Proposed Remedial Action Plan for TCE in Groundwater

VCP-C049
Cottonwood Heights, Utah
Salt Lake County, Utah

Prepared for:
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(formerly Praxair Distribution, Inc.)
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Sign-off Sheet and Signatures of Environmental Professionals

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Abbreviations

BMPs	Best Management Practices
COC	Certificate of Completion
CoC	Chain-of-Custody
CSM	Conceptual Site Model
COPC	Constituent of Potential Concern
DQO	Data Quality Objective
DVT	Design Verification Testing
DO	Dissolved Oxygen
ft	Feet
LCS	Laboratory Control Sample
LGE	Linde Gas & Equipment Inc.
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
µg/m^3	Micrograms per cubic meter
µg/kg	Micrograms per kilogram (aka, parts per billion-ppb; soil)
µg/L	Micrograms per liter (aka, parts per billion-ppb; groundwater)
mg/kg	milligrams per kilogram (aka, parts per million-ppm)
ORP	Oxygen-Reducing Potential
PFM	Passive Flux Meter
PRB	Permeable Reactive Barrier
PCE	Tetrachloroethylene (aka, perchloroethylene or perc)
PVC	Polyvinyl Chloride
PDI	Praxair Distribution, Inc.
PARCC	Precision, Accuracy, Reproducibility, Comparability, and Completeness
PRAP	Proposed Remedial Action Plan
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
RL	Reporting Limit
RSL	Risk-Based Screening Level
SIM	Single Ion Monitoring
SMP	Site Management Plan
SOP	Standard Operating Procedure
SSDS	Subsurface Soil Gas Depressurization System
TCE	Trichloroethylene

Abbreviations (cont.)

UDEQ (UDAQ/UDERR)	Utah Department of Environmental Quality (Division of Air Quality/Division of Environmental Response and Remediation)
US EPA	United States Environmental Protection Agency
VISL	Vapor Intrusion Screening Level
VOC	Volatile Organic Compound
VCP	Voluntary Cleanup Program

1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

Stantec Consulting Services, Inc. (Stantec) has prepared this report to outline Linde Gas & Equipment Inc.'s (LGE, formerly Praxair Distribution, Inc. [PDI]) proposed remediation and remedial progress monitoring of dissolved trichloroethylene (TCE) in groundwater beneath, and in close proximity to, the LGE facility located at 6880 South 2300 East in Salt Lake City, Utah. As detailed in this Proposed Remedial Action Plan (PRAP), LGE and Stantec anticipate that the proposed remediation of TCE within groundwater will result in sequential reduction and then elimination of gaseous-phase TCE within subsurface soil gas that poses the potential for indoor intrusion into localized, above-grade structures.

This PRAP details remedial objectives, actions, and subsequent investigative strategies for monitoring of media including groundwater, indoor air, subsurface soil gas, and sub-slab soil gas associated with on- and off-site lands located west/northwest ((topographically and hydraulically downgradient) of the LGE property, in an effort to monitor progress and success of the remedial measures proposed herein. This report provides a summary of historical monitoring and mitigation activities at the site and outlines proposed actions to remediate localized groundwater, monitor site conditions, continue to protect human health and the environment, and pursue formal site closure by the Utah Department of Environmental Quality, Voluntary Cleanup Program (UDEQ, VCP).

1.2 SUMMARY SITE HISTORY

As detailed in past Stantec reports submitted to the UDEQ, historical subsurface investigations indicated that the source of dissolved TCE was the release of TCE solvent constituents atop the facility's outside, asphalt-paved surface before migrating into the facility's stormwater management system by predecessor land owner Whitmore Oxygen Company, who owned and operated a gas manufacturing business at 6880 South 2300 East prior to LGE's purchase of the plant in 1998. Reportedly, TCE was used by Whitmore Oxygen to clean metal parts including compressed gas cylinders. Investigative data to date does not indicate any ongoing source of TCE to the subsurface environment currently or since LGE's acquisition of the plant.

During initial subsurface investigations conducted at the plant site in 2004 through 2007, a total of 36 soil test borings were drilled at the facility with soil samples collected continuously to borehole completion depths approximating the water table depth of 15 feet below grade. Except for the first three borings in 2004, where only one soil sample from each boring was analyzed, at least two soil samples per boring were submitted to a Utah-certified laboratory for analysis of Volatile Organic Compounds (VOCs) including TCE by United States Environmental Protection Agency (US EPA) Method 8260. The highest TCE concentration in soil was 0.044 milligrams per kilogram (mg/kg; aka, parts per million-ppm). All TCE concentrations in soil were well below the US EPA and UDEQ Risk-Based Screening Level (RSL) for TCE in soil (the most recent May 2023 RSLs for TCE in soil are as follows: Industrial: 6 ppm and Residential: 0.94 ppm).

As reported with the work at that time, a few soil samples contained quantified concentrations of other VOCs, including tetrachloroethylene (PCE) and/or one or more petroleum hydrocarbon constituents, at concentrations in the microgram per kilogram range (µg/kg; aka, parts per billion-ppb), which were all well below corollary RSL concentrations in the ppm range deemed protective of residential land use. On occasion, petroleum hydrocarbon and trihalomethane constituents, at concentrations well below corollary UDEQ groundwater protection standard concentrations, were detected in groundwater samples collected from soil test borings or monitoring wells. Numerous off-site, potential sources of petroleum hydrocarbon and trihalomethane constituents are located in hydraulically-upgradient (southeast/east) directions in relation to the LGE property and the downgradient, residential neighborhood.

All data to date indicate that TCE is the primary constituent of potential concern (COPC) at the site. Historically, TCE was detected in groundwater monitoring wells MW-2 and MW-3 located at the LGE property and in monitoring well MW-6 which is located in a hydraulically-downgradient direction (northwest/west) in relation to the LGE property. Since groundwater monitoring began in 2005, TCE concentrations have decreased significantly. They are below the UDEQ Ground Water Quality Protection and Maximum Contaminant Level (MCL) Standard for TCE of 5 ppb. Reference Figure 1 for the locations of the LGE property, nine original groundwater monitoring wells, and the two residences that are discussed in detail in this report.

Stantec collects groundwater samples on a semi-annual (approximately every six months) basis to monitor ongoing, natural attenuation of TCE. Natural attenuation processes in groundwater, such as biological degradation, adsorption, dispersion, and dilution, have reduced TCE in groundwater to recent concentrations approximating 1 to 3 micrograms per liter (µg/L; aka, parts per billion-ppb). The US EPA Vapor Intrusion Screening Level (VISL) "target groundwater concentration" for TCE in groundwater that might pose potential risk for possible vapor intrusion into overlying buildings is 1.19 ppb.

Subsurface soil gas investigations throughout the neighborhood west of the LGE property indicated that localized subsurface soil gas in the vicinity of the two residences identified on Figure 1 contained low concentrations of gaseous-phase TCE. In December 2012, on behalf of LGE, Stantec oversaw the installation of a dedicated, subsurface soil gas depressurization system (SSDS) at each of the two residences. Each SSDS system is comprised of a 1-hp vacuum blower unit interconnected to solid polyvinyl chloride (PVC) piping that extracts subsurface soil gas from immediately beneath each residence's basement concrete-slab floor. The soil gas is vacuum-extracted from the subsurface and discharged to the natural atmosphere atop each residence's rooftop by means of solid PVC piping, in accordance with measures and emission standards approved by the UDEQ, Division of Air Quality (UDAQ).

Every six months, Stantec collects SSDS off-gas emission samples for laboratory analysis for VOCs and submits off-gas emission summary reports to the UDAQ. All SSDS off-gas emissions have been and remain currently in compliance with UDAQ regulations. Likewise, at a minimum of every six months, Stantec also collects indoor air samples for TCE laboratory analysis from the basement

of each residence and submits the results to the UDEQ and each of the two Residence A and Residence B owners.

Stantec's Conceptual Site Model (CSM) indicates that the source of gaseous-phase TCE in subsurface soil gas is attributable to off-gassing of TCE from groundwater (the saturated, phreatic zone) to overlying subsurface soil gas within the unsaturated, vadose zone. In an effort to remediate TCE in groundwater, which in turn is expected to reduce the mass of gaseous-phase TCE in subsurface soils beneath and in close proximity to the two residences, LGE intends to implement a localized groundwater remediation program, the details of which are presented in this report.

The following section *4.0 Conceptual Site Model,* discusses Stantec's preliminary CSM, including existing and anticipated future land use and potential human health exposure scenarios. It is based on the data and reports submitted previously to UDEQ. A schematic diagram of the preliminary CSM is presented as Appendix A herein.

1.3 GENERALIZED REMEDIAL PLAN

As discussed in detail in following section 6.3, LGE proposes to inject Regenesis' proprietary permeable reactive barriers (PRBs) including PlumeStop® Liquid Activated Carbon™ (collectively, "PlumeStop") into TCE-impacted groundwater located beneath western-most portions of the LGE property as well as within the eastern backyard of the Residence B property. The injected carbon product is intended to capture TCE within the aquifer for supplemental natural reduction in TCE concentrations in groundwater located downgradient of the carbon injection-points. In turn, it is anticipated that the reduction in TCE concentrations in groundwater will result in a reduction of gaseous-phase TCE in the vadose zone, thereby reducing or eliminating the potential for intrusion of gaseous-phase TCE into subsurface soil gas and overlying buildings.

The remedial program is designed to pressure-inject activated carbon into the upper 10 feet of the aquifer beneath each of the two properties, the depth range within the aquifer quantified to contain the greatest TCE mass and highest TCE concentrations. Carbon product injection depths (approximately 9 to 19 feet beneath the residence property and 14 to 24 feet below the LGE property) will vary between the two properties, depending on the subsurface depth to the area-specific water table.

There will be numerous PlumeStop carbon injection points at the LGE property and immediately east of Residence B. As groundwater flows/attenuates naturally through the PRB treatment/injection areas, it is anticipated that the injected carbon will intercept and capture TCE in groundwater, thereby reducing the total mass of TCE attenuating farther downgradient (toward the northwest/west) from the PRB injection areas.

Preliminary Regenesis estimations based on site-specific, hydrogeologic data observed to date, in conjunction with Stantec's evaluation of Regenesis-estimated, groundwater linear flow velocity values at different locations in the aquifer beneath the LGE and nearby neighborhood

properties, indicate that it could require two to four years for TCE concentrations in groundwater located in the vicinity of Residence B to decrease to concentrations below the US EPA VISL for TCE of 1.19 ppb in groundwater, the risk-based TCE concentration that might pose potential risk for vapor intrusion. Regenesis expects that the in-situ carbon within the PRB injection areas will continue to intercept TCE in groundwater for a few years following initial injection into the subsurface.

Details of the Stantec/Regenesis proposed approach for injecting Regenesis' PlumeStop product into the aquifer beneath localized areas of the LGE and Residence B properties are set forth in this report, including measures for monitoring the progress of remedial impact to the aquifer and subsurface soil gas located near and downgradient of PlumeStop injection areas.

Operation of the SSDS mitigation systems at both Residences A and B will continue until monitoring data indicate that the SSDS systems are no longer needed, as deemed acceptable to the UDEQ. This report proposes sequential investigative actions for monitoring of ground water quality, indoor air quality, and SSDS off-gas emissions. The ground water and air quality laboratory results will be submitted to the UDEQ on schedules proposed in this report and will be used to help monitor for protection to human health and the environment as well as determine when the site has satisfied UDEQ requisites for issuance of a Certificate of Completion (COC).

2.0 BACKGROUND SITE CHARACTERIZATION

2.1 HISTORICAL SOIL, SUBSURFACE SOIL GAS, AND GROUNDWATER QUALITY RESULTS

Subsurface investigations conducted from 2004 to 2007 by Stantec (formerly JBR Environmental Consultants, Inc.) indicated that the source of TCE to the subsurface environment is attributable to historical release of TCE solvent constituents into the VCP site's stormwater management system by predecessor land owner Whitmore Oxygen Company, who owned and operated the facility before LGE. Investigative data to date do not indicate an ongoing source of TCE to the natural environment.

There have been no known or reported releases of TCE constituents from facility operations since LGE's purchase of the property in 1998. Additionally, as detailed in preceding section 2.0, 2004 through 2007 investigations indicated that subsurface soils beneath the site did not contain any VOCs including TCE at concentrations that might pose potential risk to human health or potential leaching to the underlying aquifer at the facility site. TCE concentrations in vadose zone soils were on the order of ppb, well below the US EPA RSLs for TCE in soil deemed protective of human health and the environment (i.e., the soil RSL concentrations for TCE are currently - Industrial: 6 ppm and Residential: 0.94 ppm).

Groundwater monitoring began in 2005, and TCE was detected in one or more on- and/or off-site groundwater monitoring wells during monitoring events that followed. Since then, TCE concentrations have been decreasing, and since October 2014 have been below the UDEQ Ground Water Quality Protection and MCL Standard for TCE of 5 ppb. However, TCE concentrations appear now to have reached asymptotic levels, whereby they remain generally between non-detection (1 ppb) and below 3 ppb, and have been relatively consistent since 2014. Historical groundwater quality data indicated a localized area of TCE-impacted groundwater that extended generally between LGE property monitoring well MW-2 and off-site, neighborhood monitoring well MW-6 (see Figures 1 and 2).

In the neighborhood west of the LGE property, numerous sub-slab soil gas and/or indoor air samples were collected from nearby residences. None of these air samples contained TCE at a concentration greater than the respective US EPA/UDEQ TCE VISL concentration deemed protective of indoor air quality (0.478 micrograms per cubic meter, µg/m^3) or sub-slab soil gas (15.9 µg/m^3) – *except for* two residences located immediately west of the LGE property. Air samples were analyzed by the laboratory utilizing Reporting Limits that were less than the respective indoor air or sub-slab soil gas VISL for TCE.

In an effort to intercept subsurface soil gas that might contain gaseous-phase TCE from entering the two local residences, Stantec oversaw the December 2012 installation of a dedicated SSDS at each of two residences, namely Residence A located at 2196 Pink Coral Circle and Residence B located at 2202 Pink Coral Circle (reference Figure 1). The installations were detailed in LGE's Residence A and Residence B *Mitigation System Installation and Monitoring*

Summary Reports which were submitted to the UDEQ during March 2015. The two separate SSDS systems are mitigating the potential for indoor intrusion of gaseous-phase TCE into the two respective residences. Indoor air quality and SSDS off-gas emissions associated with both residences have been sampled by Stantec on at least a semi-annual (approximately every six months) basis since SSDS installation.

Laboratory analysis of SSDS off-gas emissions can be used to help estimate TCE concentrations in subsurface soil gas located beneath the homes. Since starting in December 2012, semi-annual SSDS off-gas emission sampling and laboratory analysis for VOCs including TCE by Method TO-15 (Single Ion Monitoring/SIM) indicates that TCE concentrations in both SSDS off-gas emissions have declined steadily over time.

The last time TCE was detected above a laboratory Reporting Limit of 0.27 µg/m^3 in Residence B SSDS off-gas emissions was at 3.1 µg/m^3 during the October 2021 sampling event; i.e., TCE was not detected by the laboratory during the March 2022, October 2022, and April 2023 sampling events. TCE was detected in Residence A SSDS off-gas emissions at 6.8 µg/m^3 during both the October 2022 and April 2023 sampling events. The US EPA residential sub-slab soil gas VISL for TCE that is deemed protective against potential vapor intrusion into a residential building is 15.9 µg/m^3. The laboratory's Reporting Limit of 0.27 µg/m^3 is below the US EPA residential sub-slab soil gas VISL for TCE.

Semi-annual, indoor air sampling started within both residences in December 2012. TCE was never quantified by laboratory analysis in indoor air samples collected within the Residence A basement, except for the January 2013 sampling event (TCE: 0.24 µg/m^3, which exceeded the laboratory Reporting Limit of 0.16 µg/m^3 and was less than the subsequent US EPA VISL of 0.478 µg/m^3). The VISL represents a TCE concentration that is used as a preliminary screening level indicating the potential for possible risk to indoor air quality.

TCE was quantified in Residence B indoor air during 2012 and 2013 sampling events; however, during the March 2014 through October 2020 semi-annual sampling events, TCE was not quantified above the laboratory Reporting Limit of 0.27 µg/m^3. As of April 2021 however, there have been TCE indoor air sample results in Residence B that exceed the TCE VISL.

In October 2021, Stantec observed the drilling, installation, and groundwater sampling of several additional soil test borings at the LGE property and within the yard of Residence B, some of which were converted to groundwater monitoring wells HP-1, HP-2, HP-3, HP-5, HP-8, and HP-9 (reference Figure 2). Table 1 presents summary well construction details, while Table 2 provides a summary of historical ground water quality monitoring data, generated at the site since monitoring began in 2005 and including the most recent sampling event of April 2023.

Historical sampling data to date indicate that TCE in soil gas and groundwater appears limited to localized areas near Residence B and the western-most portion of the LGE property, generally located between groundwater monitoring wells MW-2 and MW-6. It is Stantec's belief that TCE in groundwater beneath, and/or in close proximity to, Residence B is volatilizing into the gaseous-

phase within localized, vadose zone, subsurface soils that overlie TCE-impacted groundwater. Stantec believes that reducing TCE concentrations/mass in localized groundwater should result in a corollary reduction in gaseous-phase TCE concentrations/mass in overlying vadose zone soils, which in turn should also decrease risk for possible gaseous-phase TCE intrusion into overlying structures/buildings.

Field parameter monitoring data measured historically indicates that the dissolved oxygen (DO) content of ground water beneath the area of investigation is relatively high. The oxygen-reduction potential (ORP) data are relatively high in value, as well. The DO and ORP data indicate that the uppermost aquifer beneath the area of investigation is oxygen-enriched, and this has been consistent since monitoring began in 2005.

The fact that residual TCE in groundwater at the site is not degrading into reductive de-chlorination by-products (such as dichloroethane-DCA, dichloroethene-DCE, vinyl chloride, etc.), by means of anaerobic (oxygen-deficient) characteristics, in conjunction with the relatively high DO and ORP characteristics of groundwater, indicate that TCE concentrations in groundwater are declining predominantly by aerobic natural attenuation processes. Stantec's experience investigating similar conditions (chlorinated aliphatic hydrocarbons within oxygen-enriched aquifers) at other sites located in the Salt Lake Valley indicate that, as long as the aquifer remains oxygen-enriched, TCE concentrations in ground water should continue to decline without degrading into reductive de-chlorination by-products in the aqueous phase.

Chloroform, bromodichloromethane, and other similar trihalomethane constituents are believed to be associated with either laboratory interference (potable water used for cleaning equipment, etc.) or more probably (and as has been identified by Stantec and the UDEQ during groundwater investigations elsewhere in the Salt Lake Valley) use of potable water for private and public irrigation purposes and/or water leaks associated with subsurface municipal water supply and/or sanitary sewer distribution piping. When oxygen-enriched, potable water is released to the subsurface, the released water can impact natural groundwater quality resulting in an increase in DO and trihalomethane constituents.

3.0 SUMMARY TCE-IMPACTED GROUNDWATER AND HYDROGEOLOGIC CHARACTERISTICS

3.1 VADOSE (UNSATURATED) ZONE AND PHREATIC (SATURATED) ZONE HYDROGEOLOGIC CHARACTERISTICS

Stantec's review of drilling logs associated with historical soil test boings and groundwater monitoring wells, including hydrogeologic and water level data observed during the most recent subsurface investigation documented within Stantec/LGE's *October 2021 Groundwater Monitoring Summary Report*, indicate the following:

- The upper 10 feet or so of subsurface soils beneath the LGE property and neighborhood lands to the west are characterized predominantly by unsaturated, medium- to coarse-grained sand and gravels.

- Subsurface soils located generally between 10 to 29.5 feet below grade, typically the deepest depth to which soil test borings and wells were completed, are characterized predominantly by similar sand to gravel soils with varying degrees of silt- and/or clay-rich matrix and/or thin, interspersed clay layers.

- As of the October 2022 water level measurement data, as measured in wells across the LGE site, the depth to the static water table approximated 12.5 to 14 feet below grade beneath the western-most portion of the LGE property (i.e., vicinity of wells MW-2 and MW-3) and nine to 11 feet (9- to 11-ft.) at neighborhood monitoring wells HP-5, HP-8, HP-9, MW-6, and MW-7. Historical water levels in wells have remained relatively consistent since monitoring began in 2009.

Stantec's review of historical water quality data at the site, as presented on Table 2 herein, indicates that the greatest mass of TCE in groundwater appears to be located predominantly between LGE monitoring wells MW-2 and HP-3 and neighborhood monitoring well MW-6. TCE was quantified within intermediary-located, monitoring wells HP-5 and HP-9 during the October 2022 sampling event (with "J-estimated" TCE concentrations in soil test borings HP-4, HP-6, HP-7, and HP-10, each of which was only sampled during October 2021, prior to abandonment).

Groundwater potentiometric contours, flow patterns, and hydraulic gradients have been consistent over time. Groundwater flow is generally from the southeast/east toward the northwest/west.

3.2 ENVIROFLUX AQUIFER VELOCITY AND TCE FLUX ESTIMATIONS

During September 2022, Stantec collected groundwater samples from monitoring wells MW-2 and HP-5, utilizing specialized sampling equipment produced by EnviroFlux of Gainesville, Florida. Two 10-ft. long Passive Flux Meters™ (PFMs) were installed within each groundwater monitoring well, at a depth interval approximating the upper 10 feet of the static water column in each well, and then left in the wells for approximately 25 days. Each 10-ft. long PFM was comprised of two interconnected, 5-ft. long sampling sleeves.

The PFM within well HP-5 was positioned such that it monitored groundwater between the generalized water column depth interval of 5 to 15 feet below the top of well casing. The PFM within well MW-2 was positioned such that it monitored groundwater between the generalized water column depth interval of 14.5 to 24.5 feet below the top of the well casing. Both wellheads are located only a couple to a few inches below natural grade. Well HP-5 was completed to 15 feet below grade, while well MW-2 was completed to 24.5 feet below grade. After a 25-day timeframe, the two PFMs were extracted from each monitoring well and shipped via overnight delivery to EnviroFlux for estimation of aquifer velocity and TCE mass flux throughout the vertical, saturated water column within each well MW-2 and HP-5. The conservative, 25-day sampling timeframe is deemed more than adequate for purposes of investigating water quality at the two groundwater monitoring wells.

As downloaded from EnviroFlux' public website:

> "*A PFM is a nylon mesh tube filled with a sorbent/tracer mixture. The PFMs are inserted into groundwater monitoring wells where they passively intercept groundwater flow. Inside the PFM is a permeable sorbent that retains dissolved contaminants present in the groundwater. The PFM can be used for a broad range of contaminants (hydrophobic organic compounds, organic or inorganic ions, etc.) by selecting appropriate sorbents. The sorbent mixture is preloaded with specified amounts of resident tracers. The tracers are leached from the sorbent as groundwater flows through the PFM. For common organic contaminants such as chlorinated solvents (TCE, PCE, etc.), activated carbon is used as the sorbent and a suite of different alcohols are used for the tracers.*
>
> *After a specified period of exposure to groundwater flow (usually one to four weeks), the PFM is removed from the well or boring. The sorbent is then extracted to quantify the mass of all contaminants intercepted by the PFM and the residual masses of all resident tracers. The contaminant masses are used to calculate time-averaged contaminant fluxes, while residual resident tracer masses are used to calculate cumulative groundwater flux. Depth variations of both water and contaminant mass fluxes are measured by a single PFM by vertically segmenting the exposed sorbent mixture and analyzing for resident tracers and contaminants. Thus, at any specific well depth, an extraction from the locally exposed sorbent yields the mass of resident tracer remaining and the mass of contaminant intercepted. In other words the PFM device provides a vertical profile of horizontal fluxes*."

As summarized in more detail within Regenesis' November 2022 *Proposal for TCE Groundwater Treatment at the LGE Property*, a copy of which is presented as Appendix B herein, EnviroFlux estimated the following data (excerpted from Regenesis' proposal: page 7, Design Verification Testing (DVT):

Table2. Summary of flux average contaminant concentration

Well_ID	Sample_ID	Depth below top of well casing (ft)	Darcy Velocity (cm/day)	TCE (ug/L)*
HP-5	HP5-5.0-6.8	5.9	0.0	0.0
	HP5-6.8-8.4	7.6	0.0	0.0
	HP5-8.4-10	9.2	0.8	0.0
	HP5-10-11.6	10.8	0.2	1.3
	HP5-11.6-13.3	12.5	2.2	4.1
	HP5-13.3-15	14.2	2.5	7.9
MW-2	MW2-14.7-16.2	15.5	1.3	1.0
	MW2-16.2-17.8	17.0	2.3	1.4
	MW2-17.8-19.5	18.7	3.9	4.4
	MW2-19.5-21.2	20.4	1.8	10.4
	MW2-21.2-22.8	22.0	1.4	0.4
	MW2-22.8-24.5	23.7	0.8	1.1

***** Stantec's Footnote to above Regenesis Table 2: µg/L: micrograms per liter; i.e., parts per billion-ppb.

As communicated to Stantec by EnviroFlux:

> "*Flux refers to the mass of water and contaminants flowing per unit area at a measured point in a well screen, averaged over a 25 day timeframe. The ambient groundwater flux values are shown in terms of Darcy velocity (centimeters per day; i.e., cm/day), which is the volumetric water flux through a specified cross-sectional area. The contaminant flux values were determined as (Flux=mass/unit area/time) and represented with the units of milligrams per square-meter per day (mg/m^2/day). The flux average concentration values were calculated based on the measured contaminant and Darcy fluxes. The contaminant mass flux values measured at the local scale (approximately 5-ft vertical intervals) were integrated over the vertical profile and represented in terms of mass discharge per unit width of aquifer (mg/m/day). The results can in turn be used to estimate the mass discharge (mg/day) through a specified aquifer width.*"

In summary, EnviroFlux estimated that the greatest mass of TCE within well HP-5 was located within an approximate interval of 11.5 to 15 feet below top of well casing, while the greatest mass of TCE in well MW-2 was estimated to be within an approximate interval of 17.5 to 21 feet below top of well casing. Although none of the "HP" wells, including well HP-5, was ever surveyed in relation to mean sea level or the "MW" monitoring wells, Stantec estimates that the MW-2 wellhead is approximately 5- to 6-ft. higher in elevation than the HP-5 well casing – as estimated by review of Google Earth-reported ground surface elevations near each well.

4.0 CONCEPTUAL SITE MODEL

4.1 POTENTIAL ENVIRONMENTAL RISK ASSOCIATED WITH CURRENT AND ANTICIPATED FUTURE LAND USE

Potential risk to human health and the environment is contingent upon numerous factors, including but not limited to: presence and toxicity of contamination; potential receptors; potential exposure pathways; exposure duration; etc. Exposure pathways may be complete or incomplete, depending on whether there is actual contact between a human and/or ecological receptor and contaminated media, such as soil, groundwater, and/or soil gas.

A 'completed pathway' is an exposure scenario whereby a potential receptor is exposed to a confirmed contaminant source through a confirmed migration pathway. An 'incomplete pathway' is missing one of these components (i.e., no receptor, no contaminant, or no exposure route). Unacceptable risks and complete pathways may be remediated, and/or controlled by means of Engineered and/or Institutional Controls.

The following sub-section outlines existing and anticipated future land use and potential human health exposure scenarios, including Stantec's preliminary CSM. The preliminary CSM presents anticipated, relational interactions between potential contaminant sources, exposure pathways, and receptors – based on current/existing and future-projected, site conditions. Remedial and subsequent investigative actions proposed in this report are anticipated to provide qualitative and quantitative analytical data pertinent to evaluation and refinement of this preliminary CSM.

4.2 CONCEPTUAL SITE MODEL SUMMARY

The source of TCE to the environment was an undocumented release of TCE atop the ground surface from historical (before 1998) operations before LGE acquired the property, which in turn impacted groundwater quality. As detailed in preceding section 2.0, there is no known current or recent, aboveground source of contaminant constituents including TCE to the subsurface environment at the VCP site.

Historical (2004 through 2007) investigations indicated that subsurface soils beneath the LGE property did not contain any VOC including TCE, at a concentration that might pose potential risk to human health or potential leaching to the underlying aquifer at the site. TCE concentrations in vadose zone soils were on the order of ppb, well below the US EPA RSLs for TCE in soil deemed protective of human health and the environment (i.e., the soil RSL concentrations for TCE are currently - Industrial: 6 ppm and Residential: 0.94 ppm). Accordingly, soil does not appear to represent a potential source of TCE release to the environment, including potential leaching to the underlying water table and groundwater.

TCE is the only contaminant of potential concern that has been detected in groundwater – but at concentrations well below UDEQ's Groundwater Protection and MCL Standard. Groundwater within the uppermost aquifer beneath the neighborhood and surrounding Cottonwood Heights,

Utah vicinity is not being used as a potable water source, nor for irrigation, currently and for the foreseeable future. The depth to groundwater impacted by TCE is well below the anticipated depth range (typically, 0 to 6 feet below grade) at which subsurface utilities exist currently and might be installed in the near-future. Thus, it is anticipated that there is little to no risk associated with human dermal and ingestion contact with/exposure to TCE-impacted groundwater.

TCE-impacted groundwater appears localized in lateral extent and limited to areas located beneath the western-most portion of the LGE property and localized portions of the Residence A and B properties, as downgradient monitoring wells MW-7, MW-8, MW-9, and numerous other historical groundwater monitoring borings did not contain TCE in groundwater at concentrations above Reporting Limits/RLs and/or Method Detection Limits/MDLs well below 1 ppb. Stantec's review of the location of the TCE-impacted groundwater in relation to closest, potential groundwater sinks (e.g., possible groundwater discharge points to a body of surface water) indicates that the TCE-impacted groundwater poses little to no risk for such discharge. The closest apparent groundwater sink is Little Cottonwood Creek, which is located a few miles northwest/downgradient of the area.

Groundwater beneath the western-most portion of the LGE property, as well as localized groundwater near Residence B, contains currently, and/or recently (2022), TCE at concentrations between 1 to 2 ppb. Such TCE concentrations in groundwater pose potential for off-gassing into overlying unsaturated, vadose zone soil of gaseous-phase TCE concentrations that might pose unacceptable risk to residential indoor air (i.e., TCE concentrations in groundwater exceed the US EPA "target groundwater concentration" VISL of 1.19 ppb deemed protective against potential vapor intrusion into abovegrade buildings, etc.).

On occasion, TCE has been detected in indoor air within the basement of Residence B and within sub-slab soil gas located beneath Residence A and Residence B. As discussed in detail in preceding report section 2.1, Stantec believes that the gaseous-phase TCE is attributable to TCE mass flux from groundwater, whereby TCE transitions from groundwater into the gaseous state at/above the water table and then migrates into overlying, unsaturated soils comprising the vadose zone.

Appendix A herein is a graphical representation of Stantec's preliminary CSM. The CSM identifies potential hypothetical, exposure scenarios, including current use of the LGE and Residence A and B properties.

As the preliminary CSM indicates, there do not appear to be any significant risk concerns based on current land use – *except for* potential gaseous-phase TCE intrusion into the basements of the Residences A and B and possibly localized, subsurface utility corridors that enter the two residences. As detailed in section 2.1, routine semi-annual sampling of indoor air inside Residence A for the past decade has not detected gaseous-phase TCE within indoor air samples when the SSDS is operating. The SSDS in Residence A will continue to be operated for the foreseeable future.

Residence B is currently vacant, is secured and maintained by a property manager, and will remain vacated until the indoor air quality is deemed satisfactory. The SSDS at Residence B will also continue operating for the foreseeable future.

There is an approximate 25-feet wide, asphalt-paved driveway owned by a 'self-storage' business (STOR-N-LOCK PARTNERS) that is located between the LGE plant property and Residence B. The driveway provides access between a locked, gated entrance at Whitmore Way (to the south) and the self-storage units (non-habitable structures) that are located north/ northwest of the LGE property. There are no below-grade or abovegrade buildings or structures located within this driveway area, except for a buried stormwater line that is located reportedly along a north-south alignment beneath the middle of the asphalt driveway. The driveway and stormwater manways are visible on Figure 2.

Possible future land redevelopment and/or subsurface utility work/maintenance *may* pose potential risk concerns under certain future-potential, area-specific, land use scenarios – specifically areas of the subsurface located between the western-most portion of the industrial LGE property and the two residences. Neither Stantec nor LGE is aware of or have reason to anticipate significant planned land redevelopment activities at or around the LGE property or remediation area. In the event of future subsurface utility work, which is not anticipated, intermixing of subsurface soil gas and clean ambient atmospheric air and the relatively short duration for such hypothetical exposure would mitigate potential risk.

4.2.1 Site Security Concerns

The perimeter of the LGE plant property is enclosed by a six feet (6-ft.) high, chain-link security fence, with one locked, gated entrance. It is controlled by on-site personnel who manage site access. The neighboring storage facility is similarly enclosed with gated access. Residence B is not occupied, and is secured and maintained by a property manager. These security measures prevent unauthorized entrance and ensure access for any work/maintenance activities is properly obtained. Residence A is occupied and indoor air quality is measured regularly.

5.0 REMEDIAL OBJECTIVES AND VCP SITE CLEANUP LEVELS

Current human health and environmental exposure risk is associated with gaseous-phase TCE in subsurface soil gas located above/near TCE-impacted groundwater. The health concern is for potential gaseous-phase TCE intrusion into Residences A and B and possibly localized, subsurface utility corridors that enter the homes. Remedial actions proposed herein are anticipated to address these current potential exposure scenarios, as well as also address potential future risk scenarios associated with potential construction and/or maintenance of new abovegrade and/or underground structures/buildings/utilities located at and/or between the western-most portion of the LGE property and Residences A and B.

The current, primary remedial objective is to eliminate the potential for TCE concentrations within indoor air at Residences A and B that exceed the US EPA VISL deemed protective of indoor residential air quality (0.478 µg/m^3). Future sampling of indoor air at both residences will be a direct means for monitoring progress toward achieving this objective.

It is anticipated that injection of Regenesis' PlumeStop carbon product, as proposed in this report, will reduce and/or eliminate TCE concentrations in localized groundwater, which in turn will then reduce and/or eliminate TCE concentrations in localized, subsurface soil gas. PlumeStop injections will help reduce TCE concentrations in groundwater located in areas downgradient of proposed injection-points to below at least 1.19 ppb (US EPA's target groundwater concentration deemed protective of vapor intrusion) and/or eliminate TCE in groundwater.

The proposed remedy is intended to eliminate the potential for gaseous-phase TCE intrusion into Residences A and B. Future sampling of groundwater at the site, after injecting the PlumeStop product, in conjunction with subsequent monitoring of indoor air quality at the two residences, will monitor progress toward achieving these remedial objectives.

Section *9.0 Contingency Plan* addresses the possibility that other remedial options may be necessary, as well as other contingencies and/or proposed plans of action in the event that site-specific conditions change from those anticipated at the time of preparation of this report and/or remedial objectives outlined herein are not achieved in a timeframe deemed acceptable to LGE and the UDEQ.

6.0 PROPOSED TCE GROUNDWATER TREATMENT PROGRAM

6.1 EVALUATION OF ALTERNATIVE REMEDIAL OPTIONS FOR TCE IN GROUNDWATER

Based on local aquifer characteristics observed to date, specifically including TCE concentrations that appear to have reached asymptotic concentrations (i.e., 1 to 3 ppb since 2014) that remain above the US EPA VISL target groundwater concentration for TCE (1.19 ppb) in groundwater which might pose potential risk for gaseous-phase TCE intrusion into overlying buildings, LGE requested that Stantec evaluate possible alternative, remedial options for enhancing the rate at which TCE concentrations in groundwater might be reduced. It is expected that as TCE concentrations/mass in groundwater decline, so too will TCE concentrations in overlying/nearby subsurface soil gas decline. As the total mass of TCE declines in the subsurface environment, it is anticipated that the potential for possible gaseous-phase TCE migration into Residences A and B should also decrease.

Various remedial options were evaluated by Stantec, including pump and treat, air sparging, injection of microbes designed to induce TCE reductive dechlorination in groundwater, ongoing natural attenuation, and injection of Regenesis' proprietary carbon product Plumestop. Regenesis' PlumeStop product has been used successfully at numerous other sites throughout the United States to reduce TCE and other similar contaminant constituent concentrations in groundwater. Likewise, carbon is used worldwide to capture contaminant constituents from water.

Upon analysis of the EnviroFlux results, as well as site-specific drilling logs, monitoring well construction details, historical water level data, TCE and VOC analytical results, and other pertinent hydrogeologic information shared by Stantec, Regenesis proposed a remedial approach to utilize its PlumeStop carbon product to help remediate TCE in groundwater at the site. Regenesis summarized site-specific data, assumptions, and a proposed remedial approach within their November 2022 *Proposal for TCE Groundwater Treatment at the LGE Property*, a copy of which is presented as Appendix B herein.

Stantec's analysis of alternative remedial options and corollary timeframes for reducing TCE concentrations in groundwater indicates that a practicable, timely, and cost-effective remedial option is injection of Regenesis' Plumestop product into the aquifer beneath western portions of the LGE property and within the eastern backyard of Residence B located immediately west and hydraulically-downgradient of the LGE property. The following section presents a summary of Regenesis' proprietary PlumeStop carbon product specifications, proposed injection plan, and subsequent proposed environment monitoring plan designed to monitor the progress and success of the proposed remedial actions.

6.2 REGENESIS' PLUMESTOP™ CARBON INJECTION PRODUCT

PlumeStop Liquid Activated Carbon™ is composed of very fine particles of activated carbon suspended in water through the use of a unique organic polymer dispersion chemistry. Activated carbon is used universally to treat water sources for potable usage, effectively removing a large variety of contaminant constituents, including TCE and other chlorinated aliphatic hydrocarbon and volatile constituents. The sorptive capacity of activated carbon is significantly more than that which typifies natural soil organic carbon, and the liquid activated carbon of PlumeStop permits easy injection/application into subsurface environments.

Once in the subsurface, the material behaves as a colloidal biomatrix, adsorbing to the aquifer matrix, rapidly removing contaminants from groundwater, while still permitting contaminant biodegradation. PlumeStop can be installed in the subsurface through dispersive flow via low-pressure injection (without fracturing the formation), providing a thin-film coating over a wide area of the aquifer matrix. It does not create preferential flow pathways, plug the natural formation, or compromise monitoring wells through extreme carbon loading.

The colloidal activated carbon particles are dispersed from a series of injection points into the natural aquifer, at which point the carbon binds to the saturated soil matrix to create a permeable reactive zone/PRB with an extensive sorption capacity. Contaminants such as TCE in groundwater passively flow through the PlumeStop reactive zone, where they are adsorbed out of the groundwater, preventing further downgradient migration. Contaminant advection in the aqueous phase is thereby reduced and/or eliminated and contaminant gaseous-phase partitioning into the overlying/nearby, vadose zone is also reduced and/or eliminated.

Regenesis estimates that TCE concentrations in groundwater can be reduced to 0.5 ppb or less in and between groundwater monitoring wells MW-2, MW-6, HP-1, HP-2, HP-3, HP-5, HP-8, and HP-9 within an approximate timeframe of as little as 2.5 years following PlumeStop injections. Stantec's analysis of Regenesis-estimate groundwater flow velocity values indicates that it could possibly require 2.5 to four years for TCE concentrations in groundwater beneath the basement footprint of Residence B and groundwater in downgradient monitoring well MW-6 to decrease below 0.5 ppb.

Stantec anticipates that such projected decreases in TCE concentrations in groundwater beneath and upgradient of Residences A and B should also reduce TCE mass in subsurface soil gas beneath and in close proximity to both residences. Future monitoring for TCE in groundwater, indoor air, and subsurface soil gas will document the degree and timeliness of success of the proposed injections of PlumeStop, as outlined below.

6.3 PROPOSED PLUMESTOP INJECTION PLAN

6.3.1 Proposed Areal Extent of Injection-Points

The following provides a brief summary of the primary actions proposed within Regenesis' proposal presented in Appendix B herein. Regenesis proposes two north-to-south oriented, alignments of PlumeStop carbon product injection-points, each of which is characterized as a permeable reactive barrier (PRB) in the proposal. One north-south PRB is proposed along/parallel to the western-most LGE property boundary, while the other PRB is proposed along/parallel to the eastern-most Residence B property boundary.

The proposed locations and lateral spacings of PRB injection-points are generalized on Regenesis proposal Figures 1, 2, and 3, copies of which are presented in Appendix B herein as well as immediately following Stantec Figure 2 of this report. Actual injection-point locations will depend in part on drill rig accessibility and subsurface utility locations.

Each PRB alignment is oriented generally perpendicular (north-south) in relation to the northwesterly/west groundwater flow direction. Most PRB injection-points are positioned to inject PlumeSTOP product into areas of the aquifer anticipated to contain TCE, as exhibited by historical groundwater quality monitoring results.

6.3.2 Proposed PlumeStop Injection Protocol

Each injection-point will entail drilling of a soil test boring through which the PlumeStop product will be pressure-injected into natural subsurface soils. Regenesis is offering to subcontract a local direct-push drilling firm to utilize a GeoProbe™-type drill rig to drill the soil test borings for PlumeStop product injection. Regenesis intends to contract a drilling firm with whom it has worked with previously and who is familiar with the PlumeStop product injection process.

The product injection, piping assembly will be extended down each borehole to the desired injection depth and then PlumeStop product will be slurry-pumped under low pressure down the pipe assembly and into surrounding, natural subsurface soils. Prior to downhole injection, the PlumeStop product will be mixed with potable water within a portable Regenesis trailer, similar to that presented as Figure 4 within Regenesis' proposal. The source of potable water will be City of Cottonwood Heights, Utah's public drinking water supply, secured either via the LGE facility site and/or a local City fire hydrant – to be determined and City-permitted well in advance of the proposed field project.

As detailed in the Design Summary on page 2 of Regenesis' proposal, Regenesis intends to inject the PlumeStop product throughout the following proposed depth intervals in each injection-point borehole, which is designed to optimize impact within the estimated, greatest mass of TCE within the aquifer:

LGE Property:	14 to 24 feet below grade.
Residence B Property:	9 to 19 feet below grade.

Regenesis proposes that PlumeStop injections begin at the LGE property before injecting at the residence, so that site-specific information may be evaluated during and following the LGE injections to help optimize the proposed injection program planned for the residence. During PlumeStop injections, Stantec will monitor local water levels and water quality parameters at existing groundwater monitoring wells located in close proximity to the injection-points, while Regenesis monitors product injection rates/volumes. The cumulative information will be evaluated real-time in terms of promoting the safest, most practicable, and effective program for injecting the PlumeStop product, as determined and directed by on-site Regenesis personnel.

In consideration of the close proximity of injection-points proposed for installation in the Residence B backyard, the fact that the floor of the basement of the home is located at an approximate depth of 9 feet or so beneath the natural ground surface, and the fact that natural static water levels were recorded in groundwater monitoring wells HP-5 and HP-8 during April and October 2022 between 9 to 10 feet below grade, Regenesis is proposing that a preliminary investigation be conducted at the Residence B and LGE properties, prior to starting PlumeStop injections at either property to identify the potential that proposed injections of PlumeStop into the aquifer might cause a rise in the local water table elevation beneath, and/or immediately adjacent to, the residence, which in turn could possibly result in localized portions of the home structure being exposed directly to groundwater.

As outlined on Regenesis' Figures 1 and 2, Regenesis proposes that its subcontracted direct-push drilling firm drill two soil test borings in close proximity to proposed PlumeStop injection-points at both the LGE and Residence B properties, prior to starting the PlumeStop injection program. The four soil test borings will be drilled to completion depths approximating 10 feet below the water table to investigate site-specific, lithologic soil conditions (including grain size analysis of aquifer soils and moisture content within the vadose zone above the water table, etc.) that characterize the proposed injection zone within the aquifer at both properties. It is anticipated that each of the two borings at the LGE property will be completed to a subsurface depth of approximately 24 feet below grade, while the two borings at Residence B will be completed to approximately 19 feet below grade. The lithologic information will be used by Regenesis to help refine its final PlumeStop injection plan.

The two proposed soil test borings in the Residence B yard will be located between the home and nearby, proposed injection-points (reference Regenesis' proposal, Figure 2). Following soil sampling, each of these two borings will be converted to one-inch diameter, groundwater monitoring piezometers for monitoring of subsurface hydraulic impacts as PlumeStop is injected into the subsurface at Residence B. The two piezometers will also be used for post-injection, groundwater quality monitoring to verify remedial progress of the selected remedy.

Prior to and during the PlumeStop injections at the two properties, Stantec field staff will monitor localized groundwater levels and water quality parameters (dissolved oxygen, ORP, pH, temperature, conductivity) within monitoring wells located near injection-points. Regenesis field staff will monitor for PlumeStop material within the wells/piezometers, possibly including

installation of additional soil test borings if deemed of value during the PlumeStop injection program. Monitoring of subsurface hydraulic conditions is designed to help amend (if needed) Regenesis' PlumeStop injection program, including PlumeStop injection volumes, injection rates, injection (vertical depth) intervals, and PlumeStop concentrations, in support of optimizing overall effectiveness of each PRB.

During the injection of PlumeStop in the yard of Residence B, the injection rate will be less than that employed during injections at the LGE property. Injections will start at injection-points located farthest from the residence and then progress sequentially with injection-points being located increasingly closer to the home. Water levels in multiple wells and piezometers at Residence B will be monitored continuously during the injection program in the residence's yard.

In the event that field data indicate a rise of more than one foot (1-ft.) of the water table in one of the piezometers located immediately adjacent to Residence B, injection of PlumeStop will cease immediately at Residence B. Regenesis will reassess and adjust its local injection program, depending on field conditions. Regenesis has the ability to adjust the volume, concentration, injection rate, and injection depth interval of PlumeStop being injected to optimize the effectiveness of the PRB at Residence B and ensure that potential issues related to the localized water table intersecting the home's subsurface foundations/basement are avoided. In the event that PlumeStop product is observed in any subsurface area where not intended, or product daylights at the ground surface, injection of the product will stop immediately and Regenesis will reassess site conditions and the area-specific injection program in consultation with Stantec and the driller.

Regenesis, the drilling firm, and Stantec field staff will maintain close coordination during the entire PlumeStop injection program, monitoring site conditions and being prepared to pause and adjust operations if and when needed. Regenesis anticipates that it could require approximately 14 working days (Monday through Friday) to complete the proposed injection program. All subsurface injection-point boreholes will be abandoned, by means of a bentonite pressure-grout from the bottom of each boring flush to grade, following completion of the injection program.

Per Regenesis' proposal, Regenesis will produce an *Injection Summary Report* for Stantec/LGE that will memorialize Regenesis' involvement with the injection project, including for instance: injection-point maps, injection depth intervals, injection pressure/flow rates, reagent volumes, field observations, and any other noteworthy information deemed pertinent to the project and objectives. Stantec anticipates including a copy of the Regenesis report as an Appendix to Stantec/LGE's initial post-injection *Groundwater Monitoring Report* that is discussed in detail in following section 10.0, which outlines Stantec's proposed approach for monitoring remedial progress following the PlumeStop injection program.

6.3.3 Materials Management Plan

Stantec intends to coordinate PlumeStop material and drilling equipment storage, management, and use with LGE, Regenesis, and drilling firm representatives. Care will be administered by all parties to ensure appropriate materials management throughout the remedial project. All PlumeStop injection materials will be stored in a secure area protected from the natural elements at the LGE facility until use.

Since remedial procedures will entail use of a direct-push drilling rig, it is anticipated that no subsurface soil material will be generated during injection of the PlumeStop product and minimal (if any, anticipated to be less than five-gallons) of soil sample materials will be generated during installation of two proposed, one-inch diameter piezometers, as detailed in preceding report section 6.3.2. Any soil material generated during installation of the two piezometers at Residence B will be sampled and analyzed by a laboratory for VOCs by Method 8260 and placed on and covered by plastic sheeting, temporarily. LGE and Stantec will evaluate the analytical results in consideration of alternative disposal options and apprise the UDEQ, accordingly.

7.0 PROPOSED REMEDIAL PROGRESS MONITORING PROGRAM, *AFTER* PLUMESTOP INJECTIONS

Sections 7.1 and 7.2 outline proposed indoor air quality, SSDS off-gas emission, sub-slab soil gas, and groundwater sampling and analysis protocol that will be administered following injection of the PlumeStop product. Programmatic quality assurance/quality control (QA/QC) monitoring and sampling procedures are detailed in section *8.0 Quality Control*.

Copies of Stantec's general *Standard Operating Procedures* (SOPs) are presented as Appendix C herein and are referenced accordingly in following sections. In summary, the same air and groundwater sampling and analysis procedures that have been implemented at the site for over a decade will continue to be used to provide consistent and repetitive sampling protocol and analytical results.

7.1 ONGOING MONITORING OF INDOOR AIR AND SSDS OFF-GAS EMISSIONS AT RESIDENCES A AND B

Routine indoor air and SSDS off-gas emission sampling at both residences will continue on an ongoing, semi-annual (every six months) basis. Samples will be collected while the respective home HVAC systems are operating. It is anticipated that routine indoor air quality, sub-slab soil gas, and SSDS off-gas emission monitoring, in conjunction with groundwater analytical data (as discussed in section 7.3), will be used to help gauge how long to continue operating the SSDSs, as proposed in section 7.1.1.

Following receipt of each semi-annual laboratory result report, Stantec will prepare a *SSDS Mitigation System Off-Gas Emission Sampling Summary Report* for submittal to the UDAQ (with copies to the UDEQ) in accordance with UDAQ Rule *R307-401-15. Air Strippers and Soil Venting Projects*. Stantec will also submit to the UDEQ a brief summary letter-report that documents the indoor air sampling results. Both reports will include copies of laboratory result reports.

SSDS off-gas emission samples will be collected from dedicated SSDS off-gas sampling ports in similar fashion as collected at both residences since 2012. Indoor air samples will be collected in the same locations as sampled recently within the basements of Residence A and B. Air sampling protocol will be administered in similar fashion and general accord as historical air sampling procedures utilizing summa™ canisters, as detailed in Stantec SOP ESPA-007 *Air Sampling with Summa Canisters* and SOP ES2.05, sub-section 3.9 *Collecting (Soil Vapor) Sample Using Summa™ Canisters*. All air samples will be collected using laboratory-certified canisters and dedicated regulators, including 1-liter summa™ canisters equipped with 24-hour regulators for all indoor air samples (for TCE analysis by Method TO-15, SIM) and 6-liter summa canisters equipped with 5-minute regulators for all sub-slab soil gas and SSDS off-gas emission samples (for VOCs analysis by Method TO-15).

All air samples will be submitted to the same laboratory that has been used for air analyses since 2012, the ALS Environmental Laboratory in Salt Lake City, Utah, an affiliate of the worldwide ALS Global Corporation. Consistent with past practices, Stantec will request that the laboratory's Method Reporting/Detection Limit satisfies the US EPA indoor air residential VISL concentration for TCE (Method TO-15, SIM) of 0.478 µg/m³. Stantec will request that the laboratory's Method Reporting/Detection Limit satisfies the US EPA sub-slab soil gas residential VISL concentration for TCE (Method TO-15) of 15.9 µg/m³. ALS' standard Limit for TCE by Method TO-15, SIM is 0.27 µg/m³, while ALS' Limit for TCE by Method TO-15 is 2.7 µg/m³, both of which are below the respective VISLs deemed protective of residential land use.

7.1.1 Residence-Specific Air Quality Sampling Criteria for Permanent Decommissioning of SSDS Mitigation Systems

As outlined herein, LGE and Stantec propose a media monitoring program, the results of which will be reported in Summary Reports proposed in section 10.0 and used as the means for documenting future site monitoring and closure activities. LGE will confer with the UDEQ regarding any final sampling prior to SSDS decommissioning.

At the same time that indoor air samples and SSDS off-gas emission samples are collected/analyzed on a semi-annual basis, it is also proposed that subsurface soil gas samples be collected from each of the two sub-slab soil gas sampling probes located in the basement floors of Residences A and B (reference Figures 3A and 3B, respectively). Sub-slab soil gas samples will be collected in similar fashion as conducted historically and as detailed in Stantec SOP ES2.05 Soil Vapor Sampling.

As detailed in prior reports, two sub-slab soil monitoring/sampling probes were installed in May 2012 by Stantec in each respective basement in accordance with procedures outlined in Stantec SOP ES2.05, section 3.2 Sub-Slab Probe Installation. The approximate 6-inch long, 0.25-inch diameter, air-tight, sub-slab soil gas probes were installed through each residence's basement floor to sample soil gas located immediately beneath the basement floor. The top of each probe is flush with the existing concrete floor and equipped with an airtight, screw-cap.

Once Stantec obtains two (2) consecutive semi-annual sampling rounds of indoor air, SSDS off-gas emissions, and sub-slab soil gas that include TCE concentrations less than corollary residential VISL concentrations **at either Residence A and/or B**, then Stantec will turn-off that respective SSDS and allow the subsurface environment to equilibrate and return to natural, steady-state conditions.

Once a residence's SSDS is turned-off, then Stantec proposes the collection of another round of indoor air and sub-slab soil gas samples one (1) week later. If all air samples satisfy the above-listed VISLs, then we would leave the respective SSDS 'off' and re-sample again one quarter later (i.e., three months). If TCE is not detected in any indoor air or sub-slab soil gas sample collected at one of the respective residence(s) after the three month sampling event, LGE and the UDEQ will discuss whether any supplemental media sampling is warranted in pursuit of residence-specific, SSDS decommissioning. If at any time TCE is quantified in excess of a corollary VISL, then

LGE will contact the UDEQ to discuss the results and formulate a path-forward strategy, possibly including turning-on one or both SSDSs if deemed warranted. Thereafter, routine air monitoring would follow the program proposed in this report.

Currently, it is premature to propose a final media sampling approach that might be deemed sufficient for decommissioning of one or both of the two SSDS systems - as well as ultimate VCP project 'closure.' It is proposed that ongoing dialogue between LGE and the UDEQ and forthcoming Summary Reports that are proposed in section 10.0, be used as the means for documenting future site monitoring and closure activities deemed mutually-satisfactory to LGE and the UDEQ.

7.2 PROPOSED GROUNDWATER MONITORING PROGRAM AND SCHEDULE

In an effort to monitor the effectiveness and anticipated reduction in TCE concentrations in groundwater following PlumeStop injections, it is proposed that static groundwater levels be measured within, and groundwater samples be collected from, the following monitoring wells/piezometers on the schedule that is proposed below.

- The two (2) 1-in. diameter piezometers, proposed for installation at Residence B prior to PlumeStop injections.

and

- Existing monitoring wells: MW-2, MW-3, MW-6, MW-7, HP-1, HP-2, HP-3, HP-5, HP-8, and HP-9.

As detailed in preceding report sections, remedial objectives for groundwater quality include satisfying TCE and other VOCs' UDEQ Screening Levels (MCLs and Groundwater Protection Standards, which were achieved years ago), as well as achieving the US EPA VISL "target groundwater concentration" for TCE in groundwater that poses a potential risk for vapor intrusion into overlying buildings of 1.19 ppb. As proposed in following report sections, future groundwater monitoring will be used as a barometer that is anticipated to indicate the degree of success of the PlumeStop injections into the uppermost aquifer at the project site. Future groundwater sampling schedules may be amended and/or stopped completely, depending on future media sampling, analytical results, and corollary discussions between the UDEQ and LGE.

7.2.1 Proposed Monitoring Schedule

It is proposed that static water levels be measured and groundwater samples be collected for general water quality parameters and VOC laboratory analysis by Method EPA 8260D/5030A on a monthly basis for three consecutive months, following the PlumeStop injections. Thereafter, it is recommended that the monitoring program be reduced to quarterly sampling for three consecutive quarters, the total duration of which would provide for one (1) complete year (four seasons) of groundwater quality and water level monitoring.

After the first year of monitoring is completed, then similar groundwater monitoring will continue on a semi-annual (twice per year) schedule, as is currently practiced, until conditions indicate groundwater quality satisfies UDEQ regulatory requisites and/or as deemed acceptable to both LGE and the UDEQ.

7.2.2 Proposed Groundwater Monitoring and Sampling Protocol

Groundwater monitoring, purging, and sampling protocol, including Level III laboratory analysis/reporting and QA/QC means and data verification and UDEQ split-sampling, will be administered in similar fashion and methods, including using US EPA low flow sampling protocol, as implemented at the VCP site historically. Stantec's QA/QC program is detailed in section *8.0 Quality Control*. Stantec's general SOPs for monitoring well purging and low-flow groundwater sampling and analysis are presented in Appendix C.

The intent of the 'low-flow' purging and sampling methodology is to minimize drawdown, turbidity, and purge volumes encountered during routine ground water sampling, so that a ground water sample may be collected that is representative of true geochemical conditions in the aquifer. Parameters will be measured in the field during purging using a flow-through, sampling cell and a Horiba U-52 or In-Situ, Inc. Aqua TROLL 500 (or similar) unit, calibrated each day before use. Field measurement data associated with pH, specific conductivity, dissolved oxygen, temperature, turbidity, and ORP will be recorded in a field notebook. Individual ground water samples will be collected, once field parameters stabilize as outlined below.

The purge pumping rate will be established generally between 0.3 to 0.5 liter per minute (L/min.). During purging, water level and pump rate data will be monitored and recorded in the field logbook, every three to five minutes. Purging of water will continue at the low-flow rate, until the following field parameters have stabilized during three consecutive measurements:

- pH	+/- 0.1
- specific conductivity	+/- 3%
- ORP	+/- 10 mv
- turbidity	+/- 10%
- dissolved oxygen	+/- 0.3 mg/l

Following purging, a water sample will be collected by reducing the pumping rate slightly and then collecting a sample directly within laboratory-provided sample containers. The sample should be collected prior to passing through the flow-through cell; and therefore, the flow-through cell will be disconnected prior to each sample collection. Prior to use at each well, the water level meter, flow-through cell, and water quality field parameter sensors will be decontaminated by triple-rinsing with deionized water.

Each ground water sample will be collected by Stantec, using new disposable, latex or nitrile gloves and within laboratory-provided, sample containers, which in turn will be labelled according to sample identification, date, and requested analyses. Each sample container will be encased within ice in a laboratory-provided cooler, before being hand-delivered to

Chemtech-Ford Laboratories in Salt Lake City, Utah, a Utah-certified, analytical laboratory, for analysis of VOCs by Method EPA 8260D/5030A. When filling the VOC sample bottles, care will be administered to fill each container completely to prevent potential volatilization. Strict QA/QC and Chain-of-Custody protocol will be administered throughout the sampling program, including hand-delivery of the samples to the laboratory.

As detailed in section *8.0 Quality Control*, Stantec will request Level III laboratory QC reporting for all groundwater sampling events. Stantec will also request RLs and MDLs for TCE of 1 ppb (which is less than the VISL of 1.19 ppb for TCE in groundwater that might pose potential risk for vapor intrusion, etc.).

As discussed in more detail in section *10. Summary Reporting to the UDEQ*, Stantec will prepare the following reports on behalf of LGE, as part of the proposed scope of remedial work and subsequent VCP site monitoring:

- As is ongoing currently, and will continue for the foreseeable future, *Semi-Annual SSDS Off-Gas Emission Sampling Summary Reports* will be prepared and submitted to the UDEQ/UDAQ, accordingly.
- A *Remedial Action Summary Report* (summarizing the PlumeStop injection program) will be prepared following completion of the injection field work.
- The first post-injection *Groundwater Monitoring Summary Report* be prepared and submitted to the UDEQ, following completion of/summarizing the findings of the initial three (3) consecutive months of groundwater sampling.
- Thereafter, for three consecutive calendar quarters during the first year of monitoring, three *Quarterly Groundwater Monitoring Summary Reports* will be prepared and submitted to the UDEQ.
- Thereafter, *Semi-Annual Monitoring Summary Reports* (air and groundwater results) will be prepared and submitted to the UDEQ, accordingly.

8.0 QUALITY CONTROL

The methods and procedures detailed herein will serve as primary guidance for integration of QA/QC protocol into future site investigative activities, including investigation of environmental media such as subsurface soil gas, sub-slab soil gas, indoor air, and groundwater. This report section presents organization, objectives, procedures, functional activities, documentation requisites, and specific QA/QC activities designed to achieve project-specific Data Quality Objectives (DQOs) outlined herein. The QA/QC protocol may be referenced in future Proposed Work Plans and/or amended PRAP documents, if subsequent site monitoring, characterization, and/or remediation phases not otherwise referenced specifically within this PRAP are deemed warranted by LGE and the UDEQ.

8.1 DATA QUALITY OBJECTIVES

Data collected through implementation of site characterization activities proposed in this PRAP will be used to evaluate overall site conditions including potential contamination in different environmental media. In turn, potential risk posed by such contamination may be analyzed in light of existing and projected future land usage and associated potential receptors and potential exposure pathways.

The QA/QC program outlined herein will be used to assure that site monitoring and characterization data produced during future site investigative activities represents a data set that expresses the same average characteristics as that of the whole matrix. A systematic approach, including analytical protocols and documentation requirements, must be employed to ensure that data are collected, reviewed, and analyzed in a consistent manner, since the data generated during such investigative actions will impact and support future aspects and decisions regarding the project. In turn, the decisions can then be made at a specified and acceptable level of uncertainty.

The primary goal of the QA/QC program is to define procedures that assure the quality and integrity of the collected media samples, the representativeness of the results, the precision and accuracy of the analyses, and the completeness of the data. Data that meet the QA objectives and goals will be deemed acceptable. Data that do not meet objectives and goals will be reviewed on a case-by-case basis to ascertain usability.

8.1.1 INTENDED DATA USAGE

The analytical QA objectives are defined in terms of sensitivity and precision, accuracy, reproducibility, comparability, and completeness (PARCC parameters). Utilization of the QA program proposed herein requires implementation of procedures for obtaining and evaluating data in a manner that will result in a quantitative or qualitative representation of the PARCC parameters. The parameters of precision, accuracy, and completeness provide a quantitative measure of the quality of the data collected in the field program. The parameters of

representativeness and comparability utilize documentation of the site and laboratory procedures to qualitatively evaluate the data.

8.1.2 GENERAL QUALITY ASSURANCE CONSIDERATIONS

Data quality indicators are defined in terms of the PARCC parameters in the following subsections. The assessment of the data quality indicators is necessary to determine data usability. Appendix D herein presents copies of relevant materials excerpted from the laboratories' Quality Assurance Manuals (QAM) and deemed relevant to proposed investigative activities. Stantec intends to adopt the laboratories' manuals as part of project implementation.

Excerpted materials include, for example: copies of laboratory general and specific SOPs, technical procedures, analytical methodologies and respective Method Detection Limits (MDLs), Reporting Limits (RLs), Method Blank, Matrix Spike and Matrix Spike Duplicate (MS/MSD), Laboratory Control Samples (LCS), surrogates, and QA/QC program – as they relate specifically to PARCC parameters, document control, and record management program.

8.1.2.1 Precision

Precision is a measure of mutual agreement among replicate (or between duplicate) or co-located sample measurements of the same analyte. The closer the numerical values of the measurements are to each other, the more precise the measurement. Precision for a single analyte will be expressed as a relative percent difference (RPD) between results of field duplicate samples, laboratory duplicate samples, or MSD samples for cases where both results are sufficiently large. Otherwise, the absolute difference between the results is compared to a factor of the RL (the RL is used for non-detect results).

Precision will be determined by collecting field duplicates at a minimum of one sample per 10 standard field samples (i.e., 10%) for each matrix in addition to laboratory duplicates and laboratory MSDs. In addition, precision will be maintained by conducting routine instrument checks to demonstrate that operating characteristics are within predetermined limits.

Precision examines the spread of data about their mean. The spread represents how different the individual reported values are from the average reported values. Precision is thus a measure of the magnitude of errors and will be expressed as the RPD or the Relative Standard Deviation (RSD) for all methods. The lower these values are; the more precise are the data. These quantities are defined as follows:

$$\textbf{RPD (\%)} = 100 \times \frac{|S - D|}{(S + D)/2}$$

$$\textbf{RSD (\%)} = (s/X) \times 100$$

Where:
D = Concentration or value of an analyte in a duplicate sample
S = Concentration or value of an analyte in an original sample
X = Mean of replicate analyses
s = Standard deviation

Based on US EPA guidelines, samples and replicate Field Duplicate samples should have RPDs whose absolute values do not exceed 35 percent (for all media) in cases where both sample values are greater than or equal to five times (5x) the Reporting Limit. If one or both values are less than five times the reporting limit, the difference between the primary and replicate values should not exceed two times (2x) the reporting limit.

8.1.2.2 Accuracy

Accuracy is a measure of bias in a measurement system. Accuracy measures the average or systematic error of an analytical method. This measure is defined as the difference between the measured value and the actual value. The closer the value of the measurement agrees with the true value; the more accurate the measurement. This will be expressed as the percent recovery of a surrogate, LCS analyte, or MS analyte.

Accuracy will be expressed as the percent recovery. This quantity is defined as follows:

$$\textbf{Recovery (\%)} = \frac{|SC - UC|}{KC} \times 100$$

Where:

SC = Measured concentration of an analyte in spiked sample or LCS

UC = Measured unspiked concentration of an analyte (assume to be zero for LCS and surrogates)

KC = Known concentration of an analyte added

Recovery limits must be within established criteria presented in the laboratories' QAM.

8.1.2.3 Representativeness

Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, or an environmental condition. The design of, and rationale for, the sampling program (in terms of the purpose for sampling, selecting the sampling locations, the number of samples to be collected, the ambient conditions for sample collection, the frequencies and timing for sampling, and the sampling techniques) assures that the environmental condition has been sufficiently represented.

Samples not properly collected or preserved, or which are not analyzed by the laboratory within prescribed holding times do not provide representative data. Moreover, Method Detection Limits above respective UDEQ-specified or risk-based Screening Levels do not provide representative data.

8.1.2.4 Completeness

Completeness is defined as the measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Data completeness can be expressed as the percentage of valid data obtained from the measurement system. For data to be considered valid, it must meet all the acceptable criteria including accuracy and precision, as well as any other criteria required by the prescribed analytical method.

$$\%C = \frac{V \times 100}{n}$$

Where: %C = percent completeness
n = total number of measurements necessary to achieve a specified statistical level of confidence in decision making.
V = number of measurements judged valid

In practice, completeness is evaluated by comparing project objectives to the quality and quantity of data collected to determine if any deficiencies exist. Missing data can be the result of numerous causes, such as accessibility problems, limitations of media available to sample, mechanical breakdown, sample container breakage, and other factors. Completeness will be quantitatively assessed as the percent of controlled QC parameters that are within limits.

The requirement for completeness is 90 percent for each individual analytical method for the following QC parameters:

- Initial calibration,
- Continuing calibrations,
- LCS percent recovery,
- MS/MSD,
- Field duplicate RPDs, and
- Surrogate percent recoveries.

The completeness requirement for holding times will be 100 percent. Any deviations shall be reported in the report narrative.

8.1.2.5 Comparability

Comparability is a qualitative parameter expressing the confidence in which one data set can be compared with another. Sample data should be comparable for similar samples collected under like conditions. The comparability of data produced by and for this project is

predetermined by the commitment of project staff and contracted laboratories to use SOPs, standardized methods, where possible, including US EPA-approved analytical methods, or documented modifications thereof which provide equal or better results. These methods have specified units in which the results are to be reported.

8.1.2.6 Sensitivity

When selecting an analytical method during the DQO process, the achievable, Method Detection Limit and method Reporting Limit must be evaluated to verify that the method will meet the project quantitation limits necessary to support project decision-making requirements. This process ensures that the analytical method sensitivity has been considered and that the methods used can produce data that satisfy users' needs while making the most effective use of resources. The concentration of any one target compound that can be detected and/or quantified is a measure of sensitivity for that compound. Sensitivity is instrument-, compound-, method-, and matrix-specific, and achieving the required project quantitation limit (RL) and/or Method Detection Limit objectives depends on instrument sensitivity and potential matrix effects.

Sensitivity refers to the lowest concentration of an analyte that can be reliably identified and reported by an analytical method. Sensitivity is typically evaluated in terms of detection limits. There are two types of detection limits relevant to this project: MDLs and RLs.

- MDLs: Method Detection Limits refer to the lowest concentration where only the presence of a given analyte can be reported with confidence. The exact concentration cannot be precisely determined. For this reason, results falling between the MDL and RL are assigned a qualifier of "J" which represents the result is an estimated concentration.

- RLs: Method Reporting Limits refer to the lowest concentration where the presence and concentration can be measured and reported with 99% confidence. RLs are typically higher than MDLs for a given analyte.

While the laboratory establishes nominal MDLs and RLs for an analytical method, the MDLs and RLs for individual samples are affected by sample and analysis specific factors including sample matrix and analytical dilutions. For this reason, all individual results and qualifiers such as "J" will be reviewed to determine if sensitivity is acceptable.

All MDLs and RLs will be compared to the following screening levels, as applicable (TCE-specific, where noted):

- US EPA's current Residential and Industrial Risk-Based Screening Levels [RSLs], with a Target Hazard Quotient [THQ] of 1.0 for soil (if soil is sampled as part of activities proposed in this PRAP; TCE: 0.94 ppm and 6 ppm, respectively);

- UDEQ's current Initial Screening Levels (ISLs) specifically for petroleum hydrocarbon constituents for soil and groundwater (if analyzed, which is not anticipated at this time, as part of activities proposed in this PRAP);

- UDEQ's current Ground Water Protection Standards (UDEQ/US EPA Maximum Contaminant Level/MCL; TCE: 5 ppb), US EPA RSLs protective of Tapwater, and/or Secondary Drinking Water Protection Standards, if and where deemed applicable) for ground water; and

- US EPA's current Residential and Commercial risk-based VISLs for indoor air quality (TCE: 0.478 µg/m^3 and 2.99 µg/m^3, as well as US EPA's sub-slab soil gas Residential VISL (TCE: 15.9 µg/m^3) and the US EPA's 'target' groundwater concentrations deemed protective of potential vapor intrusion (TCE: 1.19 ppb).

At a minimum, the MDLs, and preferably the RLs, must be less than the matrix-appropriate screening levels to meet the sensitivity requirements for the project and be deemed acceptable - as is anticipated as part of this project. As a result, general sensitivity problems are not anticipated, however sensitivity concerns with individual analyses may occur.

If the sensitivity of a particular result is deemed questionable by the laboratory, the laboratory will report any such issue including appropriate justification for its analyses, interpretations, and conclusions. If the sensitivity of a particular result is deemed unacceptable, then additional actions might be warranted, including but not limited to: re-sampling and re-analysis with a lower MDL/RL.

8.2 DATA EVALUATION

The following sections describe the process of handling data in terms of data generation, checking, and formatted reports for both field sampling and laboratory analytical data. Data will be evaluated by both the analytical laboratories as well as Stantec. ALS and Chemtech-Ford will provide Level III reporting and data evaluation which will be reviewed by Stantec against project-specific DQOs.

8.2.1 DATA REDUCTION AND EVALUATION

8.2.1.1 Field Data Reduction and Evaluation

The purpose of the field data validation process is to evaluate the usability of field data that are collected or documented in accordance with specified protocols outlined in SOPs. First, all field data will be validated at the time of collection by the Field Team Leader, following QC-related protocol outlined in the SOPs. Second, field data will be validated by the Project Manager, who will review field data documentation to identify discrepancies or unclear entries. Field data documentation will be validated against the following criteria, as appropriate:

- Sample location and adherence to the Proposed Work Plan
- Field instrumentation and calibration
- Sample collection protocol

- Sample volume
- Sample preservation
- Blanks collected and submitted with each respective sample set
- Duplicates collected and submitted with each respective sample set
- Sample documentation protocol
- Field Chain-of-Custody protocol

8.2.1.2 Laboratory Data Reduction and Review

Data reduction is the process of converting measurement system outputs to an expression of the parameter that is consistent with the comparable objective identified in this plan. Reduction of analytical data will be completed in accordance with the laboratories' Quality Assurance Manuals.

The first level of review, which may contain multiple sublevels, will be conducted by the analytical laboratory that has initial responsibility for the correctness and completeness of the data. The laboratory data reviewers will evaluate the quality of the analytical data based on an established set of laboratory guidelines and the respective laboratory's Quality Assurance Manual. This person will review the data packages to confirm the following:

- Sample preparation information is correct and complete
- Analysis information is correct and complete
- The appropriate laboratory SOPs have been followed
- Analytical results are correct and complete
- QC sample results are within established control limits
- Blank results are within appropriate QC limits
- Analytical results for QC sample spikes, sample duplicates, initial and continuous calibration verifications of standards and blanks, standard procedural blanks, LCSs, and inductively coupled plasma (ICP) emission spectrometer interference check samples are correct and complete
- Tabulation of reporting limits related to the sample is correct and complete
- Documentation is complete (all anomalies in the preparation and analysis have been documented; holding times are documented)

The laboratory will perform in-house analytical data reduction and QA review under the direction of the laboratory PM or designee. The laboratory is responsible for assessing data quality and advising of any data that were rated "preliminary" or "unacceptable," or were flagged with any other notations that would caution the data user of possible unreliability. Data reduction, QA review, and reporting by the laboratory will include the following:

- Raw data produced by the analyst are processed and reviewed for attainment of QC criteria as outlined herein, the laboratory QAP, and/or established US EPA methods. The raw data will also be reviewed for overall reasonableness.
- The data reviewer will check all manually entered sample data for entry errors and will check for transfer errors in all data electronically uploaded from the instrument output into the software packages used for calculations and generation of report forms. Based on these checks, the reviewer will decide whether any sample re-analysis is required.
- The laboratory will review initial and continuing calibration data, and calculation of response factors, surrogate recoveries, MS/MSD recoveries, post-digestion (analytical) spike recoveries, internal standard recoveries, LCS recoveries, sample results, and other relevant QC measures.
- Upon acceptance of the preliminary reports by the laboratory data reviewer, the laboratory QA officer or designee will review and approve the data packages prior to the final reports being generated.

The data reduction and the QC review steps will be documented, signed, and dated by the analyst and the laboratory Project Manager or designee.

8.3 DATA REPORTING

Field measurements and observations will be recorded on standard data collection forms. Stantec field personnel will also maintain a project-specific field logbook. The book will be a bound, consecutively-paginated notebook in which project-specific data will be recorded and documented. Sequential entries into the logbook should be made in waterproof ink. It serves as a permanent record of all field events occurring during on-site site characterization activities. The general intent of the documentation is to corroborate data recorded on individual field sampling and/or activity forms specified in the various SOPs, so as to substantiate data collection dates, times, generalized procedures, personnel present, weather conditions, and any health and safety-related issues, etc.

Laboratory data will be recorded in the standard formats described herein and laboratories' Quality Assurance Manuals. Laboratory and field data will be combined and summarized in final tables that are appropriate to the type of data and convey information to support the findings of the data collection program. In all cases, data used in reports will be clearly tabulated and presented in a consistent manner for comparison of common sets of data.

QUALITY CONTROL
October 17, 2023

Laboratory data will be generated and delivered by the contract laboratories in a Level III QC reporting package. This package will include copies of the completed chain of custody forms, analytical results, laboratory narrative report, surrogate analysis results, Method Blank results, LCS results, MS/MSD results, sample duplicates, and chromatograms.

9.0 CONTINGENCY PLAN

There are many aspects of the project that might be impacted by unforeseen circumstances and/or field conditions, particularly in light of the sequential scope of work tasks, multiple properties, field equipment and large machinery, number of parties, and logistics involved with preparation and implementation. Additional factors, such as subsurface conditions observed during injection of the PlumeStop product and drill rig access in the residence's backyard, will also influence the work and scheduling.

Regenesis anticipates that it could require approximately two to three weeks (at least 14, 10-hour days) to complete the field work associated with the proposed injection program. Regenesis and Stantec will stay in tight communication with all vested parties prior to and during the project. Regenesis, the drilling firm, and Stantec field staff will communicate with one another during the entire PlumeStop injection program, monitoring site conditions and being prepared to pause and adjust operations if and as needed. In the event that field operations/findings result in the need for consultation related to any significant change in scope of work and/or other potential concerns, field conditions and observations will be shared with LGE and the UDEQ for due consideration.

LGE's ultimate objective is to eliminate the potential for gaseous-phase TCE intrusion into Residences A and B. Future sampling of groundwater at the VCP site, after injecting the PlumeStop product, in conjunction with monitoring of indoor air, sub-slab soil gas, and SSDS off-gas emission quality at the two residences, will monitor progress toward achieving remedial objectives. LGE will investigate supplemental remedial options, if the actions proposed in this report do not provide appropriate protection to human health and the environment at the VCP site, specifically including indoor air quality at Residences A and B. Any such supplemental, remedial efforts would be coordinated through the UDEQ in accordance with VCP protocol.

Future analytical results will be discussed between LGE and the UDEQ and will be used to evaluate actions proposed in this Plan and whether an Environmental Covenant is warranted or not. In pursuit of a UDEQ Certificate of Completion, which pertains to the entire VCP site, LGE will prepare a Site Management Plan. The Site Management Plan will document LGE's proposed program for contingency actions to be implemented in the hypothetical event that environmental contamination is identified during possible future site land use changes, including for instance building renovation, building demolition, new construction, and/or subsurface utility upgrades.

10.0 TENTATIVE SCHEDULE FOR PLUMESTOP INJECTION PROGRAM

Following approval of this Proposed Remedial Action Plan, LGE, Stantec, Regenesis, subcontractors (laboratories, drilling firm, PlumeStop product manufacturer, etc.), and others (private and public subsurface utility locating firms and possibly the City of Cottonwood Heights' Public Works/Water Department) must orchestrate appropriate contracting and subcontracting agreements in advance of starting the project. It is anticipated that contracting/subcontracting will require a few weeks to complete.

Regenesis anticipates that it will require several weeks to prepare for the proposed field project. Project start-up will also be contingent upon drilling firm availability and scheduling. Stantec anticipates that Stantec resources can be prepared in advance, such that Stantec field personnel and equipment should be positioned to start as soon as Regenesis and the Regenesis-contracted, drilling firm are ready to mobilize to the field.

Regenesis anticipates that it will need two to three weeks to complete the PlumeStop product injections. Thereafter, Stantec will conduct monthly, quarterly, and then semi-annual media sampling and UDEQ reporting, as outlined in following section *11. Summary Reporting to the UDEQ*.

To facilitate approval of this PRAP, a copy of Stantec's proposed Public Notice advertisement is presented in following section *12.0 Proposed Public Notice*. The notice will be advertised once in a Sunday morning edition of the *Salt Lake Tribune* newspaper, following UDEQ acceptance of the remedial actions proposed in this report.

Likewise, a finalized copy of the Public Notice will be hand-delivered and mailed via US Postal Service certified mail to the following residences located west of the LGE property (reference Figure 4):

2187 East Pink Coral Circle (EPCC) – [redacted]

2193 EPCC – [redacted]

2201 EPCC – [redacted]

2196 EPCC – [redacted]

2184 EPCC – [redacted].

11.0 *SUMMARY REPORTING* TO THE UDEQ

Stantec will prepare the following reports on behalf of LGE, as part of the proposed scope of remedial work and subsequent VCP site monitoring:

- As is ongoing currently, and will continue for the foreseeable future, *Semi-Annual SSDS Off-Gas Emission Sampling Summary Reports* will be prepared and submitted to the UDEQ/UDAQ, accordingly.
- A *Remedial Action Summary Report* (summarizing the PlumeStop injection program) will be prepared following completion of the injection field work.
- The first post-injection *Groundwater Monitoring Summary Report* be prepared and submitted to the UDEQ, following completion of/summarizing the findings of the initial three (3) consecutive months of groundwater sampling.
- Thereafter, for three consecutive calendar quarters during the first year of monitoring, three *Quarterly Groundwater Monitoring Summary Reports* will be prepared and submitted to the UDEQ.
- Thereafter, *Semi-Annual Monitoring Summary Reports* will be prepared and submitted to the UDEQ, accordingly.

Stantec's *Remedial Action Summary Report* will provide summary details and site-specific drawings that describe the implementation of the PlumeStop product injection field work, proceedings, and field observations. Specifics related to the installations of soil test borings, groundwater monitoring piezometers, and the PlumeStop injection-points will be presented in the report. A copy of Regenesis' summary report will be included as an Appendix to Stantec's report. Regenesis' report will present pertinent information including PlumeStop injection-point data, reagent volumes, injection pressure/flow rates, times of important tasks, and other information deemed relevant to the remediation program. Stantec anticipates submitting the summary report to the UDEQ within approximately two to three months following completion of the injection field work.

Stantec's *Groundwater Monitoring Summary Reports* will present summaries of Stantec's routine groundwater monitoring, sampling, and analysis tasks, designed to monitor the progress and impacts of the PlumeStop injections. Stantec's summary reports will entail similar format and material as reported previously to the UDEQ, including for instance: tabulated water level measurements prior to purging of wells, copies of Field Notes during purging and sampling of wells, figures with site- and well-specific locations and TCE analytical results; copies of laboratory result reports, etc. Stantec anticipates submitting each summary report to the UDEQ within approximately two months following completion of each individual sampling event.

12.0 PROPOSED PUBLIC NOTICE

The following text is proposed for use as LGE's Public Notice:

PUBLIC NOTICE

Linde Gas & Equipment Inc.

A 30-day public comment period will run between October 19, 2023 through November 20, 2023 to allow the public to comment on the Linde Gas & Equipment Inc. proposal for future groundwater remediation at and immediately adjacent to the LGE site located at 6880 South 2300 East in Cottonwood Heights, Utah. Sampling at the site has identified localized areas of low concentrations of trichloroethylene (TCE) in groundwater.

The property owner has submitted a Proposed Remedial Action Plan (PRAP) in accordance with the Utah Department of Environmental Quality, Voluntary Cleanup Program (UDEQ, VCP), with oversight by the Division of Environmental Response and Remediation (DERR). The Plan details proposed injection of a carbon product that is designed to capture TCE for enhanced natural reduction in TCE concentrations in groundwater, which in turn is expected to reduce or eliminate the potential for intrusion of gaseous-phase TCE into subsurface soil gas and overlying buildings.

Copies of the RAP may be reviewed electronically by accessing the UDEQ's public website by means of the following website link: https://deq.utah.gov/environmental-response-and-remediation/public-notices-utah-division-of-environmental-response-and-remediation#ems. Secondarily, if there are issues with electron viewing, copies are available for review during normal business hours at the following location:

Utah Department of Environmental Quality/DERR
195 North 1950 West
Salt Lake City, Utah 84114-4840
(801) 536-4100
Mon. – Fri.; Hours: 8 AM to 5:00 PM

All public comment should be submitted to Mr. Joseph Katz, Utah Department of Environmental Quality at the above address or by email: jkatz@utah.gov.

FIGURES
October 17, 2023

Figure 1 Residences and Monitoring Well Location Map

Stantec

Linde Gas & Equipment Inc.
6880 South 2300 East Street -Salt Lake City, Utah

FIGURE 1. Residences and Ground Water Monitoring Well Location Map

Date: 2/1/2023

Last Revision Date: 2/2/2023

Design by: TH | Reviewed by: JR & RP | Scale: One Inch approxs. 100 feet

LEGEND

Ground Water Monitoring Well

Scale (feet)

0 100 200

N

Figure 2 Groundwater Monitoring Wells and Abandoned Groundwater Sampling Borings

Generalized Scale

0 25 50

feet

Stantec

Praxair Distribution, Inc.

6880 South 2300 East Street -Salt Lake City, Utah

Figure 2 - Groundwater Monitoring Wells and Abandoned Groundwater Sampling Borings

Design by	JR	Reviewed by	RP	Date Revised	2/17/23

LEGEND

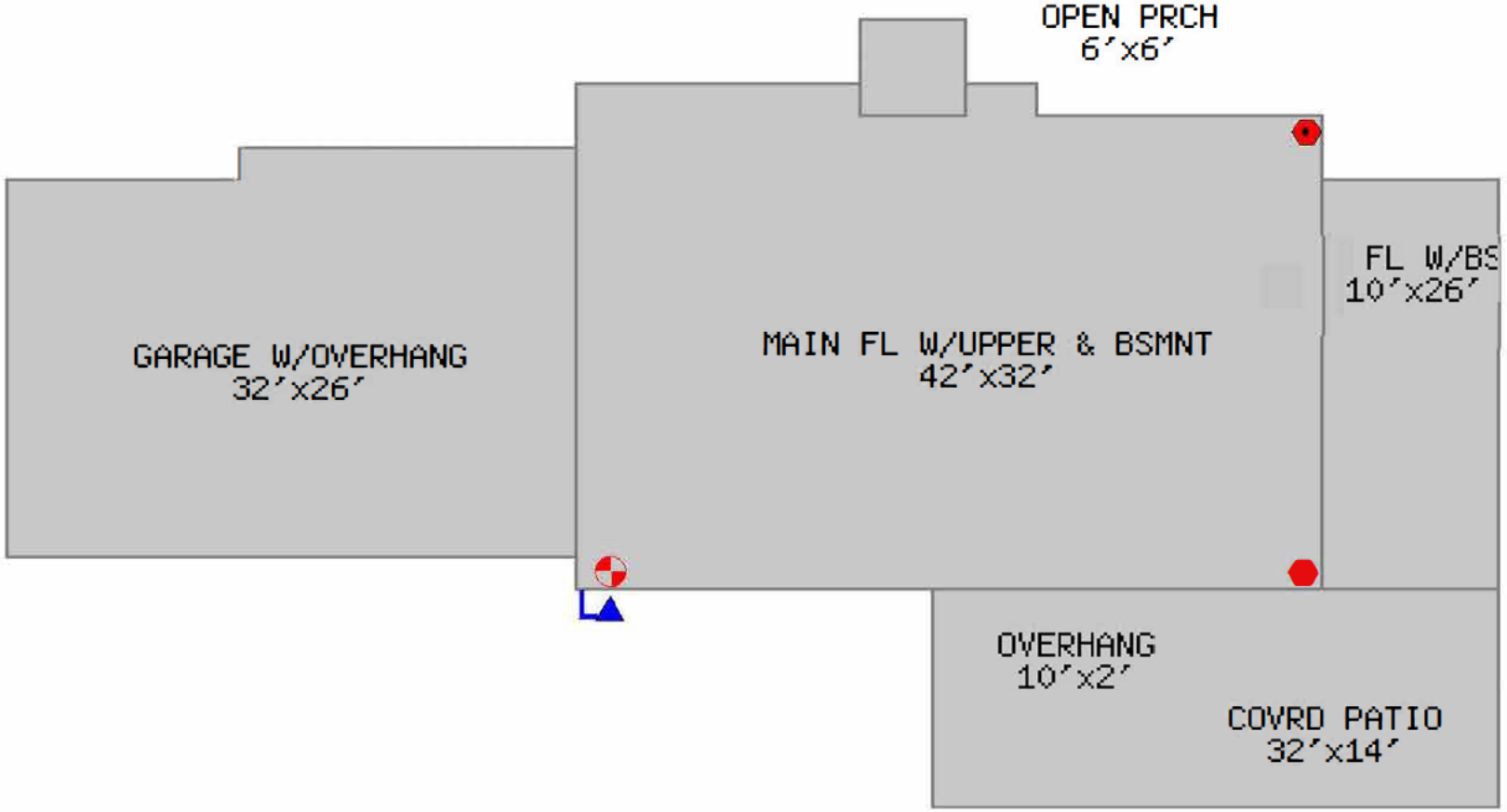
MW-2 /HP-1 **Monitoring Well**

HP-4 Abandoned Sampling Boring

N

Figure 3A General Building Diagram, Residence A

X:\UT\Clients\Praxair Distribution Inc\PDI_Whitmore_SLC\Old\Figure 2 General Building Mitigation Diagram Residence A 2196 East Pink Coral Circle_22Mar13.mxd



LEGEND

- Sub Slab Vacuum Extraction Location
- Blower Location
- Exhaust Location
- Sub Slab Probe Location

N

PRAXAIR DISTRIBUTION, INC.
6880 SOUTH 2300 EAST - SALT LAKE CITY, UTAH

FIGURE 3A
GENERAL BUILDING DIAGRAM
RESIDENCE A - 2196 EAST PINK CORAL CIRCLE

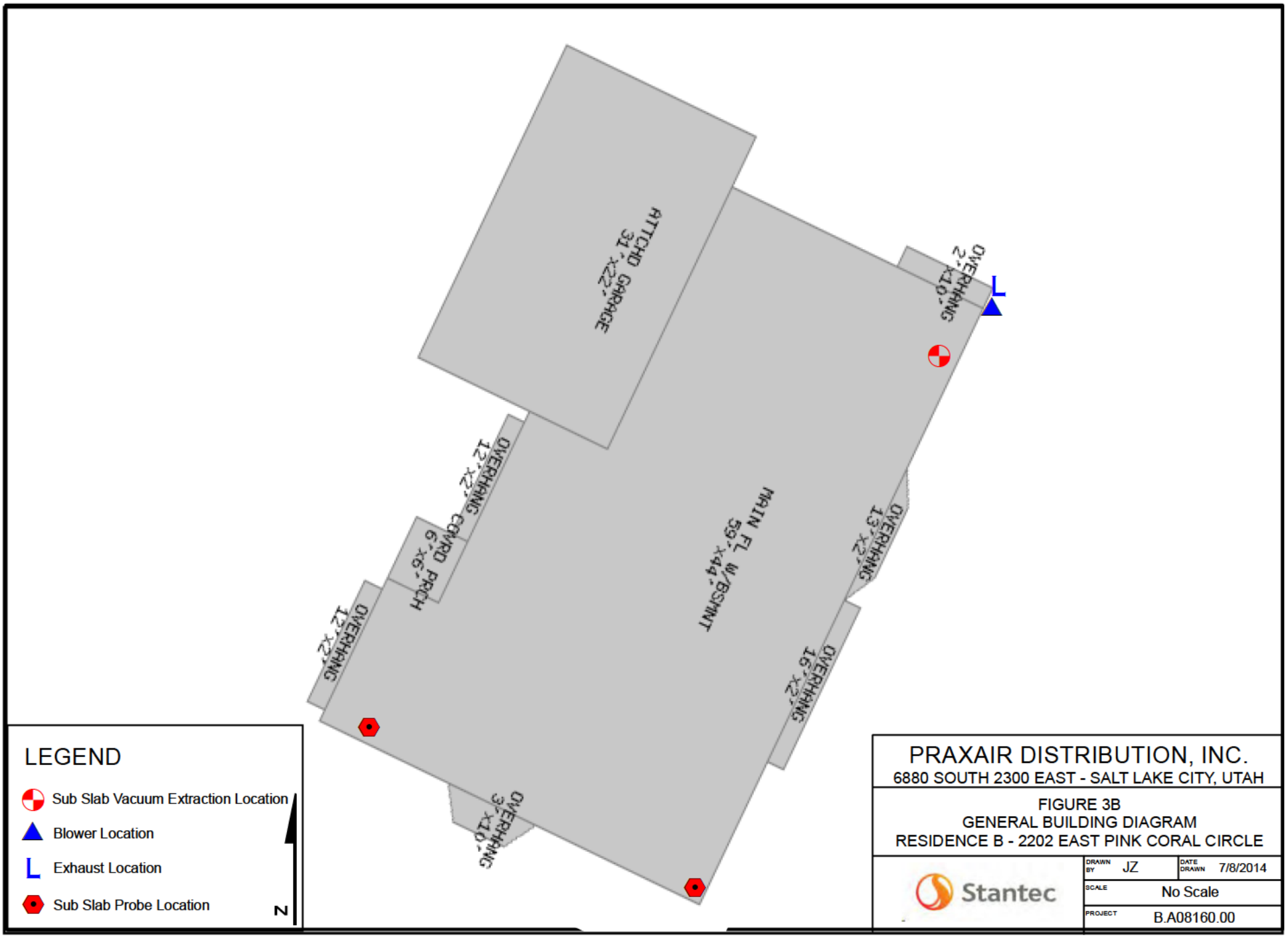
Stantec

DRAWN BY	CP
DATE DRAWN	7/8/2014
SCALE	No Scale
PROJECT	B.A08160.00

FIGURES
October 17, 2023

Figure 3B General Building Diagram, Residence B

X:\UT\Clients\Praxair Distribution Inc\PDI_Whitmore_SLC\MXDs\Individual Residence Location Maps\Figure 2 General Building Mitigation Diagram Residence B - 2202 East Pink Coral Circle_22Mar13.mxd



PRAXAIR DISTRIBUTION, INC.
6880 SOUTH 2300 EAST - SALT LAKE CITY, UTAH

FIGURE 3B
GENERAL BUILDING DIAGRAM
RESIDENCE B - 2202 EAST PINK CORAL CIRCLE

Stantec

DRAWN BY	JZ
DATE DRAWN	7/8/2014
SCALE	No Scale
PROJECT	B.A08160.00

Figure 4 Residences, Public Notice Hand-Delivery

Stantec

Praxair Distribution, Inc.
6880 South 2300 East Street -Salt Lake City, Utah

FIGURE 4. Residences to Whom the Public Notice Will Be Hand-Delivered

Design by	Drawn by	Scale	Date Drawn / Last Revision Date

LEGEND

▲ Ground Water Monitoring Well

N

Scale (feet)

0 100 200

PROPOSED REMEDIAL ACTION PLAN FOR TCE IN GROUNDWATER

FIGURES
October 17, 2023

Excerpted Figures from Regenesis' November 2022 *Proposal for TCE Groundwater Treatment at the LGE Property*

Stantec

Project No.: 203708160/05-delivs/delivs/2023/PRAPGW

Linde Praxair

Stantec

November 22, 2022

Figure 1-Injection Location Map for Praxair On-Site Barrier

REGENESIS

Technology-Based Solutions for the Environment

Linde Praxair

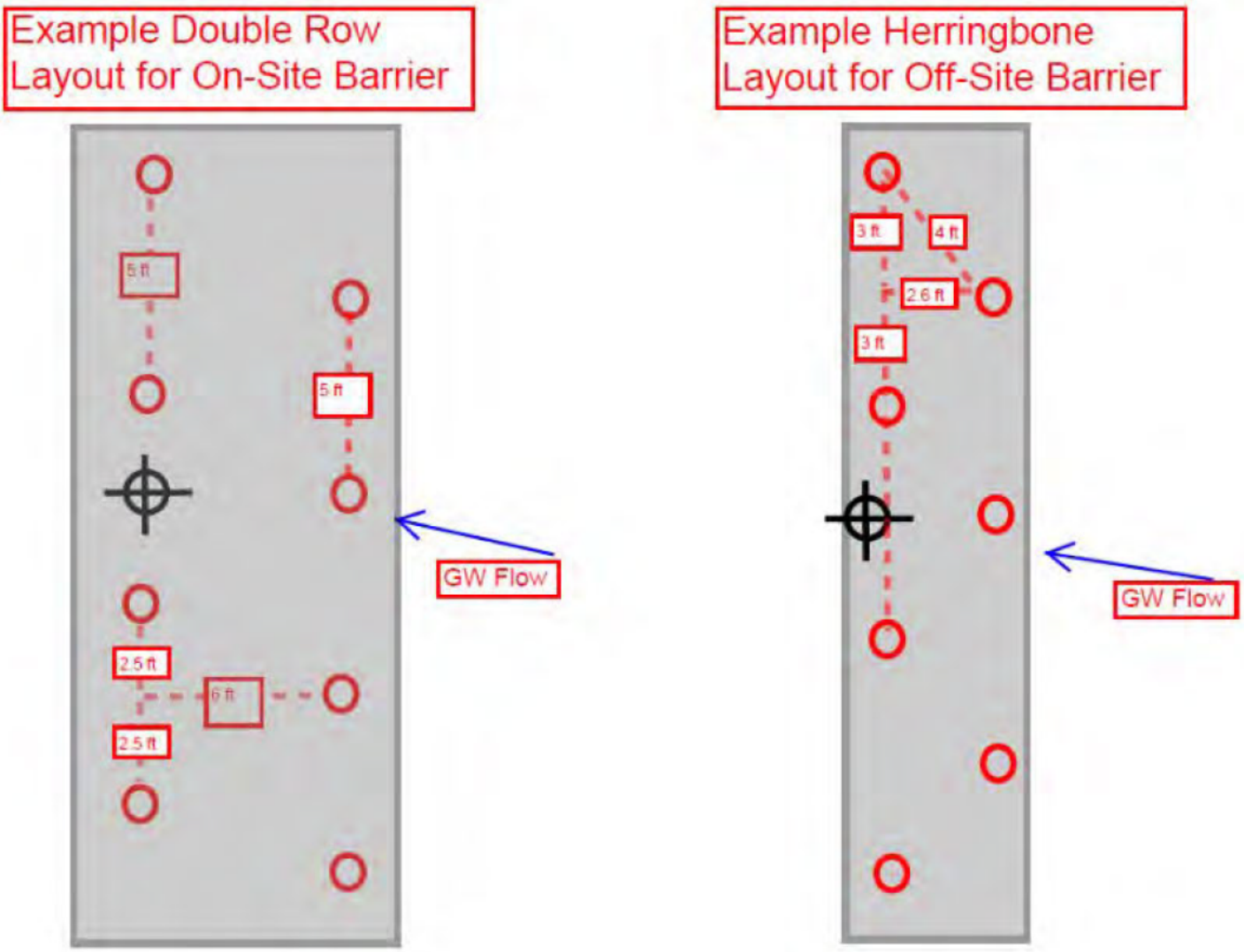
Stantec

November 22, 2022

Figure 2-Injection Location Map for Off-Site Residential Barrier

REGENESIS

Technology-Based Solutions for the Environment



Linde Praxair

Stantec

November 22, 2022

Figure 3

Injection Point Configurations

REGENESIS

Technology-Based Solutions for the Environment

TABLES
October 17, 2023

TABLE 1. Well Construction Summary

Table 1
WELL CONSTRUCTION SUMMARY
LINDE, PLC
6880 South 2300 East
Salt Lake City, Utah

MONITOR WELL I.D.	DRILLING METHOD	TOTAL DEPTH (feet BGS)	DIAMETER/ MATERIAL WELL	TOP OF CASING ELEVATION (feet RSB)	SCREENING INTERVAL (ft)
MW-1	DP	18	1.5- inch/PVC	4543.09	8-18
MW-2	DP	24.5	1.5- inch/PVC	4540.52	14.5-24.5
MW-3	DP	23.5	1.5- inch/PVC	4543.59	13.5-23.5
MW-4	DP	28	1.5- inch/PVC	4550.56	18-28
MW-5	DP	29.5	1.5- inch/PVC	4564.70	19.5-29.5
MW-6	HSA	19	2- inch/PVC	4528.92	9-19
MW-7	HSA	18	2- inch/PVC	4529.23	8-18
MW-8	HSA	20	2- inch/PVC	4525.88	10-20
MW-9	HSA	20	2- inch/PVC	4524.53	10-20
HP-1	DP	18	1- inch/PVC	NS	8-18
HP-2	DP	18	1- inch/PVC	NS	8-18
HP-3	DP	18	1- inch/PVC	NS	8-18
HP-5	DP	15	1- inch/PVC	NS	5-15
HP-8	DP	15	1- inch/PVC	NS	5-15
HP-9	DP	15	1- inch/PVC	NS	5-15

BGS = Below Ground Surface
RSB = Relative to Site Benchmark NS: Not Surveyed
HSA = Hollow-Stem Auger
DP = Direct Push

TABLES
October 17, 2023

Table 2. Historical Groundwater Analytical Results

Table 2
HISTORICAL GROUND WATER ANALYTICAL RESULTS
LINDE, PLC
6880 South 2300 East
Salt Lake City, Utah

			VOCs - EPA Method 8260B Micrograms per liter (ug/l; i.e., parts per billion-ppb)					
Monitor Well	Date	Screened Interval (feet)	Acetone	Bromodichloromethane	Chloroform	**Trichloroethene (TCE)**	Toluene	All Other VOC Compounds
MW-1	2/8/05	8-18	<10	<2	4.0	<2	<2	ND
	3/22/07		<10	<2	3.0	<2	<2	ND
	1/29/09		<10	<2	<2	<2	<2	ND
	11/5/09		<10	<2	2.1	<2	<2	ND
	11/17/10		10.7	<2	<2	<2	<2	ND
	6/21/11		<10	<2	<2	<2	<2	ND
	12/8/11		<10	<2	<2	<2	<2	ND
Dup-1	12/8/11		<10		<2	<2	<2	ND
	5/30/12		<10	<2	2 28	<2	<2	ND
	3/6/13		<10	<2	5.40	<2	<2	ND
	8/12/13		<10	<2	8.17	<2	<2	Xylenes 2.8
	3/20/14		<10	<2	4 88	<2	<2	ND
	10/24/14		< 1.5	0.67	4.10	< 0.3	< 0.3	ND
	4/30/15		<1.5	<0.3	0 81	<0.3	<0.3	ND
	11/12/15		<1.5	<0.3	1.1	<0.3	0.45 J	m,p-Xylene 0 39 J
	5/26/16		<1.5	<0.3	0.9 J	<0.3	<0.3	ND
	12/5/16		<1.5	<0.3	0.85 J	<0.3	<0.3	ND
	8/9/17	inaccessible	NS	NS	NS	NS	NS	NS
	2/28/18		NS	NS	NS	NS	NS	NS
	9/21/18		NS	NS	NS	NS	NS	NS
	3/8/19		NS	NS	NS	NS	NS	NS
	9/17/19		NS	NS	NS	NS	NS	NS
	4/16/20		NS	NS	NS	NS	NS	NS
	11/18/20		NS	NS	NS	NS	NS	NS
	3/31/21		NS	NS	NS	NS	NS	NS
	10/13/21		NS	NS	NS	NS	NS	NS
	Subsequently		NS	NS	NS	NS	NS	NS
MW-2	2/8/05	14.5-24.5	<10	<2	<2	**220**	<2	ND
	3/22/07		<10	<2	<2	**54**	<2	ND
MW-6 (DUP of MW-2)	3/22/07		<10	<2	<2	**52**	<2	ND
	1/29/09		<10	<2	<2	**19**	<2	ND
1/29/09 UDEQ Split Labeled MW-2			<2.33	<0.163	0.38J	**14**	<0.0854	ND
	11/5/09		<10	<2	<2	**13**	<2	ND
11/5/09 UDEQ Split Labeled MW-2			--	--	--	**13**	--	ND
	11/17/10		<10	<2	<2	**8.7**	<2	ND
11/17/10 UDEQ Split Labeled MW-2			<1.5	<0.2	1.1	**6.8**	<0.21	ND
	6/21/11		<10	<2	< 2	**6.61**	< 2	ND
6/21/11 UDEQ Split Labeled MW-2			--	--	--	**6.4**	--	ND
	12/8/11		<10	<2	< 2	**5.58**	<	ND
12/8/11 UDEQ Split Labeled MW-2			<2.5	<0.3	0.72	**5.1**	<0.3	ND
	5/30/12		<10	<2	10.2	4.2	< 2	ND
5/30/12 UDEQ Split Labeled MW-2			<1.9	0.83	7.0	2.9	<0.3	Methylene Chloride 1.7
	3/6/13		<10	<2	3 82	2.58	<3	ND
3/6/13 UDEQ Split Labeled MW-2			<3.2	0.51	3.8	2.5	<0.3	ND
	8/13/13		<10	<2	5.70	4.42	<3	ND
8/13/13 UDEQ Split Labeled MW-2			<3.2	0.98J	4.8	4.2	<0.3	ND
	3/20/14		<10	<2	2 26	2.03	<2	ND
3/20/14 UDEQ Split Labeled MW-2			<1.5	0.61 J	2.2	2.1	<0.3	ND
	10/24/14		<1.5	0.41 J	1.8	**5**	< 0.3	ND
10/24/14 UDEQ Split Labeled MW-2			< 1.5	0.36 J	1.7	**5**	< 0.3	ND
	4/30/15		<1.5	<0.3	1.4	2.9	<0.3	ND
4/30/15 UDEQ Split Labeled MW-2			<1.5	<0.3	1.4	2.8	<0.3	ND
	11/12/15		<1.5	<0.3	1.2	4.1	0 56 J	ND
11/12/15 UDEQ Split Labeled MW-2			<1.5	<0.3	1.2	4.1	0 56 J	ND
	5/26/16		<1.5	<0.3	0.73 J	2.2	<0.3	ND
5/26/2016 UDEQ Split Labeled MW-2			< 10	< 2.0	< 2.0	2.28	< 2.0	ND
	12/6/16		<1.5	<0.3	1.0	2.2	<0.3	ND
12/6/2016 UDEQ Split Labeled MW-2			<10	<2	1.15 J	2.45	<2	ND
	8/9/17		<5.0	<1.0	2.4	2.0	<1.0	ND
8/9/2017 UDEQ Split Labeled MW-2			<10	0 330 J	2.7	2.44	<2	ND
	2/28/18		<5.0	<1.0	1.9	1.2	<1.0	ND
Dup-1	2/28/18		<5.0	<1.0	1.8	1.1	<1.0	ND

Table 2
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LINDE, PLC
6880 South 2300 East
Salt Lake City, Utah

Monitor Well	Date	Screened Interval (feet)	VOCs - EPA Method 8260B Micrograms per liter (ug/l; i.e., parts per billion-ppb)					
			Acetone	Bromodichloromethane	Chloroform	**Trichloroethene (TCE)**	Toluene	All Other VOC Compounds
	9/21/18		<5.0	0.52 J	3.8	2.1	<1.0	ND
Dup-1	9/21/18		<5.0	0.48 J	3.7	2.1	<1.0	ND
	3/8/19		13	<1.0	5.1	1.4	<1.0	Chloromethane 2.0
Dup-1	3/8/19		<5.0	<1.0	4.7	1.3	<1.0	Chloromethane 1.9
	9/18/19		<10	<2	4 58	1.66 J	<2	ND
9/18/19 UDEQ Split Labeled MW-2			<10	0.9	4.0	1.8	<1	ND
	4/16/2020		< 10	0.51 J	3.1	1.17 J	<2	ND
	11/18/2020		<10	<2.0	3 86	2.99	<2	Bromo-dichloromethane 0.600
	3/31/2021		< 10	0 550 J	3 08	1 97 J	< 2	ND
	10/13/2021		< 10	0 550 J	2 53	2.72	< 2	ND
MW-2 DUP	10/13/2021		< 10	0.5310 J	2 51	2.67	< 2	ND
	4/6/2022		< 10	<1.0	1.70	1.7	<1.0	1,3,5-Trimethy benzene 0.7 J and Naphthalene 0.7 J
	10/21/2022		< 10	<1.0	1.40	2.3	<1.0	ND
	4/14/2023		< 10	< 1.0	< 1.0	0 5 J	< 1.0	ND
US EPA MCLs			NE	NE	NE	5	1000	NE
MW-3	2/11/05	13.5-23.5	<10	<2	<2	**9.8**	<2	ND
	3/22/07		<10	<2	<2	2.6	<2	ND
	1/29/09		<10	<2	<2	2.8	<2	ND
	11/5/09		<10	<2	<2	2.2	<2	ND
	11/18/10		91.6	<5	<2	<2	<2	ND
Dup-1	11/18/10		49.0	<2	<2	<2	<2	ND
	6/21/11		<10	<2	<2	<2	<2	ND
	12/8/11		<10	<2	<2	<2	<2	ND
	5/30/12		<10	<2	<2	<2	<2	ND
	3/6/13		<10	<2	<2	<2	<2	ND
	8/12/13		<10	<2	<2	<2	<2	ND
	3/20/14		<10	<2	<2	<2	<2	ND
Dup-1	3/20/14		<10	<2	<2	<2	<2	ND
	10/24/14		< 1.5	< 0.3	0.78	0 32 J	< 0.3	ND
	4/30/15		<1.5	<0.3	0.45	<0.3	<0.3	ND
	11/12/15		<1.5	<0.3	<0.3	<0.3	0 56 J	m,p-Xylene 0 32 J
	5/26/16		<1.5	<0.3	0.91 J	<0.3	<0.3	ND
	12/5/16		<1.5	<0.3	0.61 J	<0.3	<0.3	ND
	8/9/17		<5.0	<1.0	1.2	<1.0	<1.0	ND
	2/28/18		<5.0	<1.0	6.2	<1.0	<1.0	ND
	9/20/18		<5.0	<1.0	0.72 J	<1.0	<1.0	ND
	3/8/19		<5.0	<1.0	<1.0	<1.0	<1.0	ND
	9/18/19		<10	<2	<2	<2	<2	ND
	4/16/20		< 10	< 2	< 2	< 2	< 2	ND
	11/18/20		<10	<2	0 23	0.18 J	<2	ND
	3/31/21		<10	<2	< 2	< 2	< 2	ND
	10/13/21		< 10	< 2	< 2	< 2	< 2	ND
	4/6/22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	10/21/22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	4/14/23		< 10	<1.0	<1.0	<1.0	<1.0	ND
MW-4	2/8/05	18-28	<10	<2	15	<2	<2	ND
	3/22/07		<10	<2	6.8	<2	<2	ND
	1/29/09		<10	<2	5.2	<2	<2	ND
	11/5/09		<10	<2	4.7	<2	<2	ND
	11/17/10		41.8	<2	6.76	<2	<2	ND
	6/21/11		<10	<2	2.76	<2	<2	ND
	12/8/11		<10	<2	5 38	<2	<2	ND
	5/29/12		<10	<2	8.18	<2	<2	ND
	3/6/13		<10	<2	5 80	<2	<2	ND
	8/12/13		<10	<2	5 93	<2	<2	ND
	3/20/14		<10	<2	5 09	<2	<2	ND
	10/24/14		< 1.5	< 0.3	4 20	<0.3	< 0.3	ND
	4/30/15		< 1.5	< 0.3	5.2	<0.3	< 0.3	ND

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Salt Lake City, Utah

Monitor Well	Date	Screened Interval (feet)	VOCs - EPA Method 8260B Micrograms per liter (ug/l; i.e., parts per billion-ppb)					
			Acetone	Bromodichloromethane	Chloroform	**Trichloroethene (TCE)**	Toluene	All Other VOC Compounds
	11/12/15		<1.5	<0.3	4.9	<0.3	0 32 J	ND
	5/26/16		<1.5	<0.3	5.6	<0.3	<0.3	ND
	12/5/16		<1.5	<0.3	9.1	<0.3	<0.3	ND
	8/9/17		NS	NS	NS	NS	NS	NS
	2/28/18		<5.0	<1.0	13	<1.0	<1.0	ND
	9/20/18		<5.0	0.69 J	12	<1.0	<1.0	ND
	3/7/19		8.6	<1.0	12	<1.0	<1.0	Chloromethane 3.4
	9/17/19		<10	<2	11.3	<2	<2	ND
	4/16/20		< 10	< 2	8.1	< 2	< 2	ND
	11/18/20		NS	NS	NS	NS	NS	NS
	3/31/21		< 10	< 2	6.5	< 2	< 2	ND
	10/13/21		< 10	< 2	6.5	< 2	< 2	ND
	4/6/22		< 10	<1.0	4.2	<1.0	<1.0	ND
	10/21/22		< 10	<1.0	3.7	<1.0	<1.0	ND
	4/14/23		< 10	< 1.0	2.5	< 1.0	< 1.0	ND
MW-5	2/8/05	19.5-29.5	<10	<2	4.2	<2	<2	ND
	3/22/07		<10	<2	<2	<2	<2	ND
	1/29/09		<10	<2	<2	<2	<2	ND
	11/5/09		<10	<2	8.1	<2	<2	ND
	11/18/10		26.0	4.15	25.8	<2	<2	ND
	6/21/11		<10	6.22	28.6	<2	<2	ND
	12/8/11		<10	5.11	17	<2	<2	ND
	5/29/12		<10	4.93	23.8	<2	<2	ND
	3/6/13		<10	<2	4.79	<2	<2	ND
	8/12/13		<10	<2	3 58	<2	<2	ND
	3/20/14		<10	<2	2.17	<2	<2	ND
	10/24/14		2.6 J	< 0.3	4.9	< 0.3	< 0.3	ND
	4/30/15		<1.5	<0.3	1.1	<0.3	<0.3	ND
	11/13/15		<1.5	<0.3	4.9	<0.3	1.4	m,p-Xylene 0 87 J o-Xylene 0.31 J
	5/26/16		<1.5	<0.3	0.89 J	<0.3	<0.3	ND
	12/5/16		<1.5	<0.3	2.5	<0.3	<0.3	ND
	8/9/17		<5.0	3.8	20	<1.0	<1.0	Dibromochloro-methane 1.2
	2/27/18		<5.0	<1.0	22	<1.0	<1.0	ND
	9/20/18		<5.0	<1.0	9.4	<1.0	<1.0	ND
	3/7/19		<5.0	<1.0	14	<1.0	<1.0	Chloromethane 1.0
	9/17/19		<10	<2	5.6	<2	<2	ND
	4/15/20		< 10	<2	4.0	<2	<2	ND
	11/18/20		NS	NS	NS	NS	NS	NS
	3/31/21		< 2	< 2	1.86 J	< 2	< 2	ND
	10/13/21		< 10	< 2	2.3	< 2	< 2	ND
	4/6/22		< 10	<1.0	1.2	<1.0	<1.0	ND
	10/22/21		< 10	<1.0	1.1	<1.0	<1.0	ND
	4/14/23		< 10	< 1.0	0.7 J	< 1.0	< 1.0	ND
US EPA MCLs			NE	NE	NE	5	1000	NE
MW-6	1/29/09	9-19	<10	<2	<2	**19**	<2	ND
Dup-1	1/29/09		<10	<2	<2	**18**	<2	ND
	11/5/09		<10	<2	<2	**9.6**	<2	ND
11/5/09 UDEQ Split Labeled MW-6			ND	--	--	**11**	--	ND
	11/17/10		14.4	<2	<2	**10.2**	<2	ND
11/17/10 UDEQ Split Labeled MW-6			<1.5	<0.2	0.63	**8.1**	<0.21	ND
	6/21/11		< 10	< 2	< 2	**6.42**	< 2	ND
6/21/11 UDEQ Split Labeled MW-6			< 2.5	< 0.3	0.61	**7.6**	< 0.3	ND
	12/8/11		< 10	< 2	< 2	**7.47**	< 2	ND
12/8/11 UDEQ Split Labeled MW-6			< 2.5	< 0.3	0.63	**7.2**	< 0.3	ND
	5/30/12		< 10	< 2	2 87	**6.89**	< 2	ND
5/30/12 UDEQ Split Labeled MW-6			< 1.9	< 0.3	2.4	**6.1**	< 0.3	ND
	3/6/13		<10	<2	<2	**5.05**	<2	ND
3/6/13 UDEQ Split Labeled MW-6			<3.2	<0.3	0 95	**5.1**	<0.3	ND

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Monitor Well	Date	Screened Interval (feet)	VOCs - EPA Method 8260B Micrograms per liter (ug/l; i.e., parts per billion-ppb)					
			Acetone	Bromodichloromethane	Chloroform	**Trichloroethene (TCE)**	Toluene	All Other VOC Compounds
	8/13/13		<10	<2	<2	**5.32**	<2	ND
8/13/2013 UDEQ Split Labeled MW-6			<3.2	<0.3	0.6	**5.2**	<0.3	ND
	3/20/14		<10	<2	<2	4.51	<2	ND
3/20/2014 UDEQ Split Labeled MW-6			<1.5	<0.3	1.0	4.4	<0.3	Methylene Chloride 1.6
	10/24/14		< 1.5	< 0.3	0.88 J	3.3	<0.3	Methylene Chloride 0.6 J
10/24/14 UDEQ Split Labeled MW-6			< 1.5	< 0.3	0.79 J	3.4	< 0.3	ND
	4/30/15		<1.5	<0.3	0.7 J	3.2	<0.3	ND
4/30/15 UDEQ Split Labeled MW-6			<1.5	<0.30	0.79 J	3.4	<0.3	ND
	11/12/15		<1.5	<0.3	0.93 J	3.3	<0.3	ND
11/12/15 UDEQ Split Labeled MW-6			<1.5	<0.3	1.0	3.7	<0.3	ND
	5/26/16		<1.5	<0.3	0.62 J	2.5	<0.3	ND
5/26/2016 UDEQ Split Labeled MW-6			< 10.0	< 2.0	< 2.0	2.96	< 2.0	ND
	12/6/16		<1.5	<0.3	1.1	2.6	<0.3	ND
12/6/2016 UDEQ Split Labeled MW-6			<10	<2	1.17 J	2.74	<2	ND
	8/9/17		<5.0	<1.0	2.4	2.0	<1.0	ND
8/9/2017 UDEQ Split Labeled MW-6			<10	0.400 J	2.8	2.46	<2	ND
	2/27/18		<5.0	<1.0	2.0	1.7	<1.0	ND
	9/21/18		<5.0	1.4	6.2	2.1	<1.0	ND
9/21/18 UDEQ Split Labeled MW-6			<10.0	1.56 J	6 86	2.07	<2.0	ND
	3/8/19		8.7	1.8	5 80	1.4	<1.0	Chloromethane 2.6
	9/18/19		<10	0.99 J	5.4	1.49 J	<2	ND
Dup-1	9/18/19		<10	0.97 J	5 35	1 53 J	<2	ND
	4/15/20		<10	<2	0.87 J/DUP: 0.93	1.85 J/DUP: 1.83 J	<2	ND
	11/18/20		<10	<2	6.18	1.71 J	<2	ND
Dup-1	11/18/20		<10	<2	5.77	1 93 J	<2	ND
UDEQ Split MW-6	11/18/20		<10	1	4.4	1.7 J	<1	ND
MW-6 DUP	3/31/21		< 10	0 570 J	3.13	2.02	< 2	ND
	3/31/21		< 10	1.13 J	3 86	0.870 J	< 2	ND
MW-6 UDEQ Split	10/13/21		< 10	< 1.0	< 1.0	2.3	< 1.0	ND
	10/13/21		< 10	< 0.138	0.810 J	2.13	< 2	ND
	4/5/22		< 10	1.6	6.2	1.4	<1.0	D bromochloromethane 0.6
Dup-1	4/5/22		< 10	1.6	6.3	1.3	<1.0	D bromochloromethane 0.6
	10/20/22		< 10	< 1.0	< 1.0	< 1.0	<1.0	ND
Dup-1	10/20/22		< 10	< 1.0	< 1.0	< 1.0	<1.0	ND
MW-6 UDEQ Split Labeled MW-15	10/20/22		< 10	< 1.0	< 1.0	< 1.0	<1.0	ND
Normal and DUP	4/14/23		< 10	1.2	3.0	0.6 J and 0.6 J	< 1.0	ND
US EPA MCLs			NE	NE	NE	5	1000	NE
MW-7	1/29/09	8-18	<10	<2	<2	<2	<2	ND
1/29/09 UDEQ Split Labeled MW-7			5.5	0.11J	1.2	0.42J	<0.0854	ND
	11/5/09		<10	<2	<2	<2	<2	ND
Dup-1	11/5/09		<10	<2	<2	<2	<2	ND
	11/17/10		48.2	<2	<2	<2	<2	ND
	6/21/11		<10	<2	< 2	<2	<2	ND
Dup-1	6/21/11		<10	<2	< 2	<2	<2	ND
	12/8/11		<10	<2	< 2	<2	<2	ND
	5/29/12		<10	<2	2.11	<2	<2	ND
	3/6/13		<10	<2	5.62	<2	<2	ND
	8/13/13		<10	<2	7 25	<2	<2	ND
Dup-1	8/13/13		<10	<2	7.46	<2	<2	ND
	3/20/14		<10	<2	5 86	<2	<2	ND
	10/24/14		< 1.5	<0.3	2.5	<0.3	< 0.3	ND
Dup-1	10/24/14		< 1.5	0.34 J	2.4	< 0.3	< 0.3	ND
	5/1/15		<1.5	<0.3	2.3	0 32 J	<0.3	ND
Dup-1	5/1/15		<1.5	<0.3	2.2	0 32 J	<0.3	ND
	11/13/15		<1.5	<0.3	1.7	0 32 J	0.61 J	m,p-Xylene 0 32 J
Dup-1	11/13/15		<1.5	ND	1.6	0 31 J	0.63 J	m,p-Xylene 0 32 J
	5/27/16		<1.5	<0.3	1.9	<0.3	<0.3	ND
Dup-1	5/27/16		<1.5	<0.3	1.7	<0.3	<0.3	0.44 J
	12/5/16		<1.5	<0.3	0.68 J	<0.3	<0.3	ND
	8/9/17		<5.0	<1.0	1.2	<1.0	<1.0	ND
	2/27/18		<5.0	<1.0	1.4	<1.0	<1.0	ND

Table 2
HISTORICAL GROUND WATER ANALYTICAL RESULTS
LINDE, PLC
6880 South 2300 East
Salt Lake City, Utah

Monitor Well	Date	Screened Interval (feet)	VOCs - EPA Method 8260B Micrograms per liter (ug/l; i.e., parts per billion-ppb)					
			Acetone	Bromodichloromethane	Chloroform	**Trichloroethene (TCE)**	Toluene	All Other VOC Compounds
	9/20/18		<5.0	<1.0	2.5	<1.0	<1.0	ND
	3/7/19		<5.0	<1.0	3.2	<1.0	<1.0	Chloromethane 3.1
	9/17/19		<10	<2	4.1	<2	<2	ND
	4/15/20		<10	<2	3.1	<2	<2	ND
	11/18/20		<10	<2	2.63	<2	<2	Bromo-dichloromethane 0.250
MW-7	3/31/21		< 10	< 2	3.11	< 2	< 2	ND
MW-7 Split	3/31/21		< 10	0.5 J	4.10	< 1	< 1	ND
	10/13/21		< 10	< 2	1 53	< 2	< 2	ND
	4/5/22		< 10	<1.0	1.9	<1.0	<1.0	ND
	10/20/22		< 10	<1.0	1.0	<1.0	<1.0	ND
	4/14/23		< 10	< 1.0	0.8 J	< 1.0	< 1.0	ND
MW-8	1/29/09	10-20	<10	<2	<2	<2	<2	ND
	11/5/09		<10	<2	<2	<2	<2	ND
	11/17/10		34.8	<2	<2	<2	<2	ND
	6/21/11		<10	<2	< 2	<2	<2	ND
	12/8/11		<10	<2	< 2	<2	<2	ND
	5/29/12		<10	<2	< 2	<2	<2	ND
	3/6/13		<10	<2	<2	<2	<2	ND
	8/12/13		<10	<2	2 37	<2	<2	ND
	3/20/14		<10	<2	3 89	<2	<2	ND
	10/24/14		< 1.5	0.38 J	2.8	0.43 J	< 0.3	ND
	5/1/15		<1.5	<0.3	3.0	0.47 J	<0.3	ND
	11/13/15		<1.5	<0.3	2.5	0 5 J	0.51	ND
	5/26/16		<1.5	<0.3	1.9	0.41 J	<0.3	ND
	12/5/16		<1.5	<0.3	1.2	0.43 J	<0.3	ND
Dup-1	12/5/16		<1.5	<0.3	1.3	0.43 J	<0.3	ND
	8/9/17		<5.0	<1.0	<1.0	<1.0	<1.0	ND
	2/27/18		<5.0	<1.0	<1.0	<1.0	<1.0	ND
	9/20/18		<5.0	<1.0	1.2	0.45 J	<1.0	ND
	3/7/19		7.0	<1.0	1.3	<1.0	<1.0	Chloromethane 1.6
	9/17/19		<10	<2	2.5	<2	<2	ND
	4/15/20		<10	<2	1.89 J	0.19 J	<2	ND
	11/18/20		<10	<2	2 27	0 35 J	<2	ND
	3/31/21		< 10	< 2	1.66 J	< 2	< 2	ND
	10/13/21		< 10	< 2	1.27 J	< 2	< 2	ND
	4/5/22		< 10	<1.0	1.2	<1.0	<1.0	ND
	10/20/22		< 10	<1.0	1.0	0.7 J	<1.0	ND
	4/14/23		< 10	< 1.0	0.6 J	< 1.0	< 1.0	ND
MW-9	3/6/13	10-20	<10	<2	4 22	<2	<2	ND
Dup-1	3/6/13		<10	<2	4 38	<2	<2	ND
	8/12/13		<10	<2	<2	<2	<2	ND
	3/20/14		<10	<2	<2	<2	<2	ND
	10/23/14		< 1.5	1.2	7.8	< 0.3	< 0.3	ND
	5/1/15		<1.5	<0.3	2.6	<0.3	<0.3	ND
	11/12/15		<1.5	<0.3	0.76 J	<0.3	<0.3	ND
	5/27/16		<1.5	<0.3	0.47 J	<0.3	<0.3	ND
	12/5/16		2.6 J	<0.3	0.4 J	<0.3	<0.3	ND
	8/9/17		<5.0	<1.0	<1.0	<1.0	<1.0	Methyl-t-butyl ether 37
	2/27/18		<5.0	<1.0	<1.0	<1.0	<1.0	ND
	9/20/18		<5.0	<1.0	0.63 J	<1.0	<1.0	ND
	3/7/19		5.2	<1.0	<1.0	<1.0	<1.0	Chloromethane 1.3
	9/17/19		<10	<2	<2	<2	<2	Methyl tert-butyl ether 16
	4/15/20		<10	<2	<2	<2	<2	ND
	11/18/20		<10	<2	0 99	<2	<2	3.07
	3/31/21		< 10	< 2	1.20 J	< 2	< 2	MTBE- 2.81
	10/13/21		< 10	< 2	1.24 J	< 2	< 2	MTBE- 3.94
	4/5/22		< 10	<1.0	1.0	<1.0	<1.0	MTBE- 1.4
	10/20/22		< 10	<1.0	1.6	<1.0	<1.0	MTBE- 1.7
	4/14/23		< 10	<1.0	0.6 J	<1.0	<1.0	MTBE- 2 0
US EPA MCLs			NE	NE	NE	5	1000	NE

Table 2
HISTORICAL GROUND WATER ANALYTICAL RESULTS
LINDE, PLC
6880 South 2300 East
Salt Lake City, Utah

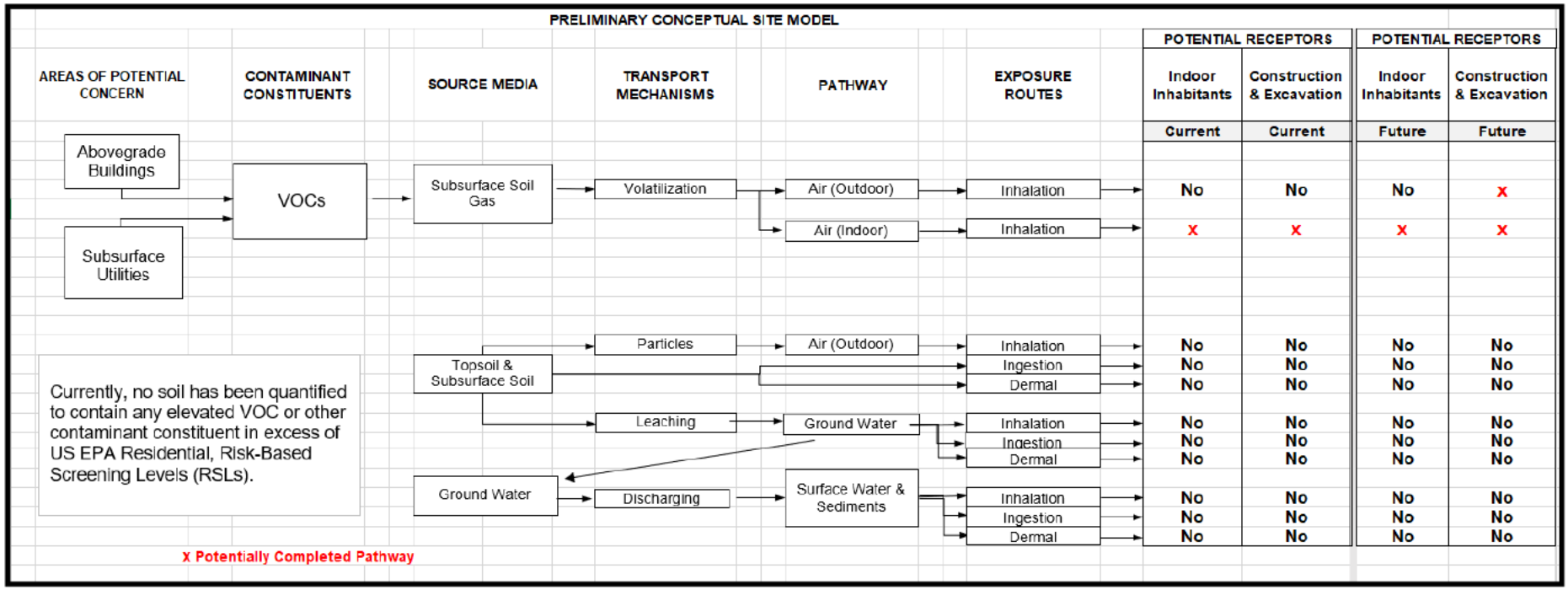
Monitor Well	Date	Screened Interval (feet)	VOCs - EPA Method 8260B Micrograms per liter (ug/l; i.e., parts per billion-ppb)					
			Acetone	Bromodichloromethane	Chloroform	**Trichloroethene (TCE)**	Toluene	All Other VOC Compounds
HP-1	10/20/21	8-18	< 10	<2	2 81	0 82 J	<2.0	ND
	4/6/22		< 10	<1.0	2.2	0.4 J	<1.0	ND
	10/21/22		< 10	<1.0	2.1	<1.0	<1.0	ND
	4/14/23		< 10	<1.0	0.7 J	<1.0	<1.0	ND
HP-2	10/21/21	8-18	<10	<2	1.43	1.45	<10	ND
	4/6/22		< 10	<1.0	<1.0	1.00	<1.0	ND
	10/21/22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	4/14/23		< 10	<1.0	<1.0	<1.0	<1.0	ND
HP-3	10/21/21	8-18	<10	<2	0.42	1.37	<10	ND
	4/6/22		< 10	<1.0	<1.0	1.20	<1.0	ND
	10/21/22		< 10	<1.0	<1.0	2.2	<1.0	ND
	4/14/23		< 10	<1.0	<1.0	< 1.0	<1.0	ND
HP-4	10/20/21 Abandoned		<10	<2	2.69	1.76 J	<2	ND
HP-5	10/21/21	5-15	<10	<2	1 39	1 94 J	<2	ND
	4-5-22		< 10	<1.0	1 30	1.60	<1.0	ND
	10/21/22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	4/14/23		< 10	<1.0	<1.0	1.1	<1.0	ND
HP-6	10/20/21 Abandoned		<10	<2	0.46	1.16 J	<2	ND
HP-7	10/20/21 Abandoned		<10	<2	<2	0.73 J	<2	ND
HP-8	10/21/21	5-15	<10	<2	<2	0 34 J	<2	ND
	4-5-22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	10/21/22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	4/14/23		< 10	<1.0	<1.0	<1.0	<1.0	ND
HP-9	10/21/21	5-15	<10	<2	0 39	1 93 J	<2	ND
	4-5-22		< 10	<1.0	<1.0	1.90	<1.0	ND
	10/21/22		< 10	<1.0	<1.0	<1.0	<1.0	ND
	4/14/23		< 10	<1.0	<1.0	1.5	<1.0	ND
HP-10	10/20/21 Abandoned		<10	<2	0.69	1 04 J	<2	ND
US EPA MCLs			NE	NE	NE	5	1000	NE

MCL = Maximum Contaminant Level VOCs = Volatile Organic Compounds ND = Not Detected NS=Not Sampled
ug/l = micrograms per liter (ppb) NE = Not Established J = Analytical Value between the Method Detection Limit and the Reporting Limit

APPENDIX A

CONCEPTUAL SITE MODEL (CSM)

PRELIMINARY CONCEPTUAL SITE MODEL



		POTENTIAL RECEPTORS		POTENTIAL RECEPTORS	
		Indoor Inhabitants	Construction & Excavation	Indoor Inhabitants	Construction & Excavation
		Current	Current	Future	Future
Subsurface Soil Gas	Volatilization → Air (Outdoor) → Inhalation	No	No	No	X
	Volatilization → Air (Indoor) → Inhalation	X	X	X	X
Topsoil & Subsurface Soil	Particles → Air (Outdoor) → Inhalation	No	No	No	No
	→ Ingestion	No	No	No	No
	→ Dermal	No	No	No	No
	Leaching → Ground Water → Inhalation	No	No	No	No
	→ Ingestion	No	No	No	No
	→ Dermal	No	No	No	No
Ground Water	Discharging → Surface Water & Sediments → Inhalation	No	No	No	No
	→ Ingestion	No	No	No	No
	→ Dermal	No	No	No	No

APPENDIX B

REGENESIS' NOVEMBER 2022 *PROPOSAL FOR TCE GROUNDWATER TREATMENT*

REGENESIS

Technology-Based Solutions for the Environment

PROJECT NAME

Linde Praxair

November 22, 2022

Project Summary

REGENESIS appreciates the opportunity to provide Stantec this remedial design and cost estimate for this project. Included within is a brief summary of our proposed solution, our understanding of your project goals, the technologies proposed, and a table summarizing the design.

Proposed Solution

We are proposing permeable reactive barriers (PRBs) utilizing PlumeStop® Liquid Activated Carbon™ (PlumeStop) to address migrating TCE impacts along the property boundary and off site residential area. The groundwater plume is present beneath the ground surface at about 14 feet on the Praxair site and about 10 feet at the residential property. TCE is present in groundwater ranging in concentration from 1 to 10 ug/L. PlumeStop will sorb the migrating groundwater contaminants and allow them to naturally degrade; thus, safely reducing the risk that contaminated groundwater presents at the site.

PlumeStop will be applied via direct push injection. The proposed barrier locations are shown on Figures 1 and 2. We recommend starting with the on-site barrier first so our RRS crew can monitor PlumeStop distribution and the effects on the groundwater table during injection. The information gathered from the injections on the Praxair site will be used to make any necessary design or application modifications to be protective of the residential property. Additional details about the injection plans are included on Figures 1 and 2.

The on-site PlumeStop barrier will be positioned near the west property line between HP-1 and HP-3. Two rows of injection points will be completed. The first row of PlumeStop injection points will be in line with the existing monitoring wells. The second row of injection points will be approximately 6 feet further up-gradient and off-set by 2.5 feet. The details of double row barrier design are presented on Figure 3.

The off-site barrier on the residential property will be positioned on the eastern side of the home between HP-5 to HP-8. Compared to the barrier at Praxair, we have made several design alterations considering that the injection is being performed next to a residential home with a basement. The barrier will parallel the planter and other landscaping features in the back yard so as to keep a reasonable distance from the home which will mitigate the risk of PlumeStop seeping into the basement during the injection process. Alternatively to the double row barrier design, at the residence we will use a herringbone pattern layout of injection points along the barrier which is shown on Figure 3. The herringbone pattern will reduce the number of injection points and volume needed to install the barrier.

After the injections are completed we anticipate PlumeStop will be mobile for up to one month. During this time, a portion of the PlumeStop will continue to flow down gradient expanding the thickness (in map view) of each of the barriers.

Project Goals

- Control dissolved phase contaminants leaving the Linde Praxair property
- Reduce dissolved phase concentrations to below 0.5 ug/L for TCE for the residential property
- Provide a turn key approach from Regenesis' Remediation Services Division (RRS).

Technologies Proposed

- PlumeStop®

Click above to access product specification sheets

Design Summary

PlumeStop		
On-Site Barrier		
Design Parameters	**Unit**	**Value**
Treatment Type		Barrier
Distance Perpendicular to Flow (ft)		110
Top Application Depth (ft bgs)		14
Bottom Application Depth (ft bgs)		24
Vertical Treatment Interval	ft	10
Soil Type		sand
Porosity	cm3/cm3	0.33
Effective Porosity	cm3/cm3	0.25
Hydraulic Gradient	ft/ft	0.006
GW Velocity	ft/yr	131.49
Eff. Pore Voume Occupancy		83%
Application Summary		
Spacing Within Rows (ft)		5.0
Number of Rows		2.0
DPT Injection Points		44
Product Dosage		
PlumeStop	lbs	7,700
S-MZVI	lbs	
HRC	lbs	
BDI Plus	Liters	
Water Required	gallons	14,545
Total Volume Applied	gallons	15,400

PlumeStop		
Off-Site Barrier		
Design Parameters	**Unit**	**Value**
Treatment Type		Barrier
Distance Perpendicular to Flow (ft)		90
Top Application Depth (ft bgs)		9
Bottom Application Depth (ft bgs)		19
Vertical Treatment Interval	ft	10
Soil Type		sand
Porosity	cm3/cm3	0.33
Effective Porosity	cm3/cm3	0.25
Hydraulic Gradient	ft/ft	0.006
GW Velocity	ft/yr	131.49
Eff. Pore Voume Occupancy		59.4%
Application Summary		
Spacing Within Rows (ft)		4.00
Number of Rows		1.33
DPT Injection Points		30
Product Dosage		
PlumeStop	lbs	6,300
S-MZVI	lbs	-
HRC	lbs	-
BDI Plus	Liters	-
Water Required	gallons	6,801
Total Volume Applied	gallons	7,500

Linde Praxair

Stantec

November 22, 2022

Figure 1-Injection Location Map for Praxair On-Site Barrier

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Figure 2-Injection Location Map for Off-Site Residential Barrier

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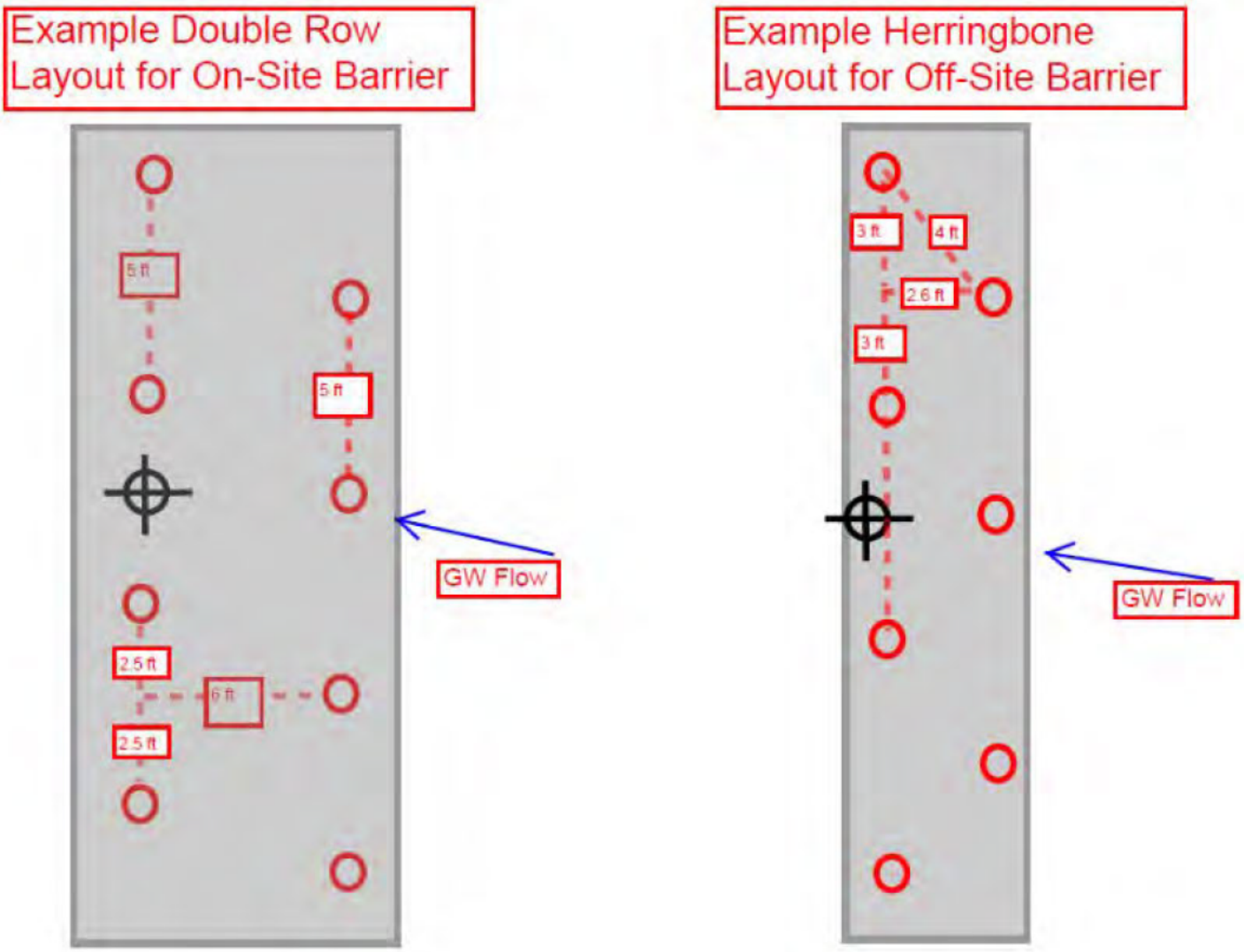

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Figure 3

Injection Point Configurations

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Technical Approach

We are proposing the application of PlumeStop to treat residual contaminants in groundwater. PlumeStop, a form of colloidal activated carbon, is an innovative groundwater remediation technology designed to readily distribute in the subsurface and to rapidly remove contaminants from groundwater to meet remedial targets. PlumeStop is composed of very fine particles of activated carbon (1-2 µm) suspended in a proprietary organic polymer dispersion chemistry and is applied under low injection pressures. The colloidal activated carbon particles are dispersed from the injection point before binding to the soil matrix to create a permeable zone with an extensive sorption capacity. Contaminants then passively flow through the PlumeStop zone where they are rapidly adsorbed out of the groundwater, preventing further migration. Additional information regarding the technology can be found via the links below.

TECHNICAL BULLETINS

- PlumeStop® Technical Bulletin 2.1: Sorption of Contaminants from Solution
- PlumeStop® Technical Bulletin 2.2: Sorption of Contaminants from Solution-Column Study
- PlumeStop® Technical Bulletin 3.1 Post-Sorption Contaminant Biodegradation
- PlumeStop® Technical Bulletin 4.1: Regeneration of Sorptive Capacity
- PlumeStop® Technical Bulletin 6.1: Treatment Solution of Back Diffusion-Tank Study

CASE STUDIES

- PlumeStop Case Study-Michigan Plating Facility
- PlumeStop® Case Study: Site Goals Achieved Within 2 Months at Manufacturing Facility

Performance Monitoring

Over time, groundwater down gradient of the barriers will clean up. Groundwater flow velocity will largely dictate how rapidly contamination will clean up down gradient of the barriers. Based on an average groundwater flow velocity of approximately 130 ft per year, we estimate that the cleanup will progress at an approximate rate of 50 feet per year down gradient of each of the barriers considering contaminant retardation. We anticipate monitoring wells within 5 feet of the barrier will meet the performance objectives within 3 months post injection. Initial performance will be partially dependent upon how quickly PlumeStop destabilizes post injection and permanently coats the aquifer. The long-term effects of the residential PlumeStop barrier will reach HP-9 in approximately 1.5 years post injection and will reach MW-6 in approximately 2.5 years post injection. To measure performance at your site, we recommend the following analytical parameters be collected at key wells within the zone of influence of treatment.

The table below outlines recommended performance monitoring parameters for each of the barriers.

Performance Monitoring Parameters	
Geochemistry Parameters	**Method**
pH	Field
Dissolved Oxygen (DO)	Field
Oxidation Reduction Potential (ORP)	Field
Conductivity	Field
Temperature	Field
Volitle Organic Compounds	EPA 8260

Design Verification Testing (DVT)

Design Verification Testing (DVT) is a term used to describe a suite of field sampling/testing activities carried out before implementing a subsurface substrate injection program. The purpose is to verify that the subsurface conditions at the selected application location match those conditions used in the design. Performing the DVT step provides critical data input to the design team allowing to adjust the necessary elements in the design. These design adjustments significantly improve substrate placement and result in an overall improvement in remedial performance and reduction in overall project cost.

Below are the flux meter DVT data for MW-2 and HP-5 which clearly define the target zones and preferred contaminant pathways at each of these locations. The contaminants appear to be migrating at approximately the same elevation and within the same geology when considering that there is a 5 ft elevation change between these two monitoring wells. The flux meter data has helped Regenesis focus the PlumeStop at the correct target intervals for each barrier. The off-site barrier was adjusted to the 9 to 19 ft interval and the on-site barrier was shifted to the 14 to 24 ft interval.

Summary of flux average contaminant concentration

Well_ID	Sample_ID	Depth below top of well casing (ft)	Darcy Velocity (cm/day)	TCE (ug/L)	Seepage Velocity ft per year	Flux Distibution %
HP-5	HP5-5.0-6.8	5.9	0.0	0.0	0.0	0%
	HP5-6.8-8.4	7.6	0.0	0.0	0.0	0%
	HP5-8.4-10	9.2	0.8	0.0	38.0	0%
	HP5-10-11.6	10.8	0.2	1.3	11.1	1%
	HP5-11.6-13.3	12.5	2.2	4.1	107.3	31%
	HP5-13.3-15	14.2	2.5	7.9	122.0	68%
MW-2	MW2-14.7-16.2	15.5	1.3	1.0	61.6	3%
	MW2-16.2-17.8	17.0	2.3	1.4	108.7	8%
	MW2-17.8-19.5	18.7	3.9	4.4	187.7	41%
	MW2-19.5-21.2	20.4	1.8	10.4	86.6	45%
	MW2-21.2-22.8	22.0	1.4	0.4	66.8	1%
	MW2-22.8-24.5	23.7	0.8	1.1	36.2	2%
	Yellow highligh denotes main contaminant transport zones					

Additional DVT items, which consists of soil borings and grain size analysis, can be completed during the first day of start up at each of the barrier locations. At least two soil cores should be completed at each barrier to provide RRS with a better understanding of the site geology prior to injection. The proposed borehole locations are shown on Figures 1 and 2. The two cores installed on the residential property should be converted into 1" diameter monitoring wells and screened from 9 to 19 ft bgs. Baseline groundwater samples should be collected from these two new wells prior to the PlumeStop application. These cores conducted during the DVT will also aid in the Placement Validation process discussed below.

Placement Validation

Placement Validation (PV) seeks to evaluate that the designed injection point spacing and volumes are adequate to achieve proper distribution within the target treatment zone. Evaluation will be based on the reagent fluid monitoring at nearby monitoring locations during the injection process and modifications may be made to the design if initial field tests are not satisfactory. PV is used to document visual PlumeStop sorption onto aquifer materials after its initial colloidal fluid state.

RRS will utilize both the existing monitoring wells, newly installed wells during the DVT and soil cores to confirm the emplacement of PlumeStop at the site. RRS will begin with injection points near existing monitoring wells. The wells will be monitored for dissolved oxygen, ORP, pH, temperature, conductivity and groundwater depth. Stantec will provide the necessary field equipment and assist Regenesis in collecting groundwater monitoring data. Considering that most of the monitoring wells are <2" in diameter, Regenesis recommends that Stantec use a peristaltic pump and flow through cell to measure changes in groundwater during the application. Groundwater will also be examined for color changes which are evidence of PlumeStop. PlumeStop is visually detectable in groundwater at concentrations greater than 50 mg/L. As the concentrations of PlumeStop increase, Regenesis has field test kits for measuring the concentration of PlumeStop observed in the monitoring wells. Only a portion of the PlumeStop injected is expected to show up in the nearby monitoring wells.

In addition to monitoring PlumeStop distribution and emplacement, both newly installed and existing monitoring wells will be used to monitor groundwater elevations closely to measure the hydraulic effects the application has on the aquifer. If necessary, the injection concentration of PlumeStop will be increased to reduce the overall injection volumes. Upon completing several injection points within a given area, RRS will install soil borings to inspect the soil for PlumeStop. A total of four post injection confirmation borings are planned, which is two for each barrier. On the residential property the soil borings will be drilled to 19 feet. On the Praxair property the soil borings will be drilled to 24 feet. The post injection soil cores will be compared to those collected from the DVT immediately prior to the application.

Technical Resources

Included below is a list of technical resources for the project.

- Plumestop Technical Bulletin 1.1: Distribution Through a Permeable Medium
- PlumeStop® Technical Bulletin 2.1: Sorption of Contaminants from Solution
- PlumeStop® Technical Bulletin 2.2: Sorption of Contaminants from Solution-Column Study

Performance Objectives

Purpose/Goals

The purpose of this remedial approach is to address off site migration concerns at the property boundary and the residential property. The goal will be to reduce TCE concentrations to <0.5 ug/L in all monitoring wells listed below. The time frame to achieve the performance objectives will be increased the greater the distance the monitoring well is from the barrier. Monitoring wells within 5 feet of the barrier should reach their performance objective within 3 months post injection. HP-9 is anticipated to reach its performance objective approximately 1.5 years following the application of PlumeStop. MW-6 is anticipated to reach its performance objective 2.5 years following the application. The table below outlines the baseline concentrations for key performance monitoring wells.

TABLE 2: BASELINE CONTAMINANT CONCENTRATIONS

Well ID	Groundwater Sampling Date**	Trichloroethene (ug/L)*
HP-1	April-2022	0.4
HP-2	April-2022	1.0
HP-3	April-2022	1.2
HP-5	April-2022	1.6
HP-8	April-2022	<1.0
HP-9	April-2022	1.9
MW-2	April-2022	1.7
MW-6	April-2022	1.7

* groundwater samp ing data reported in parts per bi ion (ppb)

** based on groundwater samp ing data as provided on Figure 4 entit ed "TCE Concentrations in Groundwater dated Apri 2022

Monitoring

To evaluate and measure performance at this site, monitoring wells shown on Table 2 will be utilized. Within this proposal it is suggested that groundwater monitoring parameters will be collected monthly for the first 3 months, and quarterly thereafter. To help support performance evaluations, REGENESIS requests the data collected be provided to us in a timely manner.

Qualifiers (Design Considerations)

Included below, a list of pertinent qualifiers has been provided to better define performance expectations at this site. REGENESIS will be happy to discuss these with you in detail.

- Seepage velocity is a primary driver of dose for PlumeStop projects. Based on the passive flux meters, the average groundwater velocity is approximately 130 feet per year.
- The proposed barriers are treating the shallow zone groundwater contaminants that extend to a depth of approximately 10 feet beneath the current groundwater table. Deeper portions of the contaminant plume, if they exist, may or may not be affected by the proposed treatment.
- Based upon our understanding of the flow dynamics the performance time frame is proportional to the monitoring well distance down gradient of the barrier.
- Two newly installed wells will be competed on the project start up/prior to injection on the Residential property. Approximate locations are marked on the map in **Figure 2**. It is anticipated, the wells will be installed on the first day of the project.
    - Newly installed wells will be sampled for baseline measurements before injection in the residential backyard begins.
- RRS will inject at a slower flowrate on locations in the residential backyard. This will reduce the chance for surfacing and impacting the basement.
    - While RRS will do everything we can to not impact the basement. We won't be held responsible for any treatment chemistry infiltration into the basement.
- RRS assumes a lower than typical production rate while working in the backyard due to workspace constraints, taking extra precautions to not tear up the yard or stain any concrete with PlumeStop.

Statement of Qualifications

RRS provides turn-key remediation planning, design, and application services. RRS field scientists are college degreed professionals that understand an accurate remediation design using the proper chemistry and appropriate dosage can fail to show good performance if management of the injection program is not performed in a manner to validate the intended treatment rationale and design. They have the unique background and experience to understand the significance of modifications made in the field. No one has more professional experience handling and applying in-situ remediation products than RRS personnel. The direct management of the injection program through RRS will optimize the design and ultimately the overall performance of the injection program.

For years, RRS has been offering industrial leading application services combined with excellence in field activity management. Our success is achieved after meeting cleanup objectives established by the environmental engineering firms who contract our services. To produce this outcome, we field project teams with the experience, discipline and dedication to work hand-in-hand with our client to address the unique requirements of each project site. Technical insight and timely, direct and honest communication are hallmarks of RRS. Our reputation for meeting or exceeding clients' objectives and those of environmental regulators has been proven in project successes throughout North America.

Further information on what sets RRS apart are provided in the following technical resources:

RRS: Performance Driven, Results Based
The RRS Difference

With decades of application experience, RRS is strategically located across the country to mobilize and assist on a wide range of sites throughout the US.

Over 100 Projects Completed Annually Across the US

RRS Scope of Services

RRS will work under the direction of Stantec to implement the field work associated with the application of the selected remediation technologies. Responsibilities for the implementation of this scope of work will be shared between RRS and Stantec. Responsibilities for each are outlined in this section and further under the Assumptions/Qualification section.

At the beginning of each day a safety tailgate meeting will be conducted and an overview of the procedures, responsibilities and goals for the day will be discussed. RRS will be equipped with multiple injection tool options to use with 1.5-inch diameter DPT rods.

The injection tool string will be advanced to the top or bottom of the TTZ and injections will be performed in a bottom-up or top-down method depending on site and lithology conditions. The remediation technologies will be mixed in an injection trailer (Figure 4) with water in batches at the designated solution percentage and kept in constant suspension throughout the injection application. Pressures, flow rates and total volume will be monitored and digitally documented for each injection interval. Multiple injection points may be injected into simultaneously to increase efficiencies on-site. The injection points and surrounding areas will be monitored for any signs of surfacing and a spill response kit will be on standby.

During the application, real-time information will be collected and analyzed to help verify design assumptions and subsurface reagent distribution. Depending on the primary product applied, data collected and analyzed may consist of groundwater quality parameters (i.e., pH, conductivity, DO, ORP, etc.), depth to water measurements, visual indicators through groundwater or soil samples, and in-field injection concentration test kits. This information is typically collected during the application when within 10 feet of an appropriately screened monitoring well. Based on the information collected, the project team may choose to modify the remediation design to further optimize the injection application. This includes modification to injection concentrations, volume per vertical foot, injection intervals, etc.

Once the injection event is completed, RRS will demobilize all equipment and personnel off-site. A detailed injection summary report which includes injection point data (interval depths, injection pressure/flow rates, reagent volume, time elapsed and if surfacing occurred), field observations and any other noteworthy information will be generated and made available to Stantec.

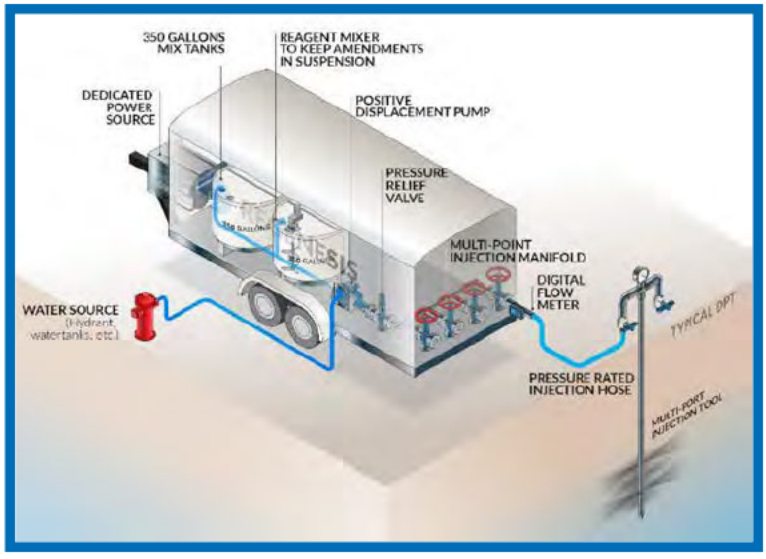


Figure 4: RRS Application Trailer

Scope of Services Summary	
Application Type	**Direct-Push Injection**
Volume	**22,900 gallons**
# of Injection Points	**74**
RRS Days On-Site	**14**
Direct-Push Services Provided by	**REGENESIS**

Project Responsibilities

RRS will:

- Provide and ship the specified quantities of the remediation reagents to the site address provided by Stantec. RRS shipping estimates assume all products will be shipped to the site at the same time.
- Coordinate with Stantec prior to any shipment of product. Alternative shipping locations or phases could lead to an increase in freight costs.
- Mobilize a 40-hour HAZWOPER certified crew experienced in the proper application of REGENESIS remediation technologies.
- Provide a forklift to maneuver the product containers for the duration of the project.
- Contract a qualified, licensed DPT drilling operator equipped with the necessary tooling and materials to safely complete the application scope of work outlined within this proposal. Necessary equipment includes track-mounted DPT rig capable of reaching depth, two-person crew, enough rods to drill up to 5 locations simultaneously, Teflon tape for all rod joints, granular bentonite, and bentonite chips.
- Provide a 500-gallon water wagon to transport water from on-site source to western barrier area.

Stantec will:

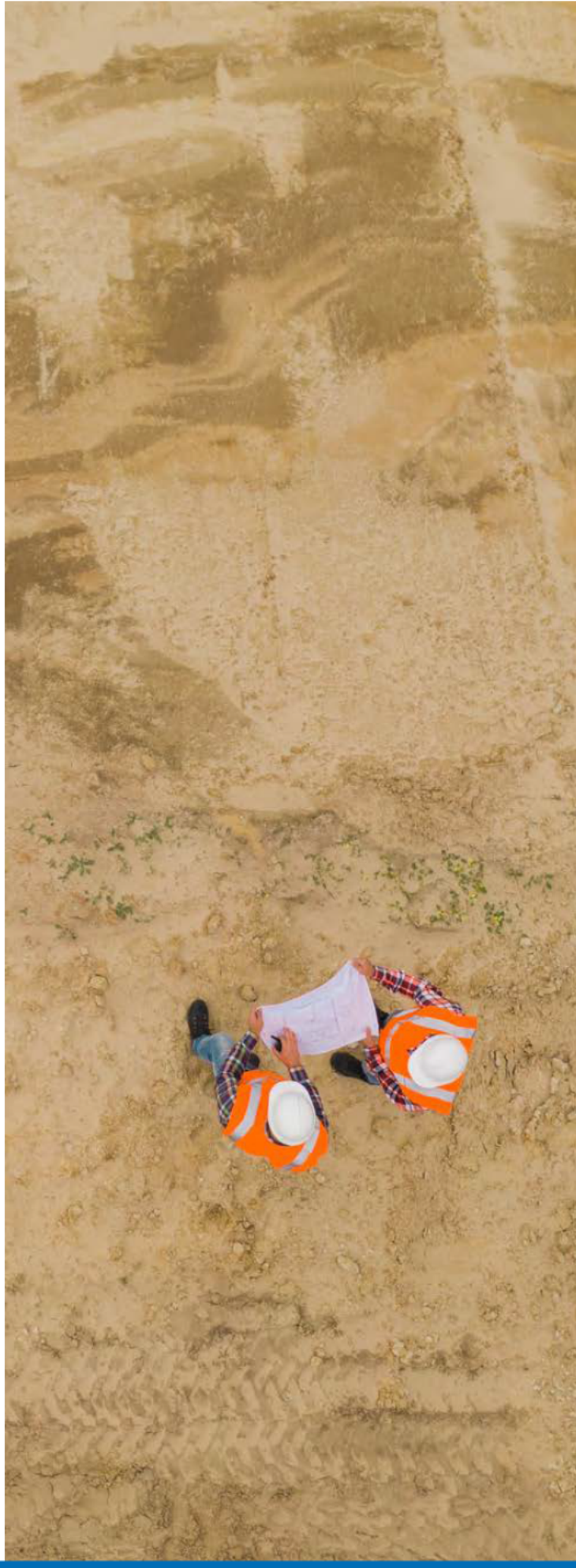
- Coordinate project schedule and reagent order with REGENESIS to ensure adequate shipping and mobilization time.
- Coordinate site access with property owner to coincide with project schedule and identify a secure product staging area.
- Take delivery of the remediation chemistry prior to RRS mobilization and stage inside a secure storage location where the material will not be affected by inclement weather or freezing conditions. During injection activities, Stantec will ensure the product is stored in a location accessible by the RRS-rented forklift.
- Should private underground utilities be within the treatment area, Stantec will contract with a private utility locating service to mark utilities prior to RRS mobilization.
- Provide a water source (e.g. hydrant or other source at Linde facility) capable of producing at least 30 GPM for the duration of the project, at no cost to RRS.
- Be responsible for disposal or recycling of totes, drums, pails and pallets. All nonhazardous refuse will be collected and placed in a Stantec-provided on-site refuse container for disposal. RRS will collect project related refuse and empty treatment chemistry containers daily to keep the site clean.
- Be responsible for transportation and disposal of any contaminated waste generated on-site during injection activities, though we do not anticipate generating any such waste during injection activities.
- Provide field water quality meter similar to a YSI 556 with a down-hole sensor, a water level meter, bailers and a technician while on-site for injection activities to assist RRS in assessing groundwater from monitoring wells.

Services Assumptions and Qualifications

In generating this proposal, REGENESIS relied upon professional judgment and site-specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site. The attached design summary tables specify the assumptions used in preparation for this technical design. We request that these modeling input assumptions be verified by your firm prior to application of the product. Other assumptions and qualifications related to this proposal are as follows:

- The product and services cost outlined will be valid for 60 days from date of proposal. If beyond 60 days, REGENESIS reserves the right to update cost.
- The freight charges included for product delivery above are estimated at the time of proposal generation. Actual freight charges are neither set nor guaranteed by REGENESIS and are calculated when the product order is placed. This price may vary from what is estimated above. Actual freight charges for product delivery will be invoiced.
- Freight delivery time frames cannot be guaranteed and RRS will not be responsible for any delays or any resulting increase in cost associated with those delays.
- If applicable, sales tax charges for product, freight, and services are considered estimated at the time of proposal submittal. The appropriate sales tax category (i.e., product, freight, and services) and actual sales tax rate is finalized at the time of invoice and may change from date of proposal submittal.
- RRS will have access to the site for equipment operation and secure storage of materials and equipment throughout the duration of the project. All access to each work area location will be clear and free of obstructions. RRS also assumes the injection trailer will be staged within 80 feet of the furthest injection point location.
- Stantec is responsible for securing any permits prior to mobilizing to the site.
- Stantec is responsible for all soil, air, and groundwater sampling and analysis.
- For safety reasons, access to the treatment area will be limited to RRS and Stantec personnel.
- The remediation design and injection procedures contain the necessary precautions to minimize the likelihood of surfacing of the treatment chemistry. RRS will monitor treatment chemistry application flow rates and pressures as well as observe for signs of reagent surfacing around active injection areas. If surfacing is detected, RRS will stop or slow down injection activities at that location to stop additional surfacing and remove/vacuum up recoverable surfaced fluid. RRS is not be responsible for treatment chemistry infiltration into undesired locations beyond our visible control.
- RRS personnel will have access to the site for work up to 12 hours per day Monday through Friday (daylight hours). However, the standard workday does not exceed 10 hours with travel time Monday through Friday. A 10-hour workday does not mean 10 hours on-site and/or injection pumping. Additional charges may apply for Saturday and/or Sunday work schedules.
- RRS is not responsible for damage to unmarked utilities and subsurface structures. Stantec will review as-built drawings with RRS to confirm clearance prior to advancing DPT injection tooling and marking injection point locations.
- Pricing and work schedule assume union labor and prevailing wages (Davis-Bacon) are not required.

- This proposal assumes probing and drilling will begin at the ground surface. RRS has included costs for the drilling subcontractor to concrete core locations in the backyard. If hand auger or air knife services are required, additional charges, including surface restoration charges could apply.
- RRS assumes that direct-push style drill rig can access all injection point locations and drive injection tooling to the required depth. If site conditions limit the use of the provided direct-push rig for any injection point and other drilling methods are required to complete the task, additional charges will apply.
- All traffic control requirements, if necessary, will be provided by Stantec.
- All injection points will be closed/backfilled with bentonite to ground surface by RRS' drilling subcontractor. Additional costs associated with restoration of the ground surface have not been included. If restoration of the ground surface is needed, additional charges will apply.
- Site conditions can change over time and should be monitored post injection. REGENESIS is not responsible for changing site conditions after completing the scope of work and demobilizing from the site. This includes but is not limited to changes related to borehole abandonment (i.e., swelling of backfill material), surface restoration, well conditions, and on-site utilities.



Health and Safety Plan

REGENESIS is committed to providing a safe and healthy working environment for all employees, Stantecs and contractors on-site. Prior to mobilization RRS will develop a site-specific Health and Safety Plan (HASP) and designate an on-site safety officer. All personnel on-site are required to participate in daily safety tailgate meetings with the goal of proactively identifying potential hazards and mitigating risks to the full extent possible.

In addition to the hours of rigorous safety training courses all personnel are required to complete, REGENESIS also incorporates a behavior-based safety program by utilizing our DoneSafe mobile application (app) interface on every site. This app encourages our personnel to actively search for potential on-site risks and document mitigation actions taken. The effectiveness of our safety program can be seen in our industry leading EMR ratings listed in Table 3.

Year	Total Hours	EMR
2021	125,592	0.71
2020	162,037	0.64
2019	169,964	0.66
2018	144,600	0.70
2017	140,706	0.70

RRS safety tailgate meetings and HASP will include the following:

- Site map with entrance and exit points and best possible muster points depending on conditions.
- List of personnel and contact information for employees on-site and supporting the project.
- Route to the nearest occupational treatment facility and hospital along with contact information.
- Job Hazard Analysis (JHA) detailing each job task on-site with its potential hazards and best practices to avoid those hazards.
- Description and hazards of the contaminants of concern (COC) with appropriate Personal Protection Equipment (PPE) requirements.
- COVID-19 precautions will be discussed, and personnel will be equipped with face coverings.
- List and description of REGENESIS chemicals on-site including a Safety Data Sheet (SDS) for each chemical.
- Checklist of site safety equipment including fire extinguishers, eyewash station, first aid kit, spill prevention kit and any site-specific equipment needed.
- Daily Tailgate safety meeting sheet with identified hazards and risks associated with the site and job tasks for that day, along with shared learning observations from the previous day.

Detailed Design Table

Project Info
Linde Praxair
Salt Lake City, UT
Dissolved Phase Contaminant Mass
Prepared For:
Stantec

Target Treatment Zone (TTZ) Info	Unit	Value
Barrier Length	ft	110
Top Treat Depth	ft	14.0
Bot Treat Depth	ft	24.0
Vertical Treatment Interval	ft	10.0
Treatment Zone Volume	ft^3	9,900
Effective Porosity	cm^3/cm^3	0.25
Treatment Zone Pore Volume	gals	24,439
Treatment Zone Effective Pore Volume	gals	18,514
Treatment Zone Pore Volume	liters	92,511
Treatment Zone Effective Pore Volume	liters	70,084
Fraction Organic Carbon (foc)	g/g	0.002
Soil Density	g/cm^3	1.7
Soil Density	lb/ft^3	108
Soil Weight	lbs	1.1E+06
Hydraulic Conductivity	ft/day	16.0
Hydraulic Conductivity	cm/sec	5.64E-03
Hydraulic Gradient	ft/ft	0.006
GW Velocity	ft/day	0.35
GW Velocity	ft/yr	129

Sources of Hydrogen Demand	Unit	Value
Dissolved Phase Contaminant Mass	lbs	0
Sorbed Phase Contaminant Mass	lbs	0
Competing Electron Acceptor Mass	lbs	18
Total Mass Contributing to H2 Demand	**lbs**	**18**

Mass Flux and HRC Demand	Unit	Value
Groundwater Mass Flux through TTZ	L/day	2,741
Stoichiometric HRC Demand	lbs	107
Mass Flux HRC Demand	lbs	1,157
Total HRC Demand	**lbs**	**1,264**

Application Dosing	Unit	Value
PlumeStop to be Applied	**lbs**	**7,700**

PlumeStop® Application Design Summary

Dissolved Phase Plume - On-Site Treatment

PlumeStop	
Treatment Type	**Barrier**
Distance Perpendicular to Flow (ft)	110
Spacing Within Rows (ft)	5
Number of Rows	2
DPT Injection Points	**44**
Top Application Depth (ft bgs)	14
Bottom Application Depth (ft bgs)	24
PlumeStop to be Applied (lbs)	**7,700**
PlumeStop to be Applied (gals)	855
PlumeStop Volume Totals	
Mixing Water (gal)	14,545
Total Application Volume (gals)	**15,400**
Injection Volume per Point (gals)	350

Technical Notes
Injection Radius for Soil Coverage (ft-est avg.)
3.4
PlumeStop Inject. Conc. (mg/L)
11,983
Special Instructions:
Gallons Per Foot
35.00

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s). The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing guidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the Government.

Prepared by: Christopher Lee - Sr. Design Specialist
Date: 11/1/2022

Detailed Design Table

Project Info		
Linde Praxair		
Salt Lake City, UT		
Dissolved Phase Contaminant Mass		
Prepared For:		
Stantec		
Target Treatment Zone (TTZ) Info	**Unit**	**Value**
Barrier Length	ft	90
Top Treat Depth	ft	9.0
Bot Treat Depth	ft	19.0
Vertical Treatment Interval	ft	10.0
Treatment Zone Volume	ft^3	6,750
Effective Porosity	cm^3/cm^3	0.25
Treatment Zone Pore Volume	gals	16,663
Treatment Zone Effective Pore Volume	gals	12,623
Treatment Zone Pore Volume	liters	63,076
Treatment Zone Effective Pore Volume	liters	47,785
Fraction Organic Carbon (foc)	g/g	0.002
Soil Density	g/cm^3	1.7
Soil Density	lb/ft^3	108
Soil Weight	lbs	7.3E+05
Hydraulic Conductivity	ft/day	16.0
Hydraulic Conductivity	cm/sec	5.64E-03
Hydraulic Gradient	ft/ft	0.006
GW Velocity	ft/day	0.35
GW Velocity	ft/yr	129
Sources of Hydrogen Demand	**Unit**	**Value**
Dissolved Phase Contaminant Mass	lbs	0
Sorbed Phase Contaminant Mass	lbs	0
Competing Electron Acceptor Mass	lbs	13
Total Mass Contributing to H2 Demand	**lbs**	**13**
Mass Flux and HRC Demand	**Unit**	**Value**
Groundwater Mass Flux through TTZ	L/day	2,243
Stoichiometric HRC Demand	lbs	73
Mass Flux HRC Demand	lbs	947
Total HRC Demand	**lbs**	**1,020**
Application Dosing	**Unit**	**Value**
PlumeStop to be Applied	**lbs**	**6,300**

PlumeStop® Application Design Summary

Dissolved Phase Plume Off-Site (Residential Barrier)

PlumeStop		Technical Notes
Treatment Type	**Barrier**	Injection Radius for Soil Coverage (ft-est avg.)
Distance Perpendicular to Flow (ft)	90	2.9
Spacing Within Rows (ft)	4.00	
Number of Rows	1.33	PlumeStop Inject. Conc. (mg/L)
DPT Injection Points	**30**	20,131
Top Application Depth (ft bgs)	9	
Bottom Application Depth (ft bgs)	19	
PlumeStop to be Applied (lbs)	**6,300**	
PlumeStop to be Applied (gals)	699	**Special Instructions:**
PlumeStop Volume Totals		**Gallons Per Foot**
Mixing Water (gal)	6,801	25.00
Total Application Volume (gals)	**7,500**	
Injection Volume per Point (gals)	250	

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to effect remediation of the site.

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Prepared by: Christopher Lee - Sr. Design Specialist
Date: 11/1/2022

APPENDIX C

STANTEC'S STANDARD OPERATING PROCEDURES

Stantec

STANDARD OPERATING PROCEDURES: ENVIRONMENTAL BOREHOLE DRILLING AND SOIL SAMPLING

SOP ES2.03
Version: 2.0 (Last revised May 11, 2020)
Approved by:
Don Carey, M.Sc., P.Eng., National Technical Leader, Site Investigation
Michelle Fraser, M.Sc., P.Geo., National Technical Leader, Hydrogeology
Discipline(s): Hydrogeology, Site Investigation

1 PURPOSE AND SCOPE

This document defines standard procedures for borehole drilling and collecting soil samples below depths of 1.5 m. Boreholes are typically used to investigate the geology, obtain soil data, and facilitate the installation of monitoring wells for the subsequent recovery of groundwater samples. This method gives descriptions of equipment and field methods necessary to supervise drilling programs and collect and classify soil samples. Refer to SOP *ES2.04 – Environmental Rock Coring and Classification* for drilling in bedrock and SOP *ES3.01 Monitoring Well Installation*, *ES3.02 Production/Test Well Installation*, and *ES3.04 Borehole/Monitoring Well Abandonment* for borehole completion.

2 PRE-MOBILIZATION

2.1 HEALTH AND SAFETY

Confirm RMS1 and RMS2 forms and other applicable safety forms are reviewed, filled in, updated and followed. Review applicable Safe Work Practices (SWPs) as required. Confirm field staff has the necessary training to complete the work safely.

2.2 PLANNING

Identify and obtain required permits for activities such as working in a roadway or working near a water body.

- A road-occupancy permit, including a traffic-control plan and traffic-control subcontractor, is usually needed on a road allowance.
- No subsurface work is to be completed without underground locates regardless of the area in which the work is being completed.
- Depending on jurisdiction, waste-generator registration, for off-site disposal of contaminated or suspect soil generated during drilling, may be needed.

Discuss program purpose and scope of work with the project manager; review proposal and all proposed borehole locations. If available, review site photographs, field records, borehole or test pit logs, cross sections, and data from previous subsurface investigations to determine expected soil types and site conditions. Determine approximate ground surface elevation for comparison to expected subsurface stratigraphy and installation depths.

2.3 BOREHOLE LAYOUT AND PROGRAM DETAILS

Obtain all necessary public and private utility locate information prior to confirming final borehole locations (refer to SWP 213).

Carefully mark planned borehole locations on a site plan or map. If precise positioning of the borehole locations is required to permit accurate delineation of subsurface conditions, GPS coordinates can be determined and loaded into a GPS unit of sufficient accuracy to locate the points, or sampling locations can be determined relative to known reference points. Alternatively, arrangements can be made to survey the subsurface soil sampling locations. See *SOP ES3.05 Surveying* for instructions on elevation surveying. If structures are present on the site, 1m x 1m reference grids can be added to site plans so field staff can line up their sample locations in the field, relative to the structures.

If the boreholes cannot be surveyed immediately, a stake should be placed in the ground at the borehole location for subsequent surveying. Boreholes that will not be surveyed should be located relative to a known reference point(s) using a tape and the location plotted on the site plan or map. The surface elevation of the boreholes may be determined using survey methods (preferred method) or obtained from a detailed contour plan of the area. Sample depths and the total borehole depths should be related to this known surface elevation. A GPS measurement may be required for remote and/or large sites.

2.4 FLOWING BOREHOLES

Deep boreholes located in low-lying areas can produce groundwater discharge that, if left uncontrolled, could result in loss of the upper bentonite seal, local land erosion, property damage or local aquifer depressurization. Some jurisdictions require that abandoned flowing boreholes be properly plugged to prevent artesian discharge. In such situations, it may be necessary to grout the borehole from bottom to top, place a packer seal above the water source, or abandon the hole with alternating layers of silica sand and bentonite. Before commencing drilling, discuss with the Project Manager if this may be a concern and what measures should be taken if flowing boreholes are encountered.

2.5 SOIL SAMPLING

The Project Manager should determine sample analysis and preservation requirements before the start of the program, along with the need for, and the type of, QA/QC samples that will be collected. Sample naming conventions will be determined by the Project Manager in accordance with *SOP ES4.02 Sample Naming Protocol.*

2.6 EXCESS SOIL STORAGE AND DISPOSAL

The Project Manager must determine methods for addressing excess soil generated during borehole drilling, in consultation with the client and/or property owner, before starting the program. If required, this plan could include storing the excess soil on polyethylene sheeting, in drums or used as backfill (pending Provincial requirements). Any offsite transportation and disposal must be conducted in accordance with provincial and federal legislation.

2.7 DRILLING DISCHARGE

A plan to address the discharge of drilling fluids generated as part of the drilling program must be determined by the project manager, in consultation with the Client and/or property owner, prior to commencing the drilling program. If required, this plan could include storing the excess drilling fluids in drums (pending Provincial requirements). Any offsite transportation and disposal must be conducted in accordance with provincial and federal legislation. For sites where contamination is not a concern the drilling fluid could usually be allowed to infiltrate on site.

2.8 ITEMS TO TAKE INTO THE FIELD

2.8.1 Mandatory Items

- Proper clothing for the activity and weather conditions
- All applicable HSE Forms
- All necessary permits
- Required PPE (SWP 105)
- Site plan with proposed borehole locations
- Any other relevant site/project information
- Field forms (Section 5.2)
- Completed Utility Clearance Forms (SWP 213)

2.8.2 Consumables

- Waterproof permanent markers
- Laboratory-prepared/supplied sample bottles
- Survey stakes and/or spray paint
- Clean cooler and ice
- Laboratory chain-of-custody forms
- De-ionized water
- Phosphate-free detergent
- Paper towels or Kimwipes

- Garbage bags
- Plastic soil sample collection bags (Ziploc or equivalent)
- Latex or Nitrile gloves
    - (*Note:* If potential contaminants of concern include VOC, BTEX or other light petroleum hydrocarbons, Nitrile gloves *must* be used).

2.8.3 Non-Consumables

Confirm all required equipment is available, clean and operational. Calibrate, handle, store and maintain equipment according to manufacturers' recommendations. Record the calibration results on *ESFF2.07 Field Instrument Calibration*. Confirm you have spare batteries and/or chargers as required. Following use, clean, maintain and store all equipment according to manufacturers' recommendations, and fill in and submit a Technical Recovery Form to confirm equipment costs are appropriately charged to the project. Equipment that may be required to complete this task includes:

- Battery-operated water level meter
- Photoionization Detector (PID, e.g. MiniRAE) and/or Organic Vapour Meter (OVM, e.g. RKI Eagle)
- Camera (or camera-equipped smart phone)
- Weighted measuring tape and/or measuring wheel
- Survey equipment
- Traffic control equipment (e.g., traffic cones, caution tape etc.)
- GPS unit
- Field Tablet
- Laminated "Field Guide for Soil and Stratigraphic Analysis"
- Stainless steel hand sampling tools (e.g., trowel)
- Two pails (for washing and rinsing sampling equipment)
- Calculator
- Scrub brush / wash tools

3 FIELD PROCEDURES

3.1 QUALITY ASSURANCE / QUALITY CONTROL

The following QA/QC procedures apply to borehole drilling and sample collection:

- To reduce the potential for cross-contamination, decontaminate non-dedicated equipment shall be decontaminated before use and between samples, in accordance with *SOP ES4.08 Equipment Decontamination.*
- All monitoring equipment (e.g., meters) should be calibrated in accordance with the manufacturers' instructions.
- Daily review and discussion of field forms with the Project Manager or Project Hydrogeologist. Sign off on field forms once reviewed for completeness.
- Confirm collection of field duplicates, trip blanks, field blanks, and rinsate samples per project requirements.
- Review of completed borehole logs and comparison with provincial water well record (if applicable) to confirm consistency.

3.2 BOREHOLE DRILLING METHODS

The borehole drilling methodology that will be used will be determined by the Project Manager. The following are the typical methodologies used, and information about which field staff should be aware.

3.2.1 Solid-Stem Auger Drilling

- Used to advance borings through overburden; not suitable in competent bedrock.
- Sampling soil using this method is not ideal because of formation disturbance.
- Augers must be removed from the borehole to permit access of a sampling device; therefore, the formation must be stable (e.g., silt or clay), or it may collapse. It is difficult to collect representative soil samples using solid stem augers when the borehole is subject to sloughing.
- This method can be used to install groundwater monitoring wells provided the saturated zone is comprised of fine-textured and stable soils. If the saturated zone is comprised of coarse-textured soils, the soils below the water table will likely collapse to the level of the water table as the augers are withdrawn.
- If auger refusal is encountered as the result of bedrock or boulders, the only way to absolutely distinguish between the bedrock and boulders is by coring.

3.2.2 Hollow-Stem Auger Drilling

- Used to advance borings through overburden; not suitable in competent bedrock.
- Provides a temporary casing in the borehole through which well pipes, sand-back backfill, bentonite seals, or more elaborate sampling equipment or instrumentation can be installed; therefore, preferable to solid-stem for installing wells.
- Each auger is typically 1.52 m (5 ft.) long and has a 108 mm (4.25 in.) ID and a 210 mm (8.25 in.) OD. The augers are connected together with bolts and are generally not water-tight.
- When advancing the augers, a cylindrical steel center plug is attached to drill rods, lowered inside the augers, and positioned at the tip of the lead auger. The center plug is held in the same relative position as the lead auger by advancing the drill rods along with the augers.
- The center plug is removed from the boring as required to permit soil sampling and reinstalled after sampling has been completed.
- Soil sampling is often completed using a split-barrel sampler, also referred to as a split spoon sampler. This sampling technique also provides standard penetration test (SPT) data. SPT involves driving a standard split-barrel sampler into the ground at the bottom of the borehole by blows from a slide hammer with a standard weight and falling distance. The split-barrel is driven 150 mm (6 inches) into the ground and the number of blows needed for the tube to penetrate each 150 mm interval up to a depth of 450 mm (18 inches) is recorded. The sum of the number of blows required for the second and third 150 mm of penetration is reported as SPT blow count value (commonly termed N-Value).
- Split-barrel samplers range in length from 0.46 m (1.5 ft.) to 0.76 m (2.5 ft.) and are typically 35 mm (1 3/8 in.) inside diameter (ID). Unless otherwise indicated by the Project Manager, split-barrel samples should be obtained at 0.76 m (2.5 ft.) depth intervals. If using a 0.61 m (2 ft) long sampler, 0.15 m (6 in.) of soil from each interval would remain unsampled.
- Alternatively, the center plug is not required when CME™ continuous samplers are used. The continuous sampler consists of a 1.52 m (5 ft.) long core-barrel sampler that is inserted through the annulus of the hollow stem augers. The sampler does not rotate with the augers. The open end of the sampler extends a short but adjustable distance beyond the auger head.
- Unlike the split-barrel sampler, the continuous sample is collected as the augers are advanced. After the augers and sampler have been advanced the desired depth, the loaded sampler is removed from the auger and replaced with an empty sampler. A continuous sampler is preferred to the split-barrel sampler when standard penetration test data are not required because of sample continuity and a greater sample volume is obtained.
- The CME™ continuous sampler is best suited to cohesive soils; however, relatively undisturbed samples of sand and non-cohesive deposits can sometimes be collected with this sampling

system. Adjustment of the distance the continuous sampler extends beyond the auger head may assist in sample recovery in non-cohesive soils.

- Sampling often completed using a split-spoon (also known as split barrel) sampler. This also allows for the collection of standard penetration test (SPT) data.
- Thin-walled tubes or Shelby tubes can also be used for sampling.
- If poor sample recovery is experienced in non-cohesive soils, a plastic or stainless steel sand trap may improve recovery.
- If heaving sands (sands under hydrostatic pressure) are encountered, potable water, if available, can be pumped down the augers to maintain a positive pressure head within the auger column.
- If auger refusal is encountered as the result of bedrock or boulders, the only way to absolutely distinguish between the bedrock and boulders is by coring.
- With most conventional drilling rigs (e.g. CME 75), drilling with augers is generally limited to depths of less than 46 m (150 ft.).

3.2.3 Direct Push

3.2.3.1 Geoprobe

- Uses a hydraulically powered percussion machine to install different types of sampling devices in unconsolidated materials.
- Sampling devices to collect soil, soil gas or groundwater can be installed.
- Soil recovery is generally good; use of casing facilitates well installation.
- Typical depths that can be achieved using this system are 10 m below ground surface (BGS) to 15 m BGS.
- Typically, a 19 mm ID monitoring well may be installed through the casing; however, 32 mm ID well materials may be installed through the open borehole.

3.2.3.2 Pionjar

- Uses a portable pneumatic hammer to advance a 0.76 m split-spoon sampler through overburden.
- A 32 mm ID monitoring well may be installed in the borehole annulus. Some contractors can overdrill the borehole using portable hollow stem augers to allow a 50 mm ID monitoring well to be installed.

3.2.3.3 Sonic Drilling

- Refers to slow rotary action and high frequency resonance down the drill stem or casing to the cutting bit.
- Generally produces undisturbed samples (102 mm ID core is standard); excellent for establishing detailed stratigraphy.
- Can be used in cobbly/boulder material, where augers would encounter refusal.
- As with hollow-stem, use of casing allows for well installation in formations that would otherwise collapse.
- Usually requires that water be brought to site, or on-site water supply used, to reduce drilling friction.

3.2.4 Mud Rotary Drilling

- Mud rotary drilling allows increased drilling speeds and the ability to reach greater depths in most formations. Can be used in consolidated or unconsolidated formations.
- Suitable for deep boreholes in overburden with cobbles or boulders, in formations where sands under hydrostatic pressure tend to heave upward, and in bedrock
- Borings are drilled using a truck-mounted drilling rig equipped with a system for circulating fluids (water or drilling fluids).
- Aqueous drilling fluids (drilling mud) prepared using specially manufactured products and water. The purpose of drilling mud is to cool and lubricate the bit, stabilize the borehole wall, limit the inflow of formation water, and remove drill cuttings.
- The borehole is advanced by rotating a bit (typically a tri-cone roller bit) attached to a drill rod through drill casing. HW sized casing (102 mm ID) is typically used with a 95 mm OD tri-cone bit when a 51 mm ID monitoring well is to be installed. Tri-cone bits are appropriate for use in consolidated formations. A drag bit is frequently used in unconsolidated formations.
- Drill cuttings are removed by water circulation. Water is injected inside the drill rods, down through the bit and out through the annulus and up to the surface. Unless there is loss to the formation, cuttings and drill water return to the surface outside of the drill rods within the borehole annulus.
- Typically, a mud pit is used to collect the return water and feed to fluid circulation system. It is possible to collect samples using a sieve as the return water discharges from the borehole; however, the samples are not representative of actual conditions since a significant portion of the fines are lost and the coarser fractions are broken down by the bit.

- Lithological changes are recognized by description of the samples returned in the drilling fluid. The depth of the changes may be identified by changes in hardness and changes in the rate of advancement of the drilling.

- Collection of in-situ, relatively undisturbed samples is possible using a split-spoon sampling device adapted to the drill rods or a wire-line; sampling slows drilling progress significantly; without split-spoon equipment, use of mud rotary for soil characterization not recommended.

- Suitable for deep boreholes in overburden with cobbles or boulders, in formations where sands under hydrostatic pressure tend to heave upward, and in bedrock.

- The use of circulated water or drilling mud should be considered with respect to its applicability for environmental projects. Generally, the volume of water or drilling mud introduced to the subsurface and not recovered (fluid loss) should be removed prior to groundwater sampling. The reason for this is that fluids, drilling mud in particular, may alter the water quality of the formation. Fluid loss can be calculated by recording the initial volume of water in the mud pit and subtracting the volume of water remaining in the mud pit upon completion of drilling. Another means to verify that all of the circulated drilling fluid has been recovered is to spike the drilling fluids with a known concentration (above background) of an inert tracer chemical. Tracer concentrations can be monitored during well development until background concentrations (indicative of a return to natural formation conditions) are achieved.

- The use of mud rotary drilling adjacent to production or residential wells is not recommended due to the possibility of the migration of drilling fluids through the aquifer.

3.2.5 Air Rotary Drilling

- Direct air rotary drilling is similar to mud rotary drilling except that the circulation medium is air rather than water or drilling mud. In this method, a large compressor is used to supply air through the drill rods to the drill bit.

- Direct air rotary drilling incorporating a casing driver (hammer) permits drilling in unstable overburden. Borehole is fully stabilized during drilling.

- Also, can be used in hard dense material (basal till, cobbles, boulders, bedrock).

- Cuttings are blown out through the top of the borehole and can be collected; however, these cuttings are generally not representative of in-situ conditions.

- Air rotary drilling in overburden is difficult due to the high potential for the hole caving in. Therefore, air rotary drilling is most appropriate for consolidated or semi-consolidated materials unless casing is used to prevent borehole collapse.

- Advantages of air rotary methods include: high penetration rates; not affected by cold weather; no plugging of aquifer with drilling fluids; estimates of formation water yield can be obtained during drilling; better identification of drill cuttings.

3.2.5.1 Direct Air Rotary with Down-the Hole Air Hammer

- Uses a pneumatic drill (hammer) operated at the bottom of the drill rods. Compressed air drives the hammer to provide a percussion effect and simultaneously removes the cuttings.
- Produces disturbed samples; not recommended when analyzing for volatiles.

3.2.5.2 Reverse Circulation

- Adaptation of the direct rotary (liquid or air) drilling method using a dual walled casing.
- Circulating medium (air, water, or mud) is pumped down between the outer casing and inner drill pipe, out through the drill bit and back up the inside of the inner drill pipe.
- Fluid loss can be minimized; however, samples are highly disturbed; not recommended when analyzing for volatiles.

3.3 BOREHOLE DRILLING SUPERVISION

Stantec field investigators engaged in supervising borehole drilling operations should:

1. Complete the top section of *ESFF2.02 Daily Activity Record*, *ESFF2.09 Sample Collection Record* and *ESFF2.23 Headspace Measurements*, as required.

2. Check in with property owner / client (if present) upon arrival at the site to discuss testing locations, schedule and work program. Accommodate the needs of the client / property owner as much as possible. Communicate any potential problems to the Project Manager as soon as possible.

3. Locate the boreholes according to the Project Manager's instructions after ensuring that the specified locations are within the subject property boundaries; can be drilled safely; and are clear of overhead and underground utilities or other structures (refer to *SWP 213* and *SWP 406*).

4. Confirm the driller and helper are using appropriate personal protective equipment. As a minimum, the Stantec field investigator should request Level D protective equipment.

5. Record sample ID number and sample location on a site plan and on applicable field forms.

6. Complete *ESFF2.18 Overburden Log*. Keep track of borehole ID and location using GPS instrument.

7. Use a consistent, systematic borehole naming system as directed by the Project Manager. Care should be taken to use unique borehole names, especially when completing supplemental investigations (e.g., avoid having two boreholes named BH1 on site).

8. Record all relevant observations / events related to drilling such as loss of equipment down-hole or volume of fluid added to the borehole, together with date and times.

9. Specify to driller appropriate sample depths and type and borehole completion depths.

10. Put on a clean pair of latex or Nitrile gloves (depending on the type of contaminant).

11. Once the sample has been obtained, the soil must be removed from the sampling device. Take care not to contaminate the sample through contact with either equipment or tools that have not been decontaminated, or with ungloved hands.

    - If sampling directly from the auger, carefully remove the soil from the auger, trimming about 1.0 cm from all sides of the sample prior to logging and storing.

    - If using a split spoon, place the split spoon on a flat surface and open the split spoon, taking care to disturb the sample as little as possible. Measure and record the soil recovery. Remove the soil from the upper end of the split spoon (most likely slough) and log the sample as described below.

    - If using a thin-walled tube or Shelby tube, measure and record the true soil recovery. Place the Shelby tube on a flat surface and carefully cut open the tube, taking care to disturb the sample as little as possible. Remove the soil from the upper end of the tube (most likely slough) and log the sample as described below. Alternatively, the tube ends can be trimmed and sealed, e.g. double bagged and taped (if less than 24 hours to extrusion is anticipated) for transport to the laboratory.

12. Identify, label, package and handle samples as described in *SOP ES4.02 Sample Naming Protocol.*

13. Log and classify soils according to the Unified Soil Classification System (USCS; ASTM 2488).

14. Fill the appropriate (lab-provided) containers with representative soil. As far as possible, confirm there is no headspace between the top of the soil and the inside of the lid, especially when

sampling for volatiles. Put remaining soil in plastic bag and/or core box if retaining remaining sample.

15. Label the soil sample containers with the following information:

- Project number
- Location
- Date (year/month/day/time)
- Borehole number (e.g., BH101, BH102, etc.)
- Depth (metres)
- Sample number
- Field investigator responsible for sampling
- If using core boxes or PVC splits, top and bottom should be marked

16. Store samples in a cooler at a maximum temperature of 10ºC, and preferably at a minimum temperature of 4ºC, except where otherwise required for testing.

17. Complete (including *signing and dating*) the laboratory-provided Chain of Custody form. As this is a legal document, it must be complete and accurate.

18. Upon completion of the borehole, check bottom depth with a tape measure before the augers are removed and check initial water level in the open borehole with a water level meter. Record these observations on the *ESFF2.21 Borehole/Monitoring Well/Drive-Point/Test Pit Completion Details*.

3.4 SITE PHOTOGRAPHS

Photographs should be taken of site conditions before any work is conducted and again just prior to leaving the site to confirm the site was left in an appropriate state. The requirement for other photographs will be determined by the Project Manager. If required, all significant geological and/or contaminant related features exposed at the sampling location should be photographed, with a scale included in the photographs to indicate dimension. After field work is completed, requirements like labelling and organization of photographs including things such as project number, sample name and the date of the photograph, indexing and use of *ESFF2.26 Photograph Log,* will be determined by the Project Manager.

4 DOCUMENTATION

4.1 MANUAL AND DIGITAL DATA STORAGE REQUIREMENTS

4.1.1 Hard Copy Notes

Confirm that field notes are accurate and complete. Provide them to the project manager for review and signature. Scan hard copy notes. Store hard copies in the project file.

4.1.2 Digital Data

Upload photographs to the server project file. Save data spreadsheets/databases and scanned hard copy notes in the server project file. If the local server is not automatically backed up regularly, save a back-up copy of data in another location.

4.2 GENERAL

Information to be documented will include the following, as applicable:

- Site name, project number and task number(s)
- Field investigator's name
- Borehole number
- Date and time of soil sample collection
- Sample numbers, locations, and depths
- Sampling method(s)
- Observations at the sampling site
- Unusual conditions (i.e., those that could affect observation and/or samples)
- Decontamination observations
- Weather conditions
- Names/contact information of all field crew members and of any site visitors should be noted on the *RMS2* form and the form should be signed as required by SWP procedures Location, description, and log of photographs
- References for all maps and photographs
- Information concerning sampling or scheduling changes, and any change orders

- Summary of daily tasks and documentation on any cost or scope of work changes required by field conditions List of field equipment used
- Signature (dated) of personnel responsible for observations

4.3 BOREHOLE RECORDS

Borehole records will be completed by the field investigator for each borehole completed. The borehole records will include the following information:

- Client
- Site Location
- Job and task numbers
- Borehole number
- Datum
- Field investigator
- Driller and company affiliation
- Borehole drilling equipment, method, and diameter
- Date started and completed (month/day/year)
- Completion depth
- Samples collected for laboratory analysis by depth of sample below surface, sample type, number and sample interval will be recorded
- Field screening results for soil headspace vapor measurements
- Origin of the lithologies (e.g., fill, glacial till, glacial outwash or alluvium, etc.), as well as descriptions of stratigraphy (lithology, grain size, sorting, texture, structure, bedding, colour, moisture content)
- Contaminant observations, if applicable (e.g., soil staining, presence of product, noticeable odours)
- Observations of any groundwater seepage into the borehole
- Borehole backfilling details (if monitoring well is not installed)

- Any other pertinent information

5 RESOURCES

5.1 RELATED SOPS

- SOP ES2.04 – Environmental Rock Coring and Classification
- SOP ES3.01 – Monitoring Well Installation
- SOP ES3.02 – Production/Test Well Installation
- SOP ES3.04 – Borehole/Monitoring Well Abandonment
- SOP ES2.01 – Environmental Surface Soil Sampling
- SOP ES3.05 – Surveying
- SOP ES4.08 – Equipment Decontamination
- SOP ES4.02 – Sample Naming Protocol

5.2 STANDARD FORMS

- ESFF2.02 – Daily Activity Record
- ESFF2.07 – Field Instrument Calibration
- ESFF2.16 – Underground Utility Locate Request
- ESFF2.18 – Overburden Log
- ESFF2.21 – Borehole - Monitoring Well - Drive Point - Test Pit Completion Details
- ESFF2.22 – Elevation Survey
- ESFF2.23 – Headspace Measurements
- ESFF2.26 – Photograph Log
- ESFF2.35 – Working Alone

1.0 PURPOSE & APPLICABILITY

The purpose of this document is to define the standard operating procedure (SOP) for collecting air samples in Summa canisters. The ultimate goal of the sampling program is to obtain samples that meet acceptable standards of accuracy, precision, comparability, representativeness, and completeness. All steps that could affect tracking, documentation, or integrity of samples have been explained in sufficient detail to allow different sampling personnel to collect samples that are equally reliable and consistent.

This procedure gives descriptions of equipment, field procedures, sample containers, decontamination, documentation, storage and holding times, and field QA/QC procedures necessary to collect air samples with Summa canisters.

This procedure may apply to all sampling by Stantec personnel or their subcontractors by the aforementioned sampling methods.

It must be recognized that field conditions may force some modifications to the SOP. Any modification to the procedure shall be approved by the Project Manager or Task Leader in advance and sufficiently documented so that the reason for the deviation can be clearly articulated to our clients and regulators, as necessary. Where SOP modification is planned sufficiently in advance, regulatory agency concurrence will be sought prior to conducting the specific activity.

2.0 DEFINITIONS

FSP	Field Sampling Plan
HASP	Health and Safety Plan
OSHA	Occupational Safety and Health Administration
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
WP	(Project) Work Plan

3.0 HEALTH AND SAFETY CONSIDERATIONS

Consideration of Health and Safety risks prior to performing this work is paramount. This risk review may be performed by modifying a generic or existing Job Safety Analysis in the HASP. There are many items to be considered. Following is a short list of the items for consideration. Careful review of these items and other site-specific conditions by the project team is essential.

- Traffic guidance and control. Even plans developed by outside traffic control contractors need to be carefully evaluated to make sure they are protective of our staff and contractors.

- Personal protective equipment, including hard hats, high-visibility traffic vest, gloves, appropriate clothing.

- Heat and cold stress.
- Biological hazards such as insects and spiders. Appropriate clothing is required such as long-sleeved shirts and long pants.
- Bloodborne pathogens. Some of our sites may have syringes and other drug paraphernalia that must be avoided.
- Chemical exposure on sites with open contamination. Respiratory protection may be necessary. Proper selection of respiratory protection is essential and an understanding of its limitation (i.e., negative pressure respiratory protection does not supply oxygen in an oxygen-deficient atmosphere). Staff should familiarize themselves with exposure limits for contaminants of concern.
- Use of air monitoring instrumentation will likely be necessary. We must be careful to make sure that our instrumentation is appropriate for the airborne contaminants of interest and that our staff understands the limitations of the instrumentation. Staff must also understand and perform calibration including zeroing with zero gas cylinders and appropriate other calibration gases.
- Noise and proper use of hearing protection devices such as ear plugs and/or muffs.
- Emergency action plan must be carefully coordinated in advance between Stantec, our subcontractors, the client, and emergency responders.
- Be aware of and use all necessary personal protective equipment (PPE) you may need while working with the canister.
- Do not connect Summa canisters to a source with positive pressure greater than 40 psi.
- Do not store Summa canisters in temperatures above140° F.
- Summa canisters should not be dented or punctured. Canisters with dents or punctures shall be taken from service.

All of these risks and others must be discussed with our subcontractors and clients to be sure they are properly addressed. Once the issues have been addressed at a project management level, they must be communicated to the staff that will actually perform the work. Details of procedures, instrument measurements and calibration, and other activities must be recorded in the field log and/or on data collection forms.

4.0 RESPONSIBILITIES

The Project Manager or Task Leader will be responsible for assigning project staff to complete air sampling activities. The Task Leader will also be responsible for assuring that this and any other appropriate procedures are followed by all project personnel.

The project staff assigned to the air sampling tasks will be responsible for completing their

tasks according to this and other appropriate procedures. All staff will be responsible for reporting deviations from the procedure or nonconformance to the Task Leader, Project Manager, or Project QA/QC Officer.

Only qualified personnel shall be allowed to perform this procedure. At a minimum, Stantec employees qualified to perform soil sampling will be required to have:

- Read this SOP.
- Read project-specific QAPP.
- Indicated to the Task Leader that all procedures contained in this SOP are understood.
- Completed the OSHA 40-hour training course and 8-hour refresher course, as appropriate.
- Previously performed air sampling activities generally consistent with those described in this SOP.

5.0 TRAINING / QUALIFICATIONS

Stantec employees who do not have previous experience with air sampling via Summa canisters will be trained on site by a qualified Stantec employee and supervised directly by that employee until they have demonstrated an ability to perform the procedures.

6.0 REQUIRED MATERIALS

The following is a typical list of equipment that may be needed to perform soil sampling:

- Photoionization detector (PID) or other air monitoring instrumentation if required by the HASP.
- Summa or Silo canister – cleaned and/or certified by the Laboratory, and leak checked prior to shipment. Canisters are available in several sizes, including 6L and 1L.
- Stainless-steel or Teflon sample inlet lines with particulate filter.
- Stainless-steel or Teflon tubing and fittings for connections.
- For sub-atmospheric pressure sampling: a fixed orifice capillary, stainless-steel adjustable micrometer valve, flow regulator, or similar device; for time duration or time integrated sampling; an electronic flow controller, mass flow controller, flow regulator or similar device; or for pressurized sampling, a mass flow controller/vacuum pump or similar device.
- Pressure gauge (if required).

- Sample labels.
- Marking pens.
- Containers for sample storage and shipment.
- Sample data forms/clip board or electronic data storage device (PDA).
- Nitrile gloves, or other specified chemical-resistant gloves.
- Work gloves.
- Appropriate tools and wrenches for attaching tubing and connections.
- Camera and film or disks.
- Blank field log forms, book, or a field-logging PDA.
- Personal safety gear (hard hat, steel-toed boots, etc.).

7.0 METHODS

7.1 Sub-atmospheric pressure or Time Duration Sampling

Air samples will be collected according to the following procedures, when performing sub-atmospheric pressure sampling or time duration sampling, with a fixed orifice capillary or adjustable micro-metering valve:

1. Prior to sampling complete the field data sampling sheet.

2. Confirm that the canister is certified as evacuated from the lab and has no dents or punctures. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan.

3. When using Summa canisters, ensure that the canister valve is fully closed before removing the brass cap from the valve on the top of the Summa canister.

4. For a time integrated sample; attach the regulator, flow restricting device, or the flow controller with vacuum pump to the top of the Summa canister. Finger-tighten the fitting then tighten with a 9/16-inch wrench. Attach the other end of the flow controller to the tubing of the vapor port or connect it to the atmosphere that is to be sampled. Confirm the flow restrictor (or other device) is set for the appropriate time integrated sample (generally 12 to 24 hours). For pressurized samples; confirm that the flow rate will not allow the canister to become pressurized beyond the recommended limit for the canister.

5. Open the canister to the flow from the regulator or flow restricting device. The pressure differential allows the sample to flow into the canister. For collection of a

grab sample; open the canister (green valve) turning counter-clockwise until there is no resistance (approximately 1-¼ turns), then turn back clockwise slightly until resistance is detected. A hissing noise will be noticeable as the vacuum inside the canister is filled when grab sampling, however not for flow regulated samples.

6. Upon completion of the sampling, close the valve to the canister by turning the green knob clockwise. Do not over-tighten. Disconnect regulator or flow restricting device. Replace the brass cap on the Summa canister. Record the appropriate information (including the negative pressure left at the end of the sampling) on the canister label, and on the field log. Complete the sample chain-of-custody with the canister ID number, the flow controller or regulator ID numbers (if applicable) and time, along with pertinent information and observations.

7.2 Decontamination Methods

Equipment does not need to be decontaminated since dedicated regulators, and or flow restricting devices and tubing will be used at each sample location.

8.0 QUALITY CONTROL CHECKS AND ACCEPTANCE CRITERIA

Refer to the Quality Assurance Project Plan for specific quality control checks and acceptance criteria.

9.0 DOCUMENTATION

A log of air sampling events will be completed for each sample. The field notebook and/or data collection forms will contain the following information:

- Project name and number.
- Sampler's name.
- Location, date and time sampling started and finished.
- Type of equipment used.
- Air monitoring data (if applicable).
- Type, make and model number of flow regulator and Summa canister (and other) equipment used.
- Air monitoring calibration and measurements.
- Flow rates if applicable.
- Sample identification and collection time.
- Sampler observations.

ACCEPTANCE

Author/Originator

Peer Reviewer

Senior Reviewer

Environment Practice QA/QC Manager

Stantec

STANDARD OPERATING PROCEDURES: **SOIL VAPOUR SAMPLING**

SOP ES2.05

Version: 2.0 (Last revised May 14, 2020)

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Discipline(s): Site Investigation, Hydrogeology

1 PURPOSE AND SCOPE

This document defines the standard operating procedures for installing and sampling sub-slab and soil vapour probes.

2 PRE-MOBILIZATION

2.1 HEALTH AND SAFETY

Confirm RMS1 and RMS2 forms and all other applicable safety forms are reviewed, filled in, updated and followed. For sub-slab sampling, consider if the basement or crawl space could act as a confined space. Review applicable SWPs as required. Confirm field staff has the necessary training to complete the work safely.

2.2 PLANNING

Discuss the purpose of the soil vapour program and the scope of work with the Project Manager or designate. Review the proposal and all proposed sampling locations.

If available, review site photos, field records, borehole logs/monitoring well records, and cross sections from previous on-site or nearby subsurface investigations to identify expected soil types, water levels, and site conditions.

Identify and obtain any required permits for activities such as working in a roadway or working near a water body.

2.3 SAMPLING LOCATION LAYOUT AND PROGRAM DETAILS

Obtain all necessary public and private utility locate information prior to confirming sampling locations (refer to SWP 213).

Carefully mark planned sampling locations on a site plan or map. GPS coordinates can be determined and loaded into a GPS unit of sufficient accuracy to locate the points, or sampling locations can be determined relative to known reference points. Alternatively, arrangements can be made to survey the sampling locations. See *SOP ES3.05 Surveying* for instructions on elevation surveying. If structures are present on the site, 1m x 1m reference grids can be added to site plans so field staff can line up their sample locations in the field, relative to the structures.

Confirm specific details of the soil vapour program design with the Project Manager, including:

- Target depths of soil vapour probes
- Drilling method and equilibrium times
- Presence of any treatment systems
- Sample collection method (canister or sorbent tube)

- Target sample volume, sample duration, and flow rate (may differ by probe location and design)
- Parameters for sample analysis
- Quality control sample requirements, which may include: duplicates, trip blanks, field blanks, batch or individual sample container certification (for canisters)

Sample naming conventions will be determined by the Project Manager in accordance with SOP *ES4.02 Sample Naming Protocol.*

2.4 EXCESS SOIL STORAGE AND DISPOSAL

The methods to be used to address any excess soil generated as part of the field program must be determined by the Project Manager, in consultation with the Client and/or property owner, prior to commencing the program. If required, this plan could include storing the excess soil on polyethylene sheeting, in drums or used as backfill (pending Provincial requirements). Any offsite transportation and disposal must be conducted in accordance with provincial and federal legislation.

2.5 ITEMS TO TAKE INTO THE FIELD

2.5.1 Mandatory Items

- Proper clothing for the activity and weather conditions
- All applicable H&S Forms
- All necessary permits
- Required PPE (SWP 105)
- Site plan with proposed sampling locations
- Any relevant site/project information
- Field forms (Section 5.2)

2.5.2 Consumables

- Distilled water
- Paper towels or Kimwipes
- Garbage bags
- Latex or nitrile gloves
- 4-mil plastic sheeting
- ¼-inch diameter Teflon or Nylaflow tubing (not silicone, rubber or tygone)

- Stainless steel probes or vapour implants, if being used
- #3 Sand
- Bentonite Chips
- Portland cement or non-VOC caulking material
- Three-way stopcock valves
- Summa™ canisters and flow valves[1] or sorbent tubes
- Helium

2.5.3 Non-consumables

Confirm all required equipment is available, clean and operational. Calibrate, handle, store and maintain equipment according to manufacturers' recommendations. Record the calibration results on *ESFF2.07 Field Instrument Calibration.* Confirm you have spare batteries and/or chargers as required. Following use, clean, maintain and store all equipment according to manufacturers' recommendations and fill in and submit the Technical Recovery Form to confirm equipment costs are appropriately charged to the project. Equipment that may be required to complete this task is identified below:

- Decontamination equipment (brush, deionized water in spray or squirt bottle)
- Traffic control equipment, if needed
- GPS
- Two pails; one with wash water/ detergent (phosphate free) and one for rinsing
- Survey equipment
- Work gloves
- Camera
- Helium shroud
- Tape measure

[1] Call the laboratory and discuss the type and volume of Summa™ canister required, detection limits, flow controllers and quality control procedures and samples with the laboratory. If you are collecting a sample from a substantially different altitude than the laboratory, or under extreme weather conditions, discuss the potential implications with the laboratory. The controllers may need to be adjusted for altitude and temperature, and there can be flow rate drift if the temperature of the controller is allowed to vary significantly.

- Broom, dustpan or hand vacuum
- Rotary hammer drill and appropriate bits (typically 1" and ½-¾")
- Photoionization detector (PID) or other air monitoring instrumentation as required by the Health and Safety Plan
- Calibrated air sampling pump

3 FIELD PROCEDURES

3.1 QUALITY ASSURANCE / QUALITY CONTROL

- Before any sampling begins, non-dedicated equipment shall be decontaminated in accordance with SOP *ES4.08 Equipment Decontamination*.
- If dedicated equipment is used, it should be wrapped in polyethylene prior to use.
- Use nitrile gloves to handle probe and sampling materials.
- Re-use of vapour tubing is not allowed.

3.2 SUB-SLAB PROBE INSTALLATION

3.2.1 Permanent Sub-slab Vapour Probe Installation

The following steps should be taken when installing permanent sub-slab vapour probes:

1. Locate subslab samples to minimize disturbance and damage to existing flooring.
2. Drill or core a 100 millimetre (mm) diameter hole in the slab to a depth of approximately 50 mm with a hand held corer. Gasoline powered drills should be avoided. Collect concrete dust during drilling using a shop vac.
3. Drill a second smaller hole centered in the first 100 mm hole with a Hefty Hammer or equivalent drill (¾" barrel). The drill must pass through the entire depth of the concrete slab.
4. Clear the hole of cuttings and debris. This may require a hammer and chisel to break out the piece of core out of the hole.
5. If the sample will be collected within 24 hours of installation, the hole should be temporarily sealed (e.g., using a rubber stopper or plastic wrap; or placing a crumbled a latex or nitrile glove, crumpled and wedged into the hole) after drilling the hole and before installation of the probe to minimize disturbance to the sub-slab vapour concentrations.
6. Mix non-shrink concrete grout to proper consistency for later use.
7. Clean all brass fittings with methyl hydrate and allow to dry (approximately 1 minute).

8. Place Teflon® tape on threads of brass flash plug.

9. Thread flush plug into brass bushing by hand and then with a ½" drive ratchet until snug.

10. Coat external threads of brass bushing with the grout.

11. Insert PVC pipe into brass bushing. Set brass bushing centered over the ¾" diameter inner hole.

12. Grout bushing into slab while holding it in place. Confirm grout does not plug the ¾" inner hole.

13. The flush plug should not extrude above the floor surface.

14. Close the valve to the probe and wait for the concrete to harden before taking a sample. Wait times of 30 minutes (Cal EPA 2005) to 1 hour (Health Canada 2008) have been recommended, provided hole has not stayed open for any appreciable time. Alternatively, a longer wait time may be needed to allow soil vapour concentrations to return to equilibrium (e.g., 24 hours).

15. Prior to sample collection, conduct leak testing to confirm the absence of unacceptable leaks (see Section 3.6 below).

16. Take picture of final installation(s) and record location(s) with relation to building features with sufficient detail to be transferred to a drawing. Document the well construction in daily field notes.

17. Clean up any mess made during the installation process before leaving the building.

3.2.2 Temporary Sub-slab Vapour Probe Installation

The following steps should be taken when installing temporary sub-slab vapour probes:

1. Drill or core a 25 to 50 mm diameter hole through the entire depth of the concrete slab.

2. Clear the hole of cuttings and debris. This may require a hammer and chisel to break out the piece of core out of the hole.

3. If the sample will be collected within 24 hours of installation, the hole should be temporarily sealed (e.g., using a rubber stopper or plastic wrap; or placing a crumbled a latex or nitrile glove, crumpled and wedged into the hole) after drilling the hole and before installation of the probe to minimize disturbance to the sub-slab vapour concentrations.

4. Prepare granular bentonite for later use.

5. Use shop vac to remove sufficient material beneath the concrete slab to allow for installation of implant.

6. Prepare sampling point by attaching tubing to vapour implant.

7. Place sampling point inside the hole.

8. Add silica sand around the tip and grout the rest of the borehole annulus (granular bentonite) into slab while holding the tubing in place.

9. Hydrate the bentonite seal until good seal is obtained (hydrating the bentonite prior to the installation may also help).

10. Due to the disturbance of the soil material beneath the concrete slab, wait 24 hours after installation prior to collecting a sample to allow sub-slab vapour concentrations to return to equilibrium.

11. Prior to sample collection, conduct leak testing to confirm the absence of unacceptable leaks (see Section 3.6 below).

12. Take picture of final installation(s) and record location(s) with relation to building features with sufficient detail to be transferred to a drawing. Document the well construction in daily field notes.

13. Clean up any mess made during the installation process before leaving the building.

3.3 SOIL VAPOUR PROBE INSTALLATION

Both auger drilling and direct-push can be used to advance a borehole for a permanent vapour well. Alternately, temporary sampling points can be installed by driving a rod with the implant inside and then withdrawing the rod, though this latter technique has limitations.

When using direct push technology, use larger size rods to allow for the proper installation of filter pack and seal. Do not allow the borehole to collapse around the probe.

3.3.1 Permanent Soil Vapour Wells

A borehole diameter of 25 mm or smaller will reduce purge volumes and reduce potential for short circuiting; 12.5mm (1/2 inch) to 19mm (3/4) inch diameter pipe is recommended.

1. Be aware that direct push rods can cause contaminants to smear along the borehole, particularly in fine-grained soil, which will make obtaining a representative sample difficult.

2. Use short screens (0.1 to 0.3 m length), which may consist of No. 10 to No. 40 slot pipe or stainless-steel probe

3. Riser pipe segments should be flush threaded; no glue should be used.

4. Place a filter pack comprised of coarse sand or fine gravel around the screen and extend the filter pack to 5 to 10 cm above the top of the screen.

5. Use a tamping rod and weighted tape to confirm position of the filter pack and seal.

6. Install a granular bentonite seal placed in several lifts that are a few cm thick and hydrate with distilled water (municipal water may emit volatiles). A minimum seal thickness of 0.3 m is recommended.

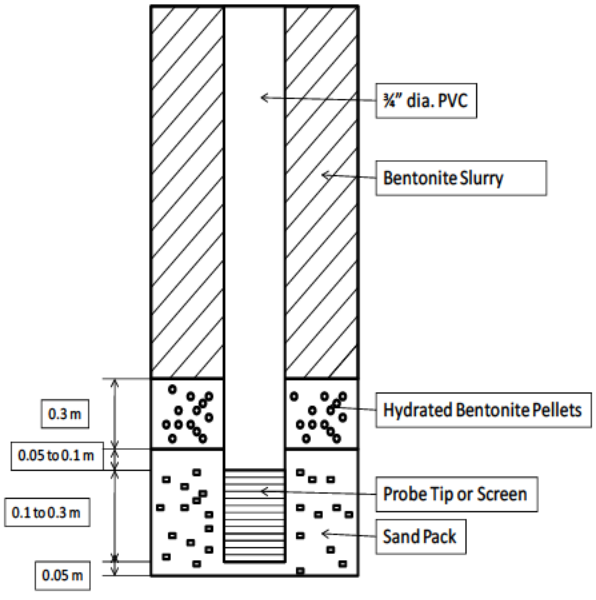

Figure 3-1 Permanent Soil Vapour Well Construction Schematic

7. Seal the remainder of the borehole annulus to near ground surface with a thick bentonite slurry.

8. For permanent probes, fill top two inches of borehole with cement grout.

9. Place an air-tight valve or stopcock at surface of probe to prevent atmospheric air from entering the probe.

10. Protect probe using a well cover or similar protective casing.

3.3.2 Sampling Through Rods/Driven Probes

This technique is best suited to coarse-grained soil. In fine-grained soil, there is a risk of smearing contamination along the borehole and short-circuiting.

1. A pilot hole would be required when dealing with asphalt or concrete surfaces. Keep the rods vertical during installation. They are typically driven into the ground using a handheld electric hammer (typical maximum depth 3m to 4.6m) or a hydraulic ram (typical maximum depth 9m).

2. Some rods are driven with the probes inside, in other cases the probe has to be installed through the rod after it is driven into the ground. Typical probe implant length is 0.15 to 0.3m, while the diameter is commonly 12.5 mm (1/2 inch).

3. Avoid lateral movement of the rod once it is installed, as this will create space for ambient air to enter the subsurface.

4. Use narrow flexible inert tubing to connect the implant to the ground surface, typically 6mm (1/4 inch) diameter.

5. Coupling should be Swagelok™ compression fittings, barbed fittings, or threaded fittings wrapped in Teflon® tape. Fittings should be air-tight. If barbed fittings are used, push tubing over a minimum of three barbs.

6. Place an air-tight valve or stopcock at surface of probe to prevent atmospheric air from entering the probe.

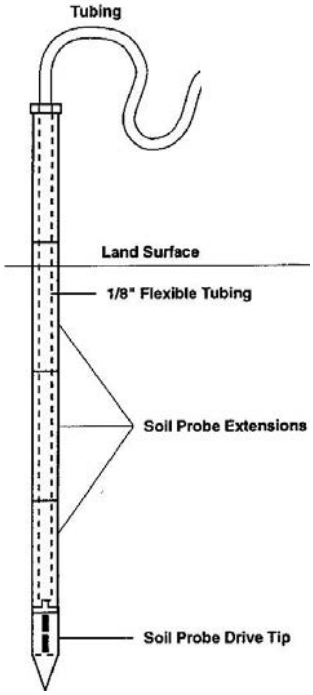

Figure 3-2 Schematic of Sampling through Rods/Driven Probes

3.4 SOIL VAPOUR PROBE DEVELOPMENT

When auger drilling or air rotary drilling are used to drill the borehole, development of the probe should consist of the removal of one well volume (auger drilling) to several well volumes (air rotary). Mud drilling should not be used when soil vapour probes are being installed.

Close the probe valve and allow the soil vapour concentrations around the probe to equilibrate prior to sampling. Recommended wait times are:

- Driven probes -15 minutes
- Direct push borehole – 1 day
- Auger drilling – several days
- Air rotary drilling – several weeks

Prior to sample collection, conduct leak testing to confirm the absence of unacceptable leaks.

Take photograph of final installation(s) and record location(s) with relation to site features with sufficient detail to be transferred to a drawing. Document the well construction.

3.5 FLOW AND VACUUM CHECK

For low permeability soils, confirm the proposed sampling flow rate is appropriate by completing a test of flow rate and vacuum once the seals have set.

1. Connect a vacuum gauge to the top of the soil vapour probe using ¼" tubing.

2. Connect a flow-meter equipped with rotameter to the vacuum gauge, then connect the vacuum pump to the rotameter.

3. Using the pump, withdraw soil gas at the proposed sampling rate (typically 20 to 100 mL/min).

4. Measure the vacuum at the desired flow rate for 2 to 3 minutes.

5. Vacuum levels less than 10 inches of water column (in. wc) are acceptable; vacuums over 10 in. wc are not acceptable and indicate that flow rate, and possibly sampling technique, will have to be modified.

6. If vacuum is much higher than expected, given the soil type, the probe may be plugged or submerged below the capillary fringe.

When low flow conditions exist, an alternate procedure for sample collection, using a Summa® canister, may include collection of a smaller aliquot of soil gas followed by a period of time for the vacuum to dissipate. The process is repeated until approximately 800 mL of soil gas is collected in the 1-L Summa® canister.

Allow the vacuum generated during performance testing to dissipate before collecting a soil vapour sample for analysis. This may take a few minutes to hours.

3.6 LEAK TESTING

A shut-in test may be used to check the tightness of all connections, fittings and other parts associated with the sampling equipment. A tracer test is used to check the tightness of the probe construction as well as the above-ground sampling equipment.

3.6.1 Shut-in Test

1. Assemble the equipment

2. Evacuate lines to a measured vacuum of 100 in wc. using a gas-tight syringe or sampling pump. If a pump is used, close the valve and turn off the pump.

3. If constant vacuum pressure is maintained for 1 minute, it is alright to proceed. If there is observable loss of vacuum, fitting will be retightened and the test repeated. Record results on *ESFF2.39 Leak Testing and Performance Testing of Soil Vapour Probes*.

3.6.2 Tracer Test

1. Construct a sampling enclosure (shroud) - typically an inverted bucket with sampling ports - of sufficient size to cover the surface seal of the vapour well.

2. Connect a valve on the shroud to the valve from the vapour sample probe. Connect the other end to an air sampling pump.

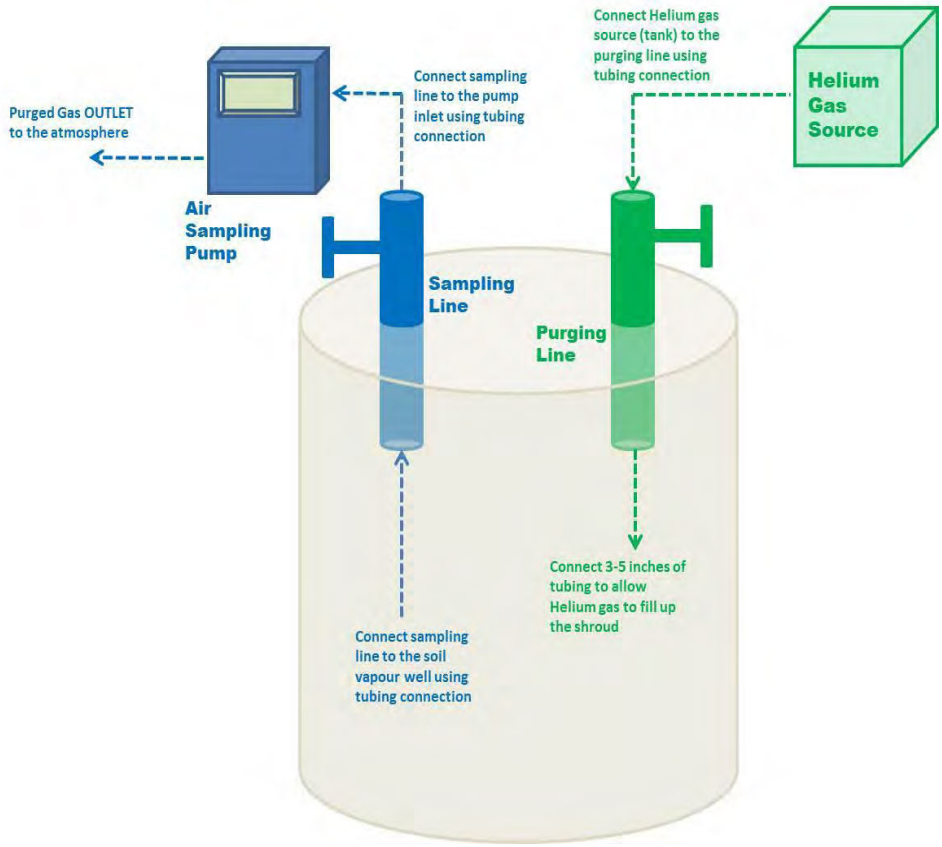

Figure 3-3 Schematic of Tracer Test Set Up

3. Connect the helium gas source to one of the valves on the shroud and fill the enclosure to at least 80% helium, measured with a helium detector. Rapid depletion of helium indicates that there is an inadequate seal between the shroud and ground surface. Corrective measures are recommended to avoid using a large quantity of helium trying to maintain the 80% helium concentration. If a plastic sheet is used, it should not cover the well-head.

4. The concentration of helium in the evacuated air can be determined by attaching the helium detector to the outlet tubing of the air sampling pump, or by pumping air into a tedlar bag and then inserting the helium probe inside the bag.

5. A helium percentage leakage of <1% is generally acceptable; a helium percentage of >10% is not. The acceptability of leakage rates between 1 and 10% depends on the project-specific data quality objectives and applicable regulatory guidance.

6. Check the oxygen concentration in the evacuated air, as high oxygen concentrations (greater than 20%) in evacuated air may indicate short circuiting.

3.7 PURGING

Leak testing and purging can be performed simultaneously. The space that needs to be purged includes:

- empty space of tubing and probe (tube radius^2*π*full length of tubing)
- void space of the sand pack (borehole radius^2*π*depth of sandpack)

If purge volume is anticipated to be less than 50 mL, purging may be performed using a gas-tight syringe.

The flow rate during purging will be approximately equivalent to the flow rate during sampling (typically between 20 and 200 mL/min). Record purge data on *ESFF2.40 Purging of Soil Vapour Probes*.

3.8 COLLECTING SAMPLES USING SORBENT TUBES

The following steps should be taken when collecting vapour samples using sorbent tubes:

1. Be aware of the potential for saturation of sorbent media (“breakthrough”). If higher concentrations are anticipated, consider collecting two samples over different sampling durations, particularly if the sample is being collected in a remote area.

2. Collect the shorter duration sample first to minimize equilibration time between the first and second sample, then collect the second, longer duration sample.

3. Analyze the longer duration sample; place the shorter duration sample on reserve with the laboratory and analyze only if the breakthrough of the longer sample duration occurs. Since the holding time for sorbent tubes is 14 days, also be aware of scheduling constraints.

4. When the samples are ready to be collected, cut off the ends of the sorbent tube using a clean glass cutter wearing nitrile gloves. Cut the glass such that a 2 to 3 mm opening is created. Follow proper health and safety protocols while cutting glass. Coated stainless steel sorbent tubes are also available, in which case the caps simply need to be removed.

5. Connect the sorbent tube in-line between the probe and the pump (the sorbent tube should be upstream of the pump).

6. Use flexible tubing to create an air-tight seal on the tube. Keep the flexible tubing short to avoid sorption effects.

7. Since sorbent tubes typically have a front and back section, connect them in the correct direction (often the tubes have an airflow direction arrow).

8. Keep the tube vertical during sampling.

9. If using more than one type of sorbent tube in parallel, be sure that the sampling tubes are in the correct location, as each side of the splitter is calibrated separately to the tube being used.

10. Once the sorbent tubes have been connected to the probe, open the valves of the sampling train and turn on the pump.

    a. Record the exact start time and stop time of the sample collection, and the pump identifier number for each sorbent tube.

    b. Record the final vacuum on the probe.

11. After sampling is complete, stop the pump and close the valves. Wearing nitrile gloves, disconnect the sorbent tubes and place an air-tight cap on each end of the sampling tube. Label the sample in accordance with direction provided by the Project Manager (labels should be kept as small as possible since glues include VOCs) and place it in a protective case to prevent breakage during shipping.

12. Hold time for sorbent tubes are typically 14 days.

13. For sorbent tubes, cool storage (4.0 °C) in sealed containers is recommended. Sorbent tubes should be stored in a sealed plastic container containing a bed of activated carbon to minimize the potential for adsorption of ambient VOCs.

14. All vapour samples should be transported in separate containers from soil and groundwater samples and separate from pumps. Samples should be submitted to the analytical laboratory undersigned chain-of-custody. Confirm that the laboratory will report the results in units of µg/m^3.

15. Clean equipment at the end of the sampling event.

16. Turn pumps in for post-calibration. Calibration (pre and post) must be documented and kept in the project file.

3.9 COLLECTING SAMPLE USING SUMMATM CANNISTERS

The following steps should be taken when collecting vapour samples using Summa canisters:

1. Prior to sampling, check the canister vacuum by attaching a vacuum gauge (usually supplied by the laboratory) to the top of the canister[2]. Prior to connecting the gauge, double check that the

[2] Some laboratories provide a gauge that is attached to the flow controller. In this case, the sample collection begins at the same time as the vacuum is checked. Be sure to attach the Summa™ canister to the vapour probe prior to checking the vacuum. To check the vacuum, open the control knob and record the vacuum.

control knob on the side of the canister is fully closed. Using a wrench, remove the valve cap on the top of the canister, and attach the gauge. When attached correctly, it should not be possible to turn the gauge assembly (follow the laboratory instructions for tightening). After taking the reading, close the control knob tightly, and disconnect the gauge.

2. The canister vacuum should be between 25 and 29 inches Hg (be aware that gauges supplied by laboratories are typically of low accuracy, +/- inches Hg). If the vacuum is less than 25 inches Hg, do not use.

3. After checking the vacuum, attach the particulate filter and flow controller (unless it is attached to the vacuum gauge), also using a wrench. When attached correctly, it should not be possible to turn the flow controller assembly.

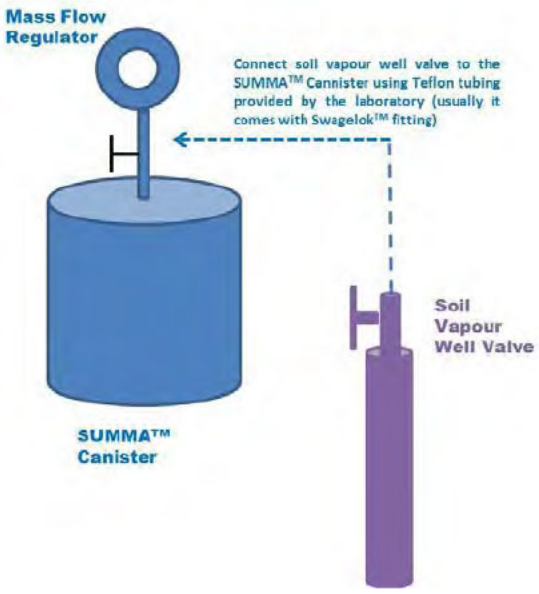

Figure 3-4 Soil Vapour Sampling Schematic

4. When ready to sample, connect the Summa™ canister to the probe using airtight fittings. Open the control knob on the side of the canister to begin sample collection and record the start time of the sample collection.

5. After sampling is complete, check the vacuum again. There should be a residual vacuum left in the canister that ideally is between 4 and 6 inches Hg. While the smaller residual vacuums are acceptable, there should be a residual vacuum left in the canister.

6. Do not write on the Summa™ canister; note the sample ID and the canister serial number in field notes and on chain-of-custody forms. Place canisters within secure packaging received from the laboratory. Do not place canister in a chilled cooler for transport since volatiles may condense from the vapour phase at lower temperatures. Do not subject samples to excessive heat.

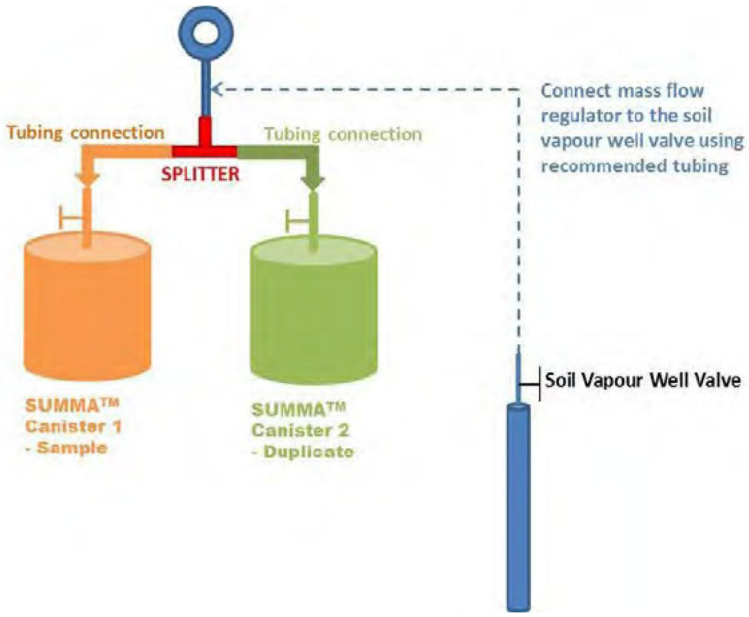

Figure 3-5 Soil Vapour Sampling Schematic Diagram - DUPLICATE Sampling

7. Canisters will be shipped via next-day air. Samples will be transported under chain-of-custody protocol (including noting the final canister vacuums and serial numbers of the canisters and flow controllers). Pre-field planning will prevent sample shipments from arriving at the laboratory during weekends.

8. The vacuum should be measured upon receipt by the laboratory.

9. Hold time for Summa™ canister are typically between 14 and 30 days.

3.10 DECOMMISSIONING OF VAPOUR PROBES

3.10.1 Sub-slab Vapour Probes

Following the completion of the sub-slab sampling program, the probe hole should be sealed by filling the probe hole with non-shrinking cement grout or other appropriate material in order to prevent soil vapour from entering the building.

3.10.2 Soil Vapour Probes

Any applicable federal/provincial requirements for well decommissioning should be followed. In the absence of regulatory guidance, the following general procedure may be used:

- Remove casing (or tubing) and cap. If it cannot be pulled out of the ground, cut it off 0.6m below the ground surface.
- Fill the remaining casing (or hole if the casing has been removed) to 0.6m below the ground surface with bentonite pellets or chips while tamping to prevent bridging of the chips or bentonite. Confirm that the bentonite is saturated to provide and effective seal.
- Fill the remainder of the casing (or hole if the casing has been removed) with silica sand or overburden material to the surface.
- If a hole was drilled in concrete, patch it with concrete grout.

3.11 SITE PHOTOGRAPHS

Take photographs of site conditions before any work is conducted and again just prior to leaving the site to confirm the site was left in an appropriate state. The requirement for other photographs will be determined by the Project Manager. After field work is completed, the project manager will determine requirements like labelling and organization of photographs including things such as project number, sample name and the date of the photograph, indexing and use of *ESFF2.26 Photograph Log*.

4 DOCUMENTATION

4.1 MANUAL AND DIGITAL DATA STORAGE REQUIREMENTS

4.1.1 Hard Copy Notes

Confirm that field notes are accurate and complete. Provide them to the project manager for review and signature. Scan hard copy notes. Store hard copies in the project file.

4.1.2 Digital Data

Upload photographs to the server project directory. Save data spreadsheets/databases and scanned hard copy notes in the server project directory. If the local server is not backed up regularly, save a back-up copy in another location (e.g., computer hard disk).

4.2 GENERAL

Information to be documented will include the following, as applicable:

- Site name
- Field investigator's name
- Date and time of sample collection, type of probe sampled
- Sample number, location, and depth (note Summa™ canister and flow controller identifier)
- Purging method
- Flow rate, sampling rate
- Leak testing
- Start and end vacuum readings
- Helium measurements in shroud at start, 15 minutes, and or end of sampling
- Observations at the site
- Unusual conditions (i.e., those that may affect observation and/or samples)
- Decontamination observations
- Weather conditions (including indoor and outdoor temperature)
- Names/contact information of all field crew members and of any site visitors should be noted on the RMS2 form and the form should be signed as required by SWP procedures.
- Location, description, and log of photographs

- References for all maps and photographs
- Information concerning sampling or scheduling changes, and any change orders
- Summary of daily tasks and documentation on any cost or scope of work changes required by field conditions
- Signature and date by personnel responsible for observations
- Field equipment used

Where feasible, obtain temperature, barometric pressure, wind speed and direction and precipitation data from three days prior to sampling up to the end of sampling.

5 RESOURCES

5.1 RELATED SOPS

- *SOP ES2.01– Surface Soil Sampling*
- *SOP ES3.05 – Surveying*
- *SOP ES4.08 – Equipment Decontamination*
- *SOP ES4.02 – Sample Naming Protocol*

5.2 STANDARD FORMS

- *ESFF2.02 – Daily Activity Record*
- *ESFF2.07 – Field Instrument Calibration*
- *ESFF2.16 – Underground Utility Locate Request*
- *ESFF2.22 – Elevation Survey*
- *ESFF2.26 – Photograph Log*
- *ESFF2.35 – Working Alone*
- *ESFF2.38 – Building Inspection and Occupant Survey*
- *ESFF2.39 – Leak Testing and Performance Testing of Soil Vapour Probes*
- *ESFF2.40 – Purging of Soil Vapour Probes*
- *ESFF2.41 – Pump Calibration (Vapour)*
- *ESFF2.42 – Soil Vapour / Indoor Air Sample Collection (Sorbent Tubes)*

- *ESFF2.43 – Soil Vapour / Indoor Air Sample Collection (Summa Canisters)*

Stantec

STANDARD OPERATING PROCEDURES: GROUNDWATER SAMPLE COLLECTION

SOP ES4.03
Version: 2.0 (Last revised May 18, 2020)
Approved by:
Don Carey, M.Sc., P.Eng., National Technical Leader, Site Investigation
Michelle Fraser, M.Sc., P.Geo., National Technical Leader, Hydrogeology
Discipline(s): Site Investigation, Hydrogeology

1 PURPOSE AND SCOPE

This document defines the standard procedures for collecting groundwater samples from monitoring wells.

2 PRE-MOBILIZATION

2.1 HEALTH AND SAFETY

Confirm that *RMS1* and *RMS2* forms and all other applicable safety forms are reviewed, filled in, updated and followed. Review applicable SWPs as required. Confirm that field staff has the necessary training to complete the work safely.

2.2 PLANNING

Identify and obtain any required permits for activities such as working in a roadway or working near a water body.

Discuss the purpose of the groundwater sampling program and scope of work with the Project Manager and review all proposed sampling locations.

If available, review site photos, field records, monitoring well records for well construction details.

If available, review field records from previous sampling rounds to determine expected static water level, expected purge volume, and presence/absence of free phase product, etc.

2.3 GROUNDWATER SAMPLING LAYOUT AND PROGRAM DETAILS

The proposed groundwater sampling locations (monitoring wells) should be marked on a site plan or map. GPS coordinates can be determined and loaded into a GPS unit of sufficient accuracy to locate the monitoring wells, or sampling locations can be determined relative to known reference points (locations should have been determined in accordance with SOP *ES3.01Monitoring Well Installation*, during well construction).

The Project Manager should determine parameters for sample analysis and sample preservation prior to the commencement of the sampling program along with the need for, and the type of, QA/QC samples that will be collected at a site. Sample naming convention will be determined by the Project Manager in accordance with the SOP *ES4.02 Sample Naming Protocol.*

Coordinate with the laboratory to understand the sample hold times, required preservatives, sample filtration requirements, and sample drop off locations.

2.4 PURGE WATER STORAGE AND DISPOSAL

The methods to be used to address purge water removed from the monitoring well must be determined by the Project Manager, in consultation with the Client and/or property owner, and in consideration of any permit/license conditions, prior to commencing the program. If required, this plan could include storing the water in 45 gallon drums for testing and/or later off-site disposal, or discharge to surface. If separate phase liquid (LNAPL or DNAPL) is present or if impacts known, the purge water must be contained for subsequent disposal. If there is LNAPL or DNAPL present in the well or within the purged water, a sample should not be collected for laboratory analysis unless the purpose is for product characterization.

2.5 ITEMS TO TAKE INTO THE FIELD

2.5.1 Mandatory Items

- Proper clothing for the activity and weather conditions
- All applicable HSE Forms
- All necessary permits and approvals
- Required PPE (*SWP 105*)
- Site plan with relevant site features and monitoring well locations.
- Any relevant site/project information
- Field forms (Section 5.2)
- Chain of custody form

2.5.2 Consumables

- Delrin™ or stainless steel Waterra™ foot valves;
- Polyethylene tubing
- Polyethylene or Teflon bailer, nylon rope
- Clean tarp or plastic sheeting
- In line filters
- Calibration solutions
- Distilled water

- Paper towels or Kimwipes
- Laboratory-supplied sample containers
- Laboratory-supplied preservatives, where applicable
- Ice
- Field forms (refer to Section 5.2)
- Chain of Custody form(s)

2.5.3 Non-consumables

Confirm that all required equipment is available, clean and operational. Calibrate, handle, store and maintain equipment according to manufacturers' recommendations. Record the calibration results on *ERFF2.07 Field Instrument Calibration.* Confirm that you have spare batteries and/or chargers as required. Following use, clean, maintain and store all equipment according to manufacturers' recommendations and fill in and submit the Technical Recovery Form to confirm that equipment costs are appropriately charged to the project. Equipment that may be required to complete this task is identified below:

- Camera
- GPS
- Computer
- Flow-through cell
- pH meter
- Specific conductance meter
- Redox potential (Eh) meter
- Turbidity meter
- Dissolved oxygen kit, including bottles and reagents
- Thermometer (non-mercury)
- Battery-operated water level meter and/or interface meter
- Keys and tools to access wells, as necessary
- Graduated bucket (e.g., 20 L pail)

- Waterproof permanent marker
- Cooler(s)

3 FIELD PROCEDURES

3.1 QUALITY ASSURANCE / QUALITY CONTROL

The following QA/QC procedures apply to groundwater sampling:

- To reduce the potential for cross-contamination, non-dedicated equipment shall be decontaminated in accordance with *SOP ES4.08 - Equipment Decontamination*
- To reduce the potential for cross-contamination, nitrile gloves should be changed at each new sampling location.
- All meters shall be calibrated in accordance with the manufacturers' instructions
- QA/QC samples will be collected during groundwater sampling. Field QA/QC samples are designed to help identify potential sources of external sample contamination and evaluate potential error introduced by sample collection and handling. The need for and type of QA/QC samples will be determined by the Project Manager. QA/QC samples will be assigned an identification number, stored in an iced cooler, and shipped to the laboratory with the other samples
- QA/QC samples may consist of one or more of the following (other QA/QC samples may be required on a project-specific basis):
    - A trip blank is a bottle of laboratory supplied organic-free water that is brought to the field, never opened and shipped back to the laboratory with the other samples. One trip blank should be sent with each cooler containing water samples to be analyzed for parameters determined by Project Manager
    - A field blank is a laboratory supplied sample bottle that is filled with laboratory supplied organic free water. This bottle is brought to each well and opened and closed to simulate sampling. One field blank should be sent with each cooler containing water samples to be analyzed for parameters determined by Project Manager
    - A duplicate sample will be collected at the same time as the initial sample. The initial sample bottles for a particular parameter or set of parameters will be filled first, followed by the duplicate sample bottles for the same parameter(s), and so on until all necessary sample bottles for both the initial sample and the duplicate sample have been filled
- Duplicate samples should be named in accordance with the SOP *ES4.02 Sample Naming Protocol.*

- Duplicates should be preferentially selected from impacted locations rather than "clean" locations. This will allow meaningful evaluations of data precision to be conducted
- Typical collection frequency for field duplicates is: <5 samples = 0; 5-10 samples = 1; and greater than >10 samples = 10%.
- Sign off on all field forms once reviewed for completeness.
- Daily review and discussion of field forms with the Project Manager or Project Hydrogeologist.

3.2 MONITORING WELL PURGING

The following steps should be taken to purge each well:

1. Complete top section of *ESFF2.08 Well Development / Purging.*
2. Confirm monitoring well number.
3. Complete a monitoring well inspection and document on *ESFF2.03 Well Condition Inspection.*
4. Measure headspace vapor in the monitoring well using an organic vapor analyzer.
5. Measure and record initial water level in accordance with *SOP ES4.01 Monitoring Well Fluid Level Measurement.*
6. Determine the presence or absence of LNAPL and DNAPL (if suspected) using a battery operated interface meter in accordance with *SOP ES4.01 Monitoring Well Fluid Level Measurement.* A disposable bailer can be used to assess the presence or absence of LNAPL or DNAPL. A bailer with a double check valve or equivalent is necessary to assess the presence of DNAPL at the base of the monitoring well.
7. Measure the total depth of the well.
8. Calculate the volume of water contained in the well by using the diameter, total depth, and a measurement of the static water level in the well using the formula shown on *ESFF2.08 Well Development / Purging.*
9. Measure and record initial water quality parameters (Eh, pH, specific conductance, temperature and turbidity).
10. Purging should be conducted until 3 to 5 well volumes are purged from the well. In a properly developed well, the water quality parameters of three successive readings are within ±0.1 pH units, ±3% for specific conductance, ±10 mV for ORP, and ±10% for turbidity and DO. Ideally, the well will not be purged below the top of the screened interval; however, given that many wells are screened across the water table to facilitate monitoring of LNAPL, the static water levels may not be above the top of the screened interval. In this case, the wells would preferably not be purged dry to avoid aeration of the sample or the potential loss of volatile compounds.
11. Purging should be halted if the water level drops below the midpoint of the well screen. If a well is pumped to the well screen midpoint or dry, then the following actions are recommended based on the well response:

a. if a well pumps to midpoint of the screen or dry during purging and the water level recovers to static conditions within about 1 hour, then purging should be conducted until the water quality parameters stabilize to within ± 10 percent of the last measurement (typically 3 - 5 casing volumes)
b. if a well pumps to midpoint of the screen or dry during purging and the water level recovers to within about 80% of the static condition in less than 8 hours, the well should be evacuated again at least once before sampling is performed
c. if the water level does not recover after 24 hours, samples will be collected the next day or once the well recovers sufficiently to permit sampling

12. Measure and record the water quality parameters following the removal of each casing volume. If there is sufficient flow, the Project Manager may require pH and Eh to be measured using the flow-through cell.
13. The results of all field measurements of water quality parameters, observations of physical appearance of the purged water, volume removed, pumping rate and pump intake location are recorded on *ESFF2.08 Well Development / Purging.*
14. The site should be cleared of all debris and waste generated during purging prior to leaving.

Tips:

- A purging rate that minimizes drawdown should be used since excessive drawdown distorts natural groundwater flow and could potentially cause migration of contaminants into a well that were not originally present at that screened interval.
- Try to avoid drawing the water level below the top of the screened interval to limit the introduction of air, soil gas, and bacteria.
- If a bailer is used, make an effort not to drop the bailer into the well as this will cause degassing of the water upon impact.
- If the natural flow of water through the filter pack is not deemed sufficient to keep the filter pack flushed, then the volume of water to be purged may need to include the water stored in the filter pack.
- In deep wells where large volumes of water would need to be purged, low flow or micro-purging methods should be considered.

3.3 GROUNDWATER SAMPLE COLLECTION

3.3.1 Inertial Lift Pump

1. Complete top section of *ESFF 2.09 Sample Collection Record for COC Preparation and SIF Check*.

2. If sampling does not immediately follow purging, measure and record initial water quality parameters (Eh, pH, specific conductance, temperature and turbidity).
3. If the well has been pumped to midpoint of the screen or dry prior to sampling, at the time of sampling, water from the top of the column should be removed until approximately 1 m of water remains above the midpoint of the well screen (if possible). The sample should be collected at this point.
4. Sampling should progress from the well that is expected to be least contaminated to the well that is expected to be most contaminated to minimize the potential for cross-contamination. Unless a sample is to be collected for product characterization, a sample should not be collected from wells that contain LNAPL or DNAPL.
5. Collect samples as soon as possible after the well has been purged to reduce the potential for degassing of the formation water.
6. Groundwater samples are collected by direct transfer, without agitation, from the pumping system to the appropriate pre-labeled containers (the use of bailers is addressed in the tips below).
7. Samples should be collected and placed into containers according to the volatility of the target analytes. The preferred collection order for some of the common groundwater analytes is as follows:
    a. Volatile Organic Compounds (VOCs) and toxic organic compounds (TOX), including bezene, toluene, ethylbenzene, and xylenes (BTEX) and Petroleum Hydrocarbon (PHC) Fraction 1 (F1)
    b. Dissolved gases and TOC
    c. Extractable organics (e.g., PHC F2)
    d. Semi VOCs (SVOCs), such as polycyclic aromatic hydrocarbons (PAHs), PHC F3
    e. Phenols
    f. PHC F4
    g. Bacteria and microscopic particulates
    h. General chemistry (major cations and anions)
    i. Nutrients
    j. Metals and cyanide
8. Samples collected for analysis of dissolved metals should be field filtered using a 0.45 micron cellulose-acetate filter. Some in-line filters are equipped with barbs that fit directly into standard 13 mm (½ in.) diameter polyethylene tubing. If the filter is not so equipped, a short length of 9.5 mm (⅜ in.) diameter tubing is required. If there is a sufficient volume of water available, the filter can be conditioned by pumping about 1 L of water through the filter prior to filling the sample bottles.
9. Field filtration is preferable if dissolved metals are to be measured. In this event, it is recommended that two sets of samples for general chemistry be collected (one filtered and one unfiltered). This should be discussed with the Project Manager.

10. Samples collected for analysis of organic constituents should not be field filtered.
11. The procedure for the collection of field duplicates is discussed in Section 3.1.
12. Measure and record the water quality field parameters following sample collection. If a field replicate is to be collected, then the water quality parameters should be measured and recorded after the collection of the field replicate as well. If there is sufficient flow, the Project Manager may require pH and Eh to be measured using the flow-through cell
13. A sample for DO titration may also be collected for each groundwater sample collected (including field replicates). Preservation of the DO sample(s) should be completed in the field using the azide modification of the Winkler method (APHA, 2006).
14. The Chain-of-Custody form should be completed in full, including the appropriate Stantec or client PO or quotation number.
15. The site should be cleared of all debris and waste generated during sampling prior to leaving.
16. Applicable Transportation of Dangerous Goods paperwork shall be completed prior to sample transport, if necessary.

Tips

- There are two common procedures by which to collect samples for the analysis of VOCs while reducing the potential for losses due to volatilization:
    - Hold the tubing upright and oscillate slowly until the water discharges from the top of the tubing and no air bubbles are left. Pull approximately 1 m of tubing from the well and allow the water to cascade into the vial without letting the tubing to come into contact with the vial itself. Repeat this step for each vial to be filled. It is common practice to fold any tubing that extends out beyond the top of the well casing back into the well. Unfortunately, this causes the tubing to kink and become perforated. The perforation will introduce air to the sample; therefore, this length of tubing should be cut off. If an additional length of tubing is needed, it is suggested that 13mm (½ in) OD tubing be fitted into the standard Waterra™ tubing.
    - Slide approximately 2.15 m (7 feet) of narrow (6 mm (¼ inch) OD x 2.4 m (8 feet)) VOC sampling tube into the standard polyethylene tubing leaving about 0.3 m (1 foot) protruding from the end. Oscillate the pumping assembly until water discharges from both tubes. Pumping can be stopped and water will cease to flow from the standard tubing but will continue to flow from the VOC tubing (the VOC tubing operates as a siphon). The flow from the narrow VOC tubing, which is steady and laminar, can then be directed into the sample vials.
- Bailers are not the preferred method for groundwater sample collection because, among other things, the transfer of water from the bailer to a sample container may significantly alter the chemistry of the groundwater due to degassing, volatilization or aeration/oxidation. If a bailer is used, (generally necessitated by low yield or low volume wells), then it is preferable to use a bottom-emptying device that allows the water to drain slowly into the sample container.

- Bailers are a good means to collect LNAPL and DNAPL samples.
- Ideally, sample collection should be at the same rate as the actual groundwater flow rate (this is typically not accurately known so a low sampling rate of less than 0.5 Lpm is suggested).
- Try to avoid drawing the water level below the top of the screened interval to limit the introduction of air, soil gas, or bacteria.
- To minimize the time between purging and sample collection, all sample containers should be labeled and prepared for filling prior to purging of the final casing volume.
- Do not allow sampling equipment (including the probe of the water level meter), to come into contact with the ground prior to insertion into the well. A clean tarp or plastic sheeting placed around the well is a convenient means of avoiding this situation.
- When using in-line filters it is suggested that water be pumped through the tubing until it begins to discharge before the filter is attached to the tubing. This avoids the buildup of backpressure that restricts the flow of water.

3.3.2 Low-Flow Sampling

Low-flow sampling techniques permit the collection of depth-discrete groundwater samples that are representative of formation groundwater without the generation of large volumes of purge water that would require waste management. Low-flow sampling techniques essentially minimize the drawdown of water in a well and the mixing or disturbance of the standing water within the well, by removing water from a discrete depth within the wells. It should be noted that low-flow sampling techniques cannot be used on low yielding wells.

The following low-flow sampling protocol was developed based on the American Standard for Testing and Materials (ASTM) Standard D 6771-02 (ASTM, 2002) and the minimal drawdown procedure developed by the United States Environmental Protection Agency (US EPA, 1996).

1. Complete top section of *ESFF2.09 Sample Collection Record for COC Preparation and SIF Check*.
2. Sampling should progress from the well that is expected to be least contaminated to the well that is expected to be most contaminated to minimize the potential for cross-contamination. Unless a sample is to be collected for product characterization, a sample should not be collected from wells that contain LNAPL or DNAPL.
3. Install the pump intake at a point within the upper portion of the screened interval of the well. When sampling for chemicals that may be present as DNAPL (e.g., trichloroethylene), the pump intake should be placed near the bottom of the well
4. Purging is completed using a peristaltic pump or bladder pump connected to dedicated high density polyethylene (HDPE) tubing. It should be noted that peristaltic pumps are not appropriate for sampling for volatile parameters. Bladder pumps should be used to sample volatile

parameters. Disposable bladders or bladders dedicated to individual monitoring wells will be used to reduce the potential for cross-contamination.

5. Purging should be conducted at a rate of less than 1 L/min so as not to aerate the water to be collected. If using a mechanical pump, set the purge flow rate at a rate of less than 0.5 L/min to minimize flow rate fluctuation. These rates will assist in reducing sample turbidity and minimize degassing and volatilization of potential dissolved volatile parameters. The volume of water purged can be measured by collecting the purge water in a calibrated bucket. Data describing the well purging rates (time interval between readings and the purge volumes) should be noted on the field forms as wells as observations of the physical appearance of the purge water. Water levels and purging volumes should be recorded on form *ESFF2.08 Well Development / Purging.*
6. Depth to water and water quality indicator (field), parameters should be measured every 3 to 5 minutes during purging to assess the drawdown in the well. The drawdown should not exceed 0.1 m to reduce potential mixing of stagnant well water with fresh formation water during purging. If the steady state drawdown exceeds 0.1 m, the purge flow rate should be reduced. If it is not possible to reduce the flow rate further, then the low-flow sampling technique is inappropriate at that particular monitoring well. Purged water should be stored within a sealed and labeled container on-site until proper disposal can be arranged.
7. Purging should continue until the water quality indicator (field) parameters have stabilized. Stabilization for this method is defined as three successive readings within ±0.1 pH units, ±3% for specific conductance, ±10 mV for ORP, and ±10% for turbidity and DO.
8. See Section 3.3.1 for preferred collection order (by analyte) and field filtering methodologies.
9. The procedure for the collection of field duplicates is discussed in Section 3.1.
10. Measure and record the water quality field parameters following sample collection. If a field replicate is to be collected, then the water quality parameters should be measured and recorded after the collection of the field replicate as well. If there is sufficient flow, the Project Manager may require pH and Eh to be measured using the flow-through cell.
11. A sample for dissolved oxygen (DO) titration may also be collected for each groundwater sample collected (including field replicates). Preservation of the DO sample(s) should be completed in the field using the azide modification of the Winkler method (APHA, 2006).
12. The Chain-of-Custody form should be completed in full, including the appropriate Stantec or client PO or quotation number.
13. The site should be cleared of all debris and waste generated during sampling prior to leaving.
14. Applicable Transportation of Dangerous Goods (TDG) paperwork shall be completed prior to sample transport, if necessary.

<u>Tips:</u>

- Note that it has been Stantec's experience that the low-flow sampling technique is not effective when sampling low yielding overburden wells because the steady state drawdown generally will exceed 0.1 m in low yield overburden wells.

- Two examples of purging and sampling equipment suitable for low-flow groundwater sampling are:

  - QED Environmental Systems' MicroPurge® equipment. The MicroPurge® system can be used with the Sample Pro® portable sampling pump, which is a pneumatic bladder pump that operates using timed ON/OFF cycles of compressed air that alternately squeeze the flexible bladder to displace water out of the pump, and release it to allow the pump to refill by submergence, without creating any disturbance that could affect sample chemistry.

  - Geoprobe® Systems' Mechanical Bladder Pump (MBP). The MBP consists of a stainless steel pump housing and spring, a reusable Teflon® bladder and dedicated concentric (outer and inner) tubing. For purging and sampling, the outer tubing is held in place at the well head, and the inner tubing is raised and lowered manually, actuating the bladder.

- Use of the equipment listed above requires special training and the low-flow purging and sampling should be performed in accordance with the manufacturer's specific instructions. Note too, that proper equipment cleaning/decontamination procedures are to be followed if the purging and sampling equipment is not dedicated to the monitoring well.

- Ideally, sample collection should be at the same rate as the actual groundwater flow rate (this is typically not accurately known so a low sampling rate of less than 0.5 Lpm is suggested).

- To reduce the time between purging and sample collection, all sample containers should be labeled and prepared for filling prior to purging of the final casing volume.

- Do not allow sampling equipment (including the probe of the water level meter) to come into contact with the ground prior to insertion into the well. A clean tarp or plastic sheeting placed around the well is a convenient means of avoiding this situation.

- When using in-line filters it is suggested that water be pumped through the tubing until it begins to discharge before the filter is attached to the tubing. This avoids the buildup of backpressure that restricts the flow of water.

3.4 SITE PHOTOGRAPHS

Photographs should be taken of site conditions before any work is conducted and again just prior to leaving the site to confirm the site was left in an appropriate state. The requirement for other photographs will be determined by the Project Manager. After field work is completed, requirements like labelling and organization of photographs including things such as project number, sample name and the date of the photograph, indexing and use of *ESFF2.26 Photograph Log,* will be determined by the Project Manager.

4 DOCUMENTATION

4.1 MANUAL AND DIGITAL DATA STORAGE REQUIREMENTS

4.1.1 Hard Copy Notes

Confirm that field notes are accurate and complete. Provide them to the Project Manager for review and signature. Scan hard copy notes. Store hard copies in the project file.

4.1.2 Digital Data

Upload photographs to the server project directory. Save data spreadsheets/databases and scanned hard copy notes in the server project directory. If the local server is not backed up regularly, save a back-up copy in another location (e.g., computer hard disk).

4.2 GENERAL

Information to be documented will include the following, as applicable:

- Site name, project number and task number(s)
- Field investigator's name
- Monitoring Well number
- Well condition
- Depth to groundwater, depth of monitoring well
- Calculated well volume
- LNAPL and DNAPL observations
- Initial groundwater field chemistry (pH, Eh, specific conductance, temperature, turbidity)
- Number of purge volumes removed, and removal methodology
- Groundwater field chemistry during purging
- Description of physical appearance of purge water
- Date and time of sampling
- Sampling methodology
- Sample number and location

- Unusual conditions (i.e., those that may affect observation and/or samples)
- Decontamination observations
- Weather conditions
- Names/contact information of all field crew members and of any site visitors should be noted on the *RMS2* form and the form should be signed as required by SWP procedures
- Location, description, and log of photographs
- References for all maps and photographs
- Information concerning sampling or scheduling changes, and any change orders
- Summary of daily tasks and documentation on any cost or scope of work changes required by field conditions
- Signature and date by personnel responsible for observations
- Field equipment used

5 RESOURCES

5.1 RELATED SOPS

- SOP *ES3.03 – Monitoring Well Development*
- SOP *ES4.01 – Monitoring Well Fluid Level Measurement*
- SOP *ES4.03 – Groundwater Sample Collection*
- SOP *ES4.02 – Sample Naming Protocol*

5.2 STANDARD FORMS

- *ESFF2.02 – Daily Activity Record*
- *ESFF2.03 – Well Condition Inspection*
- *ESFF2.04 – Water Levels*
- *ESFF2.05 – Monitoring Water / Product Levels and Vapour Concentrations*
- *ESFF2.07 – Field Instrument Calibration*
- *ESFF2.08 – Well Development / Purging*

- *ESFF2.09 – Sample Collection Record for COC Preparation and SIF Check*
- *ESFF2.24 – Drum Tracking*
- *ESFF2.26 – Photograph Log*
- *ESFF2.35 – Working Alone*

Stantec

STANDARD OPERATING PROCEDURES: EQUIPMENT DECONTAMINATION

SOP ES4.08

Version: 2.0 (Last revised May 18, 2020)

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Discipline(s): Site Investigation, Hydrogeology

1 PURPOSE AND SCOPE

This document defines the standard procedures for decontamination of personal protective equipment (PPE), sampling equipment (e.g., bailers, pumps, tubing, soil and sediment sampling equipment) and field support equipment (e.g., drill rigs, vehicles).

2 PRE-MOBILIZATION

2.1 HEALTH AND SAFETY

Confirm that *RMS1* and *RMS2* forms and all other applicable safety forms are reviewed, filled in, updated and followed. Review applicable SWPs as required. Confirm that field staff has the necessary training to complete the work safely.

2.2 PLANNING

Review all chemicals likely to be encountered during field activities. Identify appropriate decontamination fluids and disposal requirements for those chemicals. Identify appropriate waste generator registration to permit the disposal of water and waste materials generated during decontamination activities.

Review decontamination procedures with the Project Manager.

2.3 DECONTAMINATION WATER STORAGE AND DISPOSAL

The methods to be used to address water and waste materials generated during decontamination activities must be determined by the Project Manager, in consultation with the Client and/or property owner, prior to commencing the program.

If required, this plan could include storing water in 45 gallon drums for testing and/or later off-site disposal, or discharge to surface. If separate phase liquid (LNAPL or DNAPL) is present or if impacts known, the water must be contained for subsequent disposal.

Solid wastes from heavy equipment decontamination with evident contamination, or used personal protective equipment, may need to be tarped or containerized, and segregated for subsequent disposal depending on project specific requirements. These materials will be kept in a secure on-site location identified by the field staff in consultation with the Project Manager. The wastes should be labelled as appropriate.

Any offsite transportation and disposal must be conducted in accordance with provincial and federal legislation.

2.4 ITEMS TO TAKE INTO THE FIELD

2.4.1 Mandatory Items

- Proper clothing for the activity and weather conditions
- All applicable HSE Forms
- All necessary permits and approvals
- Required PPE (*SWP 105*)
- Any relevant site/project information
- Field forms (Section 5.2)

2.4.2 Consumables

- Prepared/supplied sample bottles
- Disposal drums (205 L) with secure lids
- Sponges or paper towels
- Detergent (simple green)
- Liquinox/Alconox
- Potable tap water
- Methanol/dmethyl hydrate or other appropriate decontamination fluids
- Plastic sheeting and/or heavy duty garbage bags
- Latex or nitrile gloves
- Waterproof permanent markers

2.4.3 Non-consumables

Confirm that all required equipment is available, clean and operational. Calibrate, handle, store and maintain equipment according to manufacturers' recommendations. Record the calibration results on *ESFF2.07 Field Instrument Calibration.* Confirm that you have spare batteries and/or chargers as required. Following use, clean, maintain and store all equipment according to manufacturers' recommendations and fill in and submit the Technical Recovery Form to confirm that equipment costs are appropriately charged to the project. Equipment that may be required to complete this task is identified below:

- Scrapers, flat bladed

- High pressure sprayer
- Two buckets; one with wash water/detergent (phosphate-free) and one for rinsing
- Small wash tubs
- Scrub brush / wash tools
- Garden-type water sprayers
- Spray bottles

3 DECONTAMINATION PROCEDURES

3.1 PRE-WORK

For work on agricultural land in some provinces, decontamination procedures must be undertaken for biosecurity purposes (e.g. to prevent Clubroot infestation from inadvertent transfer of seeds between work locations).

Implement the following protective measures if working on agricultural fields to reduce the potential for spread of the disease and/or introduction of contaminants to sites:

- Make sure all vehicles and equipment arrive on site clean (i.e., free of dirt and debris). This can be accomplished by advising contractors to visit a car/truck wash before travelling to/arriving at the site
- Confirm that all tracked equipment, mats, and mat moving equipment are fine cleaned and misted with disinfectant (1-2% bleach solution, left on surface for at least 15 minutes) upon entry into, and after working in, a field. Cleaning must focus on areas prone to collecting or coming into contact with soil and debris (i.e., tires, undercarriages, tracks, buckets, blades, wheel wells).
- Complete a rough cleaning (i.e., using hand tools such as shovels, brooms and/or brushes) to physically remove soil and debris from vehicles and equipment before equipment moves to a new site.

Additionally it has been found that the use of hydrovac equipment for daylighting can sometimes introduce contaminants. Hydrovac contractors should supply documentation demonstrating that they have cleaned their equipment, including inside the waste tank, prior to arrival on the site.

Set up decontamination areas, exclusion zones and clean zones, prior to commencing field work.

3.2 QUALITY ASSURANCE / QUALITY CONTROL

Equipment rinsate samples may be taken of the decontaminated sampling equipment as directed by the Project Manager to verify the effectiveness of the decontamination procedures. The rinsate procedure will include rinsing potable water or blank water provided by the lab through or over a decontaminated sampling tool (e.g., a split spoon sampler or bailer), and collecting the rinsate water in

sample bottles, which will be sent to the laboratory for analysis. The rinsate procedure, including the sample number and time relative to other soil and/or groundwater samples, will be recorded in the field notes. Sample numbering should follow *SOP ES4.02 Sample Naming Protocol*.

3.3 PERSONNEL

The decontamination procedure for field personnel, if deemed necessary, shall include one or more of the following steps, and will be carried out in the order presented:

- Glove and rubber boot wash in a detergent solution
- Glove and rubber boot rinse
- Scraping soil from non-rubber boot
- Duct tape removal, if appropriate
- Outer glove removal
- Coverall removal
- Respirator removal (if used)
- Inner glove removal (if used)

3.4 SAMPLING EQUIPMENT

In general the following steps may be used to decontaminate sampling equipment:

1. Personnel will dress in suitable personal protective equipment (PPE) to reduce personal exposure.
2. Gross contamination on equipment will be scraped off at the sampling or investigation site.
3. Equipment that will not be damaged by water will be placed in a washtub containing a solution of low-sudsing detergent and tap water and scrubbed with a bristle brush or similar utensil. Equipment will be rinsed with tap water.
4. Equipment that may be damaged by water will be carefully wiped clean using a sponge first rinsed in detergent water, rinsed with tap water, then dried with paper towel. Care will be taken to prevent any equipment damage.
5. Where applicable, a solvent rinse (e.g., methanol, hexane), may be required to remove organic contaminants. The selection of the solvent should consider factors such as HSE and regulatory requirements.
6. Rinse and detergent water will be replaced with new solutions between borings or sample locations, or as required based on the judgment of the field supervisor in discussions with the Project Manager and/or OSEC.

Following decontamination, equipment will be placed in a clean area or on clean plastic sheeting to prevent contact with potentially contaminated soil. If the equipment is not used immediately, the equipment will be covered or wrapped in plastic sheeting or heavy-duty garbage bags to minimize contact with potential airborne contaminants.

3.5 DRILLING AND HEAVY EQUIPMENT

The following steps may be used to decontaminate drilling and heavy equipment:

1. Personnel will dress in suitable PPE to reduce personal exposure.
2. Equipment showing gross contamination, or having caked-on drill cuttings will be scraped at the sampling or investigation site.
3. Equipment that will not be damaged by water, such as drill rigs, augers, drill bits, and shovels will be sprayed with a high-pressure hose. Care will be taken to adequately clean the insides of the hollow-stem augers, and not to contaminate other areas during decontamination procedures.
4. Following decontamination, care will be taken to keep the equipment clean.

Decontamination of drilling equipment and heavy equipment is generally completed by appropriately trained employees of the contracting firm.

3.6 SITE PHOTOGRAPHS

Photographs should be taken of the decontamination procedures. The requirement for other photographs will be determined by the Project Manager. After field work is completed, requirements like labelling and organization of photographs including things such as project number, sample name and the date of the photograph, indexing and use of *ESFF2.26 Photograph Log,* will be determined by the Project Manager.

4 DOCUMENTATION

4.1 MANUAL AND DIGITAL DATA STORAGE REQUIREMENTS

4.1.1 Hard Copy Notes

Confirm that field notes are accurate and complete. Provide them to the Project Manager for review and signature. Scan hard copy notes. Store hard copies in the project file.

4.1.2 Digital Data

Upload photographs to the server project directory. Save data spreadsheets/databases and scanned hard copy notes in the server project directory. If the local server is not backed up regularly, save a back-up copy in another location (e.g., computer hard disk).

4.2 GENERAL

Information to be documented will include the following, as applicable:

- Site name, project number and task number(s)
- Field investigator's name
- Date and time of work
- Expected contaminants on equipment and clothing
- Decontamination procedures and observations – including those completed prior to, during and following the work completed
- The number and types of rinsate samples collected, their sample names and the analytes for which they will be analysed
- Quantity and type of wastewater and other wastes produced, and temporary storage location
- Procedures and contractors used for disposal of development, purge and decontamination wastewater and other wastes, if applicable
- Unusual conditions (i.e., those that may affect observation and/or samples)
- Decontamination observations
- Weather conditions
- Names/contact information of all field crew members and of any site visitors should be noted on the *RMS2* form and the form should be signed as required by SWP procedures.
- Location, description, and log of photographs
- References for all maps and photographs
- Summary of daily tasks and documentation on any cost or scope of work changes required by field conditions
- Signature and date by personnel responsible for observations
- Field equipment used
- Identification of ultimate waste disposal facility, if applicable.

5 RESOURCES

5.1 RELATED SOPS

- SOP *ES2.01 – Environmental Surface Soil Sampling*
- SOP *ES2.02 – Environmental Test Pit Excavation*
- SOP *ES2.03 – Environmental Borehole Drilling and Soil Sampling*
- SOP *ES3.01 – Monitoring Well Installation*
- SOP *ES3.03 – Monitoring Well Development*
- SOP *ES4.03 – Groundwater Sample Collection*
- SOP *ES4.02 – Sample Naming Protocol*
- SOP *ES6.01 – Excavation Monitoring*
- SOP *ES6.02 – Underground Storage Tank Removal*

5.2 STANDARD FORMS

- *ESFF2.02 – Daily Activity Record*
- *ESFF2.24 – Drum Tracking*
- *ESFF2.26 – Photograph Log*
- *ESFF2.35 – Working Alone*

ESFF2.02 - DAILY ACTIVITY RECORD

Project Name: _____ Project Number: _____

Project Manager: _____ Date: _____

Field Personnel: _____ Weather: _____

Health & Safety:

RMS2 - Field Risk Assessment/Job Hazard Evaluation Complete (__)

Time	Description of Activities
	Technical Recovery Form Completed ☐

Quality Control: This form is complete (__) & legible (__). Descriptions include: scope of activity, location, field staff, methodology, timing, etc. (__).

check (_ √_)

Signatures: _____ _____

(field personnel) (date)

Signatures: _____ _____

(project manager) (date)

ESFF2.17 - SUMMARY OF DAILY DRILLING ACTIVITIES

Project Name: ______________________ Project Number: ______________________

Project Manager: ______________________ Date: ______________________

Field Personnel: ______________________ Operator/Helper: ______________________

Contractor: ______________________ Equipment: ______________________

Loca ion Drilled	Total Depth		Time (hours)							Consumables						
	feet	m	Set-up	Drilling	Well Install	Well Develop	Decon.	Stand-by	Rig Down-Time	Screen (feet)	Riser (feet)	Sand (bags)	Bentonite (bags)	Cement (bags)	Drums (each)	Well Materials
																☐ End Cap ☐ Well Cap ☐ J-plug ☐ Protective Casing ☐ Lock
																☐ End Cap ☐ Well Cap ☐ J-plug ☐ Protective Casing ☐ Lock
																☐ End Cap ☐ Well Cap ☐ J-plug ☐ Protective Casing ☐ Lock
																☐ End Cap ☐ Well Cap ☐ J-plug ☐ Protective Casing ☐ Lock
																☐ End Cap ☐ Well Cap ☐ J-plug ☐ Protective Casing ☐ Lock
Daily Totals:																_______ End Cap _______ Well Cap _______ J-plug _______ Protective Casing _______ Lock

Quality Control:
This form is complete (__) & legible (__).

Signatures: ______________________ ______________________
(field personnel) (date)

Signatures: ______________________ ______________________
(project manager) (date)

APPENDIX D

EXCERPTED MATERIALS FROM LABORATORIES' QUALITY ASSURANCE MANUALS

ALS Environmental - Salt Lake City
Detection Limits / Control Limits

Method: EPA TO-15 by IH-AN-014
Matrix: Air

		Detection Limits			Control Limits Historical/Performance			
Compound	CAS Number	MDL	RL	Units	LCL	UCL	RPD	
Dichlorodifluoromethane	75-71-8	0.15	0.5	ppb	44.8	152	25	
Methyl chloride	74-87-3	0.15	0.5	ppb	37.8	190	25	
Freon 114	76-14-2	0.15	0.5	ppb	54.2	146	25	
Vinyl chloride	75-01-4	0.15	0.5	ppb	51.9	146	25	
1,3-Butadiene	106-99-0	0.15	0.5	ppb	36.1	183	25	
Bromomethane	74-83-9	0.15	0.5	ppb	57.6	135	25	
Ethyl chloride	75-00-3	0.15	0.5	ppb	51.1	145	25	
Freon 11	75-69-4	0.15	0.5	ppb	47.8	149	25	
Freon 113	76-13-1	0.15	0.5	ppb	69	133	25	
1,1-Dichloroethene	75-35-4	0.15	0.5	ppb	53.6	145	25	
Acetone	67-64-1	0.3	1	ppb	50.1	144	25	
Carbon disulfide	75-15-0	0.15	0.5	ppb	60.9	136	25	
Methylene chloride	75-09-2	0.15	0.5	ppb	44.1	153	25	
trans-1,2-Dichloroethene	156-60-5	0.15	0.5	ppb	62.5	139	25	
Methyl t-butyl ether	1634-04-4	0.15	0.5	ppb	66.1	139	25	
Vinyl acetate	108-05-4	0.2	0.5	ppb	41.4	159	25	
Methyl ethyl ketone	78-93-3	0.15	0.5	ppb	57.2	148	25	
cis-1,2-Dichloroethene	156-59-2	0.15	0.5	ppb	63.7	142	25	
1,1-Dichloroethane	75-34-3	0.15	0.5	ppb	71.1	145	25	
Ethyl acetate	141-78-6	0.3	1	ppb	54.4	150	25	
n-Hexane	110-54-3	0.15	0.5	ppb	60.2	142	25	
Chloroform	67-66-3	0.15	0.5	ppb	64.6	131	25	
Tetrahydrofuran	109-99-9	0.15	0.5	ppb	64.2	147	25	
1,2-Dichloroethane	107-06-2	0.15	0.5	ppb	52.7	144	25	
1,1,1-Trichloroethane	71-55-6	0.15	0.5	ppb	61.5	137	25	
Carbon tetrachloride	56-23-5	0.15	0.5	ppb	57.9	143	25	
Benzene	71-43-2	0.15	0.5	ppb	56.5	144	25	
Cyclohexane	110-82-7	0.15	0.5	ppb	61.8	132	25	
Trichloroethene	79-01-6	0.15	0.5	ppb	70.9	137	25	
1,2-Dichloropropane	78-87-5	0.15	0.5	ppb	59.7	140	25	
Bromodichloromethane	75-27-4	0.15	0.5	ppb	63.3	136	25	
Heptane	142-82-5	0.15	0.5	ppb	59	148	25	
cis-1,3-Dichloropropene	10061-01-5	0.15	0.5	ppb	65.9	143	25	
Methyl isobutyl ketone	108-10-1	0.15	0.5	ppb	62.1	149	25	
trans-1,3-Dichloropropene	10061-02-6	0.15	0.5	ppb	64.7	145	25	
1,1,2-Trichloroethane	79-00-5	0.15	0.5	ppb	68.3	134	25	
Toluene	108-88-3	0.15	0.5	ppb	66.1	147	25	
2-Hexanone	591-78-6	0.32	1	ppb	58.5	162	25	

ALS Environmental - Salt Lake City
Detection Limits / Control Limits

Method: EPA TO-15 by IH-AN-014
Matrix: Air

		Detection Limits			Control Limits Historical/Performance			
Compound	CAS Number	MDL	RL	Units	LCL	UCL	RPD	
Tetrachloroethene	127-18-4	0.15	0.5	ppb	60	146	25	
Dibromochloromethane	124-48-1	0.15	0.5	ppb	57.1	181	25	
1,2-Dibromoethane	106-93-4	0.15	0.5	ppb	54.8	182	25	
Chlorobenzene	108-90-7	0.15	0.5	ppb	53.9	181	25	
Ethyl benzene	100-41-4	0.15	0.5	ppb	56	179	25	
m,p-Xylene	179601-23-1	0.3	1	ppb	54.6	173	25	
o-Xylene	95-47-6	0.15	0.5	ppb	53.3	175	25	
Styrene	100-42-5	0.3	1	ppb	61.7	146	25	
Bromoform	75-25-2	0.3	1	ppb	52.9	184	25	
1,1,2,2-Tetrachloroethane	79-34-5	0.15	0.5	ppb	49.5	151	25	
4-Ethyl toluene	622-96-8	0.3	1	ppb	47.8	194	25	
1,3,5-Trimethylbenzene	108-67-8	0.3	1	ppb	43.9	187	25	
1,2,4-Trimethylbenzene	95-63-6	0.3	1	ppb	50.4	164	25	
1,3-Dichlorobenzene	541-73-1	0.3	1	ppb	53.9	158	25	
1,4-Dichlorobenzene	106-46-7	0.3	1	ppb	52	161	25	
Benzyl chloride	100-44-7	0.37	1	ppb	30.4	196	25	
1,2-Dichlorobenzene	95-50-1	0.3	1	ppb	49.3	164	25	
1,2,4-Trichlorobenzene	120-82-1	0.42	1	ppb	0.2	198	25	
Hexachloro-1,3-butadiene	87-68-3	0.3	1	ppb	29.7	155	25	

ALS Environmental

QUALITY ASSURANCE MANUAL

ALS Environmental – Salt Lake City
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QUALITY ASSURANCE MANUAL

Doc ID:	QAM	Rev. Number:	12	Effective Date:	08/24/2022

Signatures on File

Approved By: _____ Date: _____
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Approved By: _____ Date: _____
QA Manager – Jessica Helland

Approved By: _____ Date: _____
Technical Manager –Steven J. Sagers

Approved By: _____ Date: _____
Technical Manager – Christopher Q. Coleman

Table of Contents

Cross Reference Table (ISO 17025:2017 to TNI Volume 1:2016)

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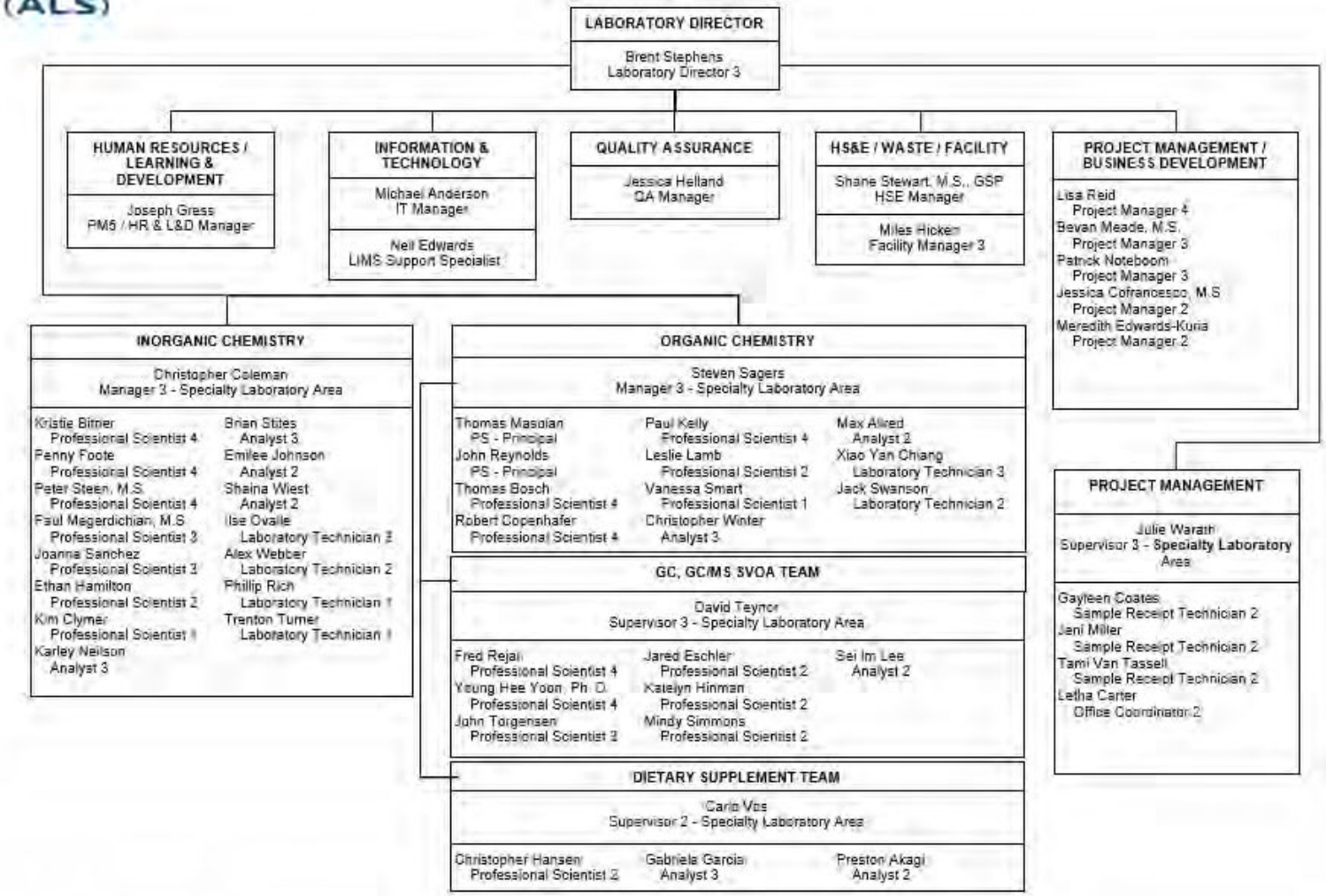
SALT LAKE LABORATORY



3/21/2022

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LABORATORY ETHICS AND DATA INTEGRITY

CE-GEN001

SOPID: CE-GEN001	Rev. Number: 5.00	Effective Date: 05/1/2019

Approved By: _____ Date: _____

Director of Operations, USA – Jim Klippel

Prepared By: _____ Date: _____

USA Quality Improvement Manager, Bob Di Rienzo

Annual Review:

Reviewed By: _____ Date: _____

Reviewed By: _____ Date: _____

Reviewed By: _____ Date: _____

Reviewed By: _____ Date: _____

Reviewed By: _____ Date: _____

LABORATORY ETHICS AND DATA INTEGRITY

CE-GEN-001

SOP ID: CE-GEN-001 Rev. Number: 5 Effective Date: 03/1/2019

Approved By: _____ Date: 3/28/2019
Director of Operations, USA – Jim Kippel

Prepared By: _____ Date: 3-25-19
USA Quality Improvement Manager,
Rob Di Rienzo

Concurrence:

Cincinnati: Laboratory Director: _____ Date: 4/2/19

Dayton: Laboratory Director: _____ Date: 4-2-19

Fort Collins: Laboratory Director: _____ Date: 4/2/19

Holland: Laboratory Director: _____ Date: 4/5/19

Houston: Laboratory Director: _____ Date: 04/05/19

Irvine: Laboratory Director: _____ Date: 4/8/19

Jacksonville:	Laboratory Director:	Date: 4/8/19
Kelso:	Laboratory Director:	Date: 4/8/19
Marshfield:	Laboratory Director:	Date: 4/9/19
Middletown:	Laboratory Director:	Date: 4/9/19
Rochester:	Laboratory Director:	Date: 4/2/19
Salt Lake City:	Laboratory Director:	Date: 4/11/19
Simi Valley:	Laboratory Director: Kate Kaneko	Date: 4/11/19
Torrance:	Laboratory Director:	Date: 12 Apr 2019
Tucson:	Laboratory Director:	Date:

Annual Review:

Reviewed By:		Date:
Reviewed By:		Date:
Reviewed By:		Date:
Reviewed By:		Date:

Sample Preservation, Containers and Hold Times

					Holding Time (Days)	
Analysis	Matrix	Method	Sample Size/Container	Preservative[1]	From Sampling	From Extraction
Acidity	W/WW	305.1	500 mL/P	Cool, 4 C	14	
Alkalinity	W/WW	310.1/310.2	500 mL/P	Cool, 4 C	14	
Ammonia	W/WW	350.1	500 mL/P	Cool, 4 C H_2SO_4 pH<2	28	
Anions	W/WW S/SW	300.0 300.0 Mod	500 mL/P 4 oz/G	Cool, 4 C	28 (2 for NO_3, NO_2 & PO_4)	
Aroclors (PCBs)	W/WW S/SW	8082	2 x 1 L/AG 4 oz/AG	Cool, 4 C	None	
BTEX	W/WW S/SW	8260C	2 x 40 mL/AG 4 oz/AG	Cool, 4 C, HCl pH<2	14 14	
Chemical Oxygen Demand (COD)	W/WW	COD/HACH	500 mL/P	Cool, 4 C H_2SO_4 pH<2	28	
Color	W	110.2	250 mL/P	Cool, 4 C	2	
Conductivity	W/WW S/SW	120.1/SM2510B/ 9050A	500 mL/P 4 oz/G	Cool, 4 C	28	
Corrosivity	W/WW S/SW	1110A	250 mL/P 4 oz/P	NA	7 7	
Cyanide	W/WW S/SW	335.4 9012B	1L/P 4 oz/P	NaOH, pH>12 Cool, 4 C	14 14	
Diesel Range Organics	W/WW S/SW	8015B	1 L/AG 4 oz/AG	Cool, 4 C	14 14	40 40
DIMP/DMMP	W/WW S/SW	ALS SOP	2 x 1L/AG 4 oz/AG	Cool, 4 C	14 14	— 40
Dioxins/Furans (7)	W/WW S/SW	8280/8290	2 x 1 L/AG 4 oz/AG	Cool, 4 C 0.008% $Na_2S_2O_3$	7 30	40 45
EMPA, IMPA,MPA, etc.	W/WW S/SW	UT04 ALS SOP	2 x 1L/AG 4 oz/AG	Cool, 4 C	14 14	40 40
Explosives	W/WW S/SW	8330	2 x 1 L/AG 4 oz/AG	Cool, 4 C, Dark 0.008% $Na_2S_2O_3$	7 14	40 40
Fluoride	W/WW	340.2	500 mL/P	NA	28	
Gasoline Range Organics	W/WW S/SW	8260C	2 X 40 mL/AG 4 oz/P	Cool, 4 C HCl, pH<2	14 14	
Herbicides	W/WW S/SW	8151A	2 x 1 L/AG 4 oz/AG	Cool, 4 C 0.008% $Na_2S_2O_3$	7 14	40 40
Hexavalent Chromium	W/WW S/SW	7196A	500 mL/P 4 oz/P/G	Cool, 4 C	1 28	 1
Ignitability	W/WW S/SW	1010A	500 mL/G 4 oz/G	None	7	
Mercury	W/WW S/SW	245.1/245.5 7470A/7471B	250mL/P/G 4 oz/P/G	HNO_3, pH<2	28 28	
Metals ICP/AA	W/WW S/SW	200 Series 6010C/6020A	500 mL/P 4 oz/P/G	HNO_3 pH<2	180 180	
NDMA	W/WW S/SW	UM34 and ALS SOP	2 x 1 L/AG 4 oz/AG	Cool, 4 C	7 14	40 40
Nitrate	W/WW	353.2	250 mL/P	Cool, 4 C	2	
Nitrate + Nitrite	W/WW	353.2	250 mL/P	Cool, 4 C H_2SO_4 pH<2	28	
Nitrite	W/WW	353.2 Mod	125 mL/P	Cool, 4 C	2	

See Notes on Page ES-15

					Holding Time (Days)	
Analysis	Matrix	Method	Sample Size/Container	Preservative [1]	From Sampling	From Extraction
Nitroglycerin/PETN	W/WW S/SW	8332	2 x 1 L/AG 4 oz/AG	Cool, 4 C	7 14	40 40
Odor	W/WW	140.1	500 mL/G	Cool, 4 C	1	
Oil & Grease [7]	W/WW	1664A	1 L/AG	Cool, 4 C H_2SO_4 or HCL pH<2	28	
Organochlorine Pesticides	W/WW S/SW	8081	2 x 1 L/AG 4 oz/AG	Cool, 4 C, pH 5-9 0.008% $Na_2S_2O_3$	7 14	40 40
ortho-Phosphate	W/WW	365.1	125 mL/P	Cool, 4 C Filter Immediately	2	
Perchlorate	W/WW S/SW	EPA 6850	500 mL/P 4 oz/AG	Cool, 4 C	28 28	
pH	W/WW S/SW	150.1 9040C/9045D	500mL/P 4 0z/P/G	Cool, 4 C	ASAP ASAP	
Phenolics	W/WW	420.4 9066	1 L/AG 4 oz/AG	Cool, 4 C H_2SO_4 pH<2	1 28	
Phosphorus—White/ Elemental (P4)	WWW S/SW	7580	250 mL/AG 4 oz/AG	Cool, 4 C, No headspace	5 30	
Polynuclear Aromatics (PAHs)	W/WW S/SW	8270D 8310	2 x 1 L/AG 4 oz/AG	Cool, 4 C, Dark 0.008% $Na_2S_2O_3$	7 14	40 40
Reactive Cyanide	W/WW S/SW	7.3.3.2	500 mL/P 4 oz/P/G	Cool, 4 C Dark	7 7	
Reactive Sulfide	W/WW S/SW	7.3.4.2	500 mL/P 4 oz/P/G	Cool, 4 C Dark	7 7	
Semivolatile Organics	W/WW S/SW	8270D	2 x 1 L/AG 4 oz/AG	Cool, 4 C 0.008% $Na_2S_2O_3$	7 14	40 40
Sulfide	W/WW S/SW	376.1 9030B	500 mL/P 4 oz/P/G	Cool, 4 C pH>9 NaOH, ZnOAc	7 7	
TCLP Metals	W/WW S/SW	1311	1 L/P	NA	180	
TCLP Semivolatiles, Pesticides, & Herbicides	W/WW S/SW	1311	3 X 1L/AG 4 oz/AG	Cool, 4 C	14 (leach) 7 (extraction)	40
TCLP Volatiles	W/WW S/SW	1311	3 X 40mL/AG 4 oz/AG	Cool, 4 C	14 (leach) 14 (analyze)	
Thiodiglycol	W/WW S/SW	UL09 LL9	2 x 1 L/AG 4 oz/AG	Cool, 4 C	14 14	— 40
Total Dissolved Solids	W/WW	160.1	500 mL/P	Cool, 4 C	7	
Total Kjeldahl Nitrogen	W/WW	351.2	1 L/P	Cool, 4 C H_2SO_4 pH<2	28	
Total Organic Carbon (TOC)	W/WW S/SW	415.1 9060A	250 mL/AG 4 oz/AG	Cool, 4 C H_2SO_4 pH<2	28 28	
Total Phosphorus	W/WW	365.4	125 mL/P	Cool, 4 C H_2SO_4 pH<2	28	
Total Recoverable Petroleum Hydrocarbons (TRPH)	W/WW	418.1	1 L/AG	Cool, 4 C H_2SO_4 pH<2	28	
Total Settleable Solids	W/WW	160.1	500 mL/P	Cool, 4 C	2	
Total Solids Moisture	W/WW S/SW	160.3	500 mL/P 4 oz/G	Cool, 4 C	7 7	

Note: See Notes on Page ES-15

Sample Preservation, Containers and Hold Times (cont.)

					Holding Time (Days)	
Analysis	Matrix	Method	Sample Size/Container	Preservative [1]	From Sampling	From Extraction
Total Suspended Solids	W/WW	160.2	500 mL/P	Cool, 4 C	7	
Total Volatile Solids	W/WW	160.4	250 mL/P	Cool, 4 C	7	
Turbidity	W/WW	180.1	250 mL/P	Cool, 4 C	2	
Volatile Organics	W/WW	524.2	2 x 40 mL/AG	Cool, 4 C Dechlorination then HCl, pH<2 No Headspace	14	
Volatile Organics	W/WW S/SW	8260C	2 x 40 mL/AG 4 oz/AG	Cool, 4 C HCl, pH<2, No Headspace	14 14	
MISCELLANEOUS						
Asbestos (7)	W	100.1	1 L/P	Cool, 4 C	2	
Asbestos (7)	W/W	100.1	1 L/P	Cool, 4 C	None	

Abbreviations used are as follows:

Matrix		Container		Preservatives	
W	Water	P	Plastic (HDPE)	NaOH	Sodium Hydroxide
WW	Waste Water	AG	Amber Glass	HCl	Hydrochloric Acid
S	Soil/Sediment	G	Glass	HNO_3	Nitric Acid
SW	Solid Waste			H_2SO_4	Sulfuric Acid
				$Na_2S_2O_4$	Sodium Thiosulfate

[1] Chemical Preservative on W/WW matrix only.

Concerning 5035 VOA analysis using Sodium bi-sulfate preparation:

If carbonaceous materials are present, do not acid preserve samples	7 days from collection hold time
If vinyl chloride, styrene, or 2-chloroethyl vinyl ether are the analysis of interest, no acid preservation is recommended and analysis is necessary as soon as possible	7 days from collection hold time

NOTES:

1. Sample preservation should be performed during sample collection.
2. Soil samples can be collected in either glass jars or stainless steel liners with both ends sealed with Teflon® paper and plastic caps.
3. Extraction hold times are from the date of sampling, and analysis hold times are from the date of extraction.
4. If analyzing for dissolved metals, the sample shall be field-filtered through a 0.45-µm filter immediately (within 15 minutes) after sample collection and prior to preservation.
5. Provide twice the number of containers listed when matrix spike, matrix duplicate, and matrix spike duplicate analyses are requested for the sample. Minimum frequency is one per 20 field samples.
6. This table includes the requirements of the U. S. Environmental Protection Agency, as published in the *Code of Federal Regulations,* Volume 49, Number 209, 40 CFR 136 dated October 26, 1984, page 43260 and SW846 Chapter 2 Table 2-36 Revision 3, December 1996.
7. ALS—SLC does not perform these analyses and subcontracts this work, with client approval, to certified vendors.

Organic QC Data Evaluation

(+) = meets criteria ***(-) = does NOT meet criteria***

LCS Recovery	MS Recovery	MS/MSD or Sample/MD RPD	Blank	Surrogate	Response
+	+	+	+	+	Samples are reported with no exceptions.
-	+	+	+	+	See LCS Flow Chart
+	-	+	+	+	See MS/MSD Flowchart
+	+	-	+	+	See MS/MSD and Duplicate Flowcharts
+	+	+	-	+	See Method Blank Flowchart
+	+	+	+	-	See Surrogate Flowchart
-	-	+	+	+	See LCS and MS/MSD Flowchart
+	-	-	+	+	See MS/MSD and Duplicate Flowcharts
+	+	-	-	+	See Method Blank Flowchart. See MS/MSD and Duplicate Flowchart.
+	+	+	-	-	See Method Blank Flowchart and Surrogate Flowchart
-	+	-	+	+	See LCS Flow Chart. See MS/MSD and Duplicate Flowcharts.
+	-	+	-	+	See Method Blank Flow Chart See MS/MSD and Duplicate Flowcharts.
+	+	-	+	-	See Surrogate Blank Flow Chart See MS/MSD and Duplicate Flowcharts.
_	_	_	_	-	Samples are reprepared and reanalyzed.

Please see the appropriate Method QC Flowchart

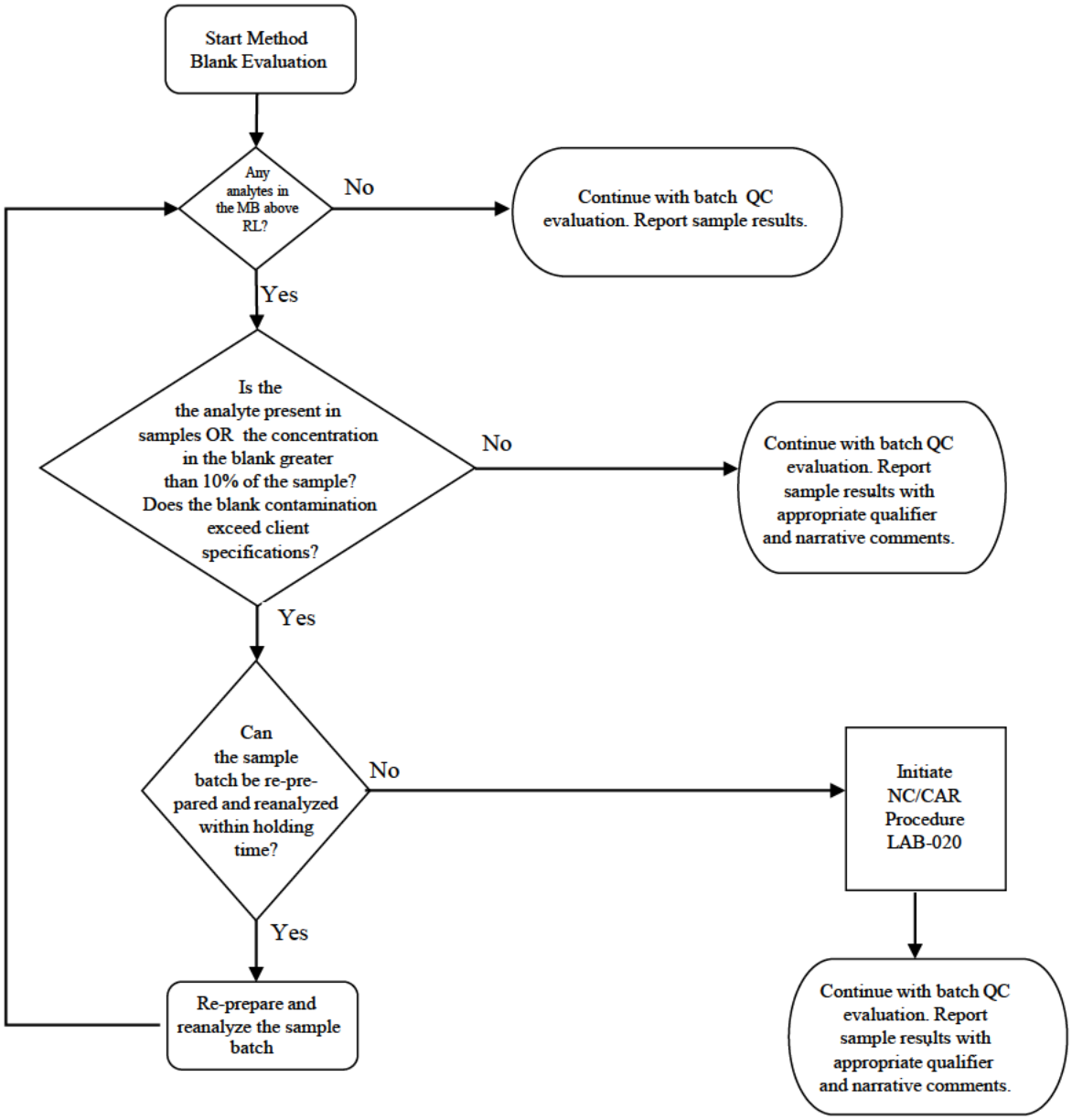
Inorganic QC Data Evaluation

(+) = meets criteria ***(-) = does NOT meet criteria***

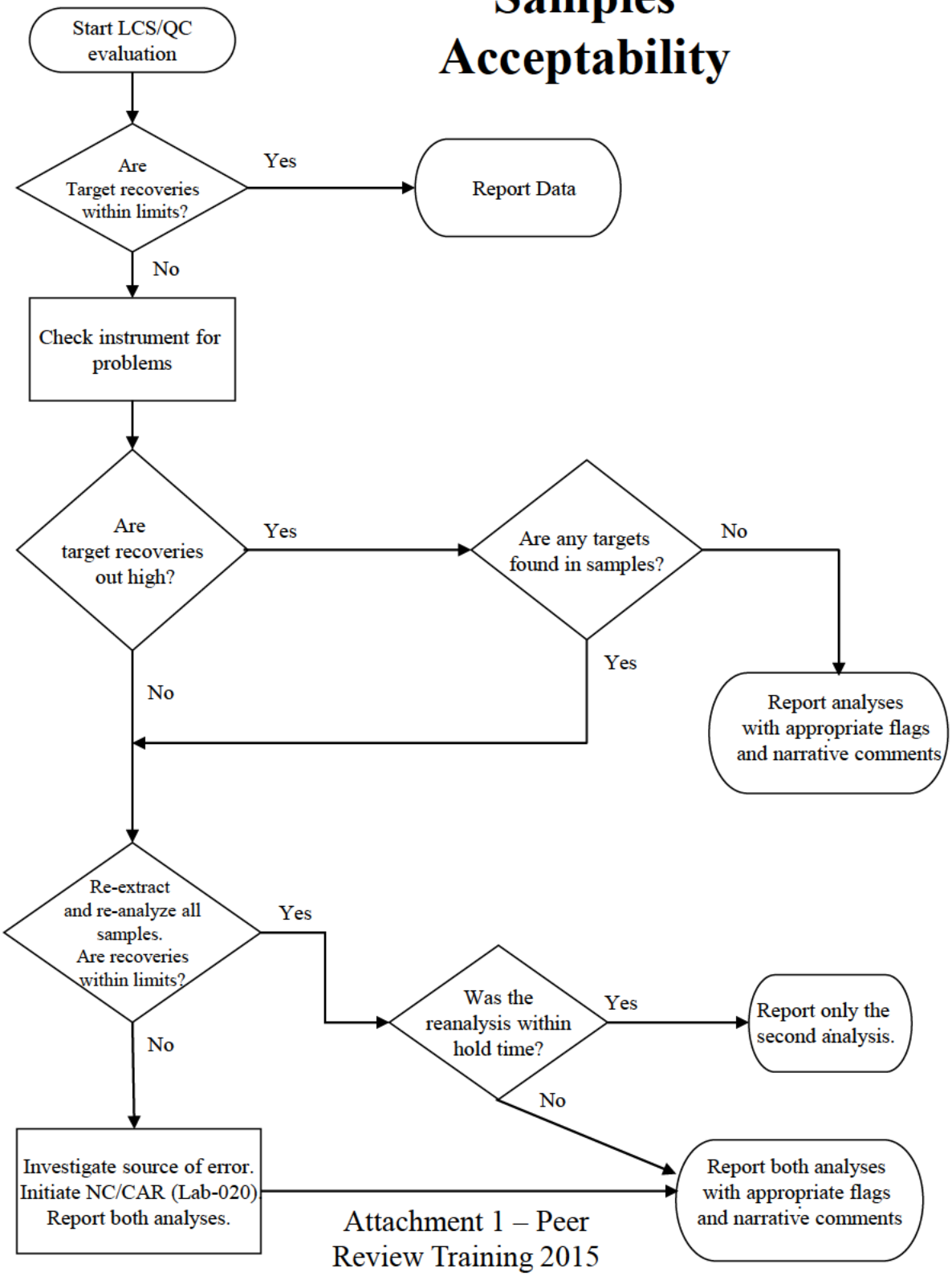
LCS Recovery	MS Recovery	MS/MSD or Sample/MD RPD	Blank	Response
+	+	+	+	Samples are reported with no exceptions.
+	+	+	–	See Method Blank Flowchart
+	+	–	+	See MS/MSD and Duplicate Flowcharts
+	–	+	+	See MS/MSD Flowchart
–	+	+	+	See LCS Flowchart for high bias
+	+	–	–	See Method Blank Flowchart, See MS/MSD and Duplicate Flowchart.
–	+	+	–	See Method Blank and LCS Flowcharts
–	+	–	+	See LCS, MS/MSD and Duplicate Flowcharts.
+	–	+	–	See MS/MSD and Method Blank Flowcharts.
+	–	–	+	See MS/MSD and Duplicate Flowcharts.
–	–	+	+	See LCS and MS/MSD Flowcharts.
+	–	–	–	See Method Blank, MS/MSD and Duplicate Flowcharts.
–	+	–	–	Samples are re-prepared and reanalyzed.
–	–	+	–	Samples are re-prepared and reanalyzed.
–	–	–	+	Samples are re-prepared and reanalyzed.
–	–	–	–	Samples are re-prepared and reanalyzed.

Please see the appropriate Method QC Flowchart

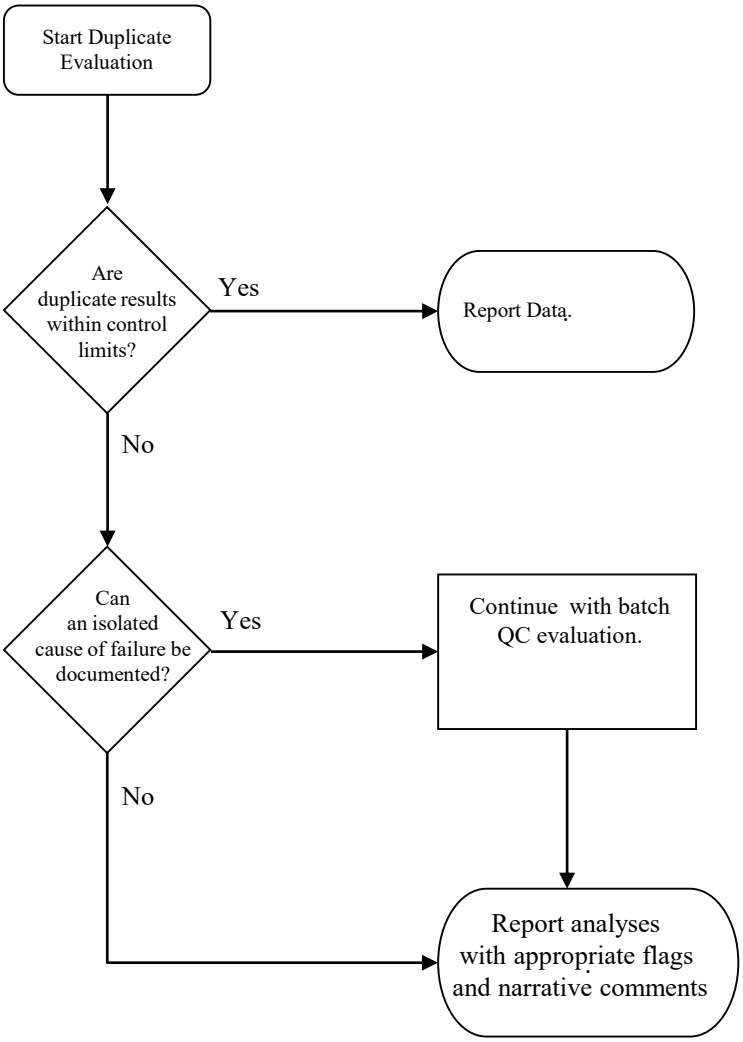
Method Blank Acceptability



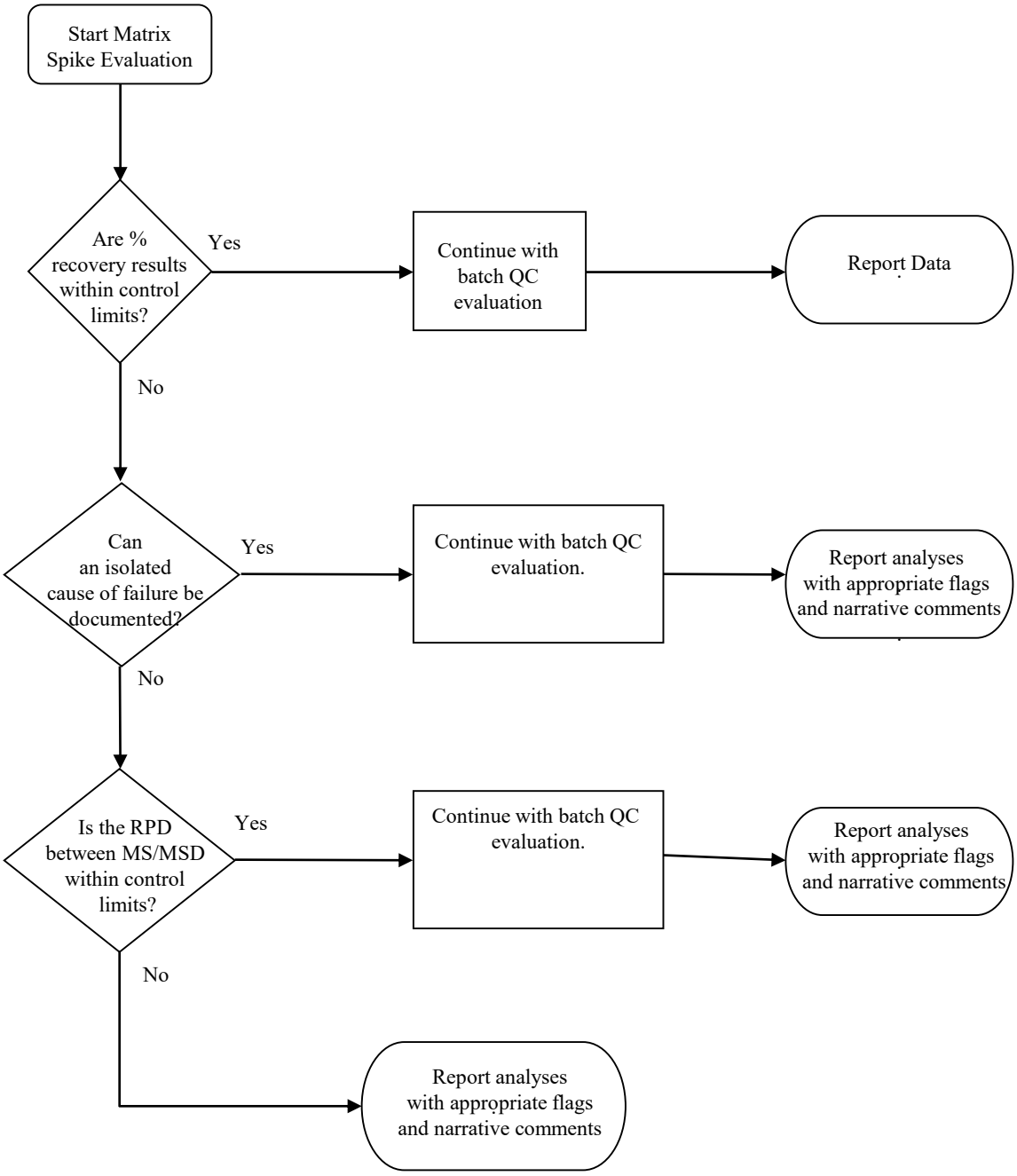
LCS/LCSD and QC/QCD Samples Acceptability



Matrix Duplicate Acceptability

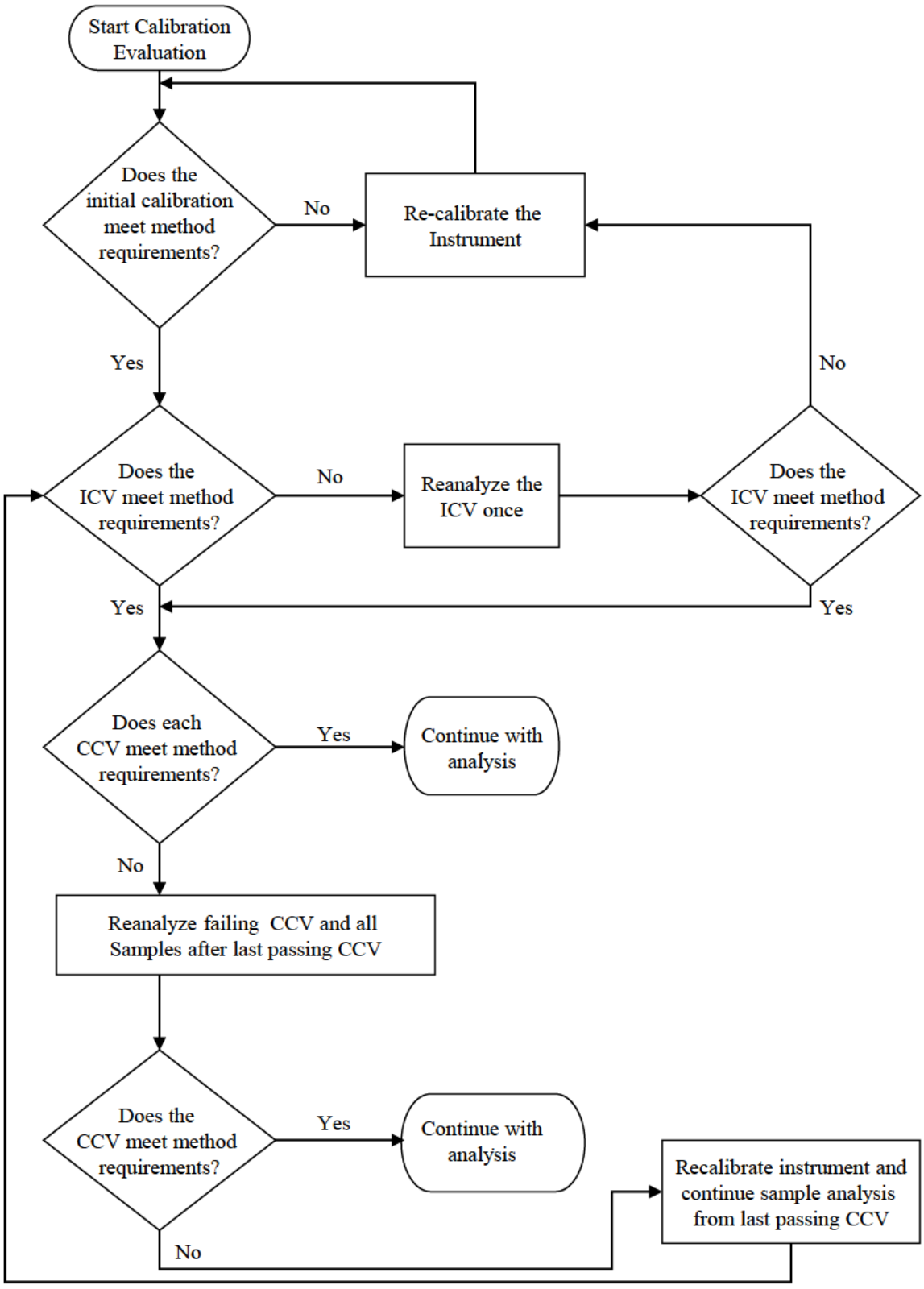


Matrix Spike/Matrix Spike Duplicate Acceptability

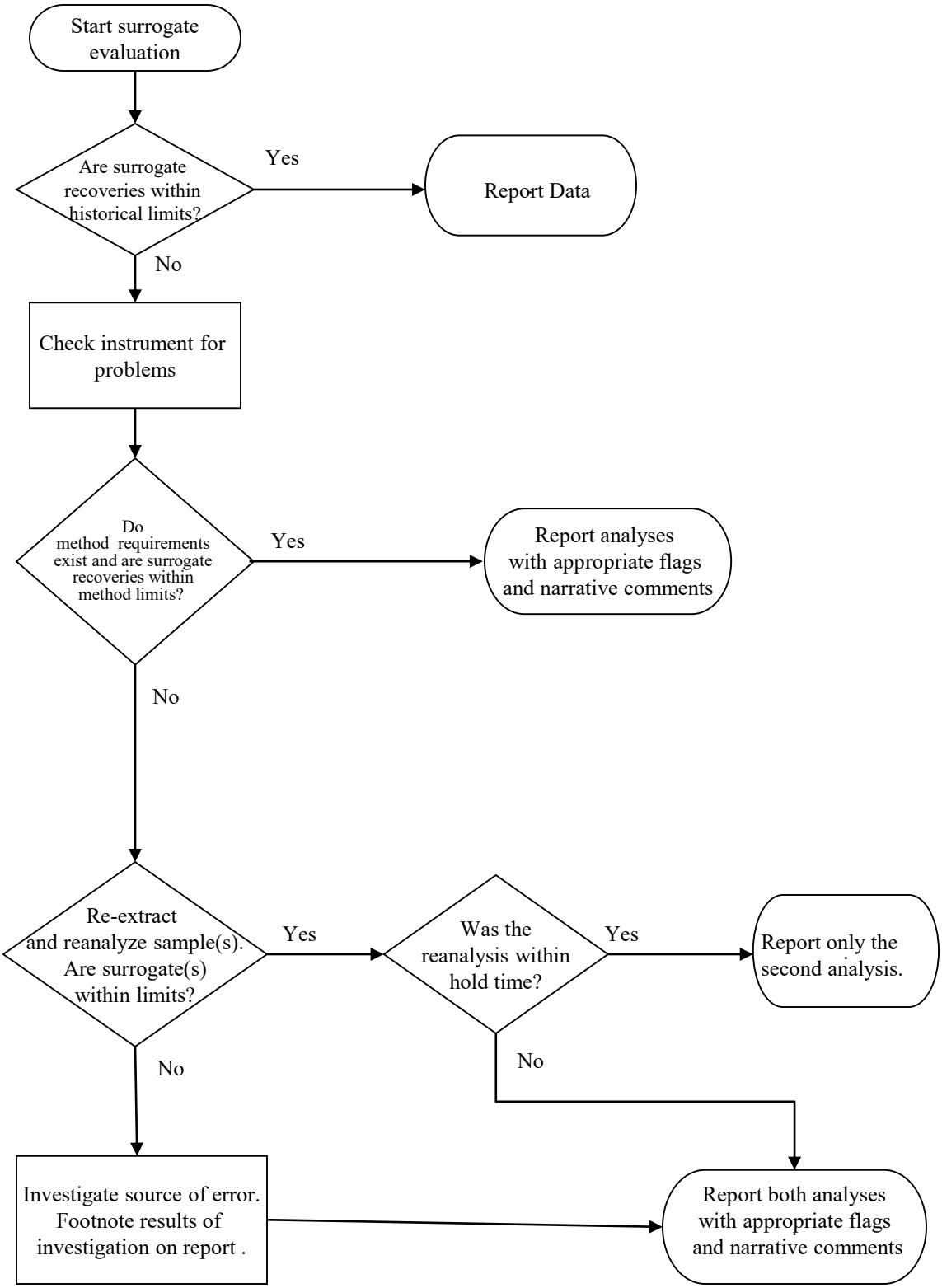


Attachment 1 – Peer Review Training 2015

Calibration Acceptablity



Surrogate Acceptability



[For lab use only]

ANALYTICAL REQUEST FORM

1. ☐ **REGULAR Status**

☐ **RUSH Status Requested - ADDITIONAL CHARGE**
RESULTS REQUIRED BY _____
DATE
CONTACT ALS SALT LAKE PRIOR TO SENDING SAMPLES

2. Date _____ Purchase Order No. _____

3. Company Name : _____

Address: _____

_____

Person to Contact: _____

Telephone ( ) _____

Fax Telephone ( ) _____

E-mail Address: _____

Billing Address (if different from above)

_____

_____

_____

4. Quote No. _____

ALS Project Manager: _____

5. Sample Collection

Sampling Site _____

Industrial Process: _____

Date of Collection _____

Time Collected _____

Date of Shipment _____

Chain of Custody No.: _____

6. How did you first learn about ALS?

_____

_____

7. REQUEST FOR ANALYSES

Client Sample Number	Matrix*	Sample/Area Volume	ANALYSES REQUESTED - Use method number if known	Units**	Lab Comments

* Specify: Solid sorbent tube, e.g. Charcoal; Filter type; Impinger solution; Bulk sample; Blood; Urine; Tissue; Soil; Water; Other

** 1. µg/sample 2. mg/m^3 3. ppm 4. % 5. µg/m^3 6. _____ (other) Please indicate one or more units in the column entitled Units**

Comments _____

_____

Possible Contamination and/or Chemical Hazards _____

7. Chain of Custody (Optional)

Relinquished by _____ Date/Time _____

Received by _____ Date/Time _____

Relinquished by _____ Date/Time _____

Received by _____ Date/Time _____

960 West LeVoy Drive / Salt Lake City, UT 84123 **800-356-9135 or 801-266-7700 / FAX: 801-268-9992**
ALS Environmental

ALS Environmental
Field Chain-of-Custody Record

CoC #:

Page _____ of _____

Client Name & Address:	Project Name & No.:
	ALS Quote No:
	Report to:
Phone:	Report to e-mail:
e-mail:	Bill to:

Matrix Codes
W) Water B) Bulk
L) Liquid F) Filter
S) Soil G) Wipe
C) Solid M) Media

Preservation Codes
1) Cool to 4°C
2) HCl to pH<2, 4°C
3) H_2SO_4 to pH<2, 4°C
4) HNO_3 to pH<2, 4°C
5) NaOH to pH>12, 4°C
6) ZnOAc/NaOH to pH>9, 4°C

Field Sample Number	Site ID	Depth	Date/Time	No. of Containers	Sample for Matrix QC	Analyses Requested								Preservation Code	Sample Matrix Code	Remarks

Possible Hazard Identification
☐ Non-Hazard ☐ Skin Irritant ☐ Rad
☐ Flammable ☐ Poison ☐ Unknown

Sample Disposal
☐ Return to Client ☐ Archive _____ Months
☐ Disposal by Lab
(fees assessed for samples retained > 3 months)

Data Deliverable:
☐ Level 1 ☐ Level 3
☐ Level 2 ☐ Level 4
EDD Type:

Requested Turn Around Time
☐ 2 Days (Rush) ☐ 7 Days (Rush)
☐ 3 Days (Rush) ☐ 14 Days
(Rush = email data by COB on day due. Surcharges assessed.)

Carrier/Airbill #:

Relinquished by: *(Signature)*	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: *(Signature)*	**Date**	**Time**	**Received by: (Signature)**	**Date**	**Time**
Relinquished by: *(Signature)*	**Date**	**Time**	**Received by: (Signature)**	**Date**	**Time**

Shipped to:

ALS Environmental
960 West LeVoy Drive
Salt Lake City, UT 84123
Phone: (800) 356-9135
Phone: (801) 266-7700
FAX: (801) 268-9992
WEB:www.alsglobal.com

White - Laboratory Copy ***Yellow - Client Copy***

ALS Environmental

Mycology Chain-of-Custody

Client Name & Address:	Project No.:
	Project Name:
Phone:	
e-mail:	Sampler Name: *(Printed)*
ALS Project Manager: Jessica Helland	

Requested Turn Around Time:

☐ Regular (4 days from receipt) ☐ 2 day RUSH

☐ Next Day RUSH ☐ Other

Sample ID	Date	Sample Location Description	Preservation Code	Sample Type Code	Analyses Requested: Air, Microscopic		Tape, Microscopic								Volume/Area	Remarks

Sample Type Codes
A) Air
D) Dust
T) Tape
S) Surface Swab
W) Water
WC) Wall Check
O) Other

Preservation Codes
1) Temp at oC
2) Sterile Saline
3) Buffer

Sample Disposal: ☐ Return to Client ☐ Archive for _____ Months ☐ Disposal by Lab (fees may be assessed for samples retained longer than 3 months)

Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time

Shipped to:
ALS Environmental
960 West LeVoy Drive
Salt Lake City, UT 84123
Phone: (800) 356-9135
Phone: (801) 266-7700
FAX: (801) 268-9992

White - Laboratory Copy ***Yellow - Client Copy***

ANALYTICAL REQUEST FORM

DIETARY SUPPLEMENTS

www.alsglobal.com

Submit samples to: 960 West LeVoy Drive
Salt Lake City, Utah 84123
Phone: 1-801-266-7700 or 1-800-356-9135
Fax: 1-801-268-9992 / alslt.lab@alsglobal.com

Company Name: _____
Mailing Address: _____
_____
Contact Name: _____
Phone Number: _____
E-Mail Address: _____
NOTE: Information provided above will appear on Analytical Report

Send Sample Receipt Notification to additional people (name & e-mail): _____

Send Analytical Report to additional people (name & e-mail): _____
_____
_____

Client PO Number: _____
Billing Address: _____
_____
Billing Contact: _____
Billing Phone: _____
Billing E-Mail: _____
Copy Invoice to: _____

Primary Sample Description	Lot Number	Matrix Code*	Analysis Requested	Specification	Serving Size	TAT Code**

* Matrix Code	** TAT Code	Fee Schedule
[P] Powder	[S] 5-7 Work Days Std.	Routine Price
[T] Tablet	[4] 4 Work Days Rush	Routine Price + 25%
[C] Capsule	[3] 3 Work Days Rush	Routine Price + 50%
[S] Softgel Capsule	[2] 2 Work Days Rush	Routine Price + 75%
[G] Granule	[1] 1 Work Day Rush	Routine Price + 100%
[CT] Chewable Tablet	[0] Same Day Rush	Routine Price + 200%
[SP] Stick Pack	Contact your ALS Project Manager before sending rush samples. Rush service may not always be available.	
[L] Liquid		
[GL] Gelatin		
[O] Other (specify)		

Sample Handling	Sample Storage	Sample Disposal
Note in comment section, any special precautions required to handle any of the samples submitted with this form. Client is responsible for any injury caused by unspecified samples.	Samples stored at room temperature. If different storage conditions are required, indicate in comment section. ALS is not responsible for degradation of unspecified samples.	Samples are disposed of 60 days from reporting. Indicate in the comment section, if other arrangements need to be made. ALS is not responsible for loss of unspecified samples.

Comments

Sample Chain of Custody

I agree to the following ALS Terms & Conditions provided with this sample submission whether or not relinquished below

Relinquished by _____ Date/Time _____
Received by ALS _____ Date/Time _____
Relinquished by _____ Date/Time _____
Received by _____ Date/Time _____

Laboratory Use Only - Sample Receipt or Other Lab Comments

NOTE: If a separate Analytical Report is required for a sample or for a group of samples, please use a separate Analytical Request Form for each sample or for each group of samples.

ChemTech-Ford
QAM Excerpts

Chemtech-Ford, Inc.
9632 South 500 West
Sandy, UT 84070
(801) 262-7299

Vice President of Quality: Paul Ellingson

Quality Manager: Ron Fuller

Laboratory Director: Dave Gayer

Date of Issue: October 1, 2017

Controlled Copy #: QM-27

Dave Gayer, Laboratory Director

Paul Ellingson, Vice President

Ron Fuller, QA Officer

Water

METHODCODE	ANALYTE	MDL	MRL	UNITS
8260 Low Level Volatiles	1,1,1,2-Tetrachloroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1,1-Trichloroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1,2,2-Tetrachloroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1,2-Trichloroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1,2-Trichlorotrifluoroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1-Dichloroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1-Dichloroethene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,1-Dichloropropene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2,3-Trichlorobenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2,3-Trichloropropane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2,4-Trichlorobenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2,4-Trimethylbenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2-Dibromo-3-chloropropane	1.0	1.0	ug/L
8260 Low Level Volatiles	1,2-Dibromoethane (EDB)	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2-Dichlorobenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2-Dichloroethane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,2-Dichloropropane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,3,5-Trimethylbenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,3-Dichlorobenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	1,3-Dichloropropane	0.3	1.0	ug/L
8260 Low Level Volatiles	1,4-Dichlorobenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	2,2-Dichloropropane	0.3	1.0	ug/L
8260 Low Level Volatiles	2-Chlorotoluene	0.3	1.0	ug/L
8260 Low Level Volatiles	2-Hexanone	20.0	20.0	ug/L
8260 Low Level Volatiles	2-Nitropropane	10.0	10.0	ug/L
8260 Low Level Volatiles	4-Chlorotoluene	0.3	1.0	ug/L
8260 Low Level Volatiles	Acetone	10.0	10.0	ug/L
8260 Low Level Volatiles	Acrylonitrile	10.0	10.0	ug/L
8260 Low Level Volatiles	Benzene	0.3	0.4	ug/L
8260 Low Level Volatiles	Bromobenzene	0.3	1.0	ug/L
8260 Low Level Volatiles	Bromochloromethane	0.3	1.0	ug/L
8260 Low Level Volatiles	Bromodichloromethane	0.3	1.0	ug/L
8260 Low Level Volatiles	Bromoform	1.0	1.0	ug/L
8260 Low Level Volatiles	Bromomethane	0.3	1.0	ug/L
8260 Low Level Volatiles	Carbon Disulfide	0.3	1.0	ug/L
8260 Low Level Volatiles	Carbon Tetrachloride	0.3	1.0	ug/L
8260 Low Level Volatiles	Chlorobenzene	0.3	1.0	ug/L

Solid

METHODCODE	ANALYTE	MDL	MRL	UNITS
8260 Low Level Volatiles	1,1,1,2-Tetrachloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1,1-Trichloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1,2,2-Tetrachloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1,2-Trichloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1,2-Trichlorotrifluoroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1-Dichloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1-Dichloroethene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,1-Dichloropropene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2,3-Trichlorobenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2,3-Trichloropropane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2,4-Trichlorobenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2,4-Trimethylbenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2-Dibromo-3-chloropropane	0.006	0.006	mg/kg dry
8260 Low Level Volatiles	1,2-Dibromoethane (EDB)	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2-Dichlorobenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2-Dichloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,2-Dichloropropane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,3,5-Trimethylbenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,3-Dichlorobenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,3-Dichloropropane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	1,4-Dichlorobenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	2,2-Dichloropropane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	2-Chlorotoluene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	2-Nitropropane	0.06	0.06	mg/kg dry
8260 Low Level Volatiles	4-Chlorotoluene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Acetone	0.06	0.06	mg/kg dry
8260 Low Level Volatiles	Benzene	0.002	0.002	mg/kg dry
8260 Low Level Volatiles	Bromobenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Bromochloromethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Bromodichloromethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Bromoform	0.006	0.006	mg/kg dry
8260 Low Level Volatiles	Bromomethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Carbon Disulfide	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Carbon Tetrachloride	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Chlorobenzene	0.002	0.006	mg/kg dry

8260 Low Level Volatiles	Chloroethane	0.3	1.0	ug/L	8260 Low Level Volatiles	Chloroethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Chloroform	1.0	1.0	ug/L	8260 Low Level Volatiles	Chloroform	0.006	0.006	mg/kg dry
8260 Low Level Volatiles	Chloromethane	0.3	1.0	ug/L	8260 Low Level Volatiles	Chloromethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	cis-1,2-Dichloroethene	0.3	1.0	ug/L	8260 Low Level Volatiles	cis-1,2-Dichloroethene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	cis-1,3-Dichloropropene	0.3	1.0	ug/L	8260 Low Level Volatiles	cis-1,3-Dichloropropene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Cyclohexanone	20.0	20.0	ug/L	8260 Low Level Volatiles	Cyclohexanone	0.12	0.12	mg/kg dry
8260 Low Level Volatiles	Dibromochloromethane	0.3	1.0	ug/L	8260 Low Level Volatiles	Dibromochloromethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Dibromomethane	0.3	1.0	ug/L	8260 Low Level Volatiles	Dibromomethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Dichlorodifluoromethane	0.3	1.0	ug/L	8260 Low Level Volatiles	Dichlorodifluoromethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Ethyl Acetate	10.0	10.0	ug/L	8260 Low Level Volatiles	Ethyl Acetate	0.06	0.06	mg/kg dry
8260 Low Level Volatiles	Ethyl Ether	0.3	1.0	ug/L	8260 Low Level Volatiles	Ethyl Ether	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Ethylbenzene	0.3	1.0	ug/L	8260 Low Level Volatiles	Ethylbenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Gasoline Range Organics	10.0	10.0	ug/L	8260 Low Level Volatiles	Gasoline Range Organics	0.06	0.06	mg/kg dry
8260 Low Level Volatiles	Hexachlorobutadiene	0.3	1.0	ug/L	8260 Low Level Volatiles	Hexachlorobutadiene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Isobutanol	10.0	10.0	ug/L	8260 Low Level Volatiles	Isobutanol	0.12	0.12	mg/kg dry
8260 Low Level Volatiles	Isopropylbenzene	0.3	1.0	ug/L	8260 Low Level Volatiles	Isopropylbenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Methyl Ethyl Ketone	10.0	10.0	ug/L	8260 Low Level Volatiles	Methyl Ethyl Ketone	0.06	0.06	mg/kg dry
8260 Low Level Volatiles	Methyl Isobutyl Ketone	10.0	10.0	ug/L	8260 Low Level Volatiles	Methyl Isobutyl Ketone	0.06	0.06	mg/kg dry
8260 Low Level Volatiles	Methylene Chloride	2.0	2.0	ug/L	8260 Low Level Volatiles	Methylene Chloride	0.01	0.12	mg/kg dry
8260 Low Level Volatiles	Methyl-tert-butyl ether (MTBE)	0.3	1.0	ug/L	8260 Low Level Volatiles	Methyl-tert-butyl ether (MTBE)	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Naphthalene	0.3	1.0	ug/L	8260 Low Level Volatiles	Naphthalene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	n-Butyl Alcohol	40.0	40.0	ug/L	8260 Low Level Volatiles	n-Butyl Alcohol	0.12	0.12	mg/kg dry
8260 Low Level Volatiles	n-Butylbenzene	0.3	1.0	ug/L	8260 Low Level Volatiles	n-Butylbenzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Nitrobenzene	20.0	20.0	ug/L	8260 Low Level Volatiles	Nitrobenzene	0.12	0.12	mg/kg dry
8260 Low Level Volatiles	n-Propyl Benzene	0.3	1.0	ug/L	8260 Low Level Volatiles	n-Propyl Benzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	p-Isopropyltoluene	0.3	1.0	ug/L	8260 Low Level Volatiles	p-Isopropyltoluene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	sec-Butyl Benzene	0.3	1.0	ug/L	8260 Low Level Volatiles	sec-Butyl Benzene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Styrene	1.0	1.0	ug/L	8260 Low Level Volatiles	Styrene	0.006	0.006	mg/kg dry
8260 Low Level Volatiles	tert-Butylbenzene	1.0	1.0	ug/L	8260 Low Level Volatiles	tert-Butylbenzene	0.006	0.006	mg/kg dry
8260 Low Level Volatiles	Tetrachloroethene	0.3	1.0	ug/L	8260 Low Level Volatiles	Tetrachloroethene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Toluene	0.3	1.0	ug/L	8260 Low Level Volatiles	Toluene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	trans-1,2-Dichloroethene	0.3	1.0	ug/L	8260 Low Level Volatiles	trans-1,2-Dichloroethene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	trans-1,3-Dichloropropene	0.3	1.0	ug/L	8260 Low Level Volatiles	trans-1,3-Dichloropropene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Trichloroethene	0.3	1.0	ug/L	8260 Low Level Volatiles	Trichloroethene	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Trichlorofluoromethane	0.3	1.0	ug/L	8260 Low Level Volatiles	Trichlorofluoromethane	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Vinyl Chloride	0.3	1.0	ug/L	8260 Low Level Volatiles	Vinyl Chloride	0.002	0.006	mg/kg dry
8260 Low Level Volatiles	Xylenes, total	0.3	1.0	ug/L	8260 Low Level Volatiles	Xylenes, total	0.002	0.006	mg/kg dry

Analysis	Analyte	MDL	MRL	Units	Analysis	Analyte	MDL	MRL	Units
8270D Semivolatiles	1,2,4-Trichlorobenzene	1	5	ug/L	8270D Semivolatiles	1,2,4-Trichlorobenzene	0.02	0.1	mg/kg
8270D Semivolatiles	1,2-Dichlorobenzene	2	5	ug/L	8270D Semivolatiles	1,2-Dichlorobenzene	0.03	0.1	mg/kg

8270D Semivolatiles	1,2-Diphenylhydrazine	2	10	ug/L	8270D Semivolatiles	1,2-Diphenylhydrazine	0.02	0.1 mg/kg
8270D Semivolatiles	1,3-Dichlorobenzene	1	5	ug/L	8270D Semivolatiles	1,3-Dichlorobenzene	0.01	0.1 mg/kg
8270D Semivolatiles	1,4-Dichlorobenzene	0.7	5	ug/L	8270D Semivolatiles	1,4-Dichlorobenzene	0.01	0.1 mg/kg
8270D Semivolatiles	2,3,4,6-Tetrachlorophenol	2	10	ug/L	8270D Semivolatiles	2,4-Dichlorophenol	0.04	0.4 mg/kg
8270D Semivolatiles	2,4,5-Trichlorophenol	3	10	ug/L	8270D Semivolatiles	2,3,4,6-Tetrachlorophenol	0.06	0.4 mg/kg
8270D Semivolatiles	2,4,6-Trichlorophenol	1	10	ug/L	8270D Semivolatiles	2,4,5-Trichlorophenol	0.03	0.4 mg/kg
8270D Semivolatiles	2,4-Dichlorophenol	0.9	10	ug/L	8270D Semivolatiles	2,4,6-Trichlorophenol	0.02	0.4 mg/kg
8270D Semivolatiles	2,4-Dimethylphenol	1	10	ug/L	8270D Semivolatiles	2,4-Dimethylphenol	0.03	0.1 mg/kg
8270D Semivolatiles	2,4-Dinitrophenol	4	20	ug/L	8270D Semivolatiles	2,4-Dinitrophenol	0.06	0.4 mg/kg
8270D Semivolatiles	2,4-Dinitrotoluene	0.8	5	ug/L	8270D Semivolatiles	2,4-Dinitrotoluene	0.07	0.2 mg/kg
8270D Semivolatiles	2,6-Dichlorophenol	2	10	ug/L	8270D Semivolatiles	2,6-Dichlorophenol	0.04	0.2 mg/kg
8270D Semivolatiles	2,6-Dinitrotoluene	0.9	5	ug/L	8270D Semivolatiles	2,6-Dinitrotoluene	0.04	0.2 mg/kg
8270D Semivolatiles	2-Nitroaniline	1	10	ug/L	8270D Semivolatiles	2-Chloronaphthalene	0.02	0.1 mg/kg
8270D Semivolatiles	2-Nitrophenol	2	10	ug/L	8270D Semivolatiles	2-Chlorophenol	0.03	0.2 mg/kg
8270D Semivolatiles	3 & 4-Methylphenol	2	10	ug/L	8270D Semivolatiles	2-Methylnaphthalene	0.04	0.1 mg/kg
8270D Semivolatiles	3,3Â´-Dichlorobenzidine	2	10	ug/L	8270D Semivolatiles	2-Methylphenol	0.02	0.2 mg/kg
8270D Semivolatiles	3-Nitroaniline	0.9	10	ug/L	8270D Semivolatiles	2-Nitroaniline	0.02	0.1 mg/kg
8270D Semivolatiles	4,6-Dinitro-2-methylphenol	1	10	ug/L	8270D Semivolatiles	2-Nitrophenol	0.04	0.4 mg/kg
8270D Semivolatiles	4-Bromophenyl phenyl ether	1	5	ug/L	8270D Semivolatiles	3 & 4-Methylphenol	0.1	0.4 mg/kg
8270D Semivolatiles	4-Chloro-3-methylphenol	2	10	ug/L	8270D Semivolatiles	3,3Â´-Dichlorobenzidine	0.03	0.2 mg/kg
8270D Semivolatiles	2-Chloronaphthalene	0.6	5	ug/L	8270D Semivolatiles	3-Nitroaniline	0.04	0.1 mg/kg
8270D Semivolatiles	2-Chlorophenol	2	10	ug/L	8270D Semivolatiles	4,6-Dinitro-2-methylphenol	0.15	0.4 mg/kg
8270D Semivolatiles	2-Methylnaphthalene	2	5	ug/L	8270D Semivolatiles	4-Bromophenyl phenyl ether	0.04	0.1 mg/kg
8270D Semivolatiles	2-Methylphenol	1	10	ug/L	8270D Semivolatiles	4-Chloro-3-methylphenol	0.02	0.2 mg/kg
8270D Semivolatiles	4-Chloroaniline	0.8	5	ug/L	8270D Semivolatiles	4-Chloroaniline	0.02	0.1 mg/kg
8270D Semivolatiles	4-Chlorophenyl Phenyl Ether	0.6	5	ug/L	8270D Semivolatiles	4-Chlorophenyl Phenyl Ether	0.08	0.1 mg/kg
8270D Semivolatiles	4-Nitroaniline	2	10	ug/L	8270D Semivolatiles	4-Nitroaniline	0.01	0.1 mg/kg
8270D Semivolatiles	4-Nitrophenol	4	20	ug/L	8270D Semivolatiles	4-Nitrophenol	0.08	0.4 mg/kg
8270D Semivolatiles	Acenaphthene	2	5	ug/L	8270D Semivolatiles	Acenaphthene	0.01	0.1 mg/kg
8270D Semivolatiles	Acenaphthylene	0.5	5	ug/L	8270D Semivolatiles	Acenaphthylene	0.01	0.1 mg/kg
8270D Semivolatiles	Azobenzene	2	5	ug/L	8270D Semivolatiles	Di-n-Octylphthalate	0.02	0.1 mg/kg
8270D Semivolatiles	Benzo (a) anthracene	0.9	5	ug/L	8270D Semivolatiles	Aniline	0.02	0.2 mg/kg
8270D Semivolatiles	Benzo (a) pyrene	0.9	5	ug/L	8270D Semivolatiles	Anthracene	0.02	0.1 mg/kg
8270D Semivolatiles	Benzo (b) fluoranthene	1	5	ug/L	8270D Semivolatiles	Azobenzene	0.01	0.1 mg/kg
8270D Semivolatiles	Benzo (g,h,i) perylene	2	5	ug/L	8270D Semivolatiles	Benzo (a) anthracene	0.02	0.1 mg/kg
8270D Semivolatiles	Benzo (k) fluoranthene	1	5	ug/L	8270D Semivolatiles	Benzo (a) pyrene	0.03	0.1 mg/kg
8270D Semivolatiles	Benzoic acid	2	10	ug/L	8270D Semivolatiles	Benzo (b) fluoranthene	0.02	0.1 mg/kg
8270D Semivolatiles	Benzyl Alcohol	1	10	ug/L	8270D Semivolatiles	Benzo (g,h,i) perylene	0.02	0.1 mg/kg
8270D Semivolatiles	Aniline	0.9	5	ug/L	8270D Semivolatiles	Benzo (k) fluoranthene	0.02	0.1 mg/kg
8270D Semivolatiles	Anthracene	0.7	5	ug/L	8270D Semivolatiles	Benzoic acid	0.04	0.4 mg/kg
8270D Semivolatiles	Di-n-butylphthalate	3	5	ug/L	8270D Semivolatiles	Benzyl Alcohol	0.01	0.1 mg/kg

8270D Semivolatiles	Bis (2-chloroethoxy) Methane	0.7	5	ug/L	8270D Semivolatiles	Bis (2-chloroethoxy) Methane	0.03	0.2	mg/kg
8270D Semivolatiles	Bis (2-chloroethyl) Ether	1	5	ug/L	8270D Semivolatiles	Bis (2-chloroethyl) Ether	0.03	0.2	mg/kg
8270D Semivolatiles	Bis (2-chloroisopropyl) Ether	1	5	ug/L	8270D Semivolatiles	Bis (2-chloroisopropyl) Ether	0.02	0.1	mg/kg
8270D Semivolatiles	Bis (2-ethylhexyl) Phthalate	5	10	ug/L	8270D Semivolatiles	Bis (2-ethylhexyl) Phthalate	0.05	0.1	mg/kg
8270D Semivolatiles	Butylbenzylphthalate	0.6	5	ug/L	8270D Semivolatiles	Butylbenzylphthalate	0.02	0.1	mg/kg
8270D Semivolatiles	Carbazole	0.8	5	ug/L	8270D Semivolatiles	Carbazole	0.02	0.1	mg/kg
8270D Semivolatiles	Chrysene	2	5	ug/L	8270D Semivolatiles	Chrysene	0.01	0.1	mg/kg
8270D Semivolatiles	Dibenzo (a,h) anthracene	1	5	ug/L	8270D Semivolatiles	Di-n-butylphthalate	0.04	0.1	mg/kg
8270D Semivolatiles	Dibenzofuran	0.6	5	ug/L	8270D Semivolatiles	Dibenzo (a,h) anthracene	0.02	0.1	mg/kg
8270D Semivolatiles	Diethylphthalate	0.6	5	ug/L	8270D Semivolatiles	Dibenzofuran	0.04	0.2	mg/kg
8270D Semivolatiles	Dimethyl phthalate	0.8	5	ug/L	8270D Semivolatiles	Diethylphthalate	0.01	0.1	mg/kg
8270D Semivolatiles	Di-n-Octylphthalate	0.5	5	ug/L	8270D Semivolatiles	Dimethyl phthalate	0.03	0.1	mg/kg
8270D Semivolatiles	Diphenylamine	2	5	ug/L	8270D Semivolatiles	Diphenylamine	0.02	0.1	mg/kg
8270D Semivolatiles	Fluoranthene	0.6	5	ug/L	8270D Semivolatiles	Fluoranthene	0.02	0.1	mg/kg
8270D Semivolatiles	Fluorene	0.7	5	ug/L	8270D Semivolatiles	Fluorene	0.02	0.1	mg/kg
8270D Semivolatiles	Hexachlorobenzene	1	5	ug/L	8270D Semivolatiles	Hexachlorobenzene	0.02	0.1	mg/kg
8270D Semivolatiles	Hexachlorobutadiene	0.5	5	ug/L	8270D Semivolatiles	Hexachlorobutadiene	0.03	0.1	mg/kg
8270D Semivolatiles	Hexachlorocyclopentadiene	0.6	10	ug/L	8270D Semivolatiles	Hexachlorocyclopentadiene	0.04	0.2	mg/kg
8270D Semivolatiles	Hexachloroethane	0.7	5	ug/L	8270D Semivolatiles	Hexachloroethane	0.02	0.1	mg/kg
8270D Semivolatiles	Indeno (1,2,3-cd) pyrene	2	5	ug/L	8270D Semivolatiles	Indeno (1,2,3-cd) pyrene	0.02	0.1	mg/kg
8270D Semivolatiles	Isophorone	1	5	ug/L	8270D Semivolatiles	Isophorone	0.01	0.1	mg/kg
8270D Semivolatiles	N-Nitrosodimethylamine	0.6	10	ug/L	8270D Semivolatiles	Naphthalene	0.003	0.1	mg/kg
8270D Semivolatiles	N-Nitrosodi-n-propylamine	0.8	5	ug/L	8270D Semivolatiles	N-Nitrosodimethylamine	0.06	0.2	mg/kg
8270D Semivolatiles	N-Nitrosodiphenylamine	1	5	ug/L	8270D Semivolatiles	N-Nitrosodi-n-propylamine	0.04	0.2	mg/kg
8270D Semivolatiles	Pentachlorophenol	4	10	ug/L	8270D Semivolatiles	N-Nitrosodiphenylamine	0.04	0.2	mg/kg
8270D Semivolatiles	Phenanthrene	0.5	5	ug/L	8270D Semivolatiles	Pentachlorophenol	0.03	0.2	mg/kg
8270D Semivolatiles	Phenol	1	10	ug/L	8270D Semivolatiles	Phenanthrene	0.01	0.1	mg/kg
8270D Semivolatiles	Naphthalene	0.9	5	ug/L	8270D Semivolatiles	Nitrobenzene	0.03	0.2	mg/kg
8270D Semivolatiles	Nitrobenzene	1	5	ug/L	8270D Semivolatiles	Phenol	0.04	0.4	mg/kg
8270D Semivolatiles	Pyrene	0.6	5	ug/L	8270D Semivolatiles	Pyrene	0.02	0.1	mg/kg
8270D Semivolatiles	Pyridine	1	10	ug/L	8270D Semivolatiles	Pyridine	0.04	0.2	mg/kg

6020	Arsenic, Total	0	0	mg/L	6020	Arsenic, Total	0.01	0.05	mg/kg	
6020	Barium, Total	0	0	mg/L	6020	Barium, Total	0.003	0.05	mg/kg	
6020	Cadmium, Total	0	0	mg/L	6020	Cadmium, Total	0.003	0.05	mg/kg	
6020	Chromium, Total	0	0	mg/L	6020	Chromium, Total	0.003	0.05	mg/kg	
6020	Lead, Total	0	0	mg/L	6020	Lead, Total	0.001	0.05	mg/kg	
6020	Silver, Total	0	0	mg/L	6020	Silver, Total	0.003	0.05	mg/kg	
6020	Selenium, Total	0	0	mg/L	6020	Selenium, Total	0.05	0.05	mg/kg	

6020	Mercury, Total	0	0	mg/L	6020	Mercury, Total	0.01	0.03	mg/kg	
8015	DRO	1	1	mg/L	8015	DRO	50	50	mg/kg	
8270 DRO Fractionation	C11-12 Aliphatic hydrocarbons	9	9	ug/L		C11-12 Aliphatic hydrocarbons	0.21	0.21	mg/kg	
8270 DRO Fractionation	C13-C16 Aliphatic hydrocarbons	9	9	ug/L		C13-C16 Aliphatic hydrocarbons	0.21	0.21	mg/kg	
8270 DRO Fractionation	C17-C21 Aliphatic hydrocarbons	9	9	ug/L		C17-C21 Aliphatic hydrocarbons	0.21	0.21	mg/kg	
8270 DRO Fractionation	C22-C35 Aliphatic hydrocarbons	9	9	ug/L		C22-C35 Aliphatic hydrocarbons	0.21	0.21	mg/kg	
8270 DRO Fractionation	C11-C13 Alkyl Naphthalenes	9	9	ug/L		C11-C13 Alkyl Naphthalenes	0.21	0.21	mg/kg	
8270 DRO Fractionation	Total C12-C22 PAH	9	9	ug/L		Total C12-C22 PAH	0.11	0.11	mg/kg	
8270 DRO Fractionation	Acenaphthene	2	5	ug/L		Acenaphthene	0.007	0.11	mg/kg	
8270 DRO Fractionation	Acenaphthylene	0.5	5	ug/L		Acenaphthylene	0.01	0.11	mg/kg	
8270 DRO Fractionation	Anthracene	0.7	5	ug/L		Anthracene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Benzo (a) anthracene	0.8	5	ug/L		Benzo (a) anthracene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Benzo (a) pyrene	0.8	5	ug/L		Benzo (a) pyrene	0.03	0.11	mg/kg	
8270 DRO Fractionation	Benzo (b) fluoranthene	1	5	ug/L		Benzo (b) fluoranthene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Benzo (g,h,i) perylene	1	5	ug/L		Benzo (g,h,i) perylene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Benzo (k) fluoranthene	0.9	5	ug/L		Benzo (k) fluoranthene	0.02	0.11	mg/kg	
8270 DRO Fractionation	2-Fluorobiphenyl			ug/L		2-Fluorobiphenyl			mg/kg	
8270 DRO Fractionation	Chrysene	1	5	ug/L		Chrysene	0.01	0.11	mg/kg	
8270 DRO Fractionation	Dibenzo (a,h) anthracene	1	5	ug/L		Fluoranthene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Fluoranthene	0.6	5	ug/L		Fluorene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Fluorene	0.7	5	ug/L		Terphenyl-dl4			mg/kg	
8270 DRO Fractionation	Terphenyl-dl4			ug/L		Indeno (1,2,3-cd) pyrene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Indeno (1,2,3-cd) pyrene	2	5	ug/L		Phenanthrene	0.01	0.11	mg/kg	
8270 DRO Fractionation	Phenanthrene	0.5	5	ug/L		Pyrene	0.02	0.11	mg/kg	
8270 DRO Fractionation	Pyrene	0.6	5	ug/L						
1664	O&G-HEM	1.8		mg/L	1664M	O&G-HEM	90	250	mg/kg	
1664	O&G-SGT	5		mg/L	1664M	O&G-SGT	90	250	mg/kg	

Quality Manual

This Quality Manual meets the requirements of ISO 17025, ISO 9001, and TNI. This Quality Manual is confidential and assigned as outlined below.

Original Document: Quality Manager

☐ Controlled Copy
☒ Uncontrolled Copy

All employees have access to a controlled version through Quality Manager, or through the Chemtech-Ford intranet. Printed copies are not considered controlled documents.

Companies whose Quality Systems are defined by this document are:

Chemtech-Ford Laboratories
9632 South 500 West
Sandy, UT 84070
801.262.7299

Timpview Analytical Laboratories
1384 West 130 South
Orem, UT 84058
801.229.2272

This Quality Manual has been approved for use by affiliate laboratories of Chemtech-Ford, Inc.

Table of Contents

Introduction

Purpose

This Quality Manual contains all the requirements that our laboratory uses to demonstrate our quality management system, technical competence, and valid results.

Section 4 specifies how we demonstrate sound management and maintain client satisfaction.

Section 5 specifies how we demonstrate technical competence in our laboratory.

In addition, this Quality Manual outlines how we meet:

- ISO 17025
- ISO 9001
- TNI

All personnel are to take an active role in establishing, implementing, and maintaining our quality management program. We do not separate quality from our daily business. Quality is integrated into every facet of the decision-making process in the management of our laboratory and the science that we practice.

It is the policy of Chemtech-Ford, Inc. and its employees to perform their duties in a consistently legal and ethical manner. A professionally high level of ethical behavior is characterized by, but not limited to, dealing honestly and forthrightly with all clients and co-workers, maintaining data integrity, the open and timely treatment of inaccurate, invalid, or misreported analytical data, and abiding by all pertinent rules, regulations, company policies, and standard operating procedures.

Chemtech-Ford, Inc. encourages its employees to demonstrate consistently ethical and professional behavior by implementing programs consonant with that purpose. These programs, generally, include:

1) a thorough training program for new employees and continuing seminars throughout employment which reflect Chemtech-Ford, Inc.'s commitment to integrity and quality control and which present specific ways to honor that commitment

2) a comprehensive documentation program for all facets of laboratory operation, which allows ready reconstruction of any quality process

3) a program of continual evaluation, both internally and externally, with required levels of quality acceptance

4) a management monitoring system which routinely evaluates the overall performance of the laboratory.

This Quality Manual summarizes the policies and procedures employed by Chemtech-Ford, Inc. It is the purpose of these policies and procedures to maintain the highest level of integrity and ethical behavior in all aspects of laboratory work.

Distribution List

The approved version of this manual is available to all employees through Quality Manager and/or Chemtech-Ford Laboratories intranet. All printed copies are uncontrolled.

In the event that a controlled copy of this manual is necessary, the Quality Manager will maintain a distribution list.

1. Scope

This Quality Manual facilitates:

- Recognition of technical competence for standardized methods, non-routine methods, and laboratory-developed methods we perform
- Inspection and product certification capabilities and/or services we provide
- Total quality for our administrative and technical systems
- Audits by clients, regulatory authorities and accreditation bodies
- Meeting the requirements of ISO 17025, ISO 9001, and TNI
- Client satisfaction

Chemtech-Ford Laboratories displays all Fields of Accreditation on our website.

2. Normative References

Reference List

ISO/IEC 17000, Conformity assessment – Vocabulary and general principles

VIM, International vocabulary of basic and general terms in metrology, issued by BIPM, IEC, IFCC, ISO, IUPAC, IUPAP and OIML.

ISO 9001:2000 – Quality Management Systems – Fundamentals and vocabulary.

ISO/IEC 17025:2005 – General Requirements for the Competence of Testing and Calibration Laboratories.

TNI Standard, Volume 1, 2009 NELAC Standard.

Cross-references

This manual is numerically aligned with the international standard ISO 17025. Furthermore, each section cross-references the ISO 9001 standard.

For ease of use, each section starts with a brief summation of what the section addresses and a listing of the quality terminology and key words.

3. Terms and Definitions

For the purposes of this manual, the following documents and their corresponding definitions apply: ISO/IEC 17000; ISO/IEC Guide 30; ISO Council Committee on Conformity Assessment (CASCO); ISO 9000; ISO 5725-1; ISO 17025; TNI 2009 Standard; AOAC; and International Vocabulary of Basic and General Terms in Metrology (VIM).

Accreditation – formal recognition of a laboratory by an independent science-based organization that the laboratory is competent to perform specific tests.

4.1 Organization

Section Synopsis

This section tells you our laboratory has:

1. Appointed a Quality Manager
2. Organized the workforce to achieve quality
3. Provided adequate resources to ensure quality

Key Words

Quality Manager
Organizational Chart
Authority
Resources
Confidential Information
Proprietary Rights
Responsibilities
Conflict of Interest

Cross-references

ISO 17025:2005 Section 4.1
ISO 9001:2000 Section 4.1, 5.1, 5.3, 5.4.1, 5.5.1, 5.5.2, 5.5.3, 6.1, 6.2.1, 6.2.2, 6.3.1, 7.1, 7.5.4

4.1.1 Legal Identification / Registration

Chemtech-Ford, Inc.
9632 South 500 West.
Sandy, UT 84070
(801)262-7299
(866)792-0093

4.1.2 Laboratory Requirements

The work area of Chemtech-Ford, Inc has been organized to satisfy the needs of the customer and regulatory authorities and to meet the international standards TNI, ISO 17025 and ISO 9001. Chemtech-Ford, Inc. is composed of the following work areas:

President/CEO/Vice Presidents
Lab Director
QA/QC Department
Customer Service Department
Receiving/Shipping Department
Organics Lab
Inorganics Lab
Microbiology Lab
Metals Lab

4.1.3 Scope of Management System

The management system covers activities all of the laboratory's facilities. The fields of activities include:

Environmental Sample Testing
Medical Device Testing
Nutraceutical Product Testing
Specialty Testing

The laboratory's scope of tests is listed in the current Price List.

4.1.5 Organization

A) Management and Technical Personnel

Policy:

The laboratory managerial and technical personnel, irrespective of other responsibilities, have the necessary authority and resources needed to meet the mandates assigned to their areas.

Details:
Responsibilities are detailed in 5.2.5

Departures from the organizational and management policies in this manual can only be approved by a Vice President.

Departures from quality management system procedures can only be approved by a Vice President or the Quality Manager.

Departures from test methods or technical standard operating procedures (SOPs) can only be approved by the Quality Manager and/or the Laboratory Director.

See also section 5.2.

B) Conflict of Interest

Policy:
Management and personnel are to be free from any undue internal and external commercial, financial and other pressures that may adversely affect the quality of their work. The integrity of test results is the responsibility of all personnel. Management ensures that employees are never instructed or forced to alter or falsify data. Chemtech-Ford Laboratories performs annual data integrity training. A review of the undue pressure policy is part of this training.

Details:
The following list provides some guidelines on how employees avoid conflict of interest situations. Employees shall not:

- falsify records, prepare fraudulent reports, or make false claims

- seek or use privileged or confidential company information, or data from any customer, for any purpose beyond the scope of employment
- conduct non-laboratory business on laboratory time, or use company facilities or equipment to conduct outside interests in business, unless prior approval has been obtained
- solicit business on their own behalf (rather than the laboratory) from a customer
- be employed by, or affiliated with, organizations whose products or services compete with laboratory products or services
- have employment that negatively affects or interferes with their performance of laboratory duties
- compete with the laboratory in the purchase, sale, or leasing of property or goods
- allow association, family, or friends to influence business decisions to their benefit. Decisions must be made on a strictly business basis, always in the best interest of the laboratory
- make any decision that provides gains or benefits to the employee and/or others
- have personal financial dealings with an individual or company that does business with the laboratory which might influence decisions made on the laboratory's behalf

Firm adherence to this code of values forms the foundation of our credibility. Personnel involved in dishonest activities are subject to a range of disciplinary action including dismissal.

C) Customer Confidentiality

Policy:
It is the policy of our laboratory to protect the confidential information and proprietary rights of our customer including the electronic storage and transmission of results.

Details and Procedures:
All employees sign a Confidentiality Agreement. The signed agreement is retained in each employee's Human Resources file.

Test results are only released to the customer. Release to someone other than the customer requires the express permission of the customer, except when the situation contravenes State or Federal Legislation and the results must be provided to the appropriate agency. The release of test results to anyone other than the customer requires the permission of management. Laboratory reports are reviewed for accuracy prior to release.

D) Operational Integrity

Policy:
The laboratory will avoid involvement in any activities that would diminish confidence in its competence, impartiality, judgment, or operational integrity.

Details and Procedures:
To ensure confidence in laboratory operations a formal quality assurance program is implemented. Technical competence is ensured through commercial performance testing studies and data formatted in DOCs (Demonstration of Competency) reports. Impartiality is assessed through audits and approvals. Judgment is ensured through the hiring of qualified personnel and by continuously refining, upgrading, and improving his or her skills. Operational integrity is reviewed by management on a regular basis at management review meetings to ensure continued suitability and effectiveness of laboratory policies and procedures. Any problems are acted on immediately through corrective action procedures.

E) Organizational Structure

Policy:
The organization and management structure of the laboratory and the relationships between management, technical operations, support services, and the quality management system is defined through the aid of an organizational chart.

Details:
The most current organizational structure is contained within Quality Manager. The organizational structure is reviewed at regular intervals (at least two times per calendar year).

F) Responsibility and Authority

The responsibility, authority and interrelationships of all personnel who manage, perform or verify work affecting the quality of the tests and/or calibrations is defined in section 5.2.5

G) Laboratory Supervision

Policy:

Adequate supervision is provided in each area of the laboratory for all testing and calibration personnel, including trainees, by persons familiar with the methods and procedures.

Details:
Adequate supervision is ensured through designated supervisors as well as through documentation such as this Quality Manual, test methods and SOPs. Initial and ongoing training for regular personnel is required. The successful completion of analyses in the commercial PT study program, and/or DOC studies are evidence of successful and continued training.

H) Technical Management

Policy:
A technical manager is assigned to each major work area of the laboratory. They have overall responsibility for the technical operations and the provision of resources needed to ensure the required quality of laboratory operations.

Details:
While the technical manager may at times delegate duties to other personnel, the technical manager is responsible for the work produced in his area of the laboratory, and is accountable for any nonconforming activities.

I) Quality Manager

Policy:
The Quality Manager is appointed by the highest level of management. The Quality Manager, who, irrespective of other duties and responsibilities, has defined responsibility and authority for ensuring that the management system related to quality is implemented and followed. The Quality Manager has direct access to the highest level of management where decisions are taken on laboratory policy or resources.

Details:
This statement notifies all laboratory personnel that the Quality Manager is authorized by senior management and the President to administer all activities relating to the Chemtech-Ford Laboratories quality system. A formal announcement to the laboratory and appropriate certification/regulatory authorities will be made if a change is made to the person filling this position.

J) Managerial Substitutions

Policy:
Deputies for key personnel are appointed to fulfill the key personnel's duties in their absence.

Details:
In the absence of the Lab Director, the Quality Manager or Deputy Lab Director will assume his/her responsibilities.

In the absence of the Quality Manager, the Lab Director will assume his/her responsibilities.

In the absence of the Laboratory Supervisor, the Lab Director, Deputy Lab Director and/or Quality Manager will assume his/her responsibilities.

Management is responsible for ensuring that current and/or increased workload requirements are met. This includes making adjustments as a result of employee absence. Only fully trained employees are utilized to fulfill the duties of personnel who are absent. Evidence of a DOC for each specific analysis must be recorded prior to allowing the employee to perform any testing in the laboratory. If sufficient human resources are not available, management will identify the best possible solution to meet operational requirements.

K) Awareness

Policy:
Management ensures that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the objectives of the management system.

Details:
Supervisors review the details of each employee's job description with the appropriate employee and how the overall Quality Policy Statement (Section 4.2.2) relates to their activities to achieve the objectives of the management system.

4.1.6 Communication Processes

Policy:
Top management ensures that appropriate communication processes are established within the laboratory and that communication takes place regarding the effectiveness of the management system.

Details:
Management meetings are held regularly. Assignments and important communications are made in this meeting. The appropriate manager communicates the assignment or communication to their direct reports. These meetings are documented and follow-up activities are recorded.

Revision History

Changes from Revision 26
Modified section 4.1.3 to include all of the facilities of the company rather than just the main facility.

4.2 Management System

Section Synopsis

This section tells you that our Management System (or Quality Management System) is based on:

1. A well-defined quality policy statement
2. Say what you do through documentation
3. Do what you say following your documentation
4. Record what you did

Key Words

Establish, Implement, and Maintain
Policies, Systems, Processes, Programs, Procedures, Instructions
Communicate, Understand
Quality Policy Statement
Quality Manual
SOP
Test Method

Cross-references

ISO 17025:2005 Section 4.2

ISO 9001:2000 Section 4.1, 4.2.1, 4.2.2, 5.1, 5.3, 5.4.1, 5.4.2, 5.5.1, 5.5.2, 6.2.1, 7.1

4.2.1 Policies and Procedures

Policy:
The Quality Management System is established, implemented, and maintained by management. It is applicable to all the fields of testing and activities in which the laboratory is involved and undertakes. All policies, systems, programs, procedures and instructions are documented to the extent necessary to enable the laboratory to assure the quality of results generated. These documents are communicated to, understood by, available to, and implemented by the appropriate personnel.

Details:
The purpose of our Quality Management System is to ensure that all services and products satisfy the customer's requirements and have been designed, tested, and delivered under controlled conditions.

The effectiveness of the Quality Management System is assessed in several ways:

- by a program of planned internal audits, covering all aspects of the operation of the quality management system
- by regular management reviews of the suitability and effectiveness of the quality management system
- by analysis of potential and actual problems as shown by customer complaints and supplier and subcontractor assessments
- by other methods approved from time to time by the appropriate authority.

This Quality Manual and associated documents (including procedures) and records serve as the quality plan for the laboratory. Other documents and records may include:

- standard operating procedures (SOPs)
- quality control plans in test methods
- organizational charts
- proposals
- project management schemes
- Equipment manuals
- Reference methods
- Regulations
- Accreditation standards
- Software

4.2.2 Quality Policy Statement

Policy:
The policies and objectives for laboratory operations are documented in this Quality Manual. The overall objectives are set out in the Quality Policy Statement and reviewed during management review. The Quality Policy Statement is issued under the authority of the Senior Management on the effective date.

Quality Policy Statement:
To ensure accurate and timely analytical services and to continuously meet or exceed the stated or implied expectations of our customers through day-to-day interactions.

Effective Date: February 15, 2016

a) *Management commitment to good professional practice and quality of services provided to the customer*: tests and calibrations are always carried out in accordance with stated standardized methods and customers' requirements. Requests to perform tests that may jeopardize an objective result or have a low validity are rejected, or the laboratory's concerns are noted in the certificate of analysis.

b) *Standards of service include*:

- Customer Satisfaction
- Accuracy
- Timeliness
- Compliance with applicable standards and procedures

Excellence in the workplace is promoted by providing all employees with the knowledge, training, and tools necessary to allow for the completion of accurate and timely work.

c) *Purpose of management system related to quality*: to manage our business by meeting the needs of our customers and the requirements of the applicable standards and procedures.

d) *Personnel*: familiarize them with quality documentation and implement the policies and procedures in their work.

e) Management is committed to complying with the applicable standards and regulations (e.g. TNI, ISO, OGWDW etc.) and to continually improve the effectiveness of the management system: the objective of this Quality Manual is to document the compliant policies and associated procedures that are integrated into our daily activities. Continual improvements are established, implemented, and locked into the management system.

Additional objectives include:

- to establish the level of the laboratory's performance
- to make test method changes to improve performance
- to participate in proficiency testing or quality evaluation programs with peer laboratories
- to ensure that all personnel are trained to a level of familiarity with the quality management system appropriate to the individual's degree of responsibility
- to improve and validate laboratory methodologies by participation in method validation collaborative tests
- to establish and report on quality savings

4.2.3 Commitment to the Management System

Policy:
Top management is committed to the development and implementation of the management system and continually improving its effectiveness.

Details:
The results of the management system are regularly reviewed during management review (see Section 4.15) and continual improvements are made as outlined in Section 4.10 – Improvements.

4.2.4 Communication of Requirements

Policy:
Top management communicates to the organization the importance of meeting customer requirements as well as statutory and regulatory requirements.

Details:
In general, the underlying message in all oral and written management communications involves meeting the aforementioned requirements. Meeting customer requirements ensures that ongoing business relationships secure the contracts that keep everyone employed. Meeting statutory and regulatory requirements ensures that laboratory operations will not be disrupted and the organization can continue to meet customer needs.

4.2.5 Quality Manual

Policy:
This Quality Manual outlines the structure of the documentation used in the quality management system. This Quality Manual makes reference to supporting procedures including technical procedures and is maintained up to date.

Details:
This quality management system is structured in three tiers of documentation. The tiers are as follows:
I. Quality Manual
II. Standard Operating Procedures and Test Methods
III. Records

For most customers, this Quality Manual and the associated documents form a general Quality Plan. If necessary, specific Quality Plans will be prepared on a 'per-customer' basis. These Quality Plans will modify the general requirements stated in the Manual and associated documents.

All of the above documents are controlled documents. Not all quality system documents and procedures are maintained in this manual, rather some are referenced and located in other documents. The following records and directive documents are contained or referenced in the Quality Manual:

- organizational chart (section 4.1.5.E)
- identification of resources and management review (section 4.15.1)
- job descriptions (section 5.2.4)
- statistical techniques (section 5.9)
- test reports (section 4.13.2 and 5.10)
- identification of the laboratory's approved signatures (section 5.10.2)

- laboratory's scope of tests (section 4.1.3)
- equipment inventory and records (sections 5.5.4 and 5.5.5)
- calibration status indicators (section 5.5.8)
- reference standards inventory (section 5.6.3)
- verification records (section 5.9)
- quality control plan / criteria for workmanship (section 5.4.1)
- corrective action records (section 4.11)
- preventive action records (section 4.12)
- customer complaint records (section 4.8.1)
- audit schedule and records (section 4.14.3)
- procurement and subcontracting records (sections 4.6 and 4.5.4)
- training records (section 5.2.5)
- master list of documentation (section 4.3.2)
- confidentiality agreements (section 4.1.5 C)
- contract review (section 4.4.2)
- validation of test methods (section 5.4.5)
- facility floor plan (section 5.3.1)

4.2.6 Change Management

The roles and responsibilities for change management are outlined in QSP 4-2-6.

4.2.7 Technical Management and the Quality Manager

The roles and responsibilities for technical management and the Quality Manager are outlined in section 5.2.5 of this manual.

Technical management ensures that section 5 of this manual is implemented and maintained. The Quality Manager ensures that section 4 of this manual is implemented and maintained.

4.2.8 Maintenance

Policy and Details:
Top management ensures that the integrity of the management system is maintained when changes to the management system are planned and implemented.

Revision History

Changes from Revision 24

Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.3 Document Control

Section Synopsis

This section tells you that Document Control involves:

1. Writing good procedures
2. Getting them to the users
3. Keeping procedures good

Key Words

Controlled Document
Master List
Unique Identification
Revise
Revision Number
Effective Date
Review and Approval
Obsolete
Archive
Hand-written changes

Cross-references

ISO 17025:2005 Section 4.3

ISO 9001:2000 Section 4.2.1, 4.2.3, 4.2.4

4.3.1 Policies and Procedures

Policy:
The SOP# QSP 4-3-1 is used to control all quality management system documents (internally generated and from external sources). These include documents of external origin, such as regulations, standards, other normative documents, test and/or calibration methods, as well as drawings, specifications, instructions, and manuals.

Details:
Document means any information or instructions including policy statements, procedures, specifications, charts, text books, posters, notices, memoranda, software, drawings, and plans. These may be in various media, whether hard copy or electronic and they may be digital, analog, photographic or written.

The documents to be controlled include:
- Quality Manual
- Standard Operating Procedures and test methods
- Forms
- Standards
- Software manuals
- Reference methods and manuals
- Equipment manuals
- Applicable regulations/statutes

The control of data related to testing and calibration is covered in section 5.4.7. The control of records is covered in section 4.13.

4.3.2 Document Approval and Issue

4.3.2.1 Review / Approval / Master List

Policy and Details:
All documents issued to personnel in the laboratory as part of the quality management system are reviewed and approved for use by authorized personnel prior to issue (i.e., reviewed by personnel knowledgeable in the documented activity and then approved by management). A master list can be obtained by viewing the lists located on the Chemtech Quality Manager and the SOP database for performance based methods, or intranet under the SOP section. The categories are divided by folders. Each folder has a hyperlinked list

of the SOPs. A listing of document revision is posted on the announcement area of the Chemtech Document Archive tab. A revision history is maintained. Documents are formally reviewed periodically to ensure their continuing suitability.

4.3.2.2 Availability and Obsolete Documents

Policy and Details:
The master list shows the current status of all controlled documents. The master list document is organized with the following information:

- Document Title
- Effective Date
- Revision Number
- Method Reference (if applicable)
- Date of last review

Controlled documents are approved before issue.

The SOP# QSP 4-3-1 for document control ensures that:

- authorized editions of appropriate documents are available at all locations where operations essential to the effective functioning of the laboratory are performed
- documents are periodically reviewed and where necessary revised to ensure continuing suitability and compliance with applicable requirements
- invalid or obsolete documents are promptly removed from all points of issue or use to assure against unintended use
- obsolete documents retained for either legal or knowledge preservation purposes are suitably marked (i.e., “INACTIVE" and dated) and/or archived appropriately.

4.3.2.3 Identification

Policy and Details:
All quality management system documentation is identified by:

- date of issue and/or revision number
- page numbering
- total number of pages (e.g., page 5 of 5)
- issuing authority (i.e., reviewer approval)

4.3.3 Document Changes

4.3.3.1 Review / Approval

Policy:
Changes to documents are reviewed and approved by the same function (i.e., personnel or position) that performed the original review.

Details:
Developments in policies and procedures require documents to be changed from time to time. Changes to documents receive the same level of review and approval as the originals.

The Quality Manual is reviewed annually by the Quality Manager. Records are kept of this review.

Test methods and SOPs are reviewed on a biennial basis. Procedures for this are outlined in SOP# QSP 4-3-1.

Obsolete documents are withdrawn, but are retained for archive purposes and clearly labeled as obsolete.

4.3.3.2 Identification of Changes

Policy:
The nature of document changes is identified in the document.

Details:
As outlined in SOP# QSP 4-3-1.

In general, the nature of changes is identified in the document by changing the font color to blue. Revision history is recorded at the end of the document.

4.3.3.3 Amendments by Hand

Policy and Details:
Hand-written amendments to documents are permitted only by those personnel authorized to do so (see section 4.1.5 A). Amendments are clearly marked, initialed, and dated. A revised document is formally re-issued at the time of the annual review. For further details refer to SOP# QSP 4-3-1.

4.3.3.4 Computerized Documents

Policy and Details:
The SOP# QSP 4-3-1 details how changes in documents maintained in computerized systems are made and controlled.

Revision History

Changes from Revision 24

None

4.4 Review of Requests, Tenders, and Contracts

Section Synopsis

This section tells you that you must:

1. Clearly understand customer requirements

Key Words

Requirements
Subcontractor
Request
Tender
Contract
Review

Cross-references

ISO 17025:2005 Section 4.4

ISO 9001:2000 Section 5.2, 6.1, 7.2.1, 7.2.2, 7.2.3

4.4.1 Policies and Procedures

Policy:
Prior to the commencement of any services that fall within the scope of this Quality System, Chemtech-Ford will ensure that the scope of the work is clearly defined and that the objectives of the project can be met. In some cases, the requests are formalized through a statement of work and signed contract. Other cases require less formalized contracts. In all instances Chemtech-Ford formalizes a contract between the laboratory and the client. The lab ensures that:

a) the customer requirements including the methods to be used are adequately defined, documented and understood (see section 5.4.2)
b) the laboratory has the capability and resources to meet the requirements
c) the appropriate test method is selected and capable of meeting the customer's requirements (see section 5.4.2)

When practicable, any differences between the request or tender and the contract are resolved before any work commences. Each contract must be acceptable by both the laboratory and the customer.

Details:
The review of capability establishes that the laboratory possesses the necessary physical, personnel, and information resources, and that the laboratory's personnel have the skills and expertise necessary for the performance of the tests in question. The review may also encompass results of earlier participation in inter-laboratory comparisons or proficiency testing and/or the running of trial test using samples or items of known value in order to determine uncertainties of measurement, limits of detection, and confidence limits.

Some contracts are formalized through a bidding process, RFP etc. Some contracts are less formal. When a formal process initiates the work, the specifications of the project are agreed upon and programed into the LIMS. When appropriate contracts are signed by necessary parties.

All work orders at Chemtech-Ford Laboratories are considered contracts between the lab and the customer. After logging the sample(s) into the LIMS and after a login review is performed by the lab, a login summary of requested analyses is submitted to the customer for their review. The customer is informed of tests to be performed including test method, subcontracted work, conditions of samples upon receipt and any other anomaly that might have an adverse effect on the results of the analyses. The customer is requested to review the work order for accuracy and note any discrepancies to the lab in a

timely manner. If the customer does not reply in a timely manner, Chemtech-Ford Laboratories proceeds with the work. For some analyses, the lab is required to start work immediately (e.g. short holding times or rush analyses). The customer has the ability to stop this work as needed.

The contract review ensures that each customer's requirements are adequately defined and documented in a timely manner. This should ensure that any order, once accepted, can be completed without delay, and that the customer's requirements including delivery date, technical specification can be met.

Typical types of contracts include:

- approved service quotations
- confidentiality agreements
- non-disclosure agreements
- sample submission requests
- memorandum of agreement
- memorandum of understanding
- research proposals and contracts
- verbal orders (oral agreements)
- activity plans

4.4.2 Records of Review

Policy:
Records of request, tender and contract review, including significant changes, are maintained. Records of pertinent discussions with a customer relating to the customer's requirements or the work during the period of execution of the contract are also maintained.

Details:
Records of request is made by the client via chain-of-custody. Alternative requests may also be made through other mechanisms (e.g. email). In the event that an alternative mechanism besides the chain-of-custody is used for a request, such documentation is retained. After samples have been entered into the LIMS and reviewed for correctness, a summary of the requested work is sent to the client via email to verify the accuracy of their request compared to Chemtech-Ford Laboratories interpretation of the request. Chemtech-Ford Laboratories assumes that the request is accurate unless the client

informs us otherwise. If there is a discrepancy, the change is noted and documented in the LIMS or chain-of-custody.

Other work may demand more complex and formalized contract review. These contracts are maintained by Chemtech-Ford Laboratories and the client. Formal contracts should be stored in the project in LIMS. The LIMS project can be customized for most of the project requirements such as pricing, analyte lists, reporting limits, QC limits, report format, report recipients, etc.

When a formal contract is entered into between the lab and the client, the appropriate lab member of management must sign the contract (usually the Vice President or their designee). The person responsible for managing the project ensures that all of the aspects of the project can be met. That person coordinates the project plan and execution of the project with the appropriate laboratory staff. They also communicate any problems meeting the client objectives to the client and will advise the lab how to proceed.

4.4.3 Review of Subcontracted Work

Policy:
Request, tender, and contract review also includes work that is subcontracted by the laboratory.

Details:
Subcontractor laboratories are reviewed as described in section 4.5. Performance based methods developed by Chemtech-Ford Laboratories are not subcontracted.

4.4.4 Notification of Customer

Policy and Details:
Customers are informed of deviations from the contract. This is typically communicated to the customer prior to the performing the deviation.

4.4.5 Contract Amendment

Policy and Details:

If a contract needs to be amended after the work has commenced, the same contract review process is repeated and any amendments are communicated to all affected personnel.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.5 Subcontracting of Tests and Calibrations

Section Synopsis

This section tells you that we must:

1. Know what tests and calibrations need to be done by another laboratory
2. Check out the other laboratories

Key Words

Competence
Register of Subcontractors
Assessment

Cross-references

ISO 17025:2005 Section 4.5

ISO 9001:2000 Section 7.2.3, 7.4.1, 7.4.3, 8.2.4

4.5.1 Subcontractor Competence

Policy:
Performance based methods developed by Chemtech-Ford Laboratories are not subcontracted unless directed by the client. Work that must be subcontracted is done so to a technically competent laboratory due to:

- unforeseen circumstances
- workload
- project specifications/requirements
- contracts requiring some extra technical expertise

Details:
The subcontracted laboratory demonstrates technical competence by possession or receipt of one or more of the following:

- recognized technical accreditation (e.g. TNI, ISO, EPA etc.)
- satisfactory performance of appropriate quality control check samples, certified reference material, in-house reference material or replicate analysis
- audit of the subcontractor's quality management system by our auditors

It is the responsibility of the Quality Manager to assess and approve the competence level of subcontractor laboratories. The approved subcontract laboratories are maintained in Quality Manager.

4.5.2 Customer Approval

Policy:
Customers are advised of work (or any portion thereof) that is being subcontracted to another laboratory and their approval is obtained (preferably in writing).

Details:
Customers are advised of subcontracted work through the contracting process (see 4.4).

4.5.3 Assurance of Subcontractor Competence

Policy:
If the laboratory selects the subcontracted lab, then the laboratory is responsible to the customer for the subcontractor's work. Technical competence of subcontractor

laboratories is demonstrated through various records including accreditation records from the laboratories Accreditation Body. There may be circumstances where the customer specifies which subcontractor is to be used. In such cases we may not be able to demonstrate the competence of the subcontractor and therefore are not responsible for the results.

Details:
Records of subcontractor competence can include, but are not limited to, the following:

- accreditation certificates or documentation
- registration certificates
- check sample results
- audit results
- approval by the Quality Manager
- approval by the client

4.5.4 Subcontractor Register

Policy:
A register of all subcontractors performing tests and calibrations is maintained in Quality Manager or within the project records.

Details:
The approved register of subcontractors is maintained by the applicable Accreditation Body or in the project records.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.6 Purchasing Services and Supplies

Section Synopsis

This section tells you that we must:

1. Know what we want
2. Check out our suppliers

Key Words

Selection
Verify
Specifications
History

Cross-references

ISO 17025:2005 Section 4.6

ISO 9001:2000 Section 6.3.1, 7.4, 7.5.5, 8.2.4

4.6.1 Policies and Procedures

Policy:
The SOP# QSP 4-6-1 is used to select and purchase services and supplies. The SOP# QSP 4-6-1 is used for procurement, reception, and storage of supplies.

Details:
Consumable materials are stored according to the appropriate test method, SOP, or work instruction.

4.6.2 Specifications

Policy:
Only services and supplies of the required quality are used. These quality requirements are detailed in laboratory SOPs under the "*Equipment and Supplies"* and *"Reagents and Standards"* sections and will identify the appropriate minimum specifications when necessary.

Details:
Packing slips are checked against package content labels and matched with the Purchase Order if accepted. Once accepted, the packing slip is dated and initialed as evidence of compliance. Certificates of analysis (COA) are scanned and maintained on file in the LIMS or other appropriate area after the COA is checked to ensure the received item meets minimum specifications.

Chemicals are purchased with manufacturer's certificates where possible. Uncertified chemicals are purchased from ISO 9000 registered companies. Whatever the source, the laboratory verifies the quality of the standards by comparing the new batch of standards to the old. Due regard is paid to the manufacturer's recommendations on storage and shelf life.

Reagents are generally purchased from manufacturers who have a quality management system based on ISO 9000. The grade of any reagent used (including water) is stated in the method together with guidance on any particular precautions to be observed in its preparation or use.

Where no independent assurance of the quality of procured goods or services is available or the supplier's evidence is insufficient the laboratory ensures that purchased goods and

services comply with specified requirements. Where possible and practical the laboratory ensures that goods are inspected, calibrated, or are otherwise in compliance with any standard specification relevant to the calibrations or tests concerned.

4.6.3 Purchasing Documents

Policy:
Purchasing requests are recorded on the Purchase Order form and contain data describing the product ordered. The Purchase Order is reviewed and approved for technical content prior to release.

Details:
The description may include type, class, grade, precise identification, specifications, drawings, inspection instructions, other technical data including approval of test results, quality required and quality management system standard under which they were produced.

The completion of the Purchase Order is the responsibility of the originator or supervisor. Either reviews the Purchase Order for accuracy and approve the technical content prior to release with their signature and the date.

4.6.4 Approved Suppliers

Policy:
Suppliers of critical services are evaluated and approved before use. An approved supplier list is maintained.

Details:
Audits or tender evaluation is conducted to qualify suppliers of critical services prior to use. The criteria for evaluation may include, but is not limited to the following:

- references
- accreditation
- formal recognition

The records are maintained by purchasing personnel.

Revision History

Changes from Revision 24

Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.7 Service to the Customer

Section Synopsis

This section tells you that we must:

1. Facilitate clarification of the customer's request
2. Give customer access to relevant testing area
3. Maintain customer contact
4. Inform customer of delays or deviations
5. Utilize customer surveys

Key Words

Clarification
Deviations
Delays
Customer Satisfaction Survey

Cross-references

ISO 17025:2005 Section 4.7

ISO 9001:2000 Section 6.1, 7.2.1, 7.2.3, 7.4.3, 7.5.1

4.7.1 Service

Policy:
Customer requests are clarified for the customers or their representatives. Furthermore, the customer or their representative will be afforded the right to monitor the performance of the laboratory in relation to the work performed, provided that the laboratory ensures confidentiality to other customers.

Details and Procedures:
Service to the customer includes:

- Affording the customer or the customer's representative reasonable access to relevant areas of the laboratory for the witnessing of work performed for the customer; it is understood that such access should not conflict with rules of confidentiality of work for other customers or with safety.

- Maintaining of open contacts. The customer values advice and guidance in technical matters, and opinions and interpretations based on results. Contact with the customer, especially in large assignments, should be maintained throughout the work. The laboratory should inform the customer of any delays or major deviations in the performance of the tests.

4.7.2 Feedback

Policy and Details:
The laboratory seeks feedback from the customer. Positive and negative feedback can be obtained passively through ongoing communications with the customer (e.g., review of test reports with customers) or actively through customer satisfaction surveys. The feedback is used to improve the quality management system, testing activities, and customer service.

One mechanism Chemtech-Ford Laboratories has established is a database that allows for the entry of customer feedback (both positive and negative). The database categorizes each item of feedback. When a laboratory representative receives feedback from a client or other interested party, this should be reported in the database. When feedback requires an action this is documented and assigned to the appropriate team member for review.

Other mechanisms are in place to review customer feedback. During weekly management meetings, customer feedback is reviewed (positive and negative).

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.8 Complaints

Section Synopsis

This section tells you that you must:

1. Maintain records of Complaints
2. Maintain records of Corrective Action

Key Words

Resolving
Investigation
Corrective Action
Follow-up Verification

Cross-references

ISO 17025:2005 Section 4.8

ISO 9001:2000 Section 7.2.3

4.8.1 Policies and Procedures

Policy:
The SOP# QSP 4-8-1 is used for resolving complaints received from customers or other parties. Records are maintained of all complaints and follow-up.

Details:
Records of complaints include the following information:

- description of the complaint
- investigation
- corrective action (if necessary)
- solution notes and date
- follow-up verification
- issuance level

See also section 4.11.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.9 Control of Nonconforming Testing and Calibration Work

Section Synopsis

This section tells you that you must:

1. Stop testing when nonconforming work is identified
2. Determine what is causing nonconforming work

Key Words

Nonconforming
Root Cause

Cross-references

ISO 17025:2005 Section 4.9

ISO 9001:2000 Section 5.5.1, 7.4.3, 7.5.1, 8.2.4, 8.3, 8.5.3

4.9.1 Procedures to Control Nonconforming Work

Policy:
The SOP# QSP 4-9-1 is used to control any aspect of testing and/or calibration work, or the results of this work, when they do not conform with the test methods or the agreed requirements of the customer.

Details:
The procedure ensures that:

- Responsibilities and authorities for the management of nonconforming work are designated and actions (including halting of work and withholding of test reports as necessary) are defined and taken into consideration when nonconforming work is identified
- an evaluation of the significance of the nonconforming work is made
- correction is taken immediately, together with any decision about the acceptability of the nonconforming work
- where necessary, the customer is notified and the work is recalled
- the responsibility for authorizing the resumption of work is defined

Identification of nonconforming work or problems with the quality management system or with testing activities can occur at various locations within the quality management system and technical operations such as:

- customer complaints
- quality control
- instrument calibration
- checking of consumable materials
- staff observations or supervision
- test report checking
- management reviews
- internal or external audits

4.9.2 Root Cause Analysis

Policy:
Where evaluation indicates that nonconforming work could recur or that there is doubt about the compliance of the laboratory's operations with its own policies and procedures, the corrective action procedures given in 4.11 are followed to identify the root cause(s) of the problem and to eliminate this (these) cause(s). All notes, discoveries, and actions

taken by participating personnel are to be reflected on the corrective action form. The QM directs this process and retains all documentation within the appropriate files for future reference. These corrective action documents will be stored for five years.

Details:
The SOP# QSP 4-11-1 outlines the recording of the root cause analysis for investigating nonconforming work.

Situations warranting corrective action investigation include:
- failure to comply with test method including all applicable procedures necessary to ensure the integrity and representative nature of the sample
- presentation of uncertain knowledge as to compliance with test methods including all applicable procedures necessary to ensure the integrity and representative nature of the sample
- failure or suspected failure in method performance as demonstrated by results provided by quality control samples
- lack of relevant evidence provided by quality audit, proficiency testing, or customer feedback
- lack of relevant evidence provided by data validation
- neglect to check the inherent property of the sample that compromises the testing

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.10 Improvements

Section Synopsis

This section tells you that you must:

1. Review procedures for improvements
2. Continually implement improvements

Key Words

Continually
Effectiveness
Analysis of data

Cross-references

ISO 17025:2005 Section 4.10

ISO 9001:2000 Section 6.1, 8.1, 8.2.1, 8.4, 8.5.1

4.10.1 Policies and Procedures

Policy:
The laboratory continually improves the effectiveness of its management system through the use of the quality policy, quality objectives, audit results, analysis of data, corrective and preventive actions, and management review.

Details:
The laboratory has implemented a continual improvement philosophy within the management system. Every employee in the laboratory is encouraged to suggest new ideas for improving services, processes, systems, productivity, and the working environment.

Opportunities for improvement of operations and processes are identified by managers on a continual basis from ongoing feedback on operations and through management reviews. Opportunities for improvement of services are identified by anyone within the organization including Sales, and Marketing.

Inputs for improvement opportunities may be obtained from the following sources:
- customer satisfaction surveys and any other customer feedback
- market research and analysis
- employees, suppliers, and other interested parties
- internal and external audits of the management system
- records of service nonconformities
- data from process and service characteristics and their trends

Opportunities for improvement may also be identified on a special project basis. The following are listed only as examples:
- improving usefulness of bench space
- reducing excessive inspection/testing
- reducing excessive handling and storage
- reducing test/calibration failures

Opportunities for improvement from daily feedback on operational performance (i.e., internal audits, customer feedback, test/calibration failures) are evaluated by the Technical or Quality Manager. Typically, they are implemented through the corrective and preventive action system.

Opportunities for improvement from analysis of longer-term data and trends are evaluated and implemented through the management review process. They are prioritized with respect to their relevance for achieving quality objectives. When opportunities for improvement are no longer supported by the current policy and objectives, management will establish new quality objectives, and possibly change the policy. The process for this evaluation is described in Section 4.15. Longer-term improvement projects are initiated through the management review process, as well as the corrective and preventive action system.

Service improvement opportunities are evaluated by management. They are implemented through the supervisor of the laboratory who ensures that the improvements are validated as outlined in Section 4.12 of this manual and appropriate level of quality control is performed on an ongoing basis.

Revision History

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Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.11 Corrective Action

Section Synopsis

This section tells you that you must:

1. Identify problems
2. Determine why the problem occurred
3. Fix the cause of the problem
4. Verify that your changes worked

Key Words

CAR
Root Cause
Monitor
Audit
Nonconforming work

Cross-references

ISO 17025:2005 Section 4.11
ISO 9001:2000 Section 5.5.1, 5.5.2, 8.1, 8.2.2, 8.2.3, 8.4, 8.5.2, 8.5.3

4.11.1 General

Policy:
The SOP# QSP 4-11-1 is utilized for implementing corrective action when nonconforming work or departures from policies and procedures in the quality management system or technical operations have been identified. The procedure requires that appropriate authority be designated for the implementation of corrective actions and includes cause analysis, selection and implementation of corrective action, and monitoring of actions.

Details:
Problems with the quality management system or technical operations of the laboratory may be identified through a variety of activities, such as control of nonconforming work, internal or external audits, management reviews, feed-back from customers, or staff observations.

Corrective action investigations are documented and required changes to operational procedures are implemented. The corrective action request (CAR), investigation and resolution are recorded in the CAR database.

4.11.2 Cause Analysis

Policy:
Corrective action always begins with an investigation to determine root cause(s) of the problem (see SOP# QSP 4-11-1).

Details:
Potential causes of the problem could include customer requirements, the samples, sample specifications, methods and procedures (see 4.11.6), personnel skills and training, consumable materials, or equipment and its calibration.

4.11.3 Selection and Implementation of Corrective Actions

Policy and Details:
After determining the cause(s) of the problem, potential corrective actions are identified. The most likely action(s) (this includes practical and/or reasonable) are selected and implemented to eliminate the problem and to prevent recurrence. It should be noted that

any corrective actions taken to eliminate the cause(s) of nonconformities or other departures are to a degree appropriate to address the magnitude of the problem and commensurate with the risks encountered (Note – in plain language, this means determine whether the benefit outweighs the cost). Controls are applied to prevent recurrence. The laboratory documents and implements the required changes resulting from corrective action investigations.

4.11.4 Monitoring of Corrective Action

Policy:
After implementing the corrective action(s), the laboratory monitors the results to ensure that the actions taken have been effective in overcoming the problems originally identified.

Details:
Monitoring is assigned to an appropriate individual such as the originator of the CAR or the originator's manager. Changes resulting from corrective action are documented.

4.11.5 Additional Audits

Policy:
Where the identification of nonconformities or departures casts doubts on compliance of policies, procedures, regulations, international quality standards, the appropriate areas of activity are promptly audited in accordance with section 4.14.

Details:
Special audits follow the implementation of corrective actions to confirm their effectiveness. A special audit is only necessary when a serious issue or risk to the business is identified. Special audits are carried out by trained and qualified personnel who are [whenever resources permit] independent of the activity to be audited. See section 4.14 for more details.

4.11.6 Responsibility

Policy:
Analytical data routinely generated by the laboratory is evaluated to determine acceptability, including precision and accuracy. Laboratory analyst and supervisors are responsible for evaluating QC in comparison to acceptance criteria.
Details:
When data falls outside of the established control limits or acceptance limits for a given method (as defined by the SOP), that information is evaluated and appropriate action taken. If a problem is discovered that could merit corrective action, the person that discovers the problem should discuss with the Quality Manager the need to initiate a formal corrective action. All Chemtech-Ford Laboratories employees can recommend corrective action. If it is determined that the problem merits corrective action, the Quality Manager will initiate the corrective action.

Revision History

Changes from Revision 24

None

4.12 Preventive Action

Section Synopsis

This section tells you that you must:

1. Identify potential problems
2. Determine why the problem could occur
3. Fix the cause of the potential problem
4. Verify that your changes worked

Key Words

PAR
Potential Nonconformity
Action Plan

Cross-references

ISO 17025:2005 Section 4.12

ISO 9001:2000 Section 4.2.4, 6.3.1, 8.4, 8.5.1, 8.5.2, 8.5.3

4.12.1 Preventative Action Identification

Policy:
Opportunities for needed improvement and potential sources of nonconformities, either technical or with the quality management system shall be identified. If action is required, action plans are developed, implemented and monitored, to reduce the likelihood of occurrence of such nonconformities and to take advantage of the improvement opportunities.

Details:

Records of preventive action include the following information:

- details of potential nonconformities
- investigation
- preventive action
- follow-up verification

4.12.2 Preventive Action Plans

Policy:
The preventive action procedure includes the initiation of such actions and application of controls to ensure that they are effective.

Details:
Preventive action may result from the review of operational procedures and analysis of data. Analysis of data includes trend analysis, analysis of proficiency testing results, and risk analysis.

Preventive actions can be designated and documented in the Corrective Action database or in management meeting notes or other approved laboratory mechanism for recording/monitoring preventive actions.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.13 Control of Records

Section Synopsis

This section tells you that you must:

1. Identify the records to be kept
2. Keep identified records in a useful state
3. Destroy records when they are no longer needed

Key Words

Collection
Indexing
Access
Storage
Maintenance
Disposition
Legible
Traceable
Retrievable
Secure

Cross-references

ISO 17025:2005 Section 4.13

ISO 9001:2000 Section 4.2.4, 6.3, 6.4, 7.1, 7.5.1, 7.5.2, 7.5.3, 8.1, 8.2.2, 8.2.3, 8.2.4

4.13.1 General

4.13.1.1 Procedures

Policy:
The SOP# QSP 4-13-1 is used to identify, collect, index, access, file, store, maintain, protect, backup, and dispose quality and technical records. Quality records include reports from internal audits and management reviews as well as corrective and preventive action records.

Details:
Records are available to demonstrate conformance to requirements and effective operation of the Quality Management System. Quality records from suppliers are also controlled.

All records, including test reports, are safely stored and held secure (either electronically or physically), and in confidence to the customer. Records are maintained in the designated archival area for five (5) years.

4.13.1.2 Record Integrity

Policy:
All records are to be legible and shall be retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss.

Details:
The retention times for records are generally set at five (5) years. Records may be in the form of any type of media, such as hard copy or electronic media.

4.13.1.3 Record Security

Policy:
All records are held secure and in confidence.

Details:
Access to records is secured through locked rooms, filing cabinets, passwords.

4.13.1.4 Record Backup

Policy:
The SOP# QSP 4-13-1 is followed to protect and backup data/records held on computers at all times and to prevent unauthorized access to or amendment of data/records on computers.

Details:
Data is password protected.

Backups ensure integrity and availability of data/information in the event of a system/power failure.

4.13.2 Technical Records

4.13.2.1 Record Information

Policy:
Original observations, calculations, derived data and sufficient information to establish an audit trail, calibration records, personnel records and a copy of each test report issued are retained for five (5) years.

The records for each test or calibration shall contain sufficient information to facilitate, if possible, identification of factors affecting the test uncertainty and to enable the test or calibration to be repeated under conditions as close as possible to the original. The records include the identity of personnel responsible for sampling, performing of each test and/or calibration and checking of results.

Details:
Technical records are accumulations of data (see 5.4.7) and information that result from carrying out tests and/or calibrations and which indicate whether specified quality or process parameters are achieved. They may include forms, contracts, work sheets, work

books, note books, instrument printouts, magnetic media, check sheets, work notes, control graphs, test reports, calibration certificates, customer's notes, papers and feedback, and test reports to customers.

The records for each test contain sufficient information to permit its repetition. Records include:

- date of sampling
- sample receipt
- sample handling, storage, and disposal
- identification of personnel
- analyst proficiency
- equipment identification and performance
- calibration records
- media performance, where appropriate
- test organism batch # or lot #, where appropriate
- results
- reports (mailed, emailed, or faxed)
- review

Note – the above records may be stored in separate locations. They are cross-referenced for easy retrieval.

4.13.2.2 Recording

Policy:
Observations, data, and calculations are clearly and permanently recorded and identifiable to the specific job at the time they are made.

Details:
Handwritten records must be legible and made with indelible ink immediately after an observation, after data is collected and/or after calculations are made.

4.13.2.3 Corrections to Records

Policy:
Changes to test data are made so as not to obscure or delete the previous data entry.

Details:
Mistakes are crossed out with a single line, initialed, dated and the correct value entered alongside. Mistakes are not erased, made illegible, or deleted. All alterations to records are signed or initialed by the person making the correction. In the case of computer-collected data, similar measures are taken to avoid loss or change of original data.

4.13.2.4 Transfer of records

Policy:
Records will be maintained or transferred in the event that a laboratory transfers ownership or goes out of business.

Details:
In the event that the laboratory changes ownership, all records will be transferred to the new owners. The new owner(s) will then be given the responsibility of maintaining the records.

If the laboratory goes out of business, all hard copy and electronic records will be maintained by the ownership group at the time of the dissolution of the company for a period of 5 years.

Revision History

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4.14 Internal Audits

Section Synopsis

This section tells you that:

1. Trained internal auditors examine your internal operations for quality
2. Auditors report the results to those in charge
3. You must correct any areas that need fixing

Key Words

Schedule
Elements
Independent
Nonconformity
CAR

Cross-references

ISO 17025:2005 Section 4.14

ISO 9001:2000 Section 8.1, 8.2.2, 8.2.3

4.14.1 Internal Audit Program

Policy:
The internal audit program involves periodic audits conducted according to a predetermined schedule for each year. Each year different aspects of the Quality System are evaluated. The schedule is reviewed during the managerial review. All elements of the management system including the testing activities are covered on a regular basis. These audits are performed to verify operations continue to comply with the requirements of this Quality Manual and are effective.

Details:
The tracking of internal audit results is maintained in Quality Manager. The frequency is also maintained in Quality Manager. The Quality Manual, test procedures, and laboratory results are verified for compliance. It is the responsibility of the Quality Manager to plan and organize audits as required by the schedule and requested by management. Audits are carried out by trained and qualified personnel who are [wherever resources permit] independent of the activity to be audited. Personnel are not to audit their own activities except when it can be demonstrated that an effective audit will be carried out (see also 4.11.5). Audits are performed through the aid of a checklist prepared in advance to minimize the possibility of overlooking any details during the audit. The results of the internal audit are maintained and accessible.

Generally, the types of audits include:
- quality management system
- technical methods
- products, services, and reports

4.14.2 Corrective Action

Policy:
When audit findings cast doubt on the effectiveness of the operations or on the correctness or validity of test or calibration results, timely corrective action is taken and customers are notified if investigations show that laboratory results may have been affected.

Details:
Nonconformities that can be resolved easily are to be corrected immediately, ideally during the audit. Records are made on the audit checklist. Nonconformities that require a

more involved resolution are recorded on a CAR and resolved as described in section 4.11.

Corrective actions and customer notifications must be kept on record for each audit deviation that casts doubt as described in this section.

4.14.3 Records and Management

Policy:
Records are made of the activity being audited, the audit findings, and corrective actions that arise. Management ensures that corrective actions are discharged within an appropriate and agreed timeline.

Details:
A report is prepared by the auditors and distributed to those audited and/or the area manager/supervisor within an appropriate and agreed timeline. The audit report may include the following sections, as appropriate:

- audit objective and scope
- area or section audited
- personnel involved – auditors and auditees
- date of audit
- reference documents
- observations including nonconformities and commendations
- opening and closing meetings
- recommendations
- audit report distribution

The appropriate manager is responsible for ensuring that corrective actions are sufficiently recorded. Follow-up is performed by the auditor and recorded when corrective action is complete and deemed effective. The audit records are kept in the laboratory.

4.14.4 Follow-up Audits

Policy:
Follow-up audits are performed to verify and record the implementation and effectiveness of the corrective action taken.

Details:
The follow-up audit is performed at a mutually acceptable time between the area implementing corrective action and the auditor. This time is determined when the CAR is issued.

Revision History

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Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

4.15 Management Reviews

Section Synopsis

This section tells you that management must:

1. Periodically review technical competence and customer satisfaction
2. Keep records of reviews
3. Ensure follow-up is executed
4. Measure progress

Key Words

Supervisor Reports
Audit Reports
CAR / PAR
Proficiency Results
Customer Satisfaction Survey
Resources

Cross-references

ISO 17025:2005 Section 4.15

ISO 9001:2000 Section 5.1, 5.4.2, 5.6, 6.2.1, 7.1, 8.5.1

4.15.1 Review of Quality Management System and Testing

Policy:
Top management periodically (at least annually) and in accordance with a predetermined schedule and SOP# QSP 4-15-1, conduct a review of the laboratory's quality management system and testing and/or calibration activities to ensure their continuing suitability and effectiveness and to introduce any necessary changes or improvements.

Details:
The review takes account of:

- suitability of policies and procedures (including the Quality Policy outlined in this manual)
- reports from managerial and supervisory personnel
- the outcome of recent internal audits
- corrective and preventive actions
- assessments by external bodies
- results of inter-laboratory comparisons or proficiency tests
- changes in the volume and type of work undertaken
- feedback from customers, including complaints and customer satisfaction surveys
- recommendations for improvement
- other relevant factors, such as quality control activities, resources and personnel training

A minimum period for conducting a management review is once a year. Results of the review feed into the laboratory planning system and include goals, objectives and action plans for the coming year.

A management review can be supplemented by consideration of related subjects at regular management meetings.

4.15.2 Findings, Actions, and Records

Policy and Details:
Findings from management reviews and the actions that arise are recorded in the minutes of the meeting. Management will ensure that the actions are discharged within an appropriate and agreed upon timeline.

Revision History

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5.1 General

Section Synopsis

This section informs you that:

1. Many factors contribute to the correctness and reliability of tests and/or calibrations
2. The laboratory must account for these factors

Key Words

Correctness
Reliability
Uncertainty

Cross-references

ISO 17025:2005 Section 5.1

ISO 9001:2000 Section 7.1, 7.5.1

5.1.1 Correctness and Reliability

Policy and Details:
Correctness and reliability of the tests and/or calibrations performed have many contributing factors including:

- Human factors (see section 5.2)
- Accommodation and environmental conditions (see section 5.3)
- Test and calibration methods and method validation (see section 5.4)
- Equipment (see section 5.5)
- Measurement traceability (see section 5.6)

5.1.2 Measurement Uncertainty

Policy:
When developing test and calibration methods and procedures, total measurement uncertainty must be accounted for in the training and qualification of personnel, and in the selection and calibration of equipment.

Details:
The extent to which the factors contribute to total measurement uncertainty differs between tests, matrices, methodologies.

See section 5.4.6 for more details.

Revision History

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5.2 Personnel

Section Synopsis

This section tells you that management:

1. Analyzes training needs
2. Provides training to employees for them to do their jobs
3. Qualifies people performing specific tasks

Key Words

Competence
Qualification
Authorize
Training Needs
Job Description
Registry of Skills

Cross-references

ISO 17025:2005 Section 5.2

ISO 9001:2000 Section 5.5.1, 6.2.1, 6.2.2, 7.5.1, 7.5.2

5.2.1 Competence and Qualification

Policy:
Management ensures the competency of all employees including specific equipment operators, those performing tests and/or calibrations, those evaluating results and signing test reports. Appropriate supervision is provided for employees undergoing training. Personnel performing specific tasks are qualified on the basis of appropriate education, training, experience and/or demonstrated skills, as required.

In addition, personnel responsible for the opinions and interpretations included in test reports also have:

- Relevant knowledge of the technology used in the performance of analyses, materials, products tested, or the way they are used or intended to be used and of the defects or degradation that may occur during sampling, analysis, or use.
- Knowledge of the general requirements expressed in the legislation and standards.
- An understanding of the significance of deviations found with regard to the normal use of the items, materials, or products concerned.

Details:
Management defines the minimum levels of qualification and experience necessary for all posts within the laboratory. The educational and experience requirements for various laboratory positions are listed in the following sections:

5.2.1.1 Laboratory Director – The minimum requirements for the technical director are:

Bachelor's degree in the chemical, environmental, biological sciences, physical sciences or engineering with at least twenty-four (24) college semester credit hours in chemistry and at least two (2) years of experience in the environmental analysis of representative inorganic and organic analytes for which the Chemtech-Ford Laboratories seeks or maintains accreditation. A master's or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.

For microbiological analyses the technical manager must have a minimum of an associate's degree with at least four (4) college semester credit hours in general microbiology when the laboratory is engaged in microbiological analysis limited to fecal coliform, total coliform, E. coli and standard plate count. In

addition, the person shall have one (1) year of experience in microbiological analyses.

If the laboratory maintains a scope beyond fecal coliform, total coliform, E. coli and standard plate count, then the technical director must have a bachelor's degree in microbiology, biology, chemistry, environmental sciences, physical sciences or engineering with a minimum of sixteen (16) college semester credit hours in general microbiology and biology and at least two (2) years of experience in the environmental analysis of representative analytes for which the laboratory seeks or maintains accreditation. A master's or doctoral degree in one of the above disciplines may be substituted for one (1) year of experience.

5.2.1.2 Quality Manager - The minimum requirements for the quality manager are:

Bachelor's degree and 2 years of experience in environmental laboratory analysis/operation or an associate's degree and 4 years of experience in environmental laboratory analysis/operation. Understanding of quality systems including QA/QC. Understanding of laboratory operations. Strong communication skills including to work with a variety of staff and management

5.2.1.3 Supervisor - The minimum requirements for a laboratory supervisor are:

A bachelor's degree plus one-year work experience in a certified environmental laboratory or in a laboratory that the prospective supervisor demonstrates as one that substantially meets equivalent quality standards for a certified laboratory; or

An associate's degree in the biological, chemical, or physical sciences from an institution of higher education, plus four years work experience in a certified laboratory or in a laboratory that the prospective supervisor demonstrates as one that substantially meets equivalent quality standards for a certified laboratory.

The supervisor must demonstrate competency to supervise testing in the areas over which they supervise.

5.2.1.4 Technical Employees - The minimum requirements for technical laboratory employees vary as to position and job requirements. The education requirements

differ based on the job assignments. In general, the requirements are:

A bachelors degree in the biological, chemical, or physical sciences from an institution of higher education; or

An associates degree in the biological, chemical, or physical sciences from an institution of higher education; or

A high school degree.

Continued competence is monitored through the use of blind performance evaluation samples and Demonstrations of Competency. Where this is not achieved, the need to retrain personnel is considered. Where a method or technique is not in regular use, verification of personnel performance before they undertake tests, may be necessary.

5.2.2 Training Policies and Procedures

Policy:
Management will formulate the goals with respect to the education and the skills of the laboratory personnel. The training program is relevant to the present and anticipated tasks of the laboratory. SOP# QSP 5-2-1 is utilized to identify training needs and providing the necessary training for personnel.

Details:
The skills and knowledge are defined in the job description for each job function as described in section 5.2.1. Management compares the job description to the skills and knowledge of the new incumbent to determine the training needs.

5.2.2.1 QA Program - Chemtech-Ford, Inc. provides easy access to controlled copies of this "quality assurance program" as written within this document for all employees of this laboratory.

5.2.2.2 Training Files - Chemtech-Ford, Inc. maintains training files for all employees involved with data generation and reduction. The training files contain the following sub-files:

- Job description (minimum qualifications, experience, and skills defined).

- Analytical qualification documentation "Demonstrations of Capability," (DOC's). DOCs are neither appropriate nor required for the analyses of Odor, Color, and Paint Filter Test. Also alternatively, duplicate checks of capability are performed for Dissolved Oxygen, Flashpoint, and all microbiological analyses.
- Training attendance sheets.
- SOP reading documentation.
- Certificates, degrees, etc.
- Signed "Ethics Statement."

Training in the laboratory must include all methods or parts of methods and techniques that personnel are asked to perform. Minimally, the analyst must demonstrate competency through observation by management and verification using replicate and/or check samples. For technicians who perform only parts of the method, confirmation of competency may be verified by observation only. Re-verification of all personnel must be performed annually on all methods or techniques pertinent to their job description by use of blind performance evaluation samples and/or Demonstrations of Competency tests.

5.2.3 Employees

Policy:
Competent permanent or contractual employees are employed in the laboratory. The technical manager ensures that contractual, additional technical employees, and key support personnel are supervised and work in accordance to the policies and procedures of this Quality Manual.

Details:
Testing must be either performed or supervised by an experienced person qualified by the experience and/or degree level requirements from section 5.2.1.

5.2.4 Job Descriptions

Policy:
Current job descriptions for managerial, technical and key support personnel involved in tests and/or calibrations are maintained centrally in the administration area of the laboratory.

Details:
Minimum contents of job descriptions include:
- The duty of performing tests.
- The act of planning tests and evaluation of results.
- The responsibility of developing and validating new methods as / when requested.
- Expertise and experience.
- Qualifications and training programs.
- Managerial duties.

5.2.5 Key Personnel and Responsibilities

Policy:
Chemtech-Ford, Inc. complies with the managerial staff requirements as identified and required by "Utah Rule R444-14-8."

Details:
Key Personnel include the following listed positions:

5.2.5.1 Authority and Interrelationships – The laboratory has designated the following lines of authority:
- CEO
- President – Reports to CEO
- Executive Vice President reports to President
- Vice President, Quality Manager, Laboratory Director report to Executive Vice President
- Deputy Lab Director report to Lab Director
- Section Manager reports to Lab Director or Deputy Lab Director
- Team Leader reports to Section Manager
- Analysts & Technicians report to Team Leader

These lines of authority may have exceptions (e.g. there may not be a Team Leader and the analyst/technician may report to a Section Manager. The organizational chart is reviewed and updated (as needed) at least semi-annually (or more frequently as needed).

5.2.5.2 Laboratory Director - The Laboratory Director is responsible for the administrative oversight and overall technical operation of the laboratory. The laboratory director will:

- Define minimum qualifications, experience, and skills necessary for all technical employees.
- Ensure and document through an annual competency check that each technical employee demonstrates initial and on-going proficiency for the tests performed by that employee.
- Review the Quality Managers audit findings and document such reviews.
- Oversee laboratory technical and support staff.
- Review and approve all new and existing analytical procedures.
- Review and approve all deviations from normal analytical protocols.
- Review external and internal quality control audits and all other relative documentation/information.
- Perform final review and approval of new laboratory projects including reports and documents.
- Nominate deputies in case of temporary absence. Unless otherwise specified, the QM or deputy Lab Director will serve as acting laboratory director in the director's absence.
- Review laboratory resources and capabilities prior to accepting new non-routine project work that may affect or adversely tax the present capacity of the laboratory.
- Ensure that subcontracted laboratories are capable and appropriately certified for analytical work sent to them.

5.2.5.3 Quality Manager (QM) - The QM reports directly to the executive team. The QM has the responsibility for the quality system and its implementation (See Section 6 of the QM). The Quality Assurance Officer will:

- Have direct access to the highest level of management at which decisions are taken on laboratory policy and resources, and to the laboratory director.

- Serve as the focal point for quality assurance and oversee and review quality control data.
- Have functions independent from laboratory operations for which he or she has quality assurance oversight.
- Have documented training or experience in quality assurance procedures and be knowledgeable in the quality assurance requirements of Utah Rule R444-14; also be knowledgeable in the quality systems.
- Have knowledge of the approved methods used by the laboratory in order to accurately evaluate laboratory performance.
- Objectively evaluate data and objectively perform assessments without undue influence.
- Oversee all quality aspects of sample handling, testing, and report generation.
- Schedule, oversee, and be responsible for reviews of the entire technical operation of the laboratory. This includes conducting annual technical audits.
- Arrange, when available, analytical participation in inter-laboratory comparisons and proficiency testing programs. For purposes of qualifying for and maintaining accreditation, the QM shall arrange for participation in an external proficiency test program according to Utah Rule R-444-14 and as identified in the Quality Systems of NELAP.
- Notify laboratory management of deficiencies in the quality system and monitor corrective actions (ensure managers review all corrective actions initiating from their areas of concern, using corrective action reports as references during QA training meetings).
- Serve as the back-up to the Laboratory Director in the absence of the Laboratory Director.

5.2.5.4 Laboratory Area Supervisors - These managers are responsible for the day-to-day operation of the laboratory. Their responsibilities include:

- Supervise all technical and non-technical employees.
- Be responsible for the production and quality of all data reported by the laboratory.
- Review and approve analytical data generated within the area.
- Develop and submit new methods and operating procedures for approval by the Laboratory Director.
- Evaluate instrument and personnel needs.
- Ensure that all samples are accepted, analyzed, and reported in accordance with laboratory SOPs.

5.2.5.5Technical Staff - Technical personnel, generally, are responsible for the routine receipt, analysis and reporting of all laboratory samples. The technical staff will:

- Report directly to the assigned supervisor.
- Perform duties in accordance to laboratory policy and procedures.
- Read, understand, and follow the Quality Manual and all appropriate SOPs.

5.2.6 Laboratory Organizational Chart

The official organizational structure is contained in Quality Manager.

5.2.7 Staff Management Policies

Policy:

Management authorizes specific personnel to perform particular types of testing, to issue test reports, to give opinions and interpretations and to operate particular types of equipment. Records of the relevant competence, educational and professional qualifications, training, skills and experience of all technical personnel and contracted personnel are maintained. This information is readily available and includes the date on which authorization and/or competence was confirmed and the criteria on which the authorization is based and the confirming authority.

Details:

5.2.7.1 Confidentiality

Each employee shall read, understand, and acknowledge that the analytical work performed in the laboratory demands a high degree of confidentiality. In a practical sense, this has to do with the potential communication of laboratory procedures and analytical results to clients, regulatory agencies, and other interested parties. All employees should understand that **analytical data legally belongs to the client who contracted such work**.

5.2.7.1.1 Telephone Correspondence

A request for analytical results via telephone should be verified by requesting the name of the requestor (and as applicable the phone number, FAX number, e-mail address, or mailing address) before releasing data. It should be clear that the contracting client is the same as the client requesting the data. **For any data request from a client other than the contracting client, the contracting client must approve its use by the requesting client before release.** Such permission must be documented (requestor, contracting client, date and time of request, staff member taking request) and placed in the client data file.

5.2.7.1.2 E-mail and FAX Correspondence

Similar guidelines to 5.2.7.1.1 apply to requests for results transmitted by e-mail or FAX. Chemtech-Ford, Inc. will keep electronic records of e-mail/FAX requests and reports for 5 years.

5.2.7.1.3 "In-Person" Requests

Similar guidelines to 5.2.7.1 apply to clients who appear at the laboratory in person and request analytical data or other laboratory documentation. Copies of such reports or documentation may be released only after determining that the requestor is the contracting party, or has written permission from the contracting party to release the data.

5.2.7.1.4 Statement of Confidentiality

Each employee shall sign a Confidentiality Agreement, which describes the understanding of such laboratory confidentiality and acknowledges the penalties for failing to follow established laboratory procedures regarding confidentiality.

5.2.7.2 Improper, Unethical, and Illegal Actions

It is the policy of Chemtech-Ford, Inc. and its employees to perform their duties in a consistently legal and ethical manner. A high level of ethical behavior is characterized by, but not limited to, dealing honestly and forthrightly with all clients and co-workers, maintaining data integrity, open and timely treatment of inaccurate, invalid, or misreported analytical data, and abiding by all pertinent rules, regulations, company policies, and standard operating procedures.

Deliberate violations of such behavior will result in disciplinary action up to and including termination, the consequences of which could additionally lead to direct liability and legal action against the responsible individual.

It is the responsibility of each Chemtech-Ford, Inc. employee to report any observed violation of this policy. This observation may result from a visual or studied review of protocol, generated data, or reported information. Laboratory management will review the evidence of any such reported violation; confirmation that such a violation occurred will result in severe disciplinary action, up to and including termination and possible legal action.

Serious violations of Chemtech-Ford, Inc.'s ethical policy include, but are not limited to, the following:

- Changing a reported value in the LIMS database without proper support of documentation;
- Intentionally misrepresenting data generated by instrument or calculation;
- Recording invalid or otherwise altered data to make the analysis conform to "expected" levels;
- Recording invalid or otherwise altered data at someone else's suggestion or insistence;
- Recording invalid or otherwise altered data to satisfy quality assurance acceptance criteria;
- Manually integrating chromatographic data to satisfy quality assurance acceptance criteria;
- Withholding information that was noted during sample receipt or analysis;
- Purposefully destroying a sample prior to the completion of analysis; and
- Willfully circumventing the sample disposal Standard Operating Procedure.

Each Chemtech-Ford, Inc. employee is required to participate in a training session within two weeks of employment. The training will include Chemtech-Ford's ethical policies, examples of unethical behaviors, and penalties for non-compliance. The new employee will be required to sign an attestation statement as a condition of employment which will again define Chemtech-Ford's policies and penalties.

Each year, or more frequently if needed, each Chemtech-Ford, Inc. employee is required to attend ethical training to review company policies and penalties. At the conclusion of the training, each employee will be required to sign an attestation called an Ethical Attestation Statement that summarizes the employee's ethical and legal responsibilities. This Statement acknowledges that penalties exist for deliberately violating this policy.

In order to promote an atmosphere of integrity, management will reiterate at routine staff meetings the importance of reporting discovered errors and the insistence that such reporting will not necessarily result in personal punishment, even though the company may suffer financially.

Furthermore, management will institute internal proficiency testing (blind and double blind samples) where applicable; QC meetings whose emphasis is on

appropriate and inappropriate laboratory technique and instrument/data manipulation will be held routinely to address this topic.

5.2.7.2 Manual Integration

In keeping with Chemtech-Ford's policy of producing data of the highest possible quality, integrations performed in the laboratory must be generated by fully calibrated instruments and not altered in an unsubstantiated manner.

Improper manual integrations performed for the purposes of meeting quality control criteria or any other reason are not allowed. Such unsubstantiated integrations are subject to possible disciplinary action by laboratory management.

If a manual integration is necessary, the integration produced after manual integration shall both be labeled and present in the raw data package. The intent is to demonstrate the results of the integration are appropriate and according to good laboratory practices. It is recommended that a short explanation be provided if an unusual integration has to be made (e.g. for unusual tailing due to matrix effect).

All manual integrations are subject to strict scrutiny to ensure that they are performed appropriately. Analysts are advised that they must be prepared at any time to defend a manual integration. When there is a question to the validity of the manual integration by the analyst, then they should discuss the integration with their supervisor. Supervisors should regularly review the manual integrations of employees.

Manual integrations are noted in the raw data package. Typically, these are denoted by an "m" next to the integrated area or concentration.

5.2.7.3 Undue Pressure

An appropriate working atmosphere will be provided at Chemtech-Ford, Inc. so that all employees will be free from any commercial, financial, or other undue pressures, which might adversely affect the quality of their work.

If a Chemtech-Ford, Inc. employee feels that his or her work has been affected by undue pressure of any sort, the following recourses are available:

5.2.7.3.1 The employee may report the source of the pressure(s) affecting lab performance to his or her supervisor, or to the laboratory director or owner if the employee believes notifying the supervisor will be ineffective or problematic; and/or

5.2.7.3.2 The employee may generate a Corrective Action Form. This form will specify those requests, behaviors, or other pressures, which adversely affect the quality of the employee's work. The form will then follow normal review channels through the laboratory in order to be resolved.

5.2.7.4 Validation of Employee Qualifications

It is the responsibility of Chemtech-Ford, Inc. management to ensure that all employees have demonstrated capability in the activities for which they have been hired and are responsible. This includes verification that a potential employee possesses all of the technical, organizational, and communication skills prior to employment; and that, once hired, each employee continues to upgrade his knowledge and skills.

Each new employee is required to read, sign, and understand a comprehensive employment documents provided at time of employment. These documents verify the position's required skills as well as educating the employee in all aspects of the company's operations and policies. This documents include, but are not limited to containing:

- An attestation that all educational qualifications and technical and communication skills requirements have been fulfilled and reviewed by management.
- A Confidentiality Agreement.
- An Ethics Statement.
- A Harassment Prevention Policy.
- An attestation that the employee has read, acknowledged, and understood the Chemtech-Ford, Inc. Quality Manual.
- An attestation that the employee has read, understood, and agreed to perform the most recent version(s) of the test method(s) for which the employee is responsible.

- Demonstrations of Capability for all technical competencies required.
- An explanation of the Chemtech-Ford, Inc. Laboratory Information Management System (LIMS) and its functions.

New employees are apprised of all laboratory security systems and the Training Files to be kept by each employee.

Specialized training sessions will be routinely held to 1) review current policies and procedures; 2) institute new policies and procedures; 3) review particular technical skills, Quality Assurance topics, or corrective actions; and 4) institute cross training. These training sessions/courses will be documented in each employee's training file.

Prior to the initiation and acceptance of test results from an employee on any test method, satisfactory demonstration of capability is required. Following the completion of all capability demonstration work, the initial analytical work of any new employee will be carefully reviewed for accuracy, thoroughness, and timeliness by the laboratory supervisor. Correct and accurate entry of data into the LIMS will also be monitored. Once the supervisor is satisfied of the technical competency of the new employee, a less rigorous review of the employee's skills and generated data will be required.

Records are held in Quality Manager.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.3 Accommodation and Environmental Conditions

Section Synopsis

This section tells you:

1. That laboratory facilities are suitable for attaining correct performance of tests and calibrations
2. Critical environmental conditions are monitored, controlled and recorded
3. Incompatible activities are separated
4. Access to laboratories is controlled
5. Good housekeeping is practiced

Key Words

Incompatible activities
Prevent cross-contamination
Controlled access

Cross-references

ISO 17025:2005 Section 5.3

ISO 9001:2000 Section 6.3, 6.4, 7.1, 7.5.1, 7.5.2, 7.6, 8.2.3

5.3.1 Facility

Policy:
Laboratory facilities shall be appropriate to allow for the proper performance of analytical testing. This may include, but not limited to, energy sources, lighting, heating, ventilation and any other environmental conditions.

Appropriate care is taken to ensure that the environment does not invalidate the results or adversely affect the required quality of any measurement. The technical requirements for accommodation and environmental conditions that can affect the results of tests and calibrations are documented.

Details:
This section deals with the test areas in the laboratory and premises for support such as sample receipt and storage. Central laboratory supplies and services, such as water purification systems, air supply, vacuum source, and sample storage, are appropriate to facilitate proper performance of tests.

5.3.2 Monitoring

Policy:
Critical environmental conditions are monitored, controlled and recorded as required by the relevant specifications, methods, and procedures or where they may influence the quality of the results. Tests and calibrations are stopped when the environmental conditions jeopardize the results of the tests and/or calibrations.

Details:
Laboratories are ventilated to reduce the levels of contamination, lower humidity, and control temperature. Laboratories' test areas are air-conditioned and the temperature is 20-25 °C.

Bench tops and floors are made of impervious, smooth easily cleaned materials. There is at least two linear meters workspace per analyst while working. Walls and ceilings are made of materials that are smooth and easily cleaned.

5.3.3 Separation of Incompatible Activities

Policy:
Effective separation between neighboring areas is made when the activities are incompatible. Measures are taken to prevent cross-contamination.

Details:
Reference materials and certified reference materials must be kept separated from samples (log-in and storage). Sample log-in and storage must be segregated, ideally in a separate area from the testing laboratory, and include proper sanitation to exclude the possibility of cross-contamination. Segregation of activities is achieved through time and space allocations.

5.3.4 Controlled Access

Policy:
Access to and use of areas affecting quality of the tests is defined and controlled.

Details:
Access to the laboratory is restricted to authorized personnel only. The authorized personnel are made aware of the following items:

- the intended use of the area
- the restrictions imposed on working within such areas
- the reasons for imposing the restrictions

5.3.4.1 *Sample Receiving* - The sample receiving area is designed to be independent of the other laboratory areas. The sample receiving area is designed with a convenient access from the out-of-doors. This access is controlled allowing security of the laboratory and sample storage. The sample receiving area may also be used for preparing and shipping of containers to clients.

5.3.4.2 *Volatiles Laboratory* - The volatiles laboratory is located within a climate controlled area away from the main laboratory in order to eliminate solvent cross-contamination from other areas of the laboratory. As with the main laboratory, access to this building is limited to authorized personnel only. All GC/MS volatiles work is performed in this area.

5.3.4.3 *Inorganic Chemistry Laboratory* - The inorganic chemistry laboratory occupies the largest of the lab area within the building. The area consists of a centrally located spacious rooms equipped with several large benches for analytical work. Conventional wet techniques such as gravimetric, colorimetric, titrimetric are performed here. Several fume hoods are located within the rooms to provide ease of sample preparation.

5.3.4.4 *Wet Chemistry Laboratory* - This laboratory is adjacent to the inorganic chemistry laboratory and contains the necessary equipment required to perform various wet chemistries (e.g., BOD, COD, and TSS).

5.3.4.5 *Metals Laboratory* - The metals analysis laboratory contains all of the metals analytical equipment. However, samples are prepared for metals analysis in the inorganic laboratory, thus reducing the possibility of instrument contamination. The metals laboratory is designed for ICP, ICP/MS, and Hg cold-vapor instrumentation.

5.3.4.6 *GC and Semi-Volatile GC/MS Laboratory* - The preparation lab contains standard fume hoods and ample bench space for sample extraction. The GC and Semi-volatile GC/MS instrument laboratory has several benches with GC and GC/MS instrumentation and supplies.

5.3.4.7 *Microbiology Laboratory* - The microbiology laboratory is a separate room that is climate-controlled with ample bench space on which to perform the required analytical procedures. The laboratory contains its own supplies and storage facilities for ease of analysis and for prevention of contamination.

5.3.4.8 *Sample Storage* - Samples remaining in the sample analysis stream are located within their respective holding areas (refrigerators, etc.) until required analyses have been complete. Additional post-analysis storage for metals-preserved sample bottles is accomplished via storage shelves located within the metals laboratory. All other inorganic/organic samples are kept for a maximum of three months (following data reporting) in refrigerated storage throughout the laboratory.

5.3.5 Good Housekeeping

Policy:
Measures are taken to ensure good housekeeping in the laboratory. Special procedures are followed when necessary.

Details:
Controlled use of cleaning and pest control materials is exercised. The laboratory complies with the local health and safety requirements.

Revision History

Changes from Revision 25
Section 5.4.5.3 Title edited for grammar.

5.4 Test Methods and Method Validation

Section Synopsis

This section tells you:

1. Preference is given to the use of a standard method when selecting procedures
2. All methods must be validated before use
3. Measurement uncertainty is estimated
4. Data is controlled

Key Words

Standard Methods
Laboratory-Developed Methods
Non-standardized Methods
Validation
Uncertainty of Measurement
Data Checks

Cross-references

ISO 17025:2005 Section 5.4

ISO 9001:2000 Section 4.2.1, 4.2.3, 6.1, 6.3, 6.4, 7.1, 7.2.1, 7.2.2, 7.3, 7.4.3, 7.5.1, 7.5.2, 7.6, 8.1, 8.2.3, 8.2.4

5.4.1 General

Policy:
Methods and procedures used for all tests and/or calibrations are appropriate as per:

- sampling, handling, transport, storage, and preparation of items to be tested and/or calibrated
- an estimation of the measurement of uncertainty as well as statistical techniques for analysis of test and/or calibration data where appropriate

Instructions on the use and operation of all relevant equipment and on the handling and preparation of items for testing and/or calibration are available. All instructions, standards, manuals and reference data relevant to the work of the laboratory are maintained current and readily available to personnel. Deviation from test and calibration methods must be documented, technically justified, authorized, and accepted by the customer.

Details:
There are SOPs for sample handling, storage, preparation of test items, QA/QC procedures (media QC, incubation times and temperatures, equipment calibration and maintenance, process control QC), and standards for approving / rejecting results. These may be combined with or separate from the method. The content of an environmental (TNI) test method should include:

- Applicable Matrices
- Detection Limit
- Method Scope
- Method Summary
- Definitions
- Interferences
- Safety
- Equipment and Supplies
- Reagents and Standards
- Sample Collection, Preservation, Shipment and Storage
- Quality Control
- Calibration and Standardization
- Procedure
- Calculations
- Method Performance
- Changes to the Approved Method
- Data Assessment and Acceptance Criteria

- Corrective Action & Contingencies for Out of Control Data
- Pollution Prevention and Waste Management
- References
- Editorial Changes to SOP
- Appendices

International, national, or regional standards or other recognized specifications that contain sufficient and concise information on how to perform the tests and/or calibrations are not necessarily supplemented or rewritten as an internal procedure when they are written in a way that can be used as published by laboratory staff. Consideration may need to be given to providing additional documentation for optional steps in the method.

5.4.2 Selection of Methods

Policy:
Test and/or calibration methods, including methods for sampling, meet the needs of the customer and are appropriate for the tests and/or calibrations it undertakes. Preference is given to reference methods published as international, national, or regional standards. The laboratory ensures that the latest edition of a standard is used unless it is not appropriate or possible to do so. When necessary, the standard is supplemented with additional details to ensure consistent application.

Details:
Methods that have been published either in international, national, or regional standards, or by reputable technical organizations, or in relevant scientific texts or journals, or as specified by the manufacturer are selected when the customer does not specify the method to be used. Methods may be adopted from but are not limited to the following sources: EPA, Standard Methods, USP, AOAC, FDA BAM, USDA FSIS & AMS, APHA SMEDP, APHA, AWWA, WEF, NELAC, TNI, Compendium of Methods for the Microbiological Examination of Foods, ISO, ICMSF, National Food Processors, American Association of Cereal Chemists, Association of Dressing and Sauces, Health Canada, Environmental Protection Agency, OIE, and ASTM.

The ability of the laboratory to achieve satisfactory performance against documented performance characteristics is verified before samples are analyzed.

Laboratory-developed methods or methods adopted by the laboratory may also be used if they are appropriate for the intended use and if they are validated. The customer is

informed as to the method chosen. The laboratory confirms that it can properly operate standardized methods before introducing the tests or calibrations. If the standardized method changes, the confirmation is repeated.

The customer is informed when the method proposed by the customer is considered to be inappropriate or out of date.

5.4.3 Laboratory-Developed Methods

Policy:
Introduction of test and calibration methods developed internally is a planned activity and is assigned to qualified personnel equipped with adequate resources. Plans are updated as development proceeds and ensures effective communication among all personnel involved.

Details:
Methods developed in-house are validated and authorized before use. Where available, Certified Reference Materials (CRMs) are used to determine any systemic bias, or where possible results are compared with other techniques, preferably based on different principles of analysis. As applicable, determination of uncertainty is part of this validation process and is essential for ongoing quality control.

5.4.4 Non-Standard Methods

Policy:
Utilization of non-standard methods is subject to agreement with the customer and includes a clear specification of the customer's requirements and the purpose of the test. The developed method is validated appropriately before use.

Details:
Discussion and agreement for the use of non-standard methods is recorded as part of contract review procedures (see section 4.4).

All non-standard and new tests are validated for their intended purpose. Qualitative test methods must be validated to demonstrate estimated sensitivity and specificity, relative accuracy to official methods (if appropriate), positive and negative deviation, limit of detection, matrix effect, repeatability, and reproducibility.

Quantitative test methods are validated to demonstrate specificity, sensitivity, relative accuracy, positive and negative deviation, repeatability, reproducibility, and limit of determination.

For new methods where procedures are developing rapidly, especially for emergency situations, it may be necessary to circumvent normal validation procedures. Minimally, this must be a demonstrated recovery in replicate.

New test and/or calibration methods are documented prior to providing test and/or calibration results to customers and contain at least the following information:

- appropriate identification
- scope
- description of the type of item to be tested or calibrated
- parameters or quantities to be determined
- apparatus and equipment, including technical performance requirements
- reference standards and reference materials required
- environmental conditions required and any stabilization period needed
- description of the procedure, including:
  - affixing identification marks, handling, transporting, storing and preparing of items
  - ensuring checks are made before the work is started
  - checking that the equipment is working properly and, where required, calibrating and adjusting the equipment before each use
  - listing method of recording the observations and results
  - indicating any safety measures to be observed
- criteria and/or requirements for approval/rejection (quality control plan)
- data to be recorded and method of analysis and presentation
- uncertainty or procedure for estimating uncertainty

5.4.5 Validation of Methods

5.4.5.1 Performance Characteristics

Policy:
Validation of a method establishes, by systematic laboratory studies, that the performance characteristics of the method meet the specifications related to the intended use of the test results.

Details:

The performance characteristics of a validation plan includes, as applicable:

- selectivity and specificity
- range
- linearity
- sensitivity
- limit of detection
- limit of quantitation
- accuracy
- precision
- reporting limit
- repeatability
- reproducibility
- recovery
- confirmation techniques
- criteria for the number of samples tested to validate method as per defined scope of method
- action levels where defined by regulation
- quality control incorporating statistics as applicable

Performance characteristics that are selected take into account the intended use of the method, whether for screening, confirmatory analysis, or quantitation.

The design, verification of the method and documentation procedures for validation are planned and conducted by qualified personnel, equipped with adequate resources.

This section lists a few acceptable validation procedures. The choice of the procedure depends on the extent of the deviation from the published method.

Validation of methodology is a value judgment in which the performance parameters of the method are compared with the requirements for the test data. A prerequisite for a valid method is that data produced by the method must attain a state of statistical control. Such a state is obtained when the mean value of a large number of individual values tends to approach a limiting value called the limiting mean.

Methods may be validated by one or more alternative procedures. Some of these procedures are described below. Apparent differences can be analyzed statistically to

confirm their significance. In all cases, the reasons for choosing one or more alternatives must be documented.

- analysis of standard reference materials (SRM) that are identical or almost identical to the test samples
- in the absence of suitable SRMs, analysis of reference materials that are similar in all respect to the test samples; the use and validity of this reference material must be documented
- using an alternative method to measure the same parameter provides a very high level of confidence if results are confirmed
- recovery studies by the addition of a known concentration of the parameter of interest to some of the replicates being measured

The parameters to be determined include:

- the scope of the method and any known interference
- detection limit
- the range of concentration where the method is valid
- precision and bias

Judgment is required to determine if some or all of the above is required. Requirements will depend largely on the extent of deviation from the original method.

Developments in methodology and techniques require methods to be changed from time to time. The difference in performance between revised and obsolete methods is established so that it is possible to compare old and new data.

Where a change in method involves only minor adjustments, such as sample size, or different reagents, the amended method is validated and the changes brought to the attention of the accreditation body at the next accreditation audit. Where the proposed change involves technology or methodology, the laboratory seeks the approval of the accreditation body.

Records are kept on all validation activities. The records include any of the performance characteristics chosen, reference procedures or guidance documents followed to validate the method or custom validation procedure, and a final confirmation (memo to file) that the method validation results are acceptable for continued use of the method. An example statement would be “This serves as record that the validation of the XYZ Test Method has been approved for use by [name and title of approver]”.

5.4.5.2 Fit for Use

Policy:
The laboratory validates non-standardized methods, laboratory-designed/developed methods, standardized methods used outside their intended range, and amplifications of standard methods to confirm that the methods are fit for the intended use. The validation is as extensive as is necessary to meet the needs in the given application or field of application (may include procedures for sampling, handling, and transportation). The laboratory records the results obtained, the procedure used for the validation, and a statement as to whether the method is fit for the intended use.

Details and Procedure:
Validation records are kept as in section 5.4.5.1. Included in these records is the validation procedure. The procedure used for the validation is likely to vary between different methods. Therefore, the procedures included in the laboratory records are not as detailed as a typical SOP, but are sufficient enough to re-create how the method was validated.

The techniques used for the determination of the performance of a method, are one of, or a combination of, the following:

- calibration using reference standards or reference materials
- comparison of results achieved with other methods
- inter-laboratory comparisons
- systematic assessment of the factors influencing the result
- assessment of the uncertainty of the results based on scientific understanding of the theoretical principles of the method and practical experience.

When changes are made in the validated non-standard method, the influence of such changes carried out is documented and if appropriate a new validation is performed.

5.4.5.3 Customer's Needs

Policy:
The range and accuracy of the values obtainable from validated methods (e.g., the uncertainty of the results, detection limit, selectivity of the method, linearity, limit of repeatability and/or reproducibility, robustness against external influences and/or cross-sensitivity against interference from the matrix of the sample/test object) as assessed for the intended use is relevant to the customer's needs.

Details:
Validation includes the specification of the requirements, determination of the characteristics of the methods, the comparison of the requirements with the values of the characteristics of the method, and a statement on the validity.

As method development proceeds, regular review is required to verify that the needs of the customer are still being fulfilled. Changing requirements requiring modifications to the development plan are approved and authorized.

Validation is always a balance between costs, risks, and technical possibilities.

5.4.6 Uncertainty of Measurement

5.4.6.1 Calibration

Policy:
Physical, chemical, and biological standards are calibrated or characterized by qualified subcontractors.

Details and Procedures:
Repeatability and reproducibility data are components of measurement uncertainty and are determined as a first step towards producing estimates of this parameter. The uncertainty of measurement may be made available on the certificate of analysis or calibration certificate from a subcontractor.

Note – in-house calibrations include procedures for uncertainty of measurement estimates where practicable.

5.4.6.2 Testing

Policy:
The SOP# QSP 5-4-1 is utilized to estimate uncertainties of measurement in testing, except when the test methods preclude such rigorous calculations. In certain cases, it is not possible to undertake metrologically and statistically valid estimations of uncertainty of measurement. In these cases, the laboratory attempts to identify all the components of uncertainty and make the best possible estimation, and ensure that the form of reporting does not give an exaggerated impression of accuracy. Reasonable estimation is based on

knowledge of the performance of the method and on the measurement scope and makes use of previous experience and validation data.

Details:
The degree of rigor needed in an estimation of uncertainty of measurement depends on factors such as:

- requirement of the test method
- requirement by the customer
- if there are narrow limits on which decisions on conformity to a specification are based

In cases where a well-recognized test method specifies limits to the values of the major sources of uncertainty of measurement and specifies the form of presentation of calculated results, the laboratory is considered to have satisfied the estimation uncertainty of measurement by following the reporting instructions (see section 5.10).

5.4.6.3 Uncertainty Components

Policy:
When estimating the uncertainty of measurement, all uncertainty components that are of importance in the given situation are taken into account using accepted methods of analysis.

Details:
Sources contributing to the uncertainty include, but are not necessarily limited to, the reference standards and reference materials used, methods and equipment used, the environmental conditions, the item being tested or calibrated and the operator.

The predicted long-term behavior of the tested and/or calibrated item is normally not taken into account when estimating the measurement uncertainty.

For further information, see ISO 5725 and the Guide to Expression of Uncertainty in Measurement.

5.4.7 Control of Data

5.4.7.1 Calculations and Data Transfers

Policy:
Calculations and data transfers are subject to appropriate checks in a systematic manner.

Details:
Test data are approved through the following arrangements by the QM, supervisor, lab director, peer etc.:

- checks to determine accuracy of calculations, conversions, and data transfers
- checks for transcription errors, omissions, and mistakes
- checks to determine consistency with normal or expected values

For those analyses where manual data reduction is required, it is performed according to the instructions provided in the test method or SOP.

5.4.7.2 Computers and Automated Equipment

Policy:
When computers or automated equipment are used for the acquisition, processing, manipulation, recording, reporting, storage or retrieval of test or calibration data, the laboratory ensures that:

- computer software developed by the user is documented in sufficient detail and suitably validated or otherwise checked as being adequate for use
- procedures are established and implemented for protecting the integrity of data; such procedures include, but are not be limited to, integrity and confidentiality of data entry or collection, data storage, data transmission, and data processing (see section 4.13.1.4)
- computers and automated equipment are maintained to ensure proper functioning and are provided with the environmental and operating conditions necessary to maintain the integrity of test and calibration data
- data is securely maintained by preventing unauthorized access to, and unauthorized amendment of, computer records

Details and Procedures:

Data generated using computer software programs that are interfaced directly to instruments incorporates all dilutions and calculations, thereby eliminating the need for manual data reduction.

Commercially developed software in general use within its designed application range may be considered sufficiently validated. Laboratory software configuration / modifications are validated as outlined in SOP# QSP 5-5-1.

It is the **stated goal** of Chemtech-Ford Laboratories to meet the requirement for Electronic records, electronic signatures, and handwritten signatures executed to electronic records as defined by 21 CFR. Part 11 (Docket No. 92NO251) RIN0910-AA29; Federal Register: March 20, 1997, Volume 62, Number 54), Rules and Regulations, pages 13429-13466. Chemtech-Ford is not now fully compliant, but records of compliance evaluation are maintained and can be inspected upon request.

For details of the requirement see:

http://www.fda.gov/ora/compliance_ref/part11/

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.5 Equipment

Section Synopsis

This section tells you to:

1. Identify information needs for accept / reject decisions
2. Install equipment capable of providing that information
3. Use the equipment in the proper environment
4. Periodically check the equipment calibration

Key Words

Required Equipment and Accuracy
Authorized Personnel
Unique Identification
Inventory
Maintenance
Procedures
Out of Service
Calibration Status
Re-verification
Checks
Correction Factors
Safeguards against Adjustment

Cross-references

ISO 17025:2005 Section 5.5

ISO 9001:2000 Section 4.2.1, 4.2.3, 5.1, 6.2.2, 6.3.1, 7.1, 7.4, 7.5.1, 7.5.2, 7.5.3, 7.6, 8.1, 8.2.3, 8.2.4

5.5.1 Required Equipment

Policy:
The laboratory is furnished with all items for sampling, measurement and test equipment required for the correct performance of the tests and/or calibrations (including sampling, preparation of test and/or calibration items, processing and analysis of test and/or calibration data). When equipment is used outside the laboratory's permanent control, it ensures that the requirements of this Quality Manual are met.

Details:
Equipment is used in an environment appropriate to its proper performance. All equipment required by a test is described in each method, including the equipment's tolerances.

A current list of equipment is maintained in Quality Manager.

5.5.2 Required Accuracy

Policy:
Equipment and software used for testing, calibration and sampling are capable of achieving the accuracy required and comply with specifications relevant to the tests and/or calibrations concerned. Calibration programs are established for key quantities or values of the instruments where these properties have a significant effect on the results. When received, equipment, including that used for sampling, is checked to establish that it meets the laboratory's specification requirements, complies with the relevant standard specifications, and is checked and/or calibrated in accordance with section 5.6 before use.

Details:
The procedures for checking newly received equipment are as determined by manufacturers' specification and/or those determined by the laboratory during procurement.

5.5.3 Authorized Personnel

Policy:
Equipment is operated by authorized personnel. Up-to-date instructions on the use and maintenance of equipment (including any relevant manuals provided by the manufacturer of the equipment) are readily available for use by the appropriate laboratory personnel.

Details:
Access to laboratory equipment is controlled to ensure that only authorized personnel use equipment.

5.5.4 Unique Identification

Policy:
Each item of equipment used for testing and calibration is uniquely identified when practicable.

Details:
Measuring and testing equipment is uniquely identified. Typical identification includes instrument type, make, model, serial number or other unique markings. Measuring and testing equipment includes any instrument that could affect the quality of test results. Components that can be interchanged between various instruments are tracked in equipment logbooks but are not assigned individual identification.

5.5.5 Inventory and Maintenance Records

Policy:
Records are maintained for each item of equipment significant to the tests and/or calibrations performed. The records include the following:

- identity of the item of equipment (and its software)
- manufacturer's name, type identification, and serial number and/or other unique identification
- Date received (if available)
- Date placed into service (if available)
- checks that equipment complies with the specification (see section 5.5.2)
- current location, where appropriate
- the manufacturer's instructions, if available, or reference to their location
- dates, results and copies of reports and certificates of all calibrations, adjustments, acceptance criteria, and due date of next calibration
- maintenance carried out to date and the maintenance plan (includes calibration)
- damage, malfunction, modification or repair to the equipment
- Analysts initials

Details:
A database is used to capture the above inventory information. The above information related to service and maintenance is kept in Quality Manager. Other information recorded may include:

- date received and date placed in service
- condition when received (e.g., new, used, refurbished)
- dates and results of calibration and/or verification and date of next calibration and/or verification
- performance history, where appropriate (e.g., response time, drift, noise level)

5.5.6 Equipment Procedures

Policy:
The SOP# QSP 5-5-1 is utilized as an established plan for safe handling, transport, storage, use and maintenance (including calibration) of measuring equipment, and appropriate use of correction factors to ensure proper functioning and in order to prevent contamination or deterioration.

Note – additional procedures may be necessary when measuring equipment is used outside the permanent laboratory for tests, calibrations, or sampling (currently not applicable at our laboratory).

Details and Procedures:
The procedures for each piece of measuring equipment are located in the appropriate room where the equipment is located. These procedures detail any information for safe handling, transport, storage, use, and maintenance of measuring equipment.

5.5.7 Out of Service Equipment

Policy:
Equipment that has either been subjected to overloading or mishandling, or gives suspect results, or has been shown to be defective or outside specified limits, is taken out of service, clearly marked, and appropriately stored until it has been repaired and shown by calibration or test to perform correctly.

Details:
Routine testing work is completely discontinued on equipment that even shows minor nonconformances. Not only do we do this for ethical reasons in support of our customer, but minor nonconformances are often indicative of major breakdowns in expensive equipment. These breakdowns need to be avoided wherever possible.

Out of service equipment is clearly marked as outlined in section 5.5.8.

The laboratory examines the effect of the defect or departure from specified limits on previous test and/or calibrations and institutes the "Control of Nonconforming Work" procedure as outlined in section 4.9.

5.5.8 Calibration Status

Policy:
Equipment requiring calibration is labeled to indicate the calibration status and/or operational status and the date when re-calibration is due when appropriate.

Details:
Calibration labels have a write-on surface and a pressure sensitive adhesive. The areas that are filled out include the person who performed the calibration, the date it was performed, the date it is due for re-calibration, and the equipment's identification number.

CALIBRATION
BY_____DATE_____
DUE_____ID#_____

Measuring equipment that has failed calibration or is deemed out of service is labeled with one of the following labels:

CALIBRATION VOID

DO NOT USE

OUT OF SERVICE

DO NOT USE

A piece of equipment that is not calibrated or checked is labeled with the following label:

FOR REFERENCE ONLY

5.5.9 Return to Service

Policy:
When equipment goes outside the direct control of the laboratory for a period, the laboratory ensures that the function and calibration status of the equipment are checked and validated and shown to be satisfactory before the equipment is returned to service.

Details and Procedures:
The procedures used to check and ensure that the function and calibration status of the equipment are satisfactory before the equipment is returned to service are outlined in the

manufacturer's equipment manual. Any additional quality control checks are outlined in the "Quality Control Plan" section of the appropriate test method.

5.5.10 Periodic Checks

Policy:
When intermediate checks are needed to maintain confidence in the calibration status of equipment, these checks are carried out periodically according to defined procedure.

Details and Procedures:
As stated in section 5.5.6, the procedures for each piece of measuring equipment are available on the laboratory computer network. SOP# QSP 5-5-1 outlines a general maintenance plan for equipment and includes various checks. Internal quality control checks are specified in individual test methods that are located in the appropriate laboratory areas thereby providing procedures for intermediate checks.

5.5.11 Correction Factors

Policy
Calibrations that give rise to a set of correction factors are updated along with all copies of this data (e.g., in computer software).

Details and Procedures:
The updating of correction factors, including all copies, is assured by following the appropriate test method or SOP. It is the responsibility of the QM to ensure that all copies are updated.

5.5.12 Safeguards against Adjustments

Policy:
Test and calibration equipment, including hardware and software, are safeguarded from adjustments that invalidate test and/or calibration results/status.

Details:
Safeguards against adjustment for laboratory equipment include:
- detailed SOPs and manufacturer's manuals on the operation of the equipment

- policies permitting only fully trained and competent personnel to operate equipment
- access to the laboratory is restricted to authorized personnel

Safeguards against adjustment for software includes:

- password protection for important files and packages
- access to the laboratory is restricted to authorized personnel
- An electronic audit trail is maintained on for the changes made in the LIMS software

Revision History

Changes from Revision 24

Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.6 Measurement Traceability

Section Synopsis

This section tells you:

1. Measurements are traceable to SI units (when applicable)
2. Reference Standards and Reference Materials are used

Key Words

Systemèm International
Reference Standard
Reference Material
Traceability

Cross-references

ISO 17025:2005 Section 5.6

ISO 9001:2000 Section 6.3.1, 7.1, 7.5.1, 7.6

5.6.1 General

Policy:
Test and/or calibration equipment for subsidiary measurements (e.g., for environmental conditions) having a significant effect on the accuracy or validity of the result of the test, calibration, or sampling are calibrated before being put into service. All measurement and test equipment having an effect on the accuracy or validity of tests is calibrated and/or verified before being put into service. As mentioned in section 5.5, the SOP# QSP 5-5-1 outlines an established program for the maintenance of equipment and includes calibration.

Details:
The program includes a system for selecting, using, calibrating, checking, controlling, and maintaining:

- measurement standards
- reference standards used as measurement standards
- measuring and test equipment used to perform tests and calibrations

Procedures are documented where appropriate. All measurements that play a defining role in testing accuracy are based directly or indirectly on reference standards, reference materials, certified reference materials, or other standards or materials having appropriate traceability.

Records are maintained in the LIMS for each standard. These records include, as applicable:

- supplier, grade, lot number, and concentration
- dates of preparation or verification
- measurement of weights, volumes, time intervals, temperatures, and pressures and related calculations
- relevant processes (e.g., pH adjustment, sterilization)
- verification results
- identification of personnel involved

Reagents prepared in the laboratory are labelled to identify substance, strength, solvent (where not water), and date of preparation and/or expiry. The person responsible for the preparation of the reagent is identified either from the label or from records.]

5.6.2 Specific Requirements

5.6.2.1 Calibration

Policy:
The program for calibration equipment is designed and operated to ensure that calibration measurements are traceable to the System International (SI) units of measurement.

Details:
Traceability of measurement is assured by the use of calibration services from laboratories that can demonstrate competence, measurement capability and traceability. The calibration certificates issued by these laboratories show that there is a link to a primary standard or to a natural constant realizing the SI unit by an unbroken chain of calibrations. The calibration certificates contain the measurement results including the measurement uncertainty and/or a statement of compliance with an identified metrological specification (see also section 5.10.4.2).

Calibration laboratories accredited to ISO 17025 are considered competent to provide the appropriate calibration services.

Traceability to SI units of measurement may be achieved by reference to an appropriate primary standard or by reference to a natural constant the value of which, in terms of the relevant SI unit, is known.

The term "identified metrological specification" means that it must be clear from the calibration certificate against which specification the measurements have been compared with, by including the specification or by giving an unambiguous reference to the specification.

When the terms "international standard" or "national standard" are used in connection with traceability, it is assumed that these standards fulfil the properties of primary standards for the realization of SI units.

Maintain certificates of all reference standards, measuring equipment, or certified reference material used in ensuring traceability. Where traceability to national standards of measurement is not applicable, the laboratory provides satisfactory evidence of correlation

of results, for example by participation in a suitable program of inter-laboratory comparisons or proficiency testing.

Reference standards, such as thermometers and weights, are traceable to a national or international standard (e.g., NIST).

5.6.2.1.1 Instrument Performance Evaluation

5.6.2.1.1.1 General calibration of laboratory instruments falls into two categories: 1) calibration which is conducted on a routine basis as part of the analytical procedure prior to each use; and 2) periodic, scheduled calibration of instruments and gauges against known standards to ensure the continuing precision and accuracy of such instruments.

5.6.2.1.1.2 All instrumentation must be demonstrably calibrated and evaluated for appropriateness before analysis is initiated. Divergence from acceptable benchmark criteria requires correction before analyses may be performed. The instrument performance evaluation material may be a standard spiked into the solvent used for analysis, but it is not extracted as if it were a sample.

5.6.2.1.2 Calibration

5.6.2.1.2.1 Generally, as applicable to the method, calibration curves are established for each parameter using known concentrations of standards. At least three different concentrations in non-interfering matrices, that span the range of expected sample values are analyzed and plotted. Generally, a correlation coefficient of better than 0.995 constitutes an acceptable calibration.

5.6.2.1.2.2 Method-specific calibration requirements are included in individual SOPs. In this case, the analytical method will take precedence.

5.6.2.1.3 Continuing Calibration

5.6.2.1.3.1 Prior to use each day, the initial calibration must be verified. Typically, one of the mid-point calibration standards are analyzed and the results are compared to the expected results. If the results fall within the method acceptance limits, then analysis can proceed. If the results are not within the acceptance limits, then the problem must be corrected prior to analysis of samples. Some methods require that samples be bracketed by valid opening and closing

calibration standards. When bracketing is required, only results between valid calibration verification standards can be used.

5.6.2.1.3.2 Reportable analytical results are those within the calibration range of the parameter. In general, values above the highest standard are not reported. The lowest reportable value is the MRL. Instrumental calibration will be verified either initially and during sample analysis or at a rate that the established method requires. The continuing calibration (may be substituted by the check standard) is made with standards independent from that used for instrumental calibration. The calibration check must agree within established limits with the calibration or the instrument is re-celebrated. Continuing calibration standards must agree within established limits of calibration. If not, the cause of the discrepancy is identified, corrected, and documented.

5.6.2.1.4 Initial Calibration Verification (ICV)

5.6.2.1.4.1 An ICV is a well-characterized material that is run, at a minimum, with each calibration. The material, which is obtained from a documented second source. In order to assess the performance of the method, the ICV is run in the same manner as the other calibration standards. If the results are not within acceptable limits, the source of the problem is evaluated. Continual failure indicates there is a problem with the system, the ICV standard or the calibration standards. Prior to analysis, the ICV must pass method criteria. A calibration check solution or sample material should be analyzed at least each day of analysis to demonstrate that calibration and standardization of instrumentation is within acceptable limits.

5.6.2.1.5 Calibration Policy

5.6.2.1.5.1 The calibration policies and procedures set forth in this section apply to all instruments requiring scheduled calibrations against traceable standards, including: analytical and test equipment in the laboratory, flow rate (e.g., rotometers), volume (e.g., dry gas meters), temperature measurement equipment, balances, weights, thermometers, pH meters, SRM's, etc.

5.6.2.1.5.1.1 The standards used in the laboratory measurement system will be calibrated against higher-level, primary standards having certified accuracy. NIST or other equivalently-recognized standardization will certify these higher-level standards.

5.6.2.1.5.3 Calibration standard reagents purchased from commercial vendors will be required to have a certificate of analysis. Whenever a certified, calibration standard is available from NIST, commercial vendors will be required to establish traceability of the certificate of analysis to the certified standard.

5.6.2.2 Testing

5.6.2.2.1 Uncertainty

Policy:
The requirements given in section 5.6.2.1 apply to measuring and test equipment with measuring functions used, unless it has been established that the associated calibration uncertainty contributes little to the total uncertainty of the test result. When this situation arises, the laboratory ensures that equipment used can provide the accuracy of measurement needed.

Details:
The extent to which the requirements in section 5.6.2.1 are followed depends on the relative contribution of calibration uncertainty to the total uncertainty. If calibration is the dominant factor, the requirements are strictly followed. If, however, calibration is not one of the major contributors to the total uncertainty, other ways for providing confidence may be used, as given in section 5.6.2.2.2.

5.6.2.2.2 Traceability

Policy:
Where traceability to SI units of measurement is not possible and/or not relevant, other means for providing confidence in the results are applied such as:

- the use of suitable reference materials certified to give a reliable characterization of the material
- mutual-consent standards or methods which are clearly specified and agreed upon by all parties concerned
- participation in a suitable program of inter-laboratory comparisons or proficiency testing

Details:
Reliable characterization involves an estimate of recovery.

The laboratory participates in proficiency testing and/or check sample programs. The list of programs is maintained by the Quality Manager.

5.6.3 Reference Standards and Reference Materials

5.6.3.1 Reference Standards

Policy:
The SOP# QSP 5-6-1 outlines the program for the calibration of reference standards. Reference standards are obtained or calibrated by a body that can provide traceability as described in section 5.6.2.1. Such reference standards of measurement held by the laboratory are used for calibration only and for no other purpose, unless it can be shown that their performance as reference standards would not be invalidated.

Details:
Reference standards are obtained from ISO certified vendors], if applicable.

5.6.3.2 Reference Materials

Policy:
Where possible, reference materials are traceable to SI units of measurement, or to certified reference materials. Internal reference materials are checked as far as is technically and economically practicable.

Details:
Reference materials, including calibration standards, used in chemical measurement are prepared so that the point of measurement is similar or equivalent to that of the samples. The matrix, prior to the addition of the analyte does not have a detectable concentration of the analyte. Reagents used in the preparation of reference materials, including calibration standards are of certified purity.

5.6.3.3 Intermediate Checks

Policy:
Checks needed to maintain confidence in the calibration status of reference, primary, transfer or working standards and reference materials are carried out according to defined procedures and schedules.

Details and Procedures:
The control check standards used to verify the accuracy of all the other standards are prepared independently from all the other standards used to establish the original calibration. These control check standards are preferably prepared from a separate lot # or source. It is the responsibility of the Quality Manager to establish and maintain the individual schedule for each SOP and/or test method. In some cases, where the first two source standards agree but the results are called into question, then it may be appropriate to obtain an additional source for verifications.

5.6.3.4 Transport and Storage

Policy:
The SOP# QSP 5-6-1 outlines safe handling, transport, storage and use of reference standards and reference materials in order to prevent contamination or deterioration and in order to protect their integrity.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.7 Sampling

Section Synopsis

This section tells you:

1. There must be a sampling plan and procedure
2. Appropriate records of sampling are kept
3. Deviations, additions, and exclusions from the plan or procedure are recorded

Key Words

Sampling Plan and Procedure
Deviation, Addition, or Exclusion

Cross-references

ISO 17025:2005 Section 5.7

ISO 9001:2000 Section 4.2.4, 7.5.1

5.7.1 Sampling Plan and Procedures

Chemtech-Ford, Inc. Does not currently perform sampling.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.8 Handling of Test and Calibration Items

Section Synopsis

This section tells you to:

1. Keep samples in good condition.

Key Words

Identification
Receipt
Protection

Cross-references

ISO 17025:2005 Section 5.8

ISO 9001:2000 Section 6.3, 6.4, 7.1, 7.4.3, 7.5, 8.2.4

5.8.1 Procedures

Policy:
The SOP# QSP 5-8-1 outlines the procedures for the transportation, receipt, handling, protection, storage, retention and/or disposal of test and/or calibration items, including all provisions necessary to protect the integrity of the test or calibration item, and the interests of the laboratory and the customer.

Details:
Samples, reagents, and standards are stored so as to ensure their integrity by preventing against deterioration, contamination, and loss of identity. It is recognized that this is a general statement, but details are elaborated upon in SOP# QSP 5-8-1.

5.8.2 Identification of Test and/or Calibration Items

Policy:
Test and/or calibration items are systematically identified as they arrive at the laboratory. The identification is retained throughout the life of the item in the laboratory. The system is designed and operated so as to ensure that items cannot be confused physically, or when referred to in records or other documents. The system accommodates a sub-division of groups of items and the transfer of items within and from the laboratory when appropriate.

Details:
Sample labelling indicates the unique identification and conforms to applicable legal requirements. The laboratory has established and documents a system for appropriate chain-of-custody.

5.8.3 Receipt

Policy:
Upon receipt of the test or calibration item, any abnormalities or departures from normal or specified conditions, as described in the relevant test or calibration method, are recorded. When there is any doubt as to the suitability of an item for test or calibration, or when an item does not conform to the description provided, or the test or calibration required is not specified in sufficient detail, the laboratory consults the customer for further instructions before proceeding and keeps a record of the discussion.

The Chemtech-Ford sample acceptance policy is detailed in document QSP 5-8-3.

Details:
Conform to applicable regulations or contractual arrangements. The condition of sample may include or relate to damage, quantity, preparation, packaging, or temperature. Preparation may include addition of chemical preservative, removal of moisture, isolation of portion of sample to be tested, homogenization, or subsampling.

Procedures are in place to document that the elapsed time between sampling and testing does not exceed test method specifications (holding time) once the sample is received in the laboratory.

5.8.4 Protection

Policy:
The SOP# QSP 5-8-1 outlines the procedures and appropriate facilities for avoiding deterioration, loss or damage to the test or calibration item during storage, handling and preparation and testing; instructions provided with the item are followed. When items have to be stored or conditioned under specified environmental conditions, these conditions are maintained, monitored, and recorded. Where a test item is to be held secure (e.g., for reasons of record, safety or value, or to enable complementary test and/or calibrations to be performed later), the laboratory has arrangements for storage and security that protect the condition and integrity of the secured item concerned.

Details:
A sampling procedure and information on storage and transport of samples, including all information that may influence the test or calibration result, is provided to those responsible for taking and transporting the samples.

The laboratory establishes whether the sample has received all necessary preparation or whether the customer requires preparation to be undertaken or arranged by the laboratory. Proper requirements for packaging, environmental conditions, and separation from incompatible materials are observed. Where samples have to be stored or conditioned under specific conditions, these conditions are maintained, monitored, and recorded, where necessary.

Where a sample, or portion of a sample, is to be held secure (e.g., for reasons of record, safety, or value, or to enable check tests to be performed later), the laboratory has storage and security arrangements that protect the condition and integrity of the sample.

Revision History

Changes from Revision 24

Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.9 Assuring the Quality of Test Results

Section Synopsis

This section tells you:

1. That results are monitored
2. There is a plan for monitoring

Key Words

Internal Quality Control
Statistical Techniques
Inter-laboratory Comparisons
Proficiency Testing
Certified Reference Materials
Secondary Reference Material
Replicates
Re-testing
Correlation

Cross-references

ISO 17025:2005 Section 5.9

ISO 9001:2000 Section 6.3, 6.4, 7.1, 7.2.1, 7.2.2, 7.3, 7.4.3, 7.5.1, 7.5.2, 7.5.3, 7.5.5, 8.1, 8.2.3, 8.2.4, 8.4

5.9.1 Quality Control / Quality Assurance

Policy:
Quality control procedures are utilized to monitor the validity of test and/or calibration results. These procedures are for each test method utilized in the laboratory. The resulting data are recorded so that trends are detectable (and where practicable, statistical techniques are applied to the reviewing of the results). This monitoring is planned and reviewed and may include, but not limited to, the following:

- regular use of certified reference materials and/or internal quality control using secondary reference materials
- participation in inter-laboratory comparisons or proficiency testing programs
- replicate tests or calibrations using the same or different methods
- re-testing or re-calibration of retained items
- correlation of results for different characteristics of an item

Details:
The methods utilized from the above list will be appropriate for the type and volume of the work undertaken. Records are maintained of assurance activities and any actions taken.

As a guide, for routine analyses the level of internal quality control is typically 5% of the sample throughput. For more complex procedures, 20% is not unusual and on occasions even 50% may be required. For analyses performed infrequently, a full system validation is performed on each occasion. This may typically involve the use of a reference material containing a certified or known concentration of analyte, followed by replicate analyses of the sample and spiked sample. For analyses undertaken more frequently, systematic quality control procedures incorporating the use of control charts and check samples are implemented. These procedures are documented in the "Quality Control Plan" of each test method.

Proficiency testing helps to highlight not only repeatability and reproducibility performance between laboratories, but also systematic errors such as bias. It is important to monitor proficiency testing results as a means of checking quality assurance and take action as necessary.

The QM maintains a list of all the current proficiency testing programs the laboratory participates in, monitors the results, and notifies the appropriate personnel of both problematic and successful results.

Technical personnel use certified reference materials and reference materials to evaluate test performance on a daily basis and include daily process control checks. These data are used to evaluate the validity of the test results.

Replicate tests may be used if suitable reference material is available. These materials and proficiency test materials are available for improving repeatability.

Re-testing of test items is performed occasionally at the discretion of the supervisor or when test results seem anomalous.

5.9.1.1 Quality Control Procedures

The determination of precision and accuracy is an important analytical tool in evaluating the quality of generated data. Precision is defined as the ability to reproduce a value within defined limits. Accuracy is defined as producing the correct answer. Different methods are employed to measure each of these parameters.

5.9.1.1.1 ***Precision*** - Utilizing duplicate samples and comparing their respective results is the primary method for the analysis of precision. However, it has no bearing on accuracy. A result may be precise and inaccurate at the same time. One duplicate sample is analyzed for each matrix type and method, and for each sample batch, or for each sample batch containing 20 samples, whichever is less. The relative percent difference (RPD) for each component is then calculated and compared to the acceptance limits for the matrix and method.

5.9.1.1.2 ***Accuracy*** - Utilizing matrix-matched standards of known concentration and comparing them to the analyte of interest is the primary method for measuring accuracy. Participation in independent Performance Evaluation (PE) studies is also utilized to monitor accuracy of data in the laboratory.

5.9.1.1.3 ***Reproducibility*** - The tracking of reproducibility ensures that analyses performed at different times or by different individuals may be acceptably reproduced. This demonstrates that the method, instrumentation, and analytical technique are resilient enough to reproduce results within a specified range over time.

5.9.1.2 Quality Control Samples

The quality control principles contained in this section will be implemented consistently, dependent upon the type of analysis to be performed and any

associated, specific requirements of such analysis. In addition, the analyst is to use his/her best judgment to evaluate the use of additional QC bracketing samples which have a difficult matrix, react differently, or have distinctive client or reporting requirements. The additional QC can take the form of additional spikes, standards, and/or SRM's. Sufficient QC should be performed to insure that the analyst has performed due diligence with regard to QC while analyzing the sample.

5.9.1.2.1 ***Matrix Spike and Matrix Spike Duplicate*** - Matrix spikes are employed to monitor recoveries and maintain extraction and/or concentration techniques at acceptable levels. Compounds of interest are added to samples prior to extraction and analysis. Compound recoveries and reproducibility are then compared with tables of acceptance for each method. The established acceptance ranges are contained in each method SOP.

5.9.1.2.1.1 This QC procedure provides information about the effect of the sample matrix on the analyte in question. Generally, a ratio of one spike sample for each ten samples for drinking water and for each twenty samples for RCRA and wastewater analyzed must be maintained. In the event that an analytical run will have less than ten samples one spike shall accompany the batch. The method SOP should be consulted to determine the proper frequency. Solutions used to fortify samples should, when possible, be made from a source other than that from which the calibration standards are made. Percent recovery of matrix spikes is determined using the following:

Percent Recovery = (SSR-SR)/SA x 100

Where:
SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

5.9.1.2.1.2 **Spike Recoveries** - Percent spike recoveries range between ± 3 standard deviations (SD) of the historical percent recoveries when method-specified criteria are not available. It is recognized that this will not always be achievable due to matrix effects. In that case, the data will be reported and an explanation made concerning the problem.

5.9.1.2.1.3 **Laboratory matrix spikes and matrix spike duplicates** must be prepared and analyzed for each ten samples for drinking water and for each twenty

samples for RCRA and wastewater analyses. This procedure provides information regarding the precision of an analysis. (These sample types are not always possible due to the type of analysis, for example pH.) The relative difference between duplicate measurements is assessed using the following equation:

Relative Percent Difference (RPD) = $|D_1-D_2|/ ((D_1 + D_2)/2) \times 100$

Where:

D_1 = Sample Value

D_2 = Duplicate Sample Value

5.9.1.2.2 ***Laboratory Control Spikes*** - Compounds of interest are added to reagent blank samples prior to extraction and analysis, as required by each method SOP. Compound recoveries and reproducibility are then compared with tables of acceptance for each method.

5.9.1.2.3 ***Duplicates and Spike Duplicates*** - Both routine sample analysis and spiked samples are run in duplicate at a prescribed frequency. The relative percent difference between duplicate sample analysis or duplicate spike analysis must range between $\pm$ 2 standard deviations (SD) of historical relative percent difference (RPD), when method-specified criteria are not available. It is recognized that this will not always be achievable due to matrix effects. If a matrix effect is confirmed, the data will be reported and an explanation concerning the problem will be noted on the final report.

5.9.1.2.4 ***Surrogates*** - Surrogate spike compounds of interest are added to each sample prior to extraction and analysis. Compound recoveries and reproducibility are then compared with tables of acceptance for each method.

5.9.1.2.5 ***Method and Reagent Blanks*** - Method blanks must be prepared with each batch of samples and analyzed to ensure that sample contamination has not occurred. If blank analyses do not fall within acceptable limits, as noted in the method specific SOP, a modification of method reagents or cleaning of glassware may need to be implemented before further analysis is attempted. In addition to method blanks, reagent blanks shall be prepared whenever the lot number of a reagent used in the analysis has changed.

5.9.1.2.6 ***Internal Standards*** - Internal standards will be prepared from a solution containing a known amount of analyte and will be traceable to a certified reference solution. Internal standard levels spiked into the sample for analysis

will be according to method SOP protocol. During analysis, internal standard intensities will be monitored and compared to the intensities established in the calibration blank. In general, intensities should be within 60 – 135% of the original response in the calibration blank, or as otherwise specified in the method SOP.

5.9.1.2.7 ***Quality Control Check Samples*** - Quality control check samples will be prepared from a solution containing a known amount of analyte and will be traceable to a certified reference solution. These solutions will be prepared from a solution that is "second source" in difference from the calibration standards/tuning standards. These solutions will be used to verify the stability of the analytical curve established for the current analytical run.

5.9.1.2.7.1 After calibration and calibration verification, continued calibration blanks (CCB) and continued calibration verification samples (CCV) will typically be analyzed after every 10 samples and at the end of every analytical run. Control limits during analysis of these solutions will be subject to the QA protocol as defined by the method SOP.

5.9.1.2.7.2 Quality control check samples will be used to verify the efficacy of the sample preparation procedure via the analyses of preparation blanks (PB) and laboratory control samples (LCS) derived from a certified reagent traceable to a certified reference material or solution. Laboratory control samples must agree within $\pm$ 2 standard deviations of the historical data base or no greater than $\pm$ 20 percent of the true value. Where method specific ranges exist, they may be used.

5.9.1.2.8 ***Calibration Standards*** - Calibration Standards will be prepared from a solution containing a known amount of analyte and will be traceable to a certified reference solution. Calibration standards will be prepared from a solution that is "second source;" that is, different from the continued calibration verification (CCV) solution.

These solutions are to be utilized for the calibration/tuning of analytical instruments at the beginning of an analytical run and to be used for tuning frequency as required by the method SOP protocol. These solutions are also used to evaluate method MDL's and effective quantitative ranges (linearity).

When required, these samples will be analyzed as samples with control limits as required by the method QA SOP protocol. Selection of appropriate

formulae to reduce raw data to final results is included in the method analyte SOP

5.9.1.3 Other Quality Control Measures

5.9.1.3.1 Control charts can be produced by analyte for the evaluation of QA/QC data. The charts are produced by the LIMS software.

5.9.1.4 Out-of-Control Situations

On occasion, a quality control sample may fail; i.e., the recovery for one or more specific analytes may lie outside the acceptable range (creating an "out-of-control" situation). This failure may or may not affect the acceptability of the analytical run and the quality of associated generated data. Quality control guidelines, contained in Chemtech-Ford, Inc.'s Data Validation and Acceptance Procedure, have been established to be used in the evaluation of out-of-control data for each analytical SOP

5.9.2 Correction and Prevention

Policy and Details:
Quality control data are analyzed and, where they are found to be outside pre-defined criteria, planned action is taken to correct and to prevent incorrect results from being reported.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.

5.10 Reporting of Results

Section Synopsis

This section tells you:

1. What needs to be on a report
2. How to handle amendments to reports

Key Words

Specific Information
Required Information
Interpretation
Opinion
Subcontractor
Electronic Transmission of Results
Format
Amendments

Cross-references

ISO 17025:2005 Section 5.10
ISO 9001:2000 Section 6.1, 6.3.1, 7.1, 7.2.1, 7.2.2, 7.4.3, 7.5.1, 7.5.4, 7.5.5, 8.2.4

5.10.1 General

Policy:
The results of each test, or series of tests are reported accurately, clearly, unambiguously and objectively, and in accordance with any specific instructions in the test methods.

The results are reported, normally in a test report and include all the information requested by the customer and necessary for the interpretation of the test results and all information required by the method used. This information may include what is outlined in section 5.10.2, 5.10.3 and 5.10.4.

Details:
Test reports are issued as either hard copy or by electronic data transfer.

5.10.2 Test reports and certificates

Policy:
Test reports include the following information, as appropriate:

- a title (e.g., " Certificate of Analysis")
- name and address of laboratory, and location where tests were carried out if different from the address of the laboratory
- Unique identification of the test report, and on each page an identification in order to ensure that the page is recognized as a part of the test report
- name and address of the customer
- identification of the method used
- Description, condition, and unambiguous identification of the item(s) tested.
- date of receipt of test items (where this is critical to the validity and application of the results) and date(s) of performance of the analysis
- reference to sampling procedures used by the laboratory or other bodies where these are relevant to the validity or application of the results
- test results with, where appropriate, units of measurement
- the name(s), function(s) and signature(s) or equivalent of person(s) authorizing the test report
- where relevant, a statement to the effect that the results relate only to the items tested

Details:
Signing authority for test reports is the responsibility of the Lab Director. Records for individuals with signing authority for test reports are approved by the Quality Manager and maintained by same.

Analytical reports include the individual page number and total number of report pages (Page 3 of 16).

A statement is included specifying that the test report is not to be reproduced except in full, without written approval of the laboratory. Data reported to the customer contains the appropriate significant digits for each test method. Low level data are identified as being below specified limits and are flagged with a 'J' flag indicating a value found between the MDL and MRL.

5.10.3 Test Reports

5.10.3.1

Policy and Details:
In addition to the requirements listed in section 5.10.2, test reports include the following, where necessary for the interpretation of results:

- deviations from, additions to, or exclusions from the test method, and information on specific test conditions, such as environmental conditions
- where relevant, a statement of compliance/non-compliance with requirements and/or specifications
- where applicable, a statement on the estimated uncertainty of measurement of the test result; information on uncertainty is needed in test reports when it is relevant to the validity or application of the test results, when a customer's instruction so requires, or when uncertainty affects compliance to a specification limit
- where appropriate and needed opinions and interpretations (see section 5.10.5)
- additional information required by specific methods, customers, or groups of customers

5.10.3.2

Policy and Details:
In addition to the requirements listed in sections 5.10.2 and 5.10.3.1, test reports containing the results of sampling include the following, where necessary for the interpretation of test results:

- date of sampling
- unambiguous identification of substance, matrix, material or product sampled (including name of manufacturer and lot number as appropriate)
- location of sampling
- reference to sampling plan and procedures used
- details of any environmental condition during sampling that may affect the interpretation of the test results
- any standard or other specification for the sampling method or procedure, and deviations, additions to or exclusions from the specification concerned

5.10.4 Calibration Certificates

5.10.4.1

Policy:
The testing laboratory does not issue calibration certificates. However, the laboratory often receives calibration services from a calibration laboratory and needs to be familiar with the information on a calibration certificate.

Details:
In addition to the requirements listed in 5.10.2, the calibration certificate could include the following, where necessary for the interpretation of calibration results:

- the conditions (e.g., environmental) under which the calibrations were made that have an influence on the measurement results
- the uncertainty of measurement and/or a statement of compliance with an identified metrological specification or clauses thereof
- evidence that the measurements are traceable (see 5.6.2.1.1)

5.10.4.2

Policy:
This section is not applicable to a testing laboratory.

5.10.4.3

Policy:
This section is not applicable to a testing laboratory.

5.10.4.4

Policy:
A calibration certificate (or calibration label) shall not contain any recommendation on the calibration interval except where this has been agreed with the customer or it is to be used by the laboratory itself.

5.10.5 Opinions and Interpretations

Policy:
When opinions and interpretations are included in the test report, the basis upon which the opinions and interpretations have been made is documented. Opinions and interpretations are clearly marked as such in the test report.

Note - Opinions and interpretations should not be confused with inspections and product certifications as intended in ISO/IEC 17020 and ISO/IEC Guide 65.

Details:
Opinions and interpretations included in a test report may comprise, but not be limited to the following:

- opinion on conformity of the results with requirements
- fulfilment of contractual requirements
- recommendations on how to use the results
- guidance to be used for improvements

In many cases it is appropriate to communicate the opinions and interpretations by direct dialogue with the customer.

5.10.6 Testing and Calibration Results Obtained from Subcontractors

Policy and Details:
Test reports containing the results of tests performed by subcontractors are clearly identified for the subcontracted results. The subcontractor reports the results either in writing or electronically to our laboratory.

5.10.7 Electronic Transmission of Results

Policy:
In the case of transmission of test results by telephone, facsimile or other electronic or electromagnetic means, the requirements of the policies and procedures of this Quality Manual continue to apply (see also 5.2.7.1.2).

Details:
Signatures are recorded on file at the laboratory. Clients may request a hardcopy example of signatures.

5.10.8 Format of Reports

Policy:
The format of reports is designed to accommodate each type of test carried out and to minimize the possibility of misunderstanding or misuse.

Details:
The layout of the test report is such that the presentation of the test data facilitates ease of assimilation by the reader.

5.10.9 Amendments to Reports

Policy:
Material amendments to a test report after issue are made only in the form of a further document, or data transfer, which includes the statement "Amended Report". Such amendments meet all the requirements in this Quality Manual.

Details:
When it is necessary to issue a complete new test report, it is uniquely identified and contains a reference to the original that it replaces. A narrative accompanies the amended report which details the changes in the report as well as justifications for the change. Details for producing an amended report are located in document QSP-5-10-9.

Revision History

Changes from Revision 24
Revision 25 is a significant revision with numerous additions, deletions and corrections. These are not all documented in the revision history, rather all persons on the distribution list are required to read the entire document.