper disposal.

Sample storage precautions are used to ensure that cross contamination does not occur during sample storage. Refrigerator storage blanks are monitored bi-weekly for volatile compounds.. The storage blank information allows the assessment of potential cross contamination in the sample storage refrigerator.

Temperatures of cold storage areas are recorded continuously in the data logger system. Corrective action is done as necessary when temperatures are not within the control criteria. In both the Westboro and Mansfield facilities, Automated Data loggers are linked to thermocouples in custody refrigerators and freezers in the Sample Storage areas as well as department standards/storage refrigerators and freezers. The Data logger is calibrated and certified by an outside vendor annually and on a quarterly basis for DOD standards/storage refrigerators and freezers. If there is a catastrophic failure of custody refrigerators, a record of all samples affected and customers associated with such samples are notified of any samples affected by the failure. Refrigerators and/or freezers not connected to the Data Logger system have temperatures measured with NIST traceable thermometers. Temperature records indicate the thermometer or sensor (Data logger) used for obtaining the measurement.

11.6 Sample Disposal

Samples are held for 21 calendar days after the report is released to the customer. Upon written customer request samples may be held longer in an uncontrolled area. Requests for controlled sample storage must be arranged at the time of contractual commitment. Air canister samples are held for 3 days after the report is released to the customer.

An authorized waste carrier is contracted to pick up waste as needed and dispose of it, in accordance with all regulatory requirements. Post-analysis disposition of samples is dependent upon project specific requests. Remaining sample material may be returned to the customer, safely discarded, or archived for a specific time prior to disposal. The waste disposal SOP 1797 defines the specific requirements for sample disposal and other waste disposal operations.

The sample management staff are responsible for the archival and disposal of raw samples, extracts and digestates. Raw and prepared samples may not be archived or disposed until all of the designated analyses are complete and resultant analytical data is sent to customers. Samples in storage are retained a minimum of 21 calendar days after reporting the results to the customer. Any samples requiring more than 21 calendar days are archived. Air canister samples requiring storage more than 3 business days require prior approval.

When a customer has requested the return of samples, the sample management staff prepares and ships the samples according to the same custody procedures in which the samples were received and following any customer specified requirements. Protection of the samples during delivery is ensured by the implementation of special packaging procedures. Packages are delivered by a commercial carrier whose procedures for protecting the samples are not within the control of this laboratory. Customers are informed that a commercial carrier will deliver their samples if required.

12 Records

Alpha Analytical has a record system that produces accurate records, which document all laboratory activities. The laboratory retains records of all original observations, calculations and derived data, calibration records and a copy of the test for ten years minimum. The system retains records longer than the minimum upon the request of authorized customers, agencies or another regulator. Note: Ohio VAP requires notification before disposal of any VAP records.

12.1 Record Keeping System and Design

The record keeping system allows reconstruction of laboratory processes that produced the analytical data of the sample.

a) The records include the names of personnel involved in sampling, preparation, calibration or testing.

b) Information relating to laboratory facilities equipment, analytical methods, and activities such as sample receipt, preparation, or data verification are documented.

c) The record keeping system provides retrieval of working files and archived records for inspection and verification purposes.

d) Documentation entries are signed or initialed by responsible staff.

e) Generated data requiring operator logging on appropriate logsheets or logbooks are recorded directly and legibly in permanent ink

f) Entries in records are not obliterated by any method. Corrections to errors are made by one line marked through the error. The person making the correction signs and dates the correction.

g) Data entry is minimized by electronic data transfer and ensuring the number of manual data transcriptions is reduced.

12.2 Records Management and Storage

1. Records including calibration and test equipment, certificates and reports are safely stored, held secure and in confidence to the customer.
2. The laboratory maintains hardware and software necessary for reconstruction of data.
3. Records that are stored or generated by computers have hard copy or write-protected backup copies.
4. Alpha Analytical has established a record management system, for control of hard copy laboratory notebooks.

5. Access to archived information is carefully controlled and is limited to authorized personnel. These records are protected against fire, theft, loss, environmental deterioration, vermin, and in the case of electronic records, electronic or magnetic sources.
6. In the event that Alpha Analytical transfers ownership or goes out of business, there is a plan to ensure that the records are maintained or transferred according to the customer's instructions. A plan will be developed to maintain continuity of our record keeping systems as requested and/or required by both state and federal laws.

Alpha Analytical retains all original hard copy or electronic raw data for calibrations, samples, and quality control measures for ten years, including:

1. Analysts work sheets and data output records,
2. Reference to the specific method,
3. Calculation steps including definition of symbols to reduce observations to a reportable value,
4. Copies of all final reports
5. Archived SOPs,
6. Correspondence relating to laboratory activities for a specific project,
7. All nonconformance action reports, audits and audit responses,
8. Proficiency test results and raw data,
9. Data review and cross checking.

The basic information to tie together analysis and peripherals such as strip charts, printouts, computer files, analytical notebooks and run logs for Alpha Analytical includes:

1. Unique ID code for each Laboratory sample or QC sample;
2. Date of analysis;
3. Instrument identification and operating conditions;
4. SOP reference and version;
5. Calculations;
6. Analyst or operator's initials/signature.

In addition, Alpha Analytical maintains records of:

1. Personnel qualifications, experience and training
2. Initial and continuing demonstration of proficiency for each analyst
3. A log of names, initials and signatures for all individuals who are responsible for signing or initialing any laboratory records. Use of electronic signatures has been approved by regulatory agencies.

12.3 Laboratory Sample Tracking

A record of all procedures to which a sample is subjected while in the possession of the laboratory is maintained. These include but are not limited to records pertaining to:

a) Sample preservation including appropriate sample container and compliance with holding time requirement; If the time of the sample collection is not provided, the laboratory must assume the most conservative time of day (i.e., earliest).

b) Sample identification, receipt, acceptance or rejection and log-in;

c) Sample storage and tracking including shipping receipts, transmittal forms, and internal routing and assignment records; this includes inter-laboratory transfers of samples, extracts and digestates.

d) Sample preparation including cleanup and separation protocols, ID codes, volumes, weights, instrument printouts, meter readings, calculations, reagents;

e) Sample analysis;

f) Standard and reagent origin, receipt, preparation, and use;

g) Equipment receipt, use, specification, operating conditions and preventative maintenance;

h) Calibration criteria, frequency and acceptance criteria;

i) Data and statistical calculations, review, confirmation, interpretation, assessment and reporting conventions;

j) Method performance criteria including expected quality control requirements;

k) Quality control protocols and assessment;

l) Electronic data security, software documentation and verification, software and hardware audits, backups, and records of any changes to automated data entries;

m) Automated sample handling systems;

n) Records storage and retention; and

o) Disposal of hazardous samples including the date of sample or sub-sample disposal and the name of the responsible person.

p) The COC records account for all time periods associated with the samples.

q) The COC records include signatures of all individuals who had access to individual samples. Signatures (written or electronic) of all personnel who physically handle the samples. Time of day and calendar date of each transfer or handling procedure.

r) Common carrier documents.

13 Laboratory Report Format and Contents

The Process Planning and Control Procedure details the recording and reporting of data as required by the customer and in accordance with relevant environmental regulations.

Customers specify the report delivery and deliverables required for the work submitted. Report delivery includes standard turnaround and rush turnaround. Customers specify the delivery address or multiple addresses and method of delivery such as U.S. Mail, facsimile or electronic at the start of the project. Alpha Analytical provides data deliverables in hardcopy or electronic format. At the start of any project, the electronic deliverable formats required must be received before sample arrival. Affidavits are required with each report or series of reports generated for a particular project for Ohio VAP reports.

Reporting packages are available for routine regulatory reporting requirements. Regulatory reporting packages include only the information requested by the regulatory agency. In addition to regulatory report packages, Alpha Analytical prepares a standard report format. The standard report format includes:

1. Title: “Certification of Analysis”
2. Name and address of the laboratory
3. Laboratory Job Number, page number and total number of pages included in the report.
4. Name and address of the customer
5. Alpha sample number, Customer identification, Sample location
6. Samples identified that do not meet the sample acceptance requirements for project.
7. Date of sample receipt, sample collection, preparation or extraction date and time (if applicable), analysis date and time, report date and analyst
8. Identification of data reported by subcontractors
9. Test name and reference method number
10. Delivery method and sampling procedures when collected by lab personnel
11. Deviations or modifications that affect data quality and/or data integrity. These deviations or modifications are included in narrative statements and/or data merger files.
12. Statement that results relate only to the sample tested
13. Statement that report must be copied in full unless the laboratory provides written permission for partial copies
14. Glossary, References and limits of liability
15. Units of measure and reporting detection limit
16. Quality control data for: % Recovery surrogates, % Recovery of LCS, % RPD of LCSD, Blank analysis, % Recovery Matrix Spike, %RPD of Laboratory Duplicates, as applicable
17. Signature, title and date of report

18. A “Certificate/Approval Program Summary” page is included at the end of the report that identifies analytes for which Alpha Analytical holds certification and for those analytes reported that it does not. This summary also includes the certification numbers for either NELAP certified states, State certifications (e.g. Massachusetts laboratory certification identification number)..
19. Alpha Analytical does not accept samples from private residents for drinking water analysis and therefore maximum contaminant levels are not necessary. If Alpha were to change its policy and report drinking water samples, MCLs would be included with the report.

Results transmitted by facsimile or other electronic means include a statement of confidentiality and return of the materials at the laboratory’s expense.

The laboratory notifies the customer in writing of any circumstance that causes doubt on the validity of the results. The amended or modified report lists the change, reason for the change, affected page numbers, date of the amendment and authorized signature. The customer will be notified prior to changes in LIMs software or hardware configurations that will adversely affect customer electronic data.

13.1 Data Qualifiers

The following data qualifiers are used in conjunction with analytical results depending on the definition, state or regulatory program and report type.

Note: ”J” Estimated value: Upon customer request, the Target analyte concentration can be reported below the quantitation limit (RL), but above the Method Detection Limit (DL) with a “J” qualifier as long as there is a LOD study on file. (See section 5.11)

Data Qualifier	Qualifier Information	Regulatory Requirement
A	Spectra identified as "Aldol Condensation Product".	CT RCP, NC
B	The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at <5x the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than 10x the concentration found in the blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone) For DOD related projects, flag applies to detectable concentration of target analyte in the blank that exceeds ½ the LOG or is greater than 1/10 the concentration in the field sample	EPA Functional Guidelines 'MassDEP MCP, CT RCP, NJ-TO15/LL-TO15; NJ Tech Guidance 2014, DOD QSM 5.1
C	Co-elution: target analyte co-elutes with a known lab standard (i.e. surrogates, internal standards, etc.) for co-extracted analyses.	
D	Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.	NJ-TO15/LL-TO15 - Air only EPA Functional Guidelines; EPA Region 2,5
DL	Same was re-analyzed at a dilution. Qualifier applied to sample number.	

E		Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.	EPA Region 2,5 CT RCP, NJ-TO15/LL-TO15
G		The concentration may be biased high due to matrix interferences (i.e. co-elution) with non-target compound(s). The result should be considered estimated.	In-house/Forensics.
H		The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.	THE NELAC INSTITUTE (TNI) STANDARDS
I		The lower value for the two columns has been reported due to obvious interference.	In-house.
J		Estimated value. This represents an estimated concentration for Tentatively Identified Compounds (TICs).	CT RCP (for TICs),
JN (NJ)		Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.	EPA Functional Guidelines 'NJ-TO15-LL
ND	DU-J	Not detected at the method detection limit (MDL) for the sample, or estimated detection limit (EDL) for same-related analysis	In-house
P	All DU	The RPD between the results for the two columns exceeds the method-specified criteria.	MassDEP MCP, CT RCP
Q	All DU	The quality control sample exceeds the associated acceptance criteria. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)	
R	All DU	Analytical results are from sample re-analysis	Customer-specific

RE	All DU	Analytical results are from sample re-extraction.	Customer-specific
S		Analytical results are from modified screening analysis	

13.2 Compound Summation for Organic Analyses

In order to be compliant with regulations from certain states, Alpha Analytical has created the following Summation Rules to cover reporting "Total Analytes". The following are an example of several compounds that can be reported as "Totals":

Volatiles:	
1,3-Dichloropropene, Total	cis + trans isomers
Xylenes, Total	m/p + o isomers
1,2-Dichloroethene, Total	cis + trans isomers
Trihalomethanes, Total	Chloroform + Bromoform +
	Dibromochloromethane +
	Dichlorobromomethane
PCBs:	
PCBs, Total	Sum of reportable Aroclors
	(all Aroclors reported for the project)

The following are the summation rules that the LIMs uses to calculate the Total values:

Summation Rules:		
H + H = H		Key:
H + J = J		H = Hit (above RL)
J + J = J		J = J-flagged value
H + ND = H		ND = U-flagged value
J + ND = J		
ND + ND = ND		

The ND values are considered "0" during the calculations.
The "E" flagged values (over the calibration) are ignored and not utilized during the calculations.
Any "N" flagged values (do not report) are ignored and not utilized during the calculations.
For dual-column analysis, the Total is reported as part of column "A" data, unless all individuals are reported from "B" column.

For analytical group summations, the Total is reported based on the associated “Reporting List”. For example, if only 7 Aroclors are requested, then the Total is based on 7 Aroclors, not 9.

The RL and MDL for Totals will always be the lowest of the individual compounds used in the summation.

For each Total summation, two values are calculated: TOTALH (calculated from all associated hits above the R L– used in DU reporting formats) and TOTALJ (calculated from all associated hits and J flagged values – used in DJQL reporting formats). Total concentrations are calculated for all samples and QC samples (however, recoveries are not calculated since they are only calculated for the compounds spiked)

If a Total summation is requested, the individual compounds must also be reported.

14 Outside Support Services and Supplies

When Alpha Analytical purchases outside services and supplies in support of tests, the laboratory uses only those outside services and supplies that are of adequate quality to maintain confidence in the tests. Differences between Request/Tender and Contracts must be resolved before work commences.

The Purchasing SOP/1726 describes approval and monitoring of all suppliers and subcontractors used by the laboratory. Where no independent assurance of the quality of outside support services or supplies is available, the laboratory ensures that purchased equipment, materials, and services comply with specifications by evaluating method performance before routine use.

The laboratory checks shipments upon receipt as complying with purchase specifications. The use of purchased equipment and consumables is only after the evaluation and compliance to the specifications is complete. The Purchasing SOP/1726 describes the details for receipt and inspection of purchased product.

The Purchasing SOP describes the process for raising, review and placement of purchase orders. It is company policy to purchase from third party certified suppliers and subcontractors wherever possible. Purchases must be from suppliers approved by the Laboratory. Laboratory or sampling subcontractors specified by the customer are noted as “Trial” on the purchase order. This identifies the subcontractor as a non-approved subcontractor. All DoD work that is subcontracted must comply with Alpha’s management system and must comply with the QSM standard and is subject to DoD customer approval.

The laboratory maintains list of approved vendors (Form 18302) and subcontractors from whom it obtains support services or supplies required for tests.

14.1 Subcontracting Analytical Samples

Customers are advised, verbally and/or in writing, if any analyses will be subcontracted to another laboratory. Any testing covered under the NELAC Institute (TNI) Standards that requires subcontracting, will be subcontracted to another THE NELAC Institute (TNI) Standard accredited laboratory for the tests to be performed. The laboratory approves testing and sampling subcontractors by review of current state, national or other external parties’ certifications or approvals. This document must indicate current approval for the subcontracted work. Any sample(s) needing special reports (*i.e.*, MCL exceedance) will be identified on the chain of custody when the laboratory subcontracts with another laboratory. Subcontractor Laboratory Certifications are located in Qualtrax under Customer Services folder

The Sample Receipt and Login Procedure describes the process for sample handling when subcontracting samples. The quotation form lists the subcontractor in order to notify the customer of any subcontracted work. Customer notification of subcontracted work is in writing before releasing samples to the subcontractor.

The review of subcontractor documents for completeness and meeting the specifications defined for the project follows the laboratory process for reporting and verification of process data. The person responsible for receiving the order reviews the information supplied by the subcontractor instead of the Department Supervisor.

15 Customer Relations

15.1 Customer Service

The majority of the customer services occur from personnel in the administration, sample receiving and sampling areas. Customer service involves inquiries into services offered, technical consulting, placing orders, and receiving orders, providing updates on the status of orders and completing orders. Personnel interacting with customers must document and review customer specific project requirements. Call Tracker is used to document communications with customers (SOP/1723). Personnel must document customer interactions following the appropriate laboratory procedures. Each person must communicate deviations, modifications and customer requests following the laboratory defined procedures.

15.2 Project Management

During staff meetings the laboratory management reviews requests for new work. The Operations Director and/or Laboratory Technical Manager address all capacity and capability issues. Where conflicts in workload arise, customer notification is immediate. The Project Communication Form (PCF) contains the documentation of all project information. Cooperation between laboratory and customer services staff allows direct communication and scheduling. Management arranges complex scheduling and coordination between departmental areas. Documentation of approval for waivers from the DoD QSM requirements must be documented on a project specific waiver. This documentation needs to be in writing and readily available for review.

15.3 Complaint Processing

The laboratory staff documents all customers or other parties' complaints or concerns regarding the data quality or laboratory operations. The Nonconformance Report records complaints, correcting the concern, and resolving the concern with the customer or other party. The process uses the same form and process as the nonconformance action process. Where repetitive corrective actions indicate a problem, an audit of the area, Customer Inquiry and Complaint SOP/1722 is immediate to ensure the corrective action has effectively solved the concern.

16 Appendix A – Definitions/References

The following definitions are from Section 3.0 of the 2009 TNI Standard. The laboratory adopts these definitions for all work performed in the laboratory.

Acceptance Criteria: specified limits placed on characteristics of an item, process, or service defined in requirement documents. (ASQC)

Accreditation: the process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. (TNI)

Accuracy: the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator. (TNI)

Aliquot: A discrete, measured, representative portion of a sample taken for analysis. (EPA QAD glossary)

Analyst: The designated individual who performs the “hands-on” analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality. (TNI)

Analyte: The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family, and which are analyzed together. (EPA Risk Assessment Guide for Superfund; OSHA Glossary)

Analytical Uncertainty: A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis. (TNI)

Assessment: The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its systems to defined criteria (to the standards and requirements of laboratory accreditation. (TNI)

Assessment (Clarification): The evaluation process used to measure the performance or effectiveness of a system and its elements against specific criteria.

Assessment Criteria: the measures established by The NELAC Institute (TNI) Standards and applied in establishing the extent to which an applicant is in conformance with the NELAC Institute (TNI) Standards requirements.

Audit: A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives. (TNI).

Batch: Environmental samples, which are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A

preparation batch is composed of one (1) to twenty (20) environmental samples of the same quality systems matrix, meeting the above mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of prepared environmental samples (extracts, digestates or concentrates), which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed 20 samples. (TNI)

Bias: The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value). (TNI)

Blank: a sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. (TNI)

Blanks include:

Equipment Blank: a sample of analyte-free media, which has been used to rinse common sampling equipment to check effectiveness of decontamination procedures.

Field Blank: blank prepared in the field by filling a clean container with pure de-ionized water and appropriate preservative, if any, for the specific sampling activity being undertaken. (EPA OSWER)

Instrument Blank: a clean sample (e.g. distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination. (EPA-QAD)

Method Blank: A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses, (TNI)

Reagent Blank: (method reagent blank): a sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps. (QAMS)

Blind Sample: a sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst or laboratory's proficiency in the execution of the measurement process.

Calibration: set of operations which establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. (TNI)

1) In calibration of support equipment the values realized by standards are established through the use of Reference Standards that are traceable to the International System of Units (SI).

2) In calibration according to test methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the Laboratory with a certificate of analysis or purity, or prepared by the Laboratory using support equipment that has been calibrated verified to meet specifications.

Calibration Range: The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.

Calibration Curve: the graphical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response. (TNI)

Calibration Method: A defined technical procedure for performing a calibration.

Calibration Standard: A substance or reference material used to calibrate an instrument. (TNI)

Certified Reference Material (CRM): Reference material, accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute. (TNI)

Chain of Custody Form: Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; collector; time of collection; preservation; and requested analyses. See also Legal Chain of Custody Protocols (TNI)

Clean Air Act: the enabling legislation in 42 U.S.C. 7401 *et seq*., Public Law 91-604, 84 Stat. 1676 Pub.L. 95-95, 91 Stat., 685 and Pub. L. 95-190, 91 Stat., 1399, as amended, empowering EPA to promulgate air quality standards, monitor and to enforce them.

Confirmation: Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: Second column confirmation, Alternate wavelength, Derivatization, Mass spectral interpretation, Alternative detectors, or Additional cleanup procedures (TNI)

Customer: Any individual or organization for which items or services are furnished or work performed in response to defined requirements and expectations. (ANSI/ASQ E4-2004)

Congener: A member of a class of related chemical compounds (e.g., PCBs, PCDDs)

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA/Superfund): the enabling legislation in 42 U.S.C. 9601-9675 et seq., as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), 42 U.S.C. 9601 et seq., to eliminate the health and environmental threats posed by hazardous waste sites.

Conformance: an affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements. (ANSI/ASQC E4-1994)

Consensus Standard: A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof. (ANSI/ASQ ANSI/ASQ E4-2004)

Continuing calibration verification: The verification of the initial calibration that is required during the course of analysis at periodic intervals. Continuing calibration verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models. (IDQTF)

Corrective Action: the action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence. (ISO 8402)

Completeness: the percentage of measurements judged to be valid compared to the total number of measurements made for a specific sample matrix and analysis.

Data Quality Objectives (DQO):

Data Reduction: the process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form. (TNI)

Definitive Data: Analytical data of known quality, concentration, and level of uncertainty. The levels of quality and uncertainty of the analytical data are consistent with the requirements for the decision to be made. Suitable for final decision-making. (UFP-QAPP)

Demonstration of Capability: a procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision. (TNI)

Detection Limit: (previously referred to as Method Detection Limit –MDL) the lowest concentration or amount of the target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value. See Method Detection Limit.

Detection Limit (DL) (Clarification): The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type I error) is 1%.

Document Control: the act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed. (ASQC)

Environmental Data: Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology. (ANSI/ASQ E4-2004)

False Negative: An analyte incorrectly reported as absent from the sample, resulting in potential risks from their presence.

False Positive: An item incorrectly identified as present in the sample, resulting in a high reporting value for the analyte of concern.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA): the enabling legislation under 7 U.S.C. 135 *et seq*., as amended, that empowers the EPA to register insecticides, fungicides, and rodenticides.

Federal Water Pollution Control Act (Clean Water Act, CWA): the enabling legislation under 33 U.S.C 1251 et seq., Public Law 92-50086 Stat. 8.16, that empowers EPA to set discharge limitations, write discharge permits, monitor, and bring enforcement action for non-compliance.

Field Measurement: The determination of physical, biological, or radiological properties, or chemical constituents; that are measured on-site, close in time and space to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory.

Field of Accreditation: Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation. (TNI)

Finding: an assessment conclusion, referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement. (TNI)

Finding (Clarification): An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive or negative and is normally accompanied by specific examples of the observed condition (ANSI/ASQ E4-2004).

Holding Times: The maximum time that can elapse between two (2) specified activities. (TNI)

The maximum times that samples may be held prior to analysis and still be considered valid or not compromised. (40 CFR part 136)

Inspection: An activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic. (ANSI/ASQC E4-1994)

Internal Standard: A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method. (TNI)

Isomer: One of two or more compounds, radicals, or ions that contain the same number of atoms of the same elements but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane.

Laboratory: Body that calibrates and/or tests. (ISO 25)

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank or QC check sample): a sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. (TNI).

Laboratory Duplicate: aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.

Legal Chain of Custody Protocols: procedures employed to record the possession of samples from the time of sampling until analysis and are performed at the special request of the customer. These protocols include the use of a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory. (TNI)

Limit of Detection (LOD): A laboratory's estimate of the minimum amount of an analyte in a given matrix that an analytical process can reliably detect in their facility. (TNI)

Limit of Detection (Clarification): The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

Limits of Quantitation (LOQ): The minimum levels, concentrations, or quantities of a target variable (e.g. target analyte) that can be reported with a specified degree of confidence. (TNI) For DOD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard and within the calibration range.

Limit of Quantitation (Clarification): The lowest concentration that produces a quantitative result within specified limits of precision and bias.

Management: Those individuals directly responsible and accountable for planning, implementing, and assessing work. (ANSI/ASQ E4-2004)

Management System: System to establish policy and objectives and to achieve those objectives (ISO 9000).

Matrix: The substrate of a test sample. (TNI)

Matrix Spike (spiked sample, fortified sample): A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of Target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency. (TNI).

Matrix Spike Duplicate (spiked sample or fortified sample duplicate): a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte. (TNI).

Measurement System: A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s). (TNI)

Method: A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed. (TNI)

Method Detection Limit: (now referred to as Detection Limit) one way to establish a Detection Limit, defined as the minimum concentration of a substance (an analyte) that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

Method Detection Limit (MDL) (Clarification): The MDL is one way to establish a Detection Limit, not a Limit of Detection.

Method of Standard Additions: A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration. (This process is often called spiking the sample.) (Modified Skoog, Holler, and Nieman. Principles of Instrumental Analysis. 1998)

Mobile Laboratory: A portable enclosed structure with necessary and appropriate accommodation and environmental conditions for a laboratory, within which testing is performed by analysts. Examples include but are not limited to trailers, vans and skid-mounted structures configured to house testing equipment and personnel. (TNI)

National Institute of Standards and Technology (NIST): A federal agency of the US Department of Commerce's Technology Administration that is designed as the United States national metrology institute. (NMI). (TNI)

National Environmental Laboratory Accreditation Program (NELAP): The overall National Environmental Laboratory Accreditation Program of which TNI is a part.

Negative Control: Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.

Positive Control: Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.

Precision: The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms. (TNI).

Preservation: Any conditions under which a sample must be kept in order to maintain chemical and/or biological integrity prior to analysis. (TNI)

Procedure: A specified way to carry out an activity or a process. Procedures can be documented or not. (TNI)

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source. (TNI)

Proficiency Testing Program: The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories. (TNI)

Proficiency Test Sample (PT): A sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria. (TNI).

Protocol: A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) which must be strictly followed. (TNI)

Quality Assurance: An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item, or service is the type and quality needed and expected by the customer. (TNI)

Quality Assurance [Project] Plan (QAPP): A formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved. (EPA-QAD)

Quality Control: The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements or quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against “out of control” conditions and ensuring that the results are of acceptable quality. (TNI)

Quality Control Sample: A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking intended to demonstrate that a measurement system or activity is in control. (TNI)

Quality Manual: A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, the ensure the quality of its product and the utility of its product to the users. (TNI)

Quality Manual Clarification: Alpha Analytical refers to Quality Manual as Corporate Quality Systems Manual (CQSM). (Alpha)

Quality System: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance (QA) and quality control (QC) activities. (TNI)

Quality System Matrix: These matrix definitions are to be used for purposes of batch and quality control requirements: (TNI)

Air and Emissions: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device.

Aqueous: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, ground water effluents, and TCLP or other extracts.

Biological Tissue: Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.

Chemical Waste: A product or by-product of an industrial process that results in a matrix not previously defined.

Drinking Water: Any aqueous sample that has been designated a potable or potential potable water source.

Non-Aqueous Liquid: Any organic liquid with <15% settleable solids.

Saline/Estuarine: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake.

Solids: Includes soils, sediments, sludges and other matrices with >15% settleable solids.

Raw Data: The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records. (TNI)

Reference Material: Material or substance one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials. (TNI)

Reference Standard: Standard used for the calibration of working measurement standards in a given organization or at a given location. (TNI)

Representativeness: the degree to which the sample represents the properties of the particular sample being analyzed.

Resource Conservation and Recovery Act (RCRA): the enabling legislation under 42 USC 321 *et seq.* (1976), that gives EPA the authority to control hazardous waste from the “cradle-to-grave”, including its generation, transportation, treatment, storage and disposal.

Safe Drinking Water Act (SDWA): the enabling legislation, 42 USC 300f *et seq.* (1974), (Public Law 93-523), that requires the EPA to protect the quality of drinking water in the U.S. by setting maximum allowable contaminant levels, monitoring, and enforcing violations.

Sample Tracking: procedures employed to record the possession of the samples from the time of sampling until analysis, reporting and archiving. These procedures include the use of a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.

Sampling: Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure. (TNI)**Second source calibration verification (ICV):** A standard obtained or prepared from a source independent of the source of standards for the initial calibration. Its concentration should be at or near the middle of the calibration range. It is done after the initial calibration.

Selectivity: The ability to analyze, distinguish, and determine a specific analyte or parameter from another component that may be a potential interferent. (TNI)

Sensitivity: The capability of a test method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. (TNI)

Signal to Noise Ratio: The signal carries information about the analyte, while noise is made up of extraneous information that is unwanted because it degrades the accuracy and precision of an analysis and also places a lower limit on the amount of analyte that can be detected. In most measurements, the average strength of the noise is constant and independent of the magnitude of the signal. Thus, the effect of noise on the relative error of a measurement becomes greater and greater as the quantity being measured (producing the signal) decreases in magnitude. (Skoog, Holler, and Nieman. Principles of Instrumental Analysis. 1998)

Standard: The document describing the elements of laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies. (TNI)

Standard Operating Procedures (SOPs): A written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks. (TNI)

Standard Method: a test method issued by an organization generally recognized as competent to do so.

Standardized Reference Material (SRM): a certified reference material produced by the U.S. National Institute of Standards and Technology or other equivalent organization and characterized for absolute content, independent of analytical method.

Surrogate: a substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.

Technology: a specific arrangement of analytical instruments, detection systems, and/or preparation techniques. (TNI)

Test: A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate. (ISO/IEC Guide 2 - 12.1, amended)

Tentatively Identified Compound (TIC): A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations. Tentatively Identified Compounds, if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported.

Test Method: An adoption of a scientific technique for performing a specific measurement, as documented in a laboratory SOP or as published by a recognized authority.

Toxic Substances Control Act (TSCA): the enabling legislation in 15 USC 2601 et seq. (1976), the provides for testing, regulating, and screening all chemicals produced or imported into the United States for possible toxic effects prior to commercial manufacture.

Traceability: The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project. (TNI)

Tuning: A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

United States Environmental Protection Agency (EPA): the federal governmental agency with responsibility for protecting public health and safeguarding and improving the natural environment (i.e. the air, water and land) upon which human life depends. (US-EPA)

Validation: the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification: confirmation by examination and provision of evidence that specified requirements have been met. (TNI)

NOTE - In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.

The result of verification leads to a decision either to restore in service, to perform adjustments, or to repair, or to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring

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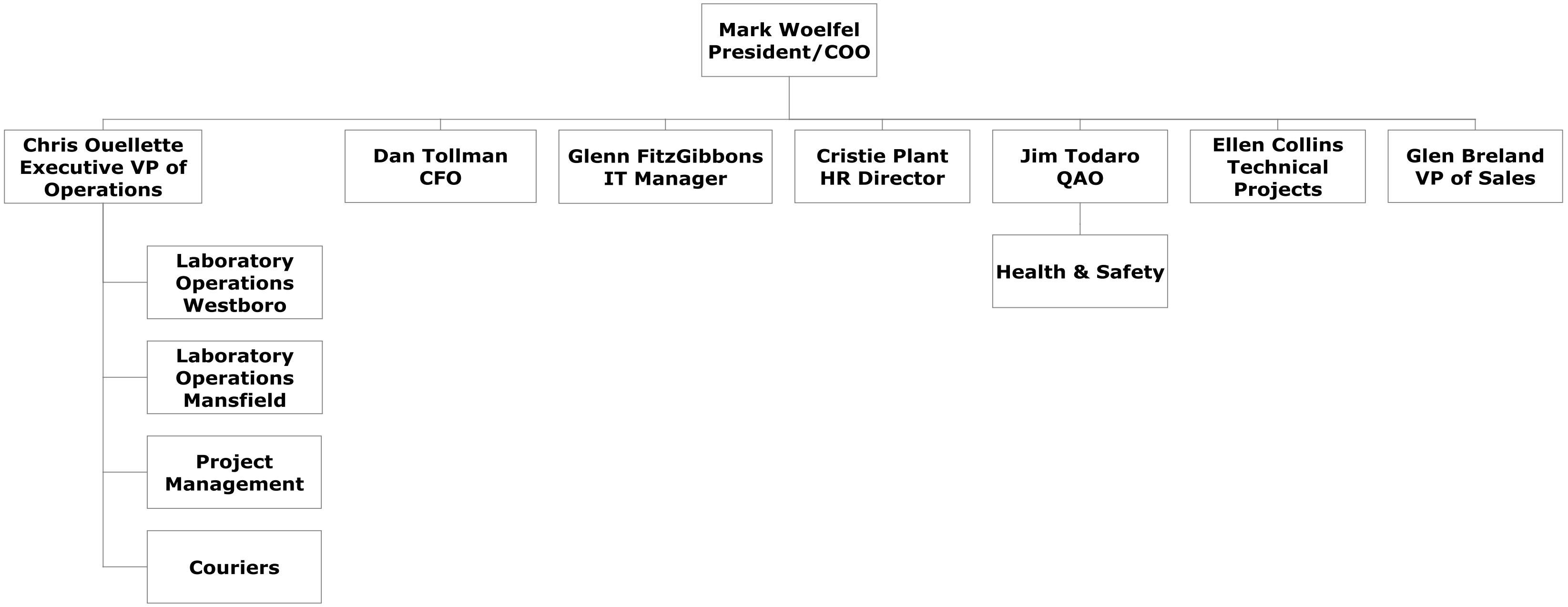
17 Appendix B – Organization Charts

The following charts provide an overview of the organizational structure of Alpha Analytical. The chart also identifies the key personnel responsible for the listed positions. For the various laboratory areas, the individual departmental supervisors are noted. For a listing of all current key personnel, please refer to Section 18, Appendix C.

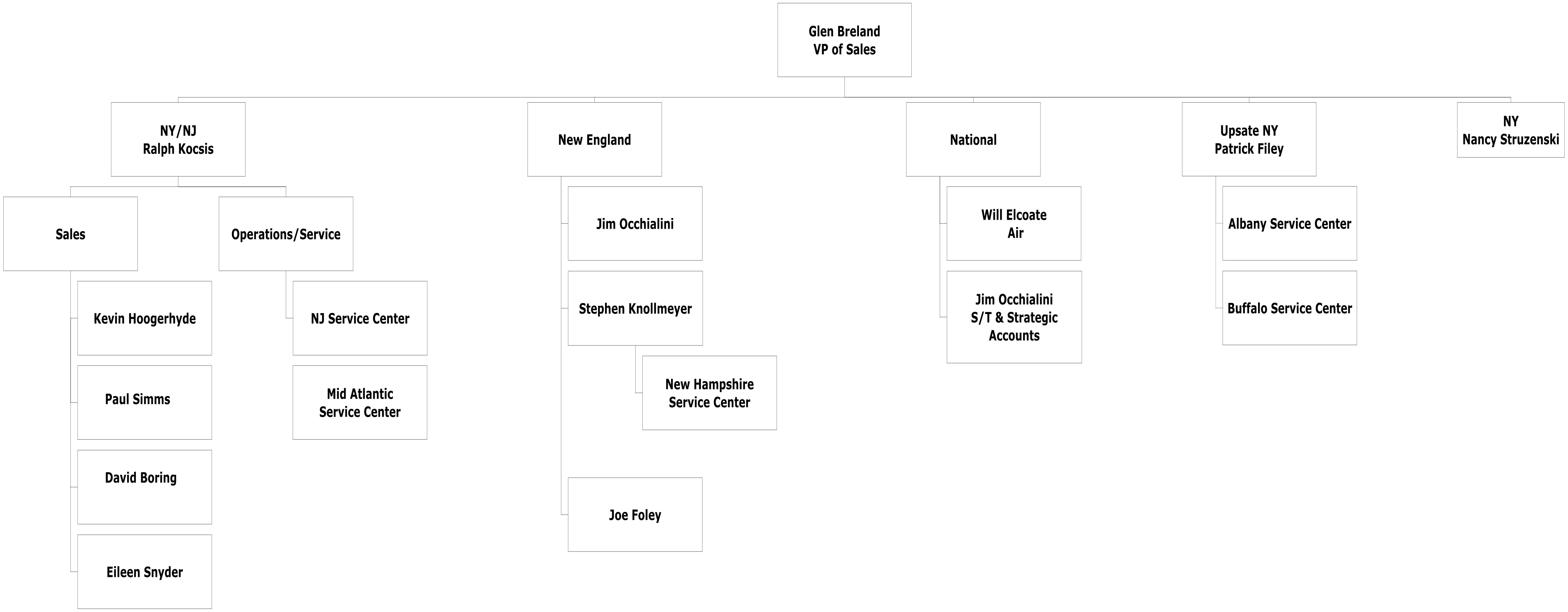
Updated 10/4/2014

2014
Alpha Analytical
Company Organizational Chart



Updated 08/11/2015

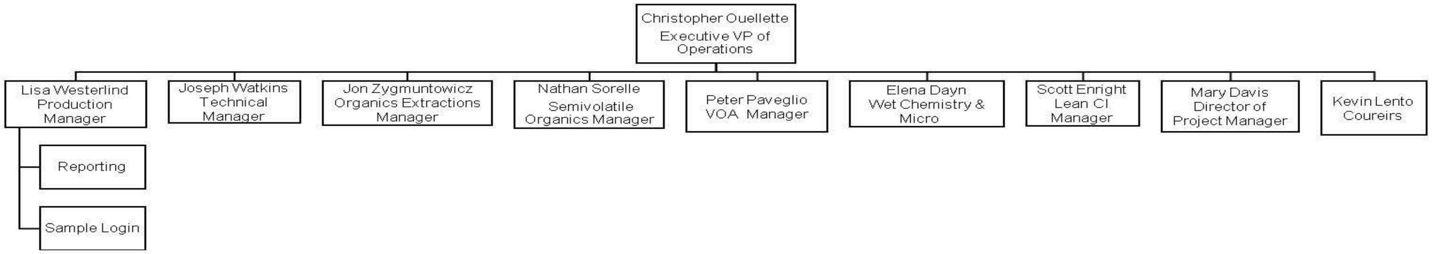
Sales Organization



Updated 03/07/2017

Westboro Facility

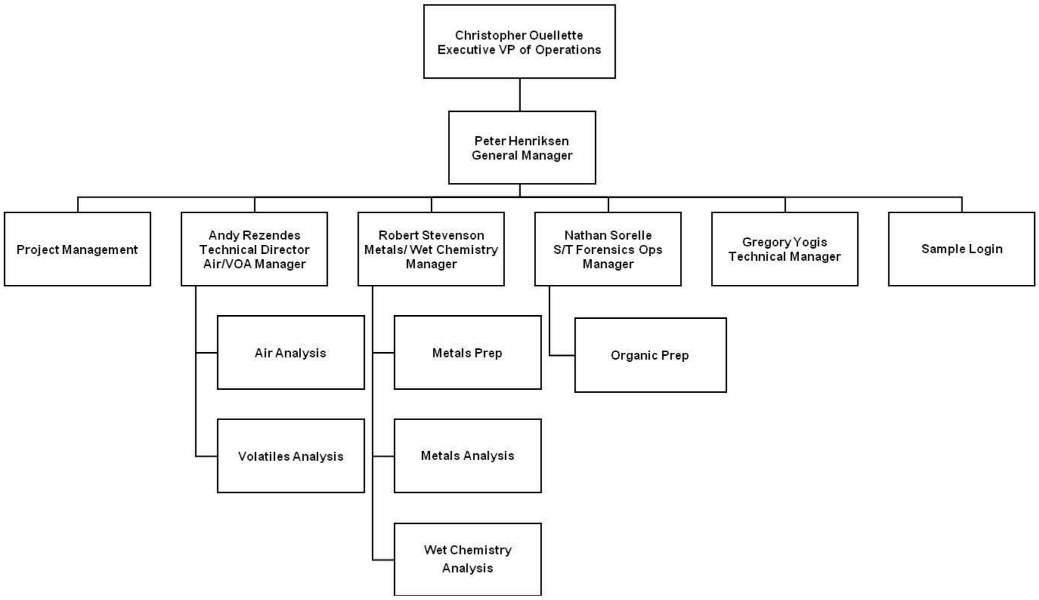
Alpha Analytical
Laboratory Organizational Chart
WESTBOROUGH



Updated 03/07/2017

Mansfield Facility

Alpha Analytical
Laboratory Organization Chart
Mansfield



18 Appendix C – List of Key Personnel

The following is a listing of all current key personnel. If role is specific to a facility it is denoted by either Westboro or Mansfield following the position title. **Updated 5/2016.**

President / COO: Mark Woelfel
Executive VP of Operations: Christopher Ouellette
CFO: Dan Tollman
Laboratory Technical Manager - Westboro: Joseph Watkins
Laboratory Technical Manager - Mansfield: Greg Yogis
Laboratory Technical Manager- Air, Volatiles Manager - Mansfield: Andy Rezendes
Quality Assurance Officer/Health & Safety Manager: James C. Todaro
VP, Technical Projects: Ellen Collins
VP Technical Sales: Glen Breland
VP Technical Sales Manager Alpha: Ralph Kocsis
VP, Technical Sales: James Occhialini, Pat Filey, Kevin Hoogerhyde, Steven Knollmeyer, Nancy Struzenski
Technical Sales Reps: Paul Simms; David Boring; Joe Foley
General Manager, Mansfield: Peter Henriksen
Director of Project Management: Mary Davis
National Air Account Manager: Will Elcoate
Information Technology Manager: Glenn Fitzgibbons
Human Resources Director: Cristie Plant
Health & Safety Officer: James Todaro
Forensic & S/T Operations Manager, Mansfield: Nathan Sorelle
SVOA Operations Manager, Westboro: Nathan Sorelle
Extractions Manager, Westboro: John Zygmuntowicz
VOA Department Manager, Westboro: Peter Paviglio
Wet Chemistry Department Manager, Westboro: Elena Dayn
Metals Department Manager, Mansfield: Robert Stevenson
Login Manager/ Reporting Manager, Westboro Lisa Westerlind
Quality Systems Specialists: Amy Rice, Rene Bennett, Jason Hebert, Blake Buckalew
Purchasing: David Peak
Logistics Manager: Kevin Lento
Equipment Specialists: Syzmon Sus

19 Appendix D – Preventive Maintenance Procedures

Optimized Service-Calibration Intervals

Equipment	Frequency	Type of Calibration or Maintenance
Balances	semiannually daily	cleaning & operations check by service technician (external) calibration verification using Class S-1 certified weights
COD Reactor	annually annually	complete operations check by service technician (external) reaction temperature verification
Conductivity Bridge	annually each use	verification of cell constant complete operations check by service technician (external) calibration verification
DI Water System	as needed monthly annually daily	complete operations check by service technician (external) Residual Chlorine check Biosuitability testing (external) pH and Conductivity check
DO Meter	annually each use	complete operations check by service technician (external) calibration against air as specified by manufacturer
Emergency/Safety Equipment	annually monthly	fire extinguishers and emergency exit lighting check eye washes, showers, fire blanket and first aid kits checked
Freezers	daily	temperature verification
Gas Chromatographs	as needed as needed beginning and end of batch and 10 to 20 samples as per method	injection port preparation; cleaning of detectors initial multi-point calibration continuing calibration verification (CCV) against initial calibration
ICP	Every other day Daily Annually Annually As needed	Change pump tubing Calibration, profile Complete operations check by service technician (external), Linear Dynamic Range determination Clean torch, clean nebulizer, clean spray chamber
Lachat analyzer	Daily As needed	Calibration, clean lines Change tubing, change O-rings
Mass Spectrometers (GC & ICP)	bi-annually as needed 12 hour or daily	change of mechanical pump oil by service technician (external) cleaning of source BFB, DFTPP or ICP-MS tune analysis followed by ICAL or CCV
Mercury Analyzer	monthly each use	clean cell and change pump windings calibration using multi-point curve
Auto-pipettes	Monthly Annually	verification of accuracy verification of precision
Microwave	Quarterly Annually	power and temperature verification RPM verification
Ovens	annually daily	complete operations check by service technician (external) temperature verification
pH Meters	annually each use	complete operations check by service technician (external) calibration using certified buffers
Refrigerators (General Use)	daily	temperature verification
Refrigerators (Sample Management)	daily	temperature verification
Spectrophotometer	Semi-annually Semi-annually daily	cleaning & operations check by service technician (external) wavelength verification (external) continuing calibration verification (CCV) against initial calibration
TCLP Rotator	annually	RPM verification
Thermometers (Mercury/Alcohol)	annually	calibration against NIST traceable thermometer (internal)
Thermometers (digital)	Quarterly	calibration against NIST traceable thermometer (external)
Thermometer (NIST Traceable)	annually	calibration and certification of conformance (external)
Turbidity meter	annually each use	cleaning & operations check by service technician (external) calibration using formazin
Weights (Class S-1)	annually	service/calibration and certification of conformance (external)

20 Appendix E – Alpha Code of Ethics Agreement

Alpha Analytical, Inc.
Ethical Conduct and Data Integrity Agreement

A. ***Personal Pledge:*** I understand that I am charged with meeting the highest degree of ethical standards in performing all of my duties and responsibilities and pledge to only report data, test results and conclusions that are accurate, precise and of the highest quality.

B. ***Protocol Pledges:*** I agree to adhere to the following protocols and principles of ethical conduct in fulfilling my work assignments at Alpha:

1. All work assigned to me will be performed using Standard Operating Procedures (SOPs) that are based on EPA approved methods or Alpha methods.

2. I will only report results or data that match the actual results observed or measured.

3. I will not intentionally nor improperly manipulate or falsify data in any manner, including both sample and QC data. Furthermore, I will not modify data values unless the modification can be technically justified through a measurable analytical process or method acceptable to Alpha. All such modifications will be clearly and thoroughly documented in the appropriate laboratory notebooks and raw data and include my initials or signature and date.

4. I will not intentionally report dates and times of analyses that are not the actual dates and times the analyses were conducted.

5. I will not intentionally represent another individual's work as my own or represent my work as someone else's.

6. I will not make false statements to, or seek to otherwise deceive Alpha staff, leaders or customers. I will not, through acts of commission, omission, erasure or destruction, improperly report measurements, standards results, data, test results or conclusions.

C. ***Guardian Pledge:***

1. I will not condone any accidental or intentional reporting of unauthentic data by other Alpha staff and will immediately report such occurrences to my supervisor, the QA Officer, the Laboratory Technical Manager or corporate leadership. I understand that failure to report such occurrences may subject me to immediate discipline, including termination.

2. If a supervisor or other member of the Alpha leadership group requests me to engage in, or perform an activity that I feel is compromising data validity or quality, I have the right to not comply with the request and appeal this action through Alpha's QA Officer, senior leadership or corporate officers, including the President of the company.

3. I understand that, if my job includes supervisory responsibilities, then I will not instruct, request or direct any subordinate to perform any laboratory practice that is unethical or improper. Also, I will not discourage, intimidate or inhibit a staff member who may

choose to appropriately appeal my supervisory instruction, request or directive that may be perceived to be improper, nor retaliate against those who do so.

D. ***Agreement Signature:*** I have read and fully understand all provisions of the *Alpha Analytical Ethical Conduct and Data Integrity Agreement*. I further realize and acknowledge my responsibility as an Alpha staff member to follow these standards. I clearly understand that adherence to these standards is a requirement of continued employment at Alpha.

____
Employee Signature

____
Printed Name

____
Date

Review Requirements
The *Ethical Conduct and Data Integrity Agreement* must be signed at the time of hire (or within 2 weeks of a staff member's receipt of this policy). Furthermore, each staff member will be required to review and sign this agreement every year. Such signature is a condition of continued employment at Alpha. Failure to comply with these requirements will result in immediate discharge from Alpha employment. This agreement is not an employment contract and does not modify in any manner the company's *Employment-at-Will* Agreement.

21 Appendix F – Floor Plan Westboro Facility

Fire Alarm Zones & Coverage

Zone 1	Manual Pull Stations, Heat & Smoke Detectors
Zone 2	Sprinklers, Tamper & Flow Switches
Zone 3	Duct Smoke Detectors
Zone 4	Smoke, Manual Pull Station, Fire suppression systems

22 Appendix G– Floor Plan Mansfield Facility

23 Appendix H – Job Titles and Requirements

TITLE*	REQUIRED EDUCATION**	MINIMUM REQUIRED ENVIRONMENTAL LAB EXPERIENCE	MINIMUM REQUIRED SKILLS***
Technical Manager (Director) Organic Laboratory	BS or BA in Chemical, Environmental, or Biological Science; including minimum 24 credit hours in Chemistry. Masters or Doctoral degree in one of above disciplines may be substituted for 1 year of experience.	Two (2) years with the analysis of organic analytes in an environmental laboratory	1. Advanced technical knowledge of all analytical methods performed by the lab 2. Advanced technical instrumentation/lab systems knowledge 3. Knowledge of safe laboratory practices, OSHA regs and emergency protocols 4. Experience with and understanding of LIMS 5. Experience with method development and implementation 6. Experience monitoring standards of performance in Quality Control and Quality Assurance
Technical Manager (Director) Inorganic Laboratory	BS or BA in Chemical, Environmental, or Biological Science; including minimum 16 credit hours in Chemistry. Masters or Doctoral degree in one of above disciplines may be substituted for 1 year of experience.	Two (2) years with the analysis of inorganic analytes in an environmental laboratory	1. Advanced technical knowledge of all analytical methods performed by the lab 2. Advanced technical instrumentation/lab systems knowledge 3. Knowledge of safe laboratory practices, OSHA regs and emergency protocols 4. Experience with and understanding of LIMS 5. Experience with method development and implementation 6. Experience monitoring standards of performance in Quality Control and Quality Assurance
Technical Manager (Director) Microbiology Laboratory	BS or BA in Chemical, Environmental, or Biological Science; including minimum 16 credit hours in the Biological Sciences, including at least one course having microbiology as a major component. Masters or Doctoral degree in one of above disciplines may be substituted for 1 year of experience.	Two (2) years with the analysis of microbiological analytes in an environmental laboratory	1. Advanced technical knowledge of all analytical methods performed by the lab 2. Advanced technical instrumentation/lab systems knowledge 3. Knowledge of safe laboratory practices, OSHA regs and emergency protocols 4. Experience with and understanding of LIMS 5. Experience with method development and implementation 6. Experience monitoring standards of performance in Quality Control and Quality Assurance
Quality Assurance Officer	BS/BA in Chemistry, Biology, Environmental or related Science	Two (2) years Environmental Laboratory Experience	1. Advanced technical knowledge of all analytical methods performed by the lab 2. Knowledgeable in Federal, State Programs (THE NELAC INSTITUTE (TNI) STANDARDS, etc.) 3. Able to develop QA/QC policies and certification requirements 4. Able to develop training programs for quality procedures 5. Documented training and/or experience in QA and QA procedures 6. Knowledge of safe laboratory practices and emergency protocols

TITLE*	REQUIRED EDUCATION**	MINIMUM REQUIRED ENVIRONMENTAL LAB EXPERIENCE	MINIMUM REQUIRED SKILLS***
Laboratory Coordinator	High School Diploma; Associates or BS/BA in Chemistry, Biology or Environmental or related Science preferred	1 year +	1. Knowledge of safe laboratory practices and emergency protocols 2. Proficient in all methods and SOP's within their department 3. Experience with and understanding of LIMS 4. Proven ability to meet TAT (turnaround times)
Quality Systems Specialist	BS/BA Chemistry	2 years +	1. General knowledge of laboratory methods 2. Experience with and understanding of LIMS 3. Strong attention to detail 4. Strong oral/written communication and organizational skills 5. Knowledge of QA/QC policies and certification requirements
EH&S Coordinator	High School or Equivalent	2 years +	1. General knowledge of lab operations 2. Detailed knowledge of safe lab practices and emergency protocols 3. Hazardous Waste Management and RCRA Regulation Training 4. DOT Hazardous Materials Regulations Training 5. OSHA Compliance Training 6. Able to develop and deliver new hire and ongoing safety training programs
Lab Technician I	HS or Equivalent	0-1 years. 1+ years preferred.	1. Knowledge of safe laboratory practices 2. Able to follow direction and Standard Operating Procedures (SOP's) 3. Familiarity with standard and reagent preparation 4. Knowledgeable in using volumetric pipettes and glassware 5. Strong oral/written communication and organizational skills
Lab Technician II	HS or Equivalent	2-4 years	1. All skills of Lab Technician I 2. Trained in majority of technician skills relative to department
Lab Technician III	HS or Equivalent	5 years +	1. All skills of Lab Technician II 2. Experienced in training staff
Lab Technician/Chemist I	BS/BA in Chemistry, Biology, Environmental or related Science	0-1 years	1. Knowledge of safe laboratory practices 2. Able to follow direction and Standard Operating Procedures (SOP's) 3. Familiarity with standard and reagent preparation 4. Knowledgeable in using volumetric pipettes and glassware 5. Strong oral/written communication and organizational skills
Lab Technician/Chemist II	BS/BA in Chemistry, Biology, Environmental or related Science	2-4 years	1. All skills of Chemist I 2. Trained in majority of department methods

TITLE*	REQUIRED EDUCATION**	MINIMUM REQUIRED ENVIRONMENTAL LAB EXPERIENCE	MINIMUM REQUIRED SKILLS***
Lab Technician/Chemist III	BS/BA in Chemistry, Biology, Environmental or related Science	5 years +	1. All skills of Chemist II 2. Experienced in training staff
Analyst I	HS or Equivalent	0-1 years	1. Knowledge of safe laboratory practices 2. Able to follow direction and Standard Operating Procedures (SOP's) 3. Experienced with sample handling, preparation and/or extraction
Analyst II	HS or Equivalent	2-4 years	1. All skills of Analyst I 2. Experienced in machine operation, maintenance and troubleshooting
Analyst III	HS or Equivalent	5 years +	1. All skills of Analyst II 2. Experienced in data review and reporting 3. Experienced in training staff
Analytical Chemist I	BS/BA in Chemistry, Biology, Environmental or related Science	6 mos-1 year	1. Knowledge of safe laboratory practices 2. Able to follow direction and Standard Operating Procedures (SOP's) 3. Experienced with sample handling, preparation and/or extraction
Analytical Chemist II	BS/BA in Chemistry, Biology, Environmental or related Science	2-4 years	1. All skills of Analytical Chemist I 2. Experienced in machine operation, maintenance and troubleshooting
Analytical Chemist III	BS/BA in Chemistry, Biology, or Environmental or related Science	5 years +	1. All skills of Analytical Chemist II 2. Experienced in data review and reporting 3. Experienced in training staff
Data Deliverable Specialist I	HS Diploma, BS/BA or Associates preferred	0-1 years	1. Introductory knowledge of laboratory methods 2.Able to follow direction and Standard Operating Procedures (SOP's) 3. Working knowledge of Adobe Acrobat, Microsoft Word, Excel 4. Good writing and typing skills
Data Deliverable Specialist II	HS Diploma, BS/BA or Associates preferred	2-4 years	1. All skills of Data Deliverable Specialist I 2. General knowledge of laboratory methods 3. Understanding of data review/ data reporting process 4. Experience with and understanding of LIMS and electronic data deliverables

TITLE*	REQUIRED EDUCATION**	MINIMUM REQUIRED ENVIRONMENTAL LAB EXPERIENCE	MINIMUM REQUIRED SKILLS***
Data Deliverable Specialist III	HS Diploma, BS/BA or Associates preferred	5 years +	1. All skills of Data Deliverable Specialist II 2. Intermediate/advanced knowledge of laboratory methods 3. Able to perform report review 4. Experience with and understanding of LIMS and electronic data deliverables 5. Able to initiate re-work where necessary
Laboratory Intern	2 Semesters of Chemistry, Biology or Environmental Science	None; Lab work study experience preferred	1. Knowledge of safe laboratory practices 2. Able to follow direction and Standard Operating Procedures

KEY

* Internal terms only. Full title would have "Environmental Laboratory" and specific department preceding it.

** Substitutions: Equivalent knowledge may be substituted for a degree in some instances.

*** Not meant to be an exhaustive list of skill requirements. For full list of skills consult the "Laboratory Skills" list. Actual Job Duties and Responsibilities can be found within job descriptions for each position.

24 Appendix I – Standard Operating Procedures

WESTBORO SOP #	Title
1728	Waste Management and Disposal
1730	Balance Calibration Check
1733	Thermometer Calibration
1735	Analytical Guidelines for Method Validation
1737	Inorganics Glassware Cleaning and Handling
1738	Water Quality Monitoring
1745	Reagent, Solvent and Standard Control
1948	Separatory Funnel Liquid-Liquid Extraction – EPA 3510C
1953	Organic Extraction Glassware Cleaning & Handling
1954	Soxhlet Extraction – EPA 3540C
1955	Sulfur Cleanup – EPA 3660A
1956	Oil and Waste Dilution – EPA 3580A
1959	Microwave Extraction – EPA 3546
1960	Sulfuric Acid Cleanup – EPA 3665A
1962	Florisil Cleanup
1963	Fractionation Cleanup
1964	Preparation of Samples for Chlorinated Herbicides
2022	Volatile Organic Compounds – EPA 624
2107	Volatile Organic Compounds – EPA 524.2
2108	Volatile Organic Compounds – EPA 8260C
2109	Polynuclear Aromatic Hydrocarbons (PAHs) by SIM – EPA 8270D (modified)
2110	Semivolatile Organics by GC/MS – EPA 625
2111	Semivolatile Organics by GC/MS – EPA 8270D
2112	TCLP/SPLP Extraction - Volatile Organics SW-846 Method 1311/1312
2113	EDB & DBCP in Water by Microextraction & Gas Chromatography – EPA 504.1, 8011
2116	Organochlorine Pesticides by Capillary Column GC – EPA 8081B
2119	Extractable Petroleum Hydrocarbons – MADEP
2120	Volatile Petroleum Hydrocarbons – MADEP
2122	Organochlorine Pesticides & PCBs by Capillary Column GC – EPA 608
2123	Polychlorinated Biphenyls in Oil – EPA 600/4-81-045
2125	TPH-Diesel Range Organics, Maine 4.1.25, EPA 8015C (Modified)
2126	TPH- Gasoline Range Organics, Maine 4.2.17, EPA 8015C (Modified)
2127	CT-ETPH
2128	Herbicides by 8151A

WESTBORO SOP #	Title
2129	PCBs by Capillary Column Gas Chromatography - EPA 8082A
2131	New Jersey EPH Method
2133	TCLP Extraction Metals and Semi-Volatile Organics – SW-846 Method 1311
2134	Hot Block Digestion for Aqueous Samples EPA 3005A
2135	SPLP Extraction Inorganics and Semivolatile Organics, EPA 1312
2161	Fecal Coliform by Membrane Filtration – SM 9222D
2163	Fecal Coliform by Multiple Tube Fermentation – SM 9221E
2191	Heterotrophic Plate Count – SM 9215B
2192	Total Coliform/E.Coli – Presence/Absence (Colilert) – SM 9223B
2193	Total Coliform by Membrane Filtration – SM 9222B
2194	Total Coliform by Multiple Tube Fermentation – SM 9221B
2195	Chlorophyll A – SM 10200H
2196	E. Coli – Membrane Filtration
2197	Chlorophyll A – EPA 446
2198	Air Density Monitoring
2199	Inhibitory Residue Test
2200	Enterococcus – MF
2201	Total Coliform, E.Coli & Enterococcus by Quantification Methods (Quanti Tray)
2202	pH, Liquid Samples
2203	pH, Soil & Waste Samples
2204	Hexavalent Chromium
2205	Biological Oxygen Demand
2206	Ammonia Nitrogen
2207	Total Kjeldahl Nitrogen
2208	Chemical Oxygen Demand
2209	Oil & Grease by n-Hexane Extraction Method & Gravimetry
2210	Cyanide, Total
2211	Phenol, Total
2212	Sulfate, Turbidimetric Method
2213	Alkalinity, Titration Method –SM 2320B
2214	Determination of Inorganic Anions by Ion Chromatography – EPA 300.0
2215	Total Organic Carbon/Dissolved Organic Carbon
2216	Chloride – SM 4500Cl-E, EPA 9251
2217	Nitrate, Nitrite and Nitrate/Nitrite Nitrogen – EPA 353.2, SM 4500NO_3-F
2218	Total Solids (Dried @ 103-105^o) and TVS – SM 2540B, SM 2540E
2219	Total Dissolved Solids – SM 2540C
2220	Total Suspended Solids – SM 2540D
2221	Total Sulfide – SM 4500S2-AD, EPA 9030B

WESTBORO SOP #	**Title**
2222	MBAS, Anionic Surfactants – SM 5540C
2223	Fluoride, Electrode Method – SM 4500F-BC
2224	Turbidity, Nephelometric Method – EPA 180.1, SM 2130B
2225	Orthophosphate, Colorimetric Single Reagent Method – SM 4500P-E
2226	Total Phosphorous, Colorimetric Combined Reagent Method – SM 4500P-E
2227	Flashpoint – EPA 1010
2228	Reactivity – EPA Chapter 7.3
2229	Total Solids (Dried @ 103-105^{o}) – SM 2540G
2230	Specific Conductance and Salinity
2231	True and Apparent Color, Visual Comparison Method
2232	Acidity, Titration Method
2233	Determination of Formaldehyde by HPLC, EPA 8315A
2234	Sulfite, Iodometric
2235	Ferrous Iron
2236	Residual Chlorine
2237	ORP
2238	Ignitability of Solids EPA 1030
2239	Physiologically Available Cyanide (PAC)
2240	Total Settleable Solids SM 2540 F
2241	Fixed and Volatile Solids in Solid and Semisolid Samples – SM 2540G
2242	Tannin & Lignin
2243	Nitrite - Manual Colorimetric Method
2244	Paint Filter Liquids Test
2245	Odor, Threshold Odor Test
2249	Dissolved Oxygen
2251	Perchlorate by IC/MS/MS
2274	Data Validation Package
3743	Free Cyanide
9177	Total Phenol - SEAL Method
9733	Oil & Grease and TPH in Soil
10807	Percent Organic Matter in Soil
12838	Buchi Concentration
17972	Extractable Organic Halides (EOX)
18236	Chloropicrin and Carbon Tetrachloride by EPA 8011
19332	DI Water Extraction ASTM D3987

MANSFIELD SOP #	**Title**
1753	Glassware Cleaning
1754	Balance Calibration
1755	Pipette Checks
1796	Sample Management - Forensics
1797	Haz Waste
1816	Reagent Solvent Standard Control
2137	ICP-MS EPA 6020A
2138	Mercury Aqueous 7470A
2139	Mercury Soil 7471B
2140	AVS SEM
2141	Hydride Generation
2142	Mercury Aqueous 1631E
2143	Mercury Soil 7474
2148	Metals Soil Digestion 3050
2150	Metals Microwave 3015
2151	Metals Acid Digestion 3020
2152	Seawater Extraction of Metals
2154	TCLP 1311
2155	EPA 8270D
2157	PAH by SIM
2158	EPA 8081B
2160	EPA 8082A Aroclors/Congeners by GC and TO-10A
2162	Pesticides/PCB Aroclors/Congeners by GC/MS SIM
2164	1,4-Dioxane GC/MS SIM
2165	Separatory Funnel Extraction EPA 3510C
2166	Tissue Prep
2167	GPC
2168	Sulfur Cleanup 3660
2169	Sulfuric Acid Cleanup 3665
2170	Silica Gel Cleanup
2171	% Lipids
2172	Microscale Solvent Extraction EPA 3570
2173	Soxhlet Extraction EPA 3540C
2174	Soxhlet Extraction of PUFs
2175	% Total Solids
2182	TOC by Lloyd Kahn
2183	Particle Size Determination
2184	Particulates in Air PM-10

MANSFIELD SOP #	Title
2185	Volatile Solids
2186	TO-15
2187	APH
2188	Air PIANO
2189	Dissolved Gases
2190	Can Cleaning
2246	TPH and SHC
2247	Alkylated PAH
2248	Organic Lead
2252	Fixed Gases
2253	TO-11A
2255	PIANO Volatiles
2256	Ethanol in Oil
2257	Whole Oil Analysis
2259	Density Determination of Oils
2260	Alumina Cleanup
2261	Shaker Table
2263	Gravimetric Determination
2264	Tissue Extraction
2265	Organic Waste Dilution
2267	Client SOP: SGC - Manual Method
2268	Client SOP: DCM Extractable Method
4246	PAHs by SPME
6398	TO-17
6438	Mercury in Sorbent Tubes by CVAA
7900	Mercury 1631E Using Cetac-M-8000 Analyzer
9077	Porewater Generation
9480	EPA-TO-12
9745	Formaldehyde - HPLC
12863	EPA 8270D GC/MS Full Scan TO-13A
13091	HPAH
13406	Particulate Organic Carbon
14500	Lead in Particulate Matter
17452	TOC by EPA 9060A
17456	Moisture, Ash and Organic Matter
18086	Total Suspended Solids (TSS) SM 2540D
17829	Specific Gravity of Soil
17830	Liquid Limit, Plastic Limit and Plasticity Index of Soils
17940	1,4-Dioxane in Drinking Water by EPA 522

MANSFIELD SOP #	Title
18705	PCB Congeners by GC/MS-SIM EPA 8270D
18710	Trace Elements in Waters and Wastes by ICP-MS EPA 200.8
18711	Metals by ICP EPA 200.7
18714	Metals by ICP EPA 6010C
18715	Mercury in Water (CVAA) EPA 245.1
18716	Hot Block Digestion for Aqueous Samples EPA 3005A
18717	Microwave Assisted Acid Digestion of TCLP Extracts EPA 3015
18718	Microwave Assisted Acid Digestion for Metals EPA 3015A/3051A
18817	Alcohols by FID- Aqueous Direct Injection EPA 8015D
19625	Glycols by GC-FID EPA 8015D
19971	Air Drying Samples for PCBs and Metals Analysis
19978	Density of Soil
22132	Data Review – Ohio VAP

CORPORATE SOP #	Title
1559	Sample Receipt and Login
1560	Sample Custody and Tracking
1561	Bottle Order Preparation
1562	Computer System Backup/Control
1563	Computer and Network Security
1564	Software Validation and Control
1565	Training Program
1566	Report Generation and Approval
1567	Organics Data Deliverable Package Review
1722	Customer Inquiry and Complaint Procedures
1723	Customer Service
1724	Quote/Contract Procedure
1725	Project Communication Form Generation
1726	Procedure
1727	Accounts Payable Invoice Processing
1729	Document Control
1731	Manual Integration and Compound Rejection
1732	DL LOD LOQ Generation
1734	Control Limit Generation
1736	Corrective and Preventative Actions
1739	Demonstration of Capability (DOC) Generation

CORPORATE SOP #	**Title**
1740	Internal Audit Procedure
1741	Data Review – Organics
1742	Calculating Measurement Uncertainty
1743	Annual Management Review
1744	Sample Compositing Procedure
1746	Nonconformance Planning/Procedures
1747	Temperature Datalogger Operation
2274	Data Validation Package
17553	Lab Supply Transfer Procedure
18909	PT Corrective and Preventive Action Process

Method Detection Limit Studies

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Created By: Elizabeth Porta
File: PM3544-1
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Alpha Analytical

Semivolatile Organics - EPA 8270D (WATER)

Holding Time: 7 days
Container/Sample Preservation: 2 - Amber 1000ml unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Pentachlorophenol	87-86-5	2	0.4361	ug/l	50-120	30	50-120	30	30			
2-Fluorophenol	*367-12-4*									*30-150*		
Phenol-d5	*4165-62-2*									*30-150*		
2,4,6-Tribromophenol	*118-79-6*									*30-150*		
Nitrobenzene-d5	*4165-60-0*									*30-150*		
2-Fluorobiphenyl	*321-60-8*									*30-150*		
Terphenyl-d14	*1718-51-0*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)
Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

PCB Congeners-EPA 8270D/NOAA (WATER)

Holding Time: 7 days
Container/Sample Preservation: 2 - Amber 1000ml unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Cl2-BZ#8	34883-43-7	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl3-BZ#18	37680-65-2	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl3-BZ#28	7012-37-5	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl4-BZ#44	41464-39-5	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl4-BZ#49	41464-40-8	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl4-BZ#52	35693-99-3	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl4-BZ#66	32598-10-0	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl5-BZ#87	38380-02-8	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl5-BZ#101	37680-73-2	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl5-BZ#105	32598-14-4	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl5-BZ#118	31508-00-6	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl6-BZ#128	38380-07-3	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl6-BZ#138	35065-28-2	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl6-BZ#153	35065-27-1	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl7-BZ#170	35065-30-6	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl7-BZ#180	35065-29-3	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl7-BZ#183	52663-69-1	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl7-BZ#184	74472-48-3	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl7-BZ#187	52663-68-0	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl8-BZ#195	52663-78-2	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl9-BZ#206	40186-72-9	1	0.5	ng/l	40-140	30	40-140	30	30			
Cl10-BZ#209	2051-24-3	1	0.5	ng/l	40-140	30	40-140	30	30			
DBOB	*10386-84-2*									*50-125*		
BZ 198	*68194-17-2*									*50-125*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

RIM Pesticides - EPA 8081B (Elutriates) (WATER)

Holding Time: 7 days
Container/Sample Preservation: 2 - Amber 500ml unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Aldrin	309-00-2	0.005	0.005	ug/l	50-120	30	50-120	30	30			
cis-Chlordane	5103-71-9	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
gamma-BHC	58-89-9	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
trans-Chlordane	5103-74-2	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
4,4'-DDT	50-29-3	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
Dieldrin	60-57-1	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
Chloropyrifos	2921-88-2	0.005	0.005	ug/l	50-120	30	50-120	30	30			
Endosulfan I	959-98-8	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
Endosulfan II	33213-65-9	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
Endrin	72-20-8	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
Heptachlor	76-44-8	0.0025	0.0025	ug/l	50-120	30	50-120	30	30			
Heptachlor epoxide	1024-57-3	0.005	0.005	ug/l	50-120	30	50-120	30	30			
Toxaphene	8001-35-2	0.125	0.0625	ug/l	50-120	30	50-120	30	30			
DBOB	*10386-84-2*									*30-150*		
BZ 198	*68194-17-2*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

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Alpha Analytical

METALS by 6020A (WATER)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation
Arsenic, Total	7440-38-2	0.0005	0.000165	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Cadmium, Total	7440-43-9	0.0002	0.0000599	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Copper, Total	7440-50-8	0.001	0.000384	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Lead, Total	7439-92-1	0.001	0.000343	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Nickel, Total	7440-02-0	0.002	0.000556	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Selenium, Total	7782-49-2	0.005	0.00173	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Silver, Total	7440-22-4	0.0004	0.000163	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved
Zinc, Total	7440-66-6	0.01	0.00341	mg/l	80-120	20	75-125	20	20		180 days	1 - Plastic 250ml HNO3 preserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

METALS by 7474 (WATER)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation
Mercury, Total	7439-97-6	0.00005	0.00001	mg/l	80-120	20	80-120	20	20		28 days	1 - Plastic 250ml HNO3 preserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

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Alpha Analytical

WETCHEM (WATER)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Method	Holding Time	Container/Sample Preservation
Chromium, Hexavalent	18540-29-9	0.01	0.003	mg/l	85-115	20	85-115	20	20	7196A	24 hours	1 - Plastic 500ml unpreserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

PAH/PCB Congeners-8270D/NOAA (SOIL)

Holding Time: 14 days
Container/Sample Preservation: 1 - Glass 60mL/2oz unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Naphthalene	91-20-3	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Acenaphthylene	208-96-8	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Acenaphthene	83-32-9	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Fluorene	86-73-7	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Phenanthrene	85-01-8	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Anthracene	120-12-7	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Fluoranthene	206-44-0	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Pyrene	129-00-0	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Benz(a)anthracene	56-55-3	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Chrysene	218-01-9	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Benzo(b)fluoranthene	205-99-2	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Benzo(k)fluoranthene	207-08-9	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Benzo(a)pyrene	50-32-8	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Indeno(1,2,3-cd)Pyrene	193-39-5	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Dibenz(a,h)anthracene	53-70-3	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
Benzo(ghi)perylene	191-24-2	8.0	4.0	ug/kg	50-120	30	50-120	30	30			
2-Methylnaphthalene-d10	*7297-45-2*									*30-150*		
Pyrene-d10	*1718-52-1*									*30-150*		
Benzo(b)fluoranthene-d12	*93951-98-5*									*30-150*		
Cl2-BZ#8	34883-43-7	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl3-BZ#18	37680-65-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl3-BZ#28	7012-37-5	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#44	41464-39-5	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#49	41464-40-8	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#52	35693-99-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#66	32598-10-0	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#87	38380-02-8	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#101	37680-73-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#105	32598-14-4	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#118	31508-00-6	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl6-BZ#128	38380-07-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl6-BZ#138	35065-28-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl6-BZ#153	35065-27-1	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#170	35065-30-6	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#180	35065-29-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#183	52663-69-1	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#184	74472-48-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#187	52663-68-0	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl8-BZ#195	52663-78-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl9-BZ#206	40186-72-9	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl10-BZ#209	2051-24-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
DBOB	*10386-84-2*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

Alpha Analytical

PAH/PCB Congeners-8270D/NOAA (SOIL)

Holding Time: 14 days
Container/Sample Preservation: 1 - Glass 60mL/2oz unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
BZ 198	*68194-17-2*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)
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Alpha Analytical

RIM Pesticides - EPA 8081B (SOIL)

Holding Time: 14 days
Container/Sample Preservation: 1 - Glass 60mL/2oz unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Aldrin	309-00-2	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
cis-Chlordane	5103-71-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
cis-Nonachlor	5103-73-1	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
gamma-BHC	58-89-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
trans-Chlordane	5103-74-2	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
4,4'-DDD	72-54-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
4,4'-DDE	72-55-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
4,4'-DDT	50-29-3	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Dieldrin	60-57-1	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Endosulfan I	959-98-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Endosulfan II	33213-65-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Endrin	72-20-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Heptachlor	76-44-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Heptachlor epoxide	1024-57-3	1.00	1.00	ug/kg	50-120	30	50-120	30	30			
Hexachlorobenzene	118-74-1	1.00	1.00	ug/kg	50-120	30	50-120	30	30			
Methoxychlor	72-43-5	5.00	5.00	ug/kg	50-120	30	50-120	30	30			
Oxychlordane	27304-13-8	1.00	1.00	ug/kg	50-120	30	50-120	30	30			
trans-Nonachlor	39765-80-5	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Toxaphene	8001-35-2	25	25	ug/kg	50-120	30	50-120	30	30			
DBOB	*10386-84-2*									*30-150*		
BZ 198	*68194-17-2*									*30-150*		

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Alpha Analytical

METALS by 6020A (SOIL)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation
Arsenic, Total	7440-38-2	0.0500	0.0066	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Cadmium, Total	7440-43-9	0.0200	0.0026	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 60mL/2oz unpreserved
Chromium, Total	7440-47-3	0.200	0.0468	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 60mL/2oz unpreserved
Copper, Total	7440-50-8	0.200	0.0194	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 60mL/2oz unpreserved
Lead, Total	7439-92-1	0.0600	0.0146	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 60mL/2oz unpreserved
Nickel, Total	7440-02-0	0.100	0.0267	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 60mL/2oz unpreserved
Zinc, Total	7440-66-6	1.00	0.260	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 60mL/2oz unpreserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)
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Alpha Analytical

METALS by 7474 (SOIL)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation
Mercury, Total	7439-97-6	0.0125	0.0016	mg/kg	78-128	20	80-120	20	20		28 days	1 - Glass 250ml/8oz unpreserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

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Alpha Analytical

WETCHEM (SOIL)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Method	Holding Time	Container/Sample Preservation
Solids, Total	NONE	0.100	0.100	%	NA	NA	NA	10	10	2540G	7 days	1 - Glass 60mL/2oz unpreserved
Total Organic Carbon	7440-44-0	0.010	0.010	%	75-125	NA	75-125	25	25	EPA 9060A	28 days	1 - Glass 60mL/2oz unpreserved
Grain Size	NONE	0.100	0.100	%	NA	NA	NA	NA	25	ASTM D422	NA	Plastic 8oz unpreserved for Grain Size

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Alpha Analytical

PAH/PCB Congeners-8270D/NOAA (TISSUE)

Holding Time: 14 days
Container/Sample Preservation: 1 - Glass 60mL/2oz unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Naphthalene	91-20-3	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Acenaphthylene	208-96-8	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Acenaphthene	83-32-9	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Fluorene	86-73-7	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Phenanthrene	85-01-8	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Anthracene	120-12-7	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Fluoranthene	206-44-0	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Pyrene	129-00-0	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Benz(a)anthracene	56-55-3	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Chrysene	218-01-9	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Benzo(b)fluoranthene	205-99-2	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Benzo(k)fluoranthene	207-08-9	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Benzo(a)pyrene	50-32-8	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Indeno(1,2,3-cd)Pyrene	193-39-5	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Dibenz(a,h)anthracene	53-70-3	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
Benzo(ghi)perylene	191-24-2	8.00	4.00	ug/kg	50-120	30	50-120	30	30			
2-Methylnaphthalene-d10	*7297-45-2*									*30-150*		
Pyrene-d10	*1718-52-1*									*30-150*		
Benzo(b)fluoranthene-d12	*93951-98-5*									*30-150*		
Cl2-BZ#8	34883-43-7	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl3-BZ#18	37680-65-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl3-BZ#28	7012-37-5	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#44	41464-39-5	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#49	41464-40-8	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#52	35693-99-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl4-BZ#66	32598-10-0	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#87	38380-02-8	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#101	37680-73-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#105	32598-14-4	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl5-BZ#118	31508-00-6	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl6-BZ#128	38380-07-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl6-BZ#138	35065-28-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl6-BZ#153	35065-27-1	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#170	35065-30-6	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#180	35065-29-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#183	52663-69-1	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#184	74472-48-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl7-BZ#187	52663-68-0	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl8-BZ#195	52663-78-2	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl9-BZ#206	40186-72-9	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
Cl10-BZ#209	2051-24-3	0.80	0.40	ug/kg	50-120	30	50-120	30	30			
DBOB	*10386-84-2*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

PAH/PCB Congeners-8270D/NOAA (TISSUE)

Holding Time: 14 days
Container/Sample Preservation: 1 - Glass 60mL/2oz unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
BZ 198	*68194-17-2*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)
Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

RIM Pesticides - EPA 8081B (TISSUE)

Holding Time: 14 days
Container/Sample Preservation: 1 - Glass 60mL/2oz unpreserved

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria		
Aldrin	309-00-2	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
cis-Chlordane	5103-71-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
cis-Nonachlor	5103-73-1	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
gamma-BHC	58-89-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
trans-Chlordane	5103-74-2	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
4,4'-DDD	72-54-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
4,4'-DDE	72-55-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
4,4'-DDT	50-29-3	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Dieldrin	60-57-1	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Endosulfan I	959-98-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Endosulfan II	33213-65-9	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Endrin	72-20-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Heptachlor	76-44-8	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Heptachlor epoxide	1024-57-3	1.00	1.00	ug/kg	50-120	30	50-120	30	30			
Hexachlorobenzene	118-74-1	1.00	1.00	ug/kg	50-120	30	50-120	30	30			
Methoxychlor	72-43-5	5.00	5.00	ug/kg	50-120	30	50-120	30	30			
Oxychlordane	27304-13-8	1.00	1.00	ug/kg	50-120	30	50-120	30	30			
trans-Nonachlor	39765-80-5	0.50	0.50	ug/kg	50-120	30	50-120	30	30			
Toxaphene	8001-35-2	25.0	25.0	ug/kg	50-120	30	50-120	30	30			
DBOB	*10386-84-2*									*30-150*		
BZ 198	*68194-17-2*									*30-150*		

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Created By: Elizabeth Porta
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Alpha Analytical

METALS by 6020A (TISSUE)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation
Arsenic, Total	7440-38-2	0.10	0.0344	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Cadmium, Total	7440-43-9	0.040	0.0105	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Chromium, Total	7440-47-3	0.40	0.0360	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Copper, Total	7440-50-8	0.40	0.0484	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Lead, Total	7439-92-1	0.12	0.0058	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Nickel, Total	7440-02-0	0.20	0.0576	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved
Zinc, Total	7440-66-6	2.00	0.149	mg/kg	75-125	20	75-125	20	20		180 days	1 - Glass 120ml/4oz unpreserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Created By: Elizabeth Porta
File: PM3545-1
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Alpha Analytical

METALS by 7474 (TISSUE)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Surrogate Criteria	Holding Time	Container/Sample Preservation
Mercury, Total	7439-97-6	0.0125	0.00361	mg/kg	80-120	20	80-120	20	20		365 days	1 - Glass 250ml/8oz unpreserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)
Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

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Alpha Analytical

WETCHEM (TISSUE)

Analyte	CAS #	RL	MDL	Units	LCS Criteria	LCS RPD	MS Criteria	MS RPD	Duplicate RPD	Method	Holding Time	Container/Sample Preservation
Moisture	NONE	0.1	NA	%	NA	NA	NA	10	10	2540B	7 days	1 - Glass 120ml/4oz unpreserved
Percent Lipids	NONE	0.1	NA	%	NA	NA	NA	20	20	NOAA	7 days	1 - Glass 60mL/2oz unpreserved

Please Note that the RL information provided in this table is calculated using a 100% Solids factor. (Soil/Solids only)

Please Note that the information provided in this table is subject to change at anytime at the discretion of Alpha Analytical, Inc.

Community Air Monitoring Plan

HARBOR VIEW SQUARE
68 West First Street
OSWEGO, NEW YORK

NYS BCP Site No. C738040

Prepared by:

synapse
connect. advise. insure.

Synapse Risk Management
360 Erie Boulevard East
Syracuse, New York 13202

July 2018

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Disclaimer

This Community Air Monitoring Plan (CAMP) was prepared by Synapse Risk Management (Synapse) for Housing Visions and is intended to be used during the implementation of the Pre-design Investigation at 68 West First Street in Oswego, New York. Any changes in project conditions and/or the scope of work will require a review and modification to this CAMP. Such changes will be completed in the form of an addendum to this plan or a revision of the plan.

The provisions of this plan are mandatory for all personnel assigned to the project. All visitors to the project site must also abide by the requirements of the plan. It should be acknowledged that the personnel of other consulting and/or contracted companies shall work in accordance with their own independent task-specific HASPs. The policies and procedures presented in this document shall not be construed to supercede any federal, state, or local regulations, and do not relieve any employer, agent, or invitee involved in the project from complying with applicable federal, state, and local regulations.

This CAMP is not intended or represented to be suitable for reuse by others on extensions of this or any other project. Any reuse without prior written approval or adaptation by Synapse will be at the user's sole risk and without liability and legal exposure to Synapse.

1 Introduction

This plan presents the Community Air Monitoring Plan (CAMP), which was prepared by Synapse Risk Management (Synapse) to protect the community from any potential airborne releases that could result during field work associated with the Harbor View Square Brownfield Cleanup Program (BCP).

This plan is consistent with requirements set forth in the New York State Department of Environmental Conservation (NYSDEC) Division of Environmental Remediation, *Technical Guidance for Site Investigation and Remediation*, May 2010 (DER-10).

1.1 Objective

This CAMP identifies the air monitoring activities to be performed at the site during implementation of both non-intrusive and intrusive activities. The overall objectives of this CAMP is as follows:

- Prevent exposures to the general public during the implementation of work activities over the course of the Harbor View Square BCP;
- Set forth the monitoring requirement and associated documentation; and
- Set forth guidance for potential contingency situations that may arise.

2 Air Monitoring

Air monitoring during the implementation of various work activities will include volatile organic compounds (VOCs) and particulate monitoring utilizing specialized instruments, visual observations for fugitives dust and documenting meteorological conditions on a daily basis. The monitoring locations, frequency and methods for monitoring VOCs and particulate are discussed in the following sections of this CAMP.

2.1 VOC Monitoring

Real time VOC monitoring will be conducted during non-invasive and invasive work activities conducted during various aspects of the BCP. The locations will be based on wind direction and frequency of the monitoring will be based the type of work being conducted. Below is breakdown of work activities that require continuous versus. periodic VOC monitoring.

Monitoring Type	Work Activities
Continuous	▪ Soil Borings or Monitoring Well Installation; ▪ Soil Excavation; ▪ Test pits; and ▪ Demolition of contaminated structures.
Periodic	▪ Groundwater sampling

The upwind location will be determined at the beginning of each work day with an initial VOC recording. If the wind direction changes during the course of the work, another VOC reading will be recorded at the new upwind location to establish baseline conditions. The downwind measurements will be recorded at the downwind perimeter of the work area. If the work activities are determined ort considered invasive then continuous monitoring will be conducted. If the work activities are considered non-invasive, then periodic monitoring for VOC will be sufficient.

Locations	Frequency
Upwind perimeter	▪ Start of work day; and ▪ New background measurements based on wind direction change.
Downwind perimeter	▪ Continuous for invasive work; and ▪ Periodic for non-invasive work.

The VOC recording will be performed utilizing a photoionization detector (PID) that should be calibrated on a daily basis. The PID shall be adjusted to provide continuous monitoring and integrating a 15 minute running average through the course of the work day.

2.2 Particulate Monitoring

The particulate monitoring will be conducted on a continuous basis and a varying locations based on wind direction. The upwind location will be determined at the beginning of each workday. If the wind direction chances through the course of the day a new upwind location will be established for baseline conditions.

Locations	**Frequency**
Upwind perimeter	Continuous
Downwind perimeter	Continuous

The particulate recordings will conducted utilizing an instrument that can measure particles less than 10 micrometers (um) in size (PM-10). The particulate monitor should be programed to record in real time and set to have an alarm notification if an action level for particulate is exceeded during work activities (150 ug/m^3).

2.3 Regional Meteorological Monitoring

Meteorological monitoring should be documented on a daily basis through the course of the work activities. On a daily basis temperature, wind direction and general atmospheric conditions, such as clear / cloudy and rain / snow should be recorded

3 Response and Action Levels

3.1 VOCs

The real-time monitoring data (15-minute averages) will dictate specific work procedures and locations. The air monitoring devices to be used include:

- Photoionization Detector (PID) with a 10.6 millivolt lamp;

- MIE DATARAM 4000 to monitor particulate levels.

Levels	**Actions**
Total VOCs at downwind perimeter exceed background by 5 parts per million (ppm) (15-Min Average)	▪ Stop work activities & continue monitoring. ▪ Work activities can resume when levels reduce below 5 ppm.
Total VOCs at downwind perimeter exceed background levels between 5 ppm & 25 ppm (15-Min Average)	▪ Stop work activities & identify the source of the VOC exceedance & correct, continue monitoring. ▪ Continue work activities if VOCs 200 feet downwind of the site perimeter or ½ distance to the nearest structure is below 5 ppm (15-Min Average). Should not be less that 20-feet.
Total VOCs at the perimeter work area exceed 25 ppm (15-Min Average)	▪ Stop all work activities.

3.2 Particulate Monitoring

Real time particulate monitoring will be conducted by Synapse at the site perimeter. Particulate monitoring will be conducted utilizing a MIE DATARAM 4000 at a minimum frequency of once per hour consistent with TAGM 4031.

Levels	Actions
Particulate level at the downwind perimeter 0.1 milligrams per cubic meter (mg/m^3) greater than the up wind location (15 min period).	▪ Implement dust suppression measures.
Visible dust observed leaving the perimeter.	▪ Implement dust suppression measures.
After implementation of dust suppression measures, particulate levels at downwind perimeter greater than 150 mg/m^3 action level.	▪ Stop all work. ▪ Work activities can only resume if 150 mg/m^3 action level are below at the downwind location and no visible dust.

4 Documentation

The following data will be recorded and documented on a daily basis when the CAMP is implemented:

- Daily calibration logs to document that instruments are working within the limits per the manufacturer;
- Weather conditions including temperature, wind direction, wind speed, other atmospheric condition, date and time;
- Logs of VOCs on a 15-minute average;
- Logs of continuous Particulate monitoring; and

5 References

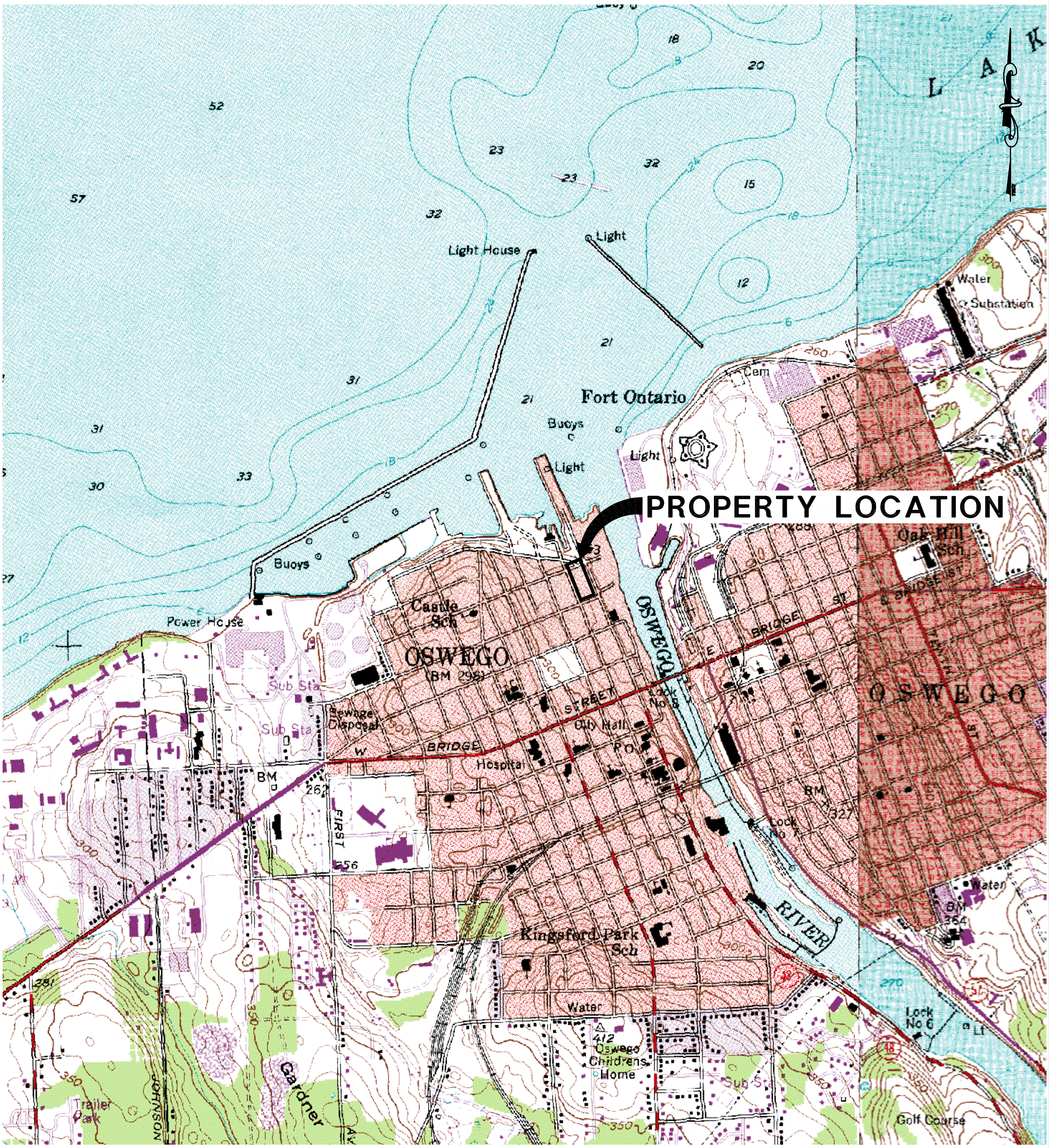
This CAMP complies with applicable Occupational Safety and Health Administration (OSHA) regulations, United States Environmental Protection Agency (USEPA) regulations, and Synapse Health and Safety policies and procedures. This plan follows the guidelines established in the following:

- NYSDEC DER-10.
- NYSDEC Technical and Administrative Guidance Memorandum (TAGM) MWR-89-4031 entitled “Fugitive Dust Suppression and Particulate Monitoring Program and Inactive Hazardous Waste Site,” dated October 27, 1989 (TAGM 4031).
- Standard Operating Safety Guides, EPA (Publication 9285.1-03, June 1992).
- Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH, OSHA, USCG, EPA (86-116, October 1985).
- Title 29 of the Code of Federal Regulations (CFR), Part 1910.120.
- Title 29 of the Code of Federal Regulations (CFR), Part 1926.
- Pocket Guide to Chemical Hazards, DHHS, PHS, CDC, NIOSH, (2010).
- Threshold Limit Values and Biological Exposure Indices, ACGIH, (2013)
  - Documentation of any exceedance and corrective response.

FIGURES

Community Air Monitoring Plan
Harbor View Square
68 West First Street
Oswego, New York

July 2018



SOURCE: USGS 7.5 MIN. TOPOGRAPHIC QUADRANGLES: OSWEGO WEST, N.Y., 1954, PHOTOREVISED 1978 AND OSWEGO EAST, N.Y., 1954, PHOTOREVISED 1978.

APPROXIMATE GRAPHIC SCALE:

0 2000' 4000'

P: EPA
5/18/17
SYNAPSE/WIP/HSGVIS 24-16/HSGVIS-2416-SL3.DWG

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SYNAPSE PROPERTY RESOURCES
360 ERIE BLVD. EAST
SYRACUSE, NEW YORK 13202

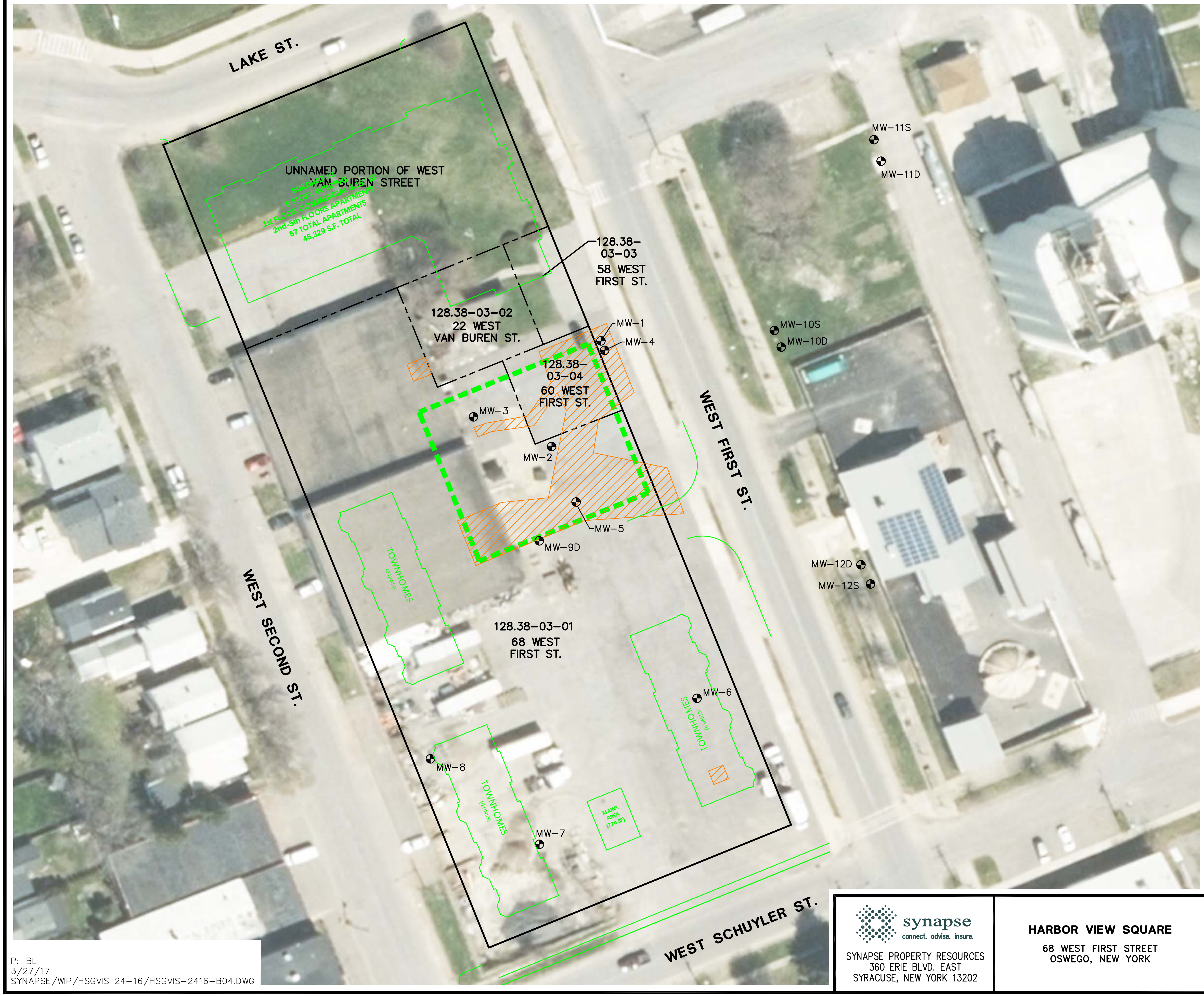
HARBOR VIEW SQUARE
NYSBCP SITE NO. C738040
68 WEST FIRST STREET
OSWEGO, NEW YORK

PROPERTY LOCATION PLAN

PROJECT NO.:
HSGVIS-24-16-05

DATE:
MAY 2017

FIGURE NO.:
1



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3/27/17
SYNAPSE/WIP/HSGVIS 24–16/HSGVIS–2416–B04.DWG

LEGEND

▬▬▬	APPROXIMATE BROWNFIELD CLEANUP PROGRAM SITE BOUNDARY
—-–-—	APPROXIMATE TAX PARCEL LINE
128.38–03–01	TAX PARCEL ID
🟩	PROPOSED INJECTION AREA (APPROXIMATE)
▨	PROPOSED EXCAVATION AREA (APPROXIMATE)
⊕ MW–1	EXISTING MONITORING WELL

NOTES:

1. 2015 AERIAL PHOTOGRAPH FROM NYSGIS CLEARINGHOUSE WEBSITE.
2. TAX PARCEL INFORMATION DIGITIZED FROM OSWEGO COUNTY, CITY OF OSWEGO TAX MAPS AND FROM TOPOGRAPHIC AND BOUNDARY SURVEY BY CREEKSIDE BOUNDARY, DATED 9/18/12.
3. ALL LOCATIONS ARE APPROXIMATE.

0 60' 120'

GRAPHIC SCALE

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HARBOR VIEW SQUARE

68 WEST FIRST STREET
OSWEGO, NEW YORK

AERIAL PROPERTY PLAN

PROJECT NO.:
HSGVIS–24–16–05

DATE:
MARCH 2016

FIGURE NO.:
F2