RACER Trust

Corrective Measures Implementation Work Plan

Former GM Delco Plant 5, Kokomo, Indiana

March 1, 2022

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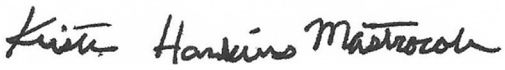

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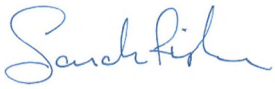

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Acronyms and Abbreviations

AAMP	Ambient Air Monitoring Plan
AOI	Area of Interest
BFS	blast furnace slag
CLP	Contract Laboratory Program
cm/sec	centimeter per second
CMCR	Corrective Measures Completion Report
CMI	Corrective Measures Implementation
CMP	Corrective Measures Proposal
CQAP	Construction Quality Assurance Plan
CVOC	chlorinated volatile organic compound
DOCC	Document of Current Conditions Report
EMHP	Excavation and Materials Handling Plan
ERC	Environmental Restrictive Covenant
FD/RC	Final Decision and Response to Comments
ft bgs	feet below ground surface
ft/day	feet per day
ft/ft	feet per foot
GM	General Motors Corporation
GCP	Groundwater Contingency Plan
HASP	Health and Safety Plan
HPT	Hydraulic Profiling Tool
ICIAP	Institutional Control Implementation and Assurance Plan
ISS	in situ solidification and stabilization
LTSP	Long-Term Stewardship Plan
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
OM&M	operations, monitoring, and maintenance plan
OSHA	Occupational Safety and Health Administration
PC	Portland cement
psi	pounds per square inch
QAPP	Quality Assurance Project Plan
RACER	Revitalizing Auto Communities Environmental Response

RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SB	soil boring
SWPPP	Storm Water Pollution Prevention Plan
TCE	trichloroethylene
UCS	unconfined compressive strength
USEPA	United States Environmental Protection Agency
VAP	vertical aquifer profiling
VI	vapor intrusion
VOC	Volatile Organic Compound
WR-OL	Well Restriction Overlay
ZVI	Zero Valent Iron

1 Introduction

Arcadis U.S., Inc. (Arcadis) has prepared this Resource Conservation and Recovery Act (RCRA) Corrective Measures Implementation (CMI) Work Plan on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust for the former GM Delco Plant 5 facility located at 1723 North Washington Street, Kokomo, Indiana (the Site; **Figure 1**).

The United States Environmental Protection Agency (USEPA) and RACER Trust signed an Administrative Order on Consent (Order, RCRA-05-2011-0017) with an effective date of September 29, 2011 (USEPA 2011). Pursuant to the Order, RACER Trust has worked in cooperation with USEPA to investigate historical releases of hazardous wastes or hazardous constituents at or from the Site located in Kokomo, Indiana (USEPA ID IND000806844).

Prior to the Order, RACER Trust and its predecessors, completed corrective action activities, including the implementation of a RCRA Facility Investigation (RFI), which is summarized in the RFI Report (Arcadis 2010) and targeted the areas of interest (AOIs) which were detailed in the Site's Document of Current Conditions (DOCC; Arcadis 2005). The AOIs addressed in the RFI are shown on **Figure 2**. The outcome of the risk assessment completed during the RFI was to identify that there were no potentially significant risks under the current land use and groundwater use and the only potential future risk was from potential vapor intrusion from a future building over five soil boring (SB) locations (SB-0746, SB-0749, SB-0756, SB-0757, and SB-0775); however, at USEPA's request, RACER Trust was asked to consider groundwater restoration as a component to the RCRA Corrective Action.

RACER Trust prepared and submitted an updated Corrective Measures Proposal (CMP) to the USEPA in 2019 (Arcadis 2019b). The CMP evaluated several options to address the potential risk to receptors and address USEPAs request for groundwater restoration. The CMP recommended the following measures for consideration by USEPA:

- Land Use Restrictions: Record an Environmental Restrictive Covenant (ERC) that places the following restrictions on the property:
    - Restrict land use to non-residential, commercial/industrial uses only and no agricultural uses.
    - Restrict the construction of or allow occupancy of an enclosed workspace unless a vapor mitigation system is installed, operated, and maintained within the dwelling or work-space.
    - Restrict groundwater use for the property, including the extraction of groundwater for any purpose, including, but not limited to: human or animal consumption, gardening, industrial processes, or agriculture, except that groundwater may be extracted in conjunction with environmental investigation and/or remediation activities.
- Well Restriction Overlay (WR-OL) District: Work with the city and county to establish a WR-OL District to ensure that no new groundwater wells will be installed in the designated area around the Site.
- Use monitored natural attention (MNA) to reduce soil and groundwater concentrations of volatile organic compounds (VOCs) migrating off site. MNA will contribute to long-term aquifer restoration and eventually lead to groundwater impacts migrating off-site at concentrations below USEPA drinking water quality Maximum Contaminant Levels (MCLs), though the timeframe to reach MCLs at the property boundary may exceed 100 years.

In the Statement of Basis, the USEPA identified their proposed corrective measures for the Site as: In-Situ Solidification and Stabilization (ISS) with MNA for Groundwater and Soil; Institutional Controls; and Long-Term Care/Stewardship (USEPA 2021a). After a public comment period, the USEPA issued a Final Decision and Response to Comments (FD/RC) which documented the above selected remedies on June 16, 2021 (USEPA 2021b).

In response to the FD/RC, Arcadis has prepared this CMI Work Plan on behalf of RACER Trust detailing the design and implementation procedure for the final corrective measure of ISS. Institutional Controls, MNA and Long-Term Care/Stewardship will be discussed in **Section 6** as part of the path forward. The remainder of this Report is organized as follows:

- **Section 2** provides a description and a brief history of the Site.
- **Section 3** presents key Corrective Action investigation results including the treatability tests.
- **Section 4** describes implementation of the corrective measure.
- **Section 5** describes the deliverables associated with this CMI Work Plan and future submittals.
- **Section 6** describes the schedule for implementation.
- **Section 7** lists the references identified in this report.

2 Site Background

The Site is a 10.5 acres property located in Kokomo, Indiana, the county seat of Howard County. The Site is bounded by Butler Street to the north, beyond which are residential and industrial properties; by an abandoned industrial property to the south (former Midwest Plating Corporation); a railroad to the west, beyond which are residential and commercial properties; and North Washington Street to the east, beyond which are residential and commercial properties.

The majority of the Site is a vacant grass field with the exception of a parking lot and abandoned road in the northern portion of the property. Figure 5 of the DOCC (Arcadis 2005) shows an overview of the land cover at the Site. The abandoned road (Spraker Street) separates the parking lot on the north side of the property from the vacant grass field comprising the remainder of the property. USEPA issued a Corrective Action Complete with Controls for the northern parking lot and abandoned Spraker Street area in 2017, which is approximately 4.8 acres in size.

2.1 Site Geology

The generalized elevation of the Site is approximately 826 feet above mean sea level, with the land surface being relatively flat. Geologic cross sections and cross section reference figures were included as Drawing 3 through Drawing 6 in the RFI Report (Arcadis 2010) and Drawing 3 and Drawing 4 of the In-Situ Chemical Oxidation Pilot Injection Summary Report (Arcadis 2015). Seven distinct hydrostratigraphic units have been identified at the Site. Three sand units separated by clay layers have been observed at the Site and have been designated as the S1 Unit, the S2 Unit, and the S3 Unit, with the S1 Unit being the shallowest and the S3 Unit being the deepest. These water-bearing zones are each isolated by aquitards consisting of clay or till in the following sequence:

- Upper Confining Unit – consisting primarily of clay and till
- S1 Unit – sand and gravel glacial outwash
- Middle Confining Unit – hard clay-rich till
- S2 Unit - sand and gravel glacial outwash
- Lower Confining Unit - hard gray clayey silt
- S3 Unit - sand and gravel glacial outwash and highly weathered limestone
- B1 Unit - limestone bedrock.

The two uppermost units have been the primary zones of concern involving site investigations and are discussed in further detail below. The soil of the Upper Confining Unit is the primary zone of chlorinated volatile organic compound (CVOC) impacts and is inferred to be a source of groundwater contamination to the S1 Unit beneath. The S1 Unit is the horizon containing the Site's most significant CVOC groundwater plume.

2.1.1 Upper Confining Unit

The Upper Confining Unit is composed of topsoil, clay, and till. Underlying the topsoil is a plastic clay, which is composed of pliable silty, sandy clay and is generally encountered from the surface to approximately 25 feet below ground surface (bgs). Beneath the plastic clay lies a zone of till consisting of non-plastic and firm silt, sands, and trace pebbles. The till is encountered between approximately 15 to 25 feet bgs and ranges in thickness from 4 to 12 feet thick.

The water table typically occurs near the base of this till unit, though the soil is of sufficiently low permeability that wetness is often difficult to observe in soil samples.

2.1.2 S1 Unit

The S1 Unit is the first encountered continuous water-bearing unit and is generally first observed between 15 to 25 feet bgs. The S1 Unit consists primarily of sand and gravel glacial outwash deposits. Outwash sediments form as meltwater from the glacier deposits sands and silts in braided-stream environments directly in front of the glacial extent. This depositional environment can create heterogeneous sedimentary deposits with complex transport flow fields that are likely multidirectional. Because braided-stream deposits tend to form long, narrow beds rather than laterally extensive, planar beds, the hydraulic conductivity is greatest in the direction parallel to the deposited beds. This anisotropy will tend to bias groundwater flow parallel to the long axis of the most highly permeable beds.

While in bulk, the S1 Unit consists mostly of very permeable sand and gravel, site data show that the S1 Unit is heterogeneous both laterally and vertically. In several borings, very highly permeable beds appear to occur at the base of the S1 Unit, while finer sand or silt beds are noted in the upper part of the unit. Neither of these observations, however, is found consistently across the Site. Based on the dynamic nature of the depositional environment, no single trend (e.g., fining upward sequence) appears to be consistently applicable.

The S1 Unit ranges in thickness from 1 foot near the eastern and southeastern margins of the study area and 35 feet near the center of the Site (e.g., primary source area). The highly irregular geometry of the S1 Unit means that flow paths within the unit will be skewed, not only by the internal aquifer properties (e.g., heterogeneity and anisotropy), but by the actual aquifer boundaries. For instance, flow along the top of the S1 Unit must descend downward if the overlying till surface descends downward.

2.2 Site Hydrology

The local potentiometric surface in the S1 Unit is presented on **Figure 3** representing the most recent groundwater gauging event from March 5, 2021. The horizontal potentiometric gradients in the S1 Unit trend east to southeast. The observed trichloroethylene (TCE) migration pathways in the groundwater appear to be to the east and south from the primary source area with an overall southeast direction. TCE groundwater concentration contours are presented on **Figure 4** from the most recent groundwater sampling event on March 29, 2021.

Estimates of hydraulic conductivity were obtained from hydraulic profiling tool (HPT) borings advanced during the Vertical Aquifer Profiling (VAP) Investigation conducted in October and November 2016. HPT results from the investigation were included as Appendix A of the VAP Investigation Report (Arcadis 2017). Hydraulic conductivity estimates from the HPT borings range from less than 0.1 feet per day (ft/day) to greater than 150 ft/day (the lower and upper limits to the HPT instrument) but are generally greater than 50 ft/day in the S1 Unit, which is in the same range as the hydraulic conductivity estimates obtained from slug testing completed at the Site.

Groundwater flow velocities may be estimated using the estimates of hydraulic conductivity above, the S1 Unit hydraulic gradient, and an estimate of mobile porosity. Hydraulic gradients with the S1 Unit in the northwest portion of the Site vary moderately depending on the measuring event, but average approximately 0.001 feet per foot (ft/ft). (Note that the gradient is as much as five times higher in the southeast portion of the Site, where the S1

Unit is thinner.) Assuming an average hydraulic conductivity of 103 ft/day obtained from the slug tests, a gradient of 0.001 ft/ft and a mobile porosity of 0.20, the linear velocity of groundwater flow would be 0.5 ft/day. In zones of the highest hydraulic conductivity (e.g., 310 ft/day), the velocity would be 1.5 ft/day. In zones of the lowest hydraulic conductivity (e.g., 14 ft/day), the velocity would be 0.7 ft/day.

2.3 Surface Water Hydrology

There are no surface water bodies in the immediate vicinity of the Site. The nearest major surface water body is Wildcat Creek, which is located approximately 1.5 miles south of the Site and flows in a west-southwest direction.

3 Corrective Action Investigation Activities

Several investigation activities were completed at the Site to assist in determination of the final corrective measures to be implemented. These investigations included: a monitored natural attenuation evaluation, source area investigation and bench scale study. Results of the pre-design investigation activities are summarized below and presented in more detail as part of the CMP (Arcadis, 2019).

3.1 Monitored Natural Attenuation (MNA) Evaluation

The MNA investigation concluded that although relatively high concentrations of TCE remain at plume core areas, downgradient concentration trends indicate an overall stable to decreasing plume configuration, with geochemical and biological conditions conducive to the attenuation of TCE and its degradation products. Generally, the evaluation demonstrated that natural attenuation has the capacity to mediate decreasing CVOC concentrations in the plume body at the Site and to control plume expansion and migration in the downgradient direction; however, the use of MNA solely as a corrective measure may not achieve remedial objectives of MCLs at the property boundary within a reasonable timeframe. To help achieve the remedial objectives in a shorter timeframe additional source area delineation was conducted and supplemental corrective measures were evaluated.

3.2 Source Area Investigation

Based on the findings of the MNA Evaluation (Arcadis 2016) and the HPT/VAP Investigation (Arcadis 2017), RACER Trust and the USEPA determined that MNA could be a viable final Corrective Measure, if RACER Trust completed additional mitigative measures to reduce the overall migration to groundwater of TCE impacts in soil and thereby reduce the timeframe to achieve groundwater restoration. In order to address portions of the Site that would have the greatest potential for reducing the groundwater concentrations, a target concentration of 100 milligrams per kilogram (mg/kg) of TCE was selected.

From March 26, 2018 through April 6, 2018, Arcadis conducted a soil and groundwater investigation. A total of 46 high resolution soil borings were installed to refine the proposed treatment footprint and further delineate the potential source areas. This included 26 primary borings and 20 additional secondary soil borings that were advanced to further define the 100 mg/kg TCE concentration contour in each area. Soil borings were advanced using direct-push drilling methodology through the upper silt and clay overburden units and into the upper portion of the S1 Unit (sand and gravel). Soil samples were collected at nominal 2-foot intervals for analysis of CVOCs. A mobile laboratory was used to provide an adaptive field sampling approach to strategically target and delineate CVOC soil concentrations. Based on the mobile laboratory data, some soil boring locations were extended deeper into the S1 Unit to further delineate the vertical extent of CVOC impacts. Soil samples with photoionization detector results greater than 100 parts per million were also field screened for the presence of dense non-aqueous phase liquid using hydrophobic dye test kits.

The results of this source area investigation identified TCE at concentrations greater than 100 mg/kg in AOI 1 (North Area) and AOI 5 (South Area) as leaching from the silt and clay unit to groundwater in the S1 Unit. The limits of this North Area and South Area are presented on **Figure 2**.

3.3 Bench Scale Study

During the source area investigation, Arcadis collected soil from the 12 ft to 19 ft bgs sampling intervals from soil boring SB-1834 for a bench scale treatability analysis to determine if ISS was a viable corrective measure. The soil was identified as a stiff, dry to moist, greyish brown silt with some sand and clay. The mobile laboratory analysed the soil in the field and identified TCE concentrations ranging from 227 mg/kg to 1,321 mg/kg. Soil was packed into a 5-gallon Department of Transportation rated bucket with a ratcheted twist-on lid to secure the sample and not allow volatilization. The sample was shipped to the Arcadis treatability laboratory in Durham, North Carolina.

Upon approval of the In-Situ Solidification/Stabilization Treatability Study Work Plan dated July 31, 2018, the treatability laboratory homogenised the soil and collected a soil sample and duplicate for VOC analysis. The TCE results from the homogenised soil were 581 mg/kg and 664 mg/kg. The soil was deemed representative of the source soils and was carried through for two treatability studies: (1) In-Situ Soil Stabilization (ISS Sorbing) with Zero Valent Iron (ZVI); and (2) In-Situ Soil Solidification (ISS Binding) with Portland Cement (PC) and Ground-Granulated Blast Furnace Slag (BFS). The objectives of the treatability bench scale studies were:

- Evaluate the optimum mix design(s) and rate of full-scale application to best meet remedial and site development objectives for soils to be remediated using ISS technology.
- Evaluate other geotechnical design and installation criteria (grain size distribution, moisture content, hydraulic conductivity, and unconfined compressive strength) as necessary for full-scale ISS technology implementation at the Site.
- Determine whether ISS technology can meet the remediation and site development goals using practicable engineering methods.

The results of the bench scale treatability study were detailed are presented in Appendix C of the CMP (Arcadis 2019b). A summary of the results is presented below.

3.3.1 In-Situ Stabilization

The objective of the In-Situ Stabilization treatability test was to identify the mix percentages of ZVI and soil that would result in destructive treatment of VOCs as well as the length of time required to achieve a beneficial reduction of VOCs in the soil. Five samples were mixed with ZVI addition ranging from 0% to 5% ZVI. A soil sample was collected from each of the mixes (Mix 1 through Mix 5) at days 1, 4, 7, 14, 28, and 56.

- Mix 1 (control, 0% ZVI) exhibited fluctuating TCE concentrations ranging from 120 mg/kg to 438 mg/kg.
- Mixes 2 through 5 had reductions in TCE concentrations ranging from 62% to 80%.
- Mix 3 (1% ZVI) had a reduction of 31% after 56 days; however, the 28-day sample showed a 75% reduction.

Results are presented in Table 11 of the In-Situ Solidification/Stabilization Treatability Study Results (Arcadis 2019a). The variation in the concentrations within the control mix and other mixes signifies that the soils, although thoroughly homogenised, may have stored mass within the matrix of the finer grained materials (i.e. silts and clays) that were not able to be broken down and exposed to the treatment media. The TCE concentrations in the soil samples collected from Mixes 2 through 5 show a general decreasing trend with Mix 5 (5% ZVI) having a sharper decrease overall.

Although the In-Situ Stabilization treatability study did not present as dramatic reduction of concentrations as expected in the short term (after 56-days), the ZVI is expected to continue to react with the impacts in the source soils, further reducing the concentrations of CVOCs.

3.3.2 In-Situ Solidification

The objective of the In-Situ Solidification treatability test was to reduce the hydraulic conductivity of the soil matrix with a target of 10^{-6} centimeters per second (cm/sec), homogenize soil of different conductivities to eliminate any high conductivity pathways, achieve physical properties (increase unconfined compressive strength) that would be conducive to redevelopment, and immobilize VOCs in a monolith which would result in reduced groundwater concentrations. A total of six mixes were prepared with different ratios of PC, BFS, and water (Table 2 of the ISS Treatability Study Results, Arcadis 2019a). Each of the mixes were subjected to the following three tests to evaluate the solidification of the mixes: Initial pocket penetrometer (Days 1 and 2); Unconfined compressive strength (UCS; Days 7 and 28); and Hydraulic conductivity (Day 28). Based on the results of the UCS test, all mixes met the minimum requirement of 50 pounds per square inch (psi).

- Mixes 1 through 4 were submitted to Geotechnics laboratory for analysis of hydraulic conductivity.
- Mixes 1 through 3 had a hydraulic conductivity value of less than 10^{-7} cm/sec while Mix 4 had a hydraulic conductivity value of less than 10^{-8} cm/sec.

Mix 3 (2.5% PC; 4.5% BFS) and Mix 4 (7% PC) were brought forward for the monolith leaching test, performed by Pace Analytical, and freeze/thaw and wetting/drying performance testing, performed by Kemron Environmental Services, Inc. The monolith leaching test completed for Mix 3 and Mix 4 resulted in a 92% and 93% reduction in TCE concentrations. Neither mix resulted in any lead concentrations above the reporting limit (10 µg/L) during the leaching evaluation. Mix 4 failed the freeze/thaw performance test with greater than 30% mass lost. Therefore, Mix 3 (2.5% PC; 4.5% BFS) was recommended for the full-scale strategy if ISS (Binding) was selected as the final remedy.

3.4 Final Corrective Measure

The final active corrective measure selected for the site includes a combination of the two ISS technologies.

- Step 1: Mix 3 (1% ZVI) for the full-scale remedial strategy in the bench scale treatability study results (Arcadis 2019a).
- Step 2: Mix 2 (5% PC) is recommended for the full-scale remedial strategy involving a combination of sorbing and binding mixtures.

The goal of the proposed final remedy detailed that the material shall be remixed with a binding reagent, such as PC, to make it geotechnically competent. The homogenized mixture would cure into a low permeability monolith, which would further eliminate soil leaching contamination into the groundwater. Based on this goal, Arcadis proposes using a binding agent of 5% PC after mixing the ZVI into the material. In the bench scale treatability study, the 5% PC mixture reached 93.6-psi after seven days, and an average of 124.9-psi after 28 days. The hydraulic conductivity at Day 47 was $7.4x10^{-08}$.

4 Corrective Measures Implementation

The final corrective measures for the Site is ISS with MNA for Groundwater and Soil; Institutional Controls; and a Long-Term Care/Stewardship program. Implementation of ISS is presented in more detail and within the Contract Drawings (**Appendix A**). MNA, Institutional Controls and Long-Term Care/Stewardship are briefly discussed; however, additional details on these corrective measures will be presented under a separate cover.

4.1 Regulatory Compliance

This section describes community involvement and permitting requirements.

4.1.1 Community Involvement

A meeting with City of Kokomo representatives is anticipated to present the planned final corrective measure. The USEPA is expected to attend this public meeting.

Following the USEPA's approval of this CMI Work Plan, a fact sheet will be prepared for review by the USEPA and distribution to the public. Particularly the residential and commercial properties adjacent to the Site will receive this fact sheet. Preparation and distribution of the fact sheet and any additional community involvement efforts deemed necessary will be coordinated with USEPA. This fact sheet will identify the means and methods for communicating remedial updates with the public.

4.1.2 Permitting

Based on the anticipated scope for ISS, a Storm Water Pollution Prevention Plan (SWPPP) will need to be submitted to Howard County Soil and Water Conservation District a minimum of 30 days prior to beginning any construction work at the Site, for approval. After the SWPPP has been approved by the Howard Country Soil and Water Conservation District, a Notice of Intent shall be submitted to Indiana Department of Environmental Management a minimum of 48 hours prior to beginning construction activities.

4.2 Mobilization and Site Preparation

This section describes mobilization and site preparation associated with ISS.

4.2.1 Equipment, Materials and Supplies

Prior to commencement of field activities, a remediation contractor properly licensed to work in the state of Indiana will be procured to perform the work. The remediation contractor will be required to mobilize the appropriate personnel, equipment, materials, and supplies to complete the work.

4.2.2 Utility Investigation

Existing utilities will be verified prior to the start of work. Indiana 811 will be contacted, and private utility surveys, including a private ground-penetrating radar, will be conducted prior to beginning work activities to identify, locate, mark, or verify any utility locations.

4.2.3 Management of Traffic

The Site will be surrounded by a six-foot high chain link fence with privacy screen. Construction traffic will enter and exit the Site via West Spraker Street while personnel will access the Site via West Butler Street. Additional details regarding traffic control are presented on **Drawing G-005 Traffic Control Plan of Appendix A**.

4.2.4 As-Built Survey

A professional land surveyor licensed in Indiana will perform necessary surveying including: an existing conditions survey, progressive topographical surveys associated with excavation, ISS treatment, ISS subgrade (bulking), overburden subgrade and a final as-built.

4.2.5 Soil Erosion and Sediment Controls

An erosion control plan will be prepared, and erosion control measures will be installed in accordance with the Indiana Storm Water Quality Manual dated October 2007. Erosion control measures will be installed prior to initiating work in accordance with **Drawings G-006 and G-007 Erosion and Sediment Control Plan and Details of Appendix A**.

Erosion control measures will be monitored and inspected to confirm that they are functioning properly and positioned adequately to be effective during use. Deficiencies will be corrected as soon as they are noted.

4.3 Air Monitoring

Air monitoring will be required to ensure that the public living and working near the work area is protected from potential exposure. Air monitoring will be conducted to quantify airborne concentrations of total suspended particulates and VOCs at the work area and property boundary. Air monitoring requirements are presented in the Ambient Air Monitoring Plan (AAMP; **Appendix B**). Additionally, a dust and odor control program will be implemented in conjunction with air monitoring to ensure action levels established in the Site-specific Health and Safety Plan (HASP; **Appendix C**) are not exceeded.

4.4 Material Handling and Waste Management

During the work, measures may need to be implemented to ensure the proper management of materials.

4.4.1 Monitoring Well Abandonment

Prior to mobilization, Arcadis will contract with a driller licensed in the State of Indiana to abandon existing groundwater monitoring wells within the limits of remediation as presented on **Drawings G-006 Erosion and Sediment Control Plan of Appendix A** and in accordance with applicable regulations. Any groundwater monitoring wells not scheduled for abandonment in the area of remediation shall be protected. Infrastructure associated abandoned wells will be removed by the remedial contractor during removal of the overburden.

4.4.2 Removal of Overburden

The remediation contractor will use standard construction equipment to excavate the overburden to the top of the ISS treatment zone within the planned remediation area (**Drawing C-101 Excavation Plan – North Area and C-104 Excavation Plan –South Area of Appendix A**). Approximately 8,403 cubic yards (cy) of overburden material will be excavated to a depth of approximately 9 to 11 ft bgs.

The remediation contractor will implement proper sloping, benching and/or sheeting and shoring techniques; therefore, additional overburden material may be excavated and staged based on the remedial contractor's approach. Sheeting and shoring methodologies proposed by the remediation contractor will be designed in accordance with Occupational Safety and Health Administration (OSHA) regulations and certified by a professional engineer licensed in the State of Indiana. The excavation shall be in accordance with OSHA Construction Standard 29 Code of Federal Regulations 1926, Subpart P.

Following excavation, the overburden material will be relocated to a temporary stockpile area onsite for characterization and reuse in accordance with the Excavation and Materials Handling Plan (EMHP; **Appendix D**) and Construction Quality Assurance Plan (CQAP; **Appendix E**). Project equipment that comes in contact with excavated materials shall be appropriately decontaminated.

4.4.2.1 Temporary Stockpile Area

The temporary stockpile area is illustrated on **Drawing G-006 Erosion and Sediment Control Plan of Appendix A**. The temporary stockpile area has been sized to accommodate 8,403 cy of overburden. The temporary stockpile area may be resized by the remedial contractor with the engineer's approval based on approach. Additional details pertaining to the design and management of the temporary stockpile area is provided in the EMHP (**Appendix D**).

4.4.2.2 Construction Debris

Construction debris from former facility operations may be encountered during excavation of the overburden. Construction debris will be segregated and staged separately for characterization and off-site disposal. No construction debris will remain on the Site following completion of the work. Additional details regarding debris management are presented in the EMHP (**Appendix D**).

4.4.2.3 Dewatering, Decontamination, and Water Management

Dewatering is not anticipated for completion of the work. Any water that comes in contact with the open excavation, the ISS treatment zone, stockpiled materials, or used in project equipment decontamination will be containerized. Containerized water will either be reused on-site or disposed of off-site in accordance with the EMHP (**Appendix D**).

4.4.3 In-Situ Solidification and Stabilization

ISS will result in a solid soil monolith that minimizes leaching and migration of constituents of concern. The underlying principle behind ISS at the Site is the direct treatment of TCE-impacted soil with concentrations exceeding 100 mg/kg. To complete this process, a two-step ISS mixing process will be applied.

- **Step 1 – ZVI Mixing:** ZVI will be added under a bentonite slurry mixture to stabilize the TCE impacted soil. As a reagent, ZVI causes a rapid chemical reaction to occur, thereby reducing the chlorinated compounds to non-hazardous byproducts. The treatment will be allowed to react for a minimum of 28 days prior to solidification. In the ZVI mixing process, the existing soil structure and strength will be destroyed. Post treatment, the soil will require solidification.
- **Step 2 – PC Mixing:** PC will then be added after the 28-day (minimum) treatment duration in the dry to make the ISS treatment zone geotechnically competent. The PC will be used as a binding agent and will cure into a lower-permeability monolith, which will further prevent soil leaching contamination into the groundwater.

4.4.3.1 ISS Treatment Zone

The proposed extent and depth of the ISS treatment zone are presented on **Drawing C-102 ISS Plan – North Area (Area A-I)** and **C-104 ISS Plan South Area (Area J) of Appendix A**. Approximately 7,915 cy of TCE-impacted soil with varying impact depths will be treated with ZVI and solidified with PC in the North Area. Approximately 980 cy of TCE-impacted soil will be treated with ZVI and solidified with PC in the South Area. Proposed treatment area depths were developed based on the depth of TCE-impacted soil greater than 100 mg/kg. The proposed ISS mixing zone extends approximately 2 feet below all TCE-impacted soil greater than 100 mg/kg.

4.4.3.2 ISS Mix Design

Arcadis is recommending a target mix design of 1%+ ZVI and 5%+ PC completed in two steps. The mix design is based on the results of the previously conducted bench scale testing (refer to **Section 3.3**). To implement Step 1 – ZVI Mixing, the remediation contractor will utilize either an auger or rotary head on an excavator to distribute the slurry mixture with 1% ZVI by dry weight to the ISS treatment zone.

- If the remediation contractor elects to remove all the overburden at once, the remedial contractor will be able to position the equipment directly on the prepared excavation subgrade to perform the work.
- If the remediation contractor selects a cell or column method, work will be performed from existing grade and an alternating cell or trench approach will be utilized to leave a stable working platform to access the ISS treatment zone.

Following completion of Step 1 – ZVI Mixing, the ISS treatment zone will be allowed to react for a period of 28 days (minimum). Once the ISS treatment zone has been allowed to react, the Contractor will revisit the ISS treatment zone for Step 2 – PC Mixing. For Step 2- PC Mixing, the remediation contractor will implement 5% PC by dry weight to the ISS treatment zone. As the ISS treatment zone following Ste 1 -ZVI Mixing will be unstable, work associated with the mixing of the PC will be performed from existing grade using an excavator bucket or equivalent.

4.4.3.3 ISS Mixing

Due to the specialized nature of the corrective measure, a remedial contractor with prior experience in soil mixing will be selected to complete the work. Arcadis will work closely with the selected remedial contractor to ensure adherence to this plan and the CQAP (**Appendix E**). Specifically, the initial mix column/cell will be used as a shakedown, to confirm that all equipment is functioning and that reasonable depths can be achieved with the equipment. Adjustments in equipment selection and/or assembly are expected following the shakedown.

During ZVI and PC mixing, the Contractor will closely monitor the slurry mixture and PC addition rates based on the ISS treatment volume. The weights and volumes of the slurry mixture will also be metered and values documented during the mixing work to ensure accurate dosing and treatment. Quality control sampling will be conducted following Step 2 – PC Mixing to ensure the soil strength will meet the requirements for potential redevelopment. Samples will be collected in accordance with the CQAP (**Appendix E**).

4.5 Site Restoration

After completion of the Stage 2 – PC Mixing, the subgrade will be regraded to create a stable working platform for placement of the staged overburden. The ISS treatment zone will be regraded using traditional construction

equipment as illustrated on **Drawing C-106 ISS Subgrade Plan – North Area and C-107 ISS Subgrade Plan – South Area of Appendix A,** following Step 2 – PC Mixing. For purposes of the ISS Subgrade design, it is assumed the ISS treatment zone will result in a 50% increase in volume due to bulking, which is approximately 4,202 cy.

4.5.1 Placement of Overburden

Following preparation of the subgrade, an 8-oz geotextile will be placed for separation of the ISS treatment zone from the overburden. The overburden will serve as a cap to protect the ISS treatment zone and establish the final Site grade. Proposed overburden subgrade is presented on **Drawing C-108 Overburden Subgrade Plan of Appendix A**. Prior to placement, overburden will be sampled and confirmed for reuse onsite in accordance with the EMHP (**Appendix D**).

4.5.2 Placement of Topsoil

Proposed final grade is presented on **Drawing C-109 Final Grading Plan of Appendix A**. Final grade assumes placement of a 4-inch topsoil layer and hydroseeding with a native seed mix and mulched in accordance with the CQAP (**Appendix E**). Prior to import, topsoil will be sampled and confirmed for use onsite in accordance with the EMHP (**Appendix D**).

4.5.3 Notice of Termination

Following the placement of vegetation, the Site will be inspected on a monthly basis until vegetation is established to comply with the SWPPP. To close out the SWPPP, compliance requires a minimum of 80% land cover at which time a Notice of Termination may be filed.

4.6 Operation, Monitoring and Maintenance

An operations, monitoring, and maintenance plan (OM&M) will be required to properly maintain the cover system. In general, monitoring will consist of inspections to observe if damage has occurred by proposed land use or maintenance activities, or by settlement or erosion. Maintenance anticipated to be completed includes periodic mowing, reseeding and/or regrading due to settlement or erosion to maintain positive stormwater drainage on site.

Frequency of inspections and submittal of inspection reports will be outlined in an OM&M plan to be drafted during preparation of the Long-Term Stewardship Plan (LTSP).

4.7 Reporting

Construction activities will be documented through the collection of daily field notes, construction reports and photo logs. At the conclusion of work, a Corrective Measures Completion Report (CMCR) will be prepared to document the implementation of ISS. The CMCR will include as-built drawings identifying the locations of treated soil, placement of overburden, and the final extents of the corrective measure.

5 Project Delivery

Deliverables included in this submittal and future submittals are presented below.

5.1 Drawings and Specifications

The drawings and specifications anticipated for the project are listed in the following subsections and attached as **Appendix A**.

5.1.1 Drawings

General

- G-001 General Notes and Legend
- G-002 Technical Specifications (1 of 2)
- G-003 Technical Specifications (2 of 2)
- G-004 Existing Site Plan
- G-005 Traffic Control Plan
- G-006 Erosion and Sediment Control Plan
- G-007 Erosion and Sediment Control Details and Notes

Civil

- C-101 Excavation Plan – North Area
- C-102 ISS Plan – North Area
- C-103 Remediation Cross-Sections – North Area
- C-104 Excavation and ISS Plan – South Area
- C-105 Remediation Cross-Sections – South Area
- C-106 ISS Subgrade Plan – North Area
- C-107 ISS Subgrade Plan – South Area
- C-108 Overburden Subgrade Plan
- C-109 Final Grading Plan
- C-110 Restoration Cross-Sections

5.1.2 Technical Specifications

The Technical Specifications are incorporated into the Contract Drawings and outline construction requirements, products, and activities. Specific information incorporated into the technical specifications include:

General

- Health and Safety
- Submittal and Progress Meetings
- Utilities
- Survey
- Site Access and Traffic Control
- Dust and Odor Control

Earthwork

- Overburden Excavation
- Material Handling and Staging
- In-Situ Solidification and Stabilization
- Site Restoration

5.2 Supporting Plans

This section outlines the contents of applicable supporting plans either attached to this work plan or to be presented under a separate cover.

Appendices – Attached

- **Ambient Air Monitoring Plan (AAMP, Appendix B)** – This plan is designed to protect on-site personnel and area residents from airborne pollutants posed by this corrective measure. The plan includes but is not limited to: levels of protection; safe work practices and safeguards; personal and environmental air monitoring; personal protective equipment; contingency and emergency planning; and logs, reports, and record keeping.
- **Health and Safety Plan (HASP, Appendix C)** – This plan is designed to protect on-site personnel and area residents from physical, chemical and all other hazards posed by the construction of this remedy. The safety plan includes but is not limited to: levels of protection; safe work practices and safeguards; medical surveillance; personal protective equipment; personal hygiene; decontamination (personal and equipment); Site work zones; contaminant control; contingency and emergency planning; and logs, reports, and record keeping.
- **Excavation and Materials Handling Plan (EMHP, Appendix D)** – All on-site material will be handled in accordance with State and Federal regulations. As such, an EMHP has been developed for the Site outlining the methodology for staging of overburden materials and the criteria and methodology for analysis of the

overburden and topsoil for use following onsite following ISS treatment. The EMHP will also include procedures for the decontamination of heavy equipment, trucks, and support vehicles leaving the site.

- **Construction Quality Assurance Plan (CQAP, Appendix E)** – This plan describes the Site-specific aspects of the quality assurance program, which shall ensure that the completed project meets or exceeds all design criteria, plans, and specifications. The CQAP contains, at a minimum, the following elements: responsibilities and authorities of all organizations and key personnel; qualifications of the Quality Assurance Official; protocols for sampling and testing used to monitor ISS construction; identification of proposed quality assurance sampling activities; and reporting requirements for construction quality assurance activities.
- **Groundwater Contingency Plan (GCP, Appendix F)** – A GCP has been prepared for the Site to ensure disturbance to TCE-impacted soil through excavation and ISS does not result in a temporary spike in groundwater concentrations. The GCP outlines plans to monitor groundwater during implementation of the work and contingency measures to be implemented to address the potential risk associated with a temporary increase in VOC concentrations in groundwater. The purpose of the GCP is to assure the short-term efficacy of the remediation by preventing the expansion of the groundwater plume.
- **Quality Assurance Project Plan (QAPP, Appendix G) -** This QAPP discusses sample analysis and data handling for samples collected in all phases of future Site work as set forth in the FD/RC (USEPA 2021b). The prepared QAPP is consistent with the requirements of the USEPA Contract Laboratory Program (CLP) for laboratories proposed outside the CLP.

<u>Plans – Under Separate Cover</u>

- **LTSP** - A **Long Term Stewardship Plan (**LTSP) will be developed for the Site following implementation of ISS. The LTSP will provide monitoring and reporting requirements, which will remain in effect while TCE-impacts remain above unrestricted use levels. The frequency of data collection and reporting will be defined within the LTSP. Furthermore, the LTSP will include the following supplemental documents.
    - **OM&M Plan -** This OM&M plan will cover long-term monitoring and maintenance of the remedy. The plan will be composed of the following elements: description of normal operation, monitoring and maintenance, potential operating problems, and routine monitoring and laboratory testing; discussion of an alternate OM&M; corrective action; HASP; description of equipment; and records and reporting mechanisms required.
    - **Institutional Control Implementation and Assurance Plan (ICIAP) –** The ICIAP discusses implementation, maintenance, monitoring, and reporting of the Institutional Controls set forth in the FD/RC.

6 Path Forward

Following USEPA's review and approval of the CMI Work Plan, implementation of the corrective measure will commence, considering USEPA's comments to this submission.

6.1 Summary of Major Deliverables/Schedule

A summary of the tentative project schedule and reporting requirements for project completion are provided in **Table 1** below. The construction schedule will be contingent upon the availability of materials at the time when procurement is required.

Table 1. Summary of Design Deliverables/Schedule

Item #	Submission	Deadline	Status
1	Award Corrective Measures Contract(s)	Sixty (60) days after receipt of USEPA's approval of the CMI Work Plan	
2	Pre-Construction Inspection and Meeting	Thirty (30) days after Award of Corrective Measures Contract(s)	
3	Initiate Construction of Corrective Measure	Thirty (30) days after Pre-Construction Inspection and Meeting	
4	Completion of Construction	One-hundred twenty (120) days after Award of Corrective Measures Contract	
5	Submit Long Term Stewardship Plan	Prior to conducting the Pre-Final Inspection for completion of the corrective measure	
6	Schedule and Conduct Final Inspection for Completion of the Work	Thirty (30) days after Completion of Construction	
7	Corrective Measures Completion Report	Forty-five (45) days after Final Inspection for Completion of the Work	
8	Land Use and Groundwater ERC	Ninety (90) days after receipt of USEPA's approval of the CMCR	

6.1.1 Final Long-Term Stewardship

As referenced above, the LTSP will provide monitoring and reporting requirements, which will remain in effect while TCE-impacts remain above unrestricted use levels. The frequency of data collection and reporting will be defined within the LTSP. Furthermore, the LTSP will have a contingency plan if natural attenuation no longer appears to be occurring or is no longer consistent as a cleanup approach based on changes to groundwater use.

6.1.2 Corrective Measures Completion Report

As referenced above a CMCR will be submitted to USEPA for review no later than 45 days after final inspection for completion of the work. The CMCR will include the elements identified within the CMI Work Plan, as well as the following:

- As Built Drawings;
- Documentation of field changes and resolutions;
- Documentation of any material (i.e., water. debris) hauled off site, if applicable;
- Documentation of any imported material (i.e., clean stone, topsoil);
- Copies of significant correspondence with USEPA;
- Community involvement activities including resolution of complaints (if any); and,
- Description of ERCs to be implemented.

6.2 Institutional Controls

Following implementation of the corrective measure, the following institutional controls will be established for the Site:

- **Land Use ERC -** A Land Use ERC would limit future land use at the Site, to commercial/industrial.

  Additionally, to mitigate the potential risk associated with vapor intrusion (VI), the Land Use ERC would require newly constructed structures to be screened for VI or have a preemptive mitigation system and/or a vapor barrier installed prior to building occupancy. Furthermore, the Land Use ERC would require a HASP and a soil management plan be prepared prior to subsurface excavations on site to control potential exposures and risks for workers (routine worker, construction worker, and redevelopment worker) contacting volatile constituents in the ambient air of a trench or excavation onsite.

- **Groundwater ERC -** A Groundwater ERC would be executed prohibiting the extraction of groundwater at the Site for any purpose, including, but not limited to: human or animal consumption, gardening, industrial processes, or agriculture, except that groundwater may be extracted in conjunction with environmental investigation and/or remediation activities. The groundwater ERC will also prohibit any activity at the Site that may interfere with the groundwater monitoring or well network.

- **Well Restriction Overlay District (WR-OL) –** A WR-OL District will be established and enforced by the City of Kokomo to protect the community from groundwater contaminated with chemicals. A WR-OL District is a unique and conservative tool described in Article 4.10 and 4.11 of the City of Kokomo Zoning Ordinance, No. 6279 (July 27, 2010) for restricting groundwater use regionally. The WR-OL District restricts the drilling of water wells that may bring contaminated groundwater to the surface. The establishment of the WR-OL District was previously discussed with the Director of the Kokomo Plan Commissions in 2010 and has received general acceptance of the proposal; however, the plan will need to be presented to the Plan Commission and receive approval before being established.

Initially, the institutional and engineered controls will be confirmed annually and five-year remedy reviews will be used as the appropriate means to update the conceptual site model, as needed. The efficacy of MNA will be monitored and assessed as part of these five-year reviews.

If at any time, natural attenuation no longer appears to be occurring, is no longer taking place at a rate consistent with the cleanup timeline or is no longer consistent as a cleanup approach based on changes to groundwater use, the LTSP will include a contingency plan to address the situation.

7 References

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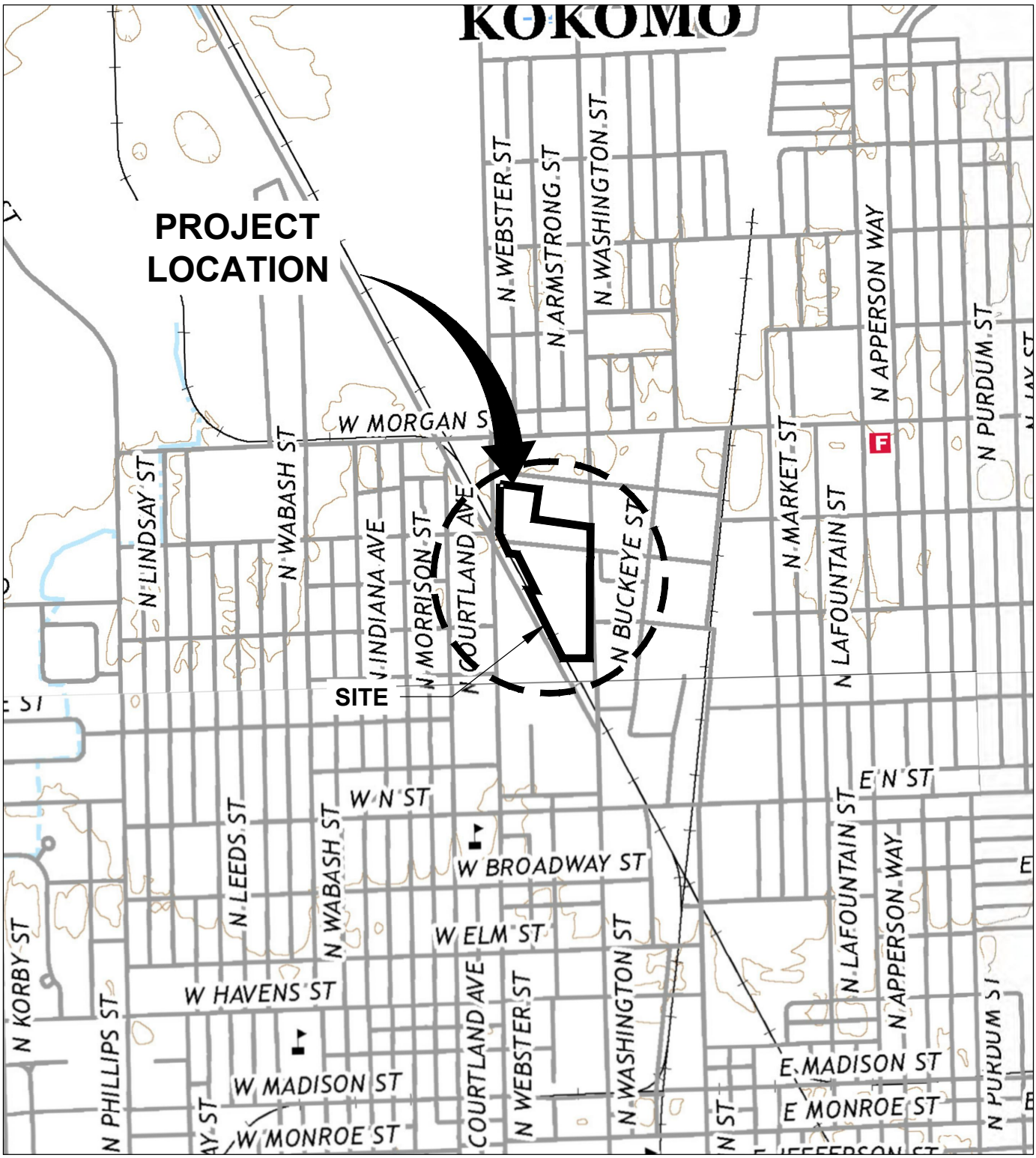
Figures



REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD GALVESTON, IND. 2016, MIAMI, IND. 2016, KOKOMO EAST, IND. 2016, AND KOKOMO WEST, IND. 2016.

0 1000' 2000'

Approximate Scale: 1 in. = 1000 ft.

RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA
CORRECTIVE MEASURES IMPLEMENTATION WORK PLAN

SITE LOCATION

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1

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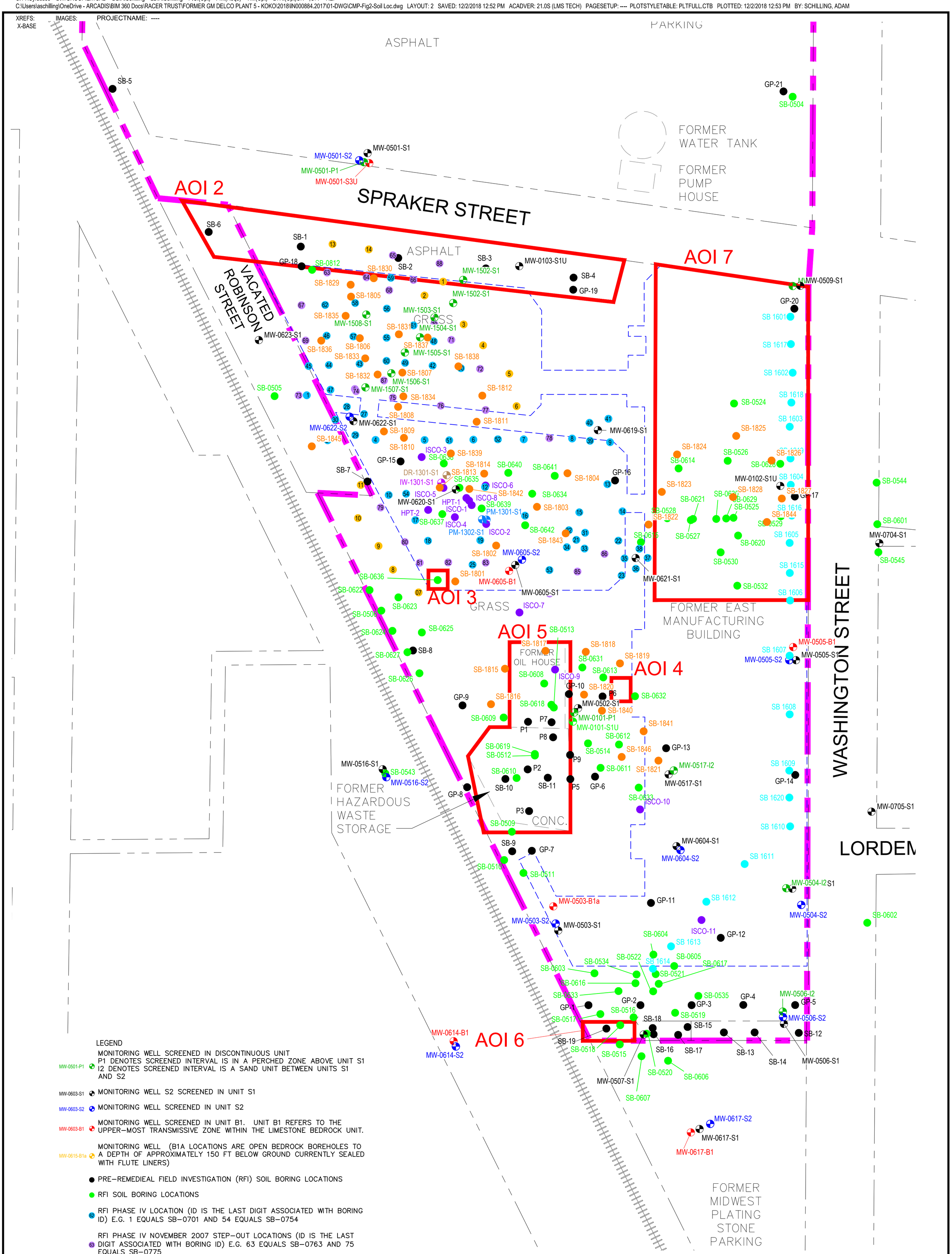
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BUTLER STREET
SPRAKER STREET
LORDEMAN STREET
KIRK STREET
PREBLE STREET
TATE STREET
MAIN STREET
WASHINGTON STREET
BUCKEYE STREET
ABANDONED NORFOLK SOUTHERN RAILROAD
GRASS
RESTAURANT
RESTAURANT PARKING
ASPHALT
FORMER WATER TANK
FORMER PUMP HOUSE
FORMER EAST MANUFACTURING BUILDING
FORMER OIL HOUSE
FORMER HAZARDOUS WASTE STORAGE
CONC.
FORMER MIDWEST PLATING STONE PARKING
AOI 1
AOI 2
AOI 3
AOI 4
AOI 5
AOI 6
AOI 7
MW-0501-S1 (813.61)
MW-0103-S1U (813.54)
MW-1501-S1 (815.22)*
MW-1502-S1 (813.55)
MW-1503-S1 (813.53)
MW-1504-S1 (813.60)
MW-1505-S1 (813.57)
MW-1506-S1 (813.58)
MW-1507-S1 (813.57)
MW-1508-S1 (813.61)
MW-0623-S1 (813.63)
MW-0622-S1 (813.63)
MW-0619-S1 (812.83)*
DR-1301-S1 (813.58)
MW-1301-S1 (813.62)
PM-1301-S1 (813.52)
MW-0620-S1 (814.55)*
MW-0621-S1 (813.43)
MW-0605-S1 (813.51)
MW-0102-S1U (813.22)
MW-0509-S1 (813.43)
MW-0618-S1 (813.15)
MW-0613-S1 (812.93)
MW-0704-S1 (813.27)
MW-0606-S1 (813.09)
MW-0505-S1 (813.27)
MW-0705-S1 (813.06)
MW-0612-S1 (812.66)
MW-0607-S1 (812.20)
MW-0502-S1 (813.41)
MW-0101-S1U (813.30)
(813.53) MW-0516-S1
MW-0517-S1 (813.32)
MW-0604-S1 (813.26)
MW-0504-S1 (813.08)
MW-0503-S1 (813.42)
MW-0506-S1 (812.99)
MW-0507-S1 (813.12)
MW-0608-S1 (812.46)
MW-0617-S1 (813.13)
MW-0609-S1 (811.89)
MW-0603-S1 (813.12)
MW-0602-S1 (812.50)
MW-0610-S1 (811.48)
MW-0616-S1 (813.03)
MW-0611-S1-R (810.79)
813.5
813.0
812.5
812.0
811.5
811.0

N

LEGEND
MW-0603-S1 MONITORING WELL SCREENED IN S1 UNIT
AREA OF INTEREST (AOI)
PROPERTY BOUNDARY
(813.61) GROUNDWATER ELEVATION (FEET ABOVE MEAN SEA LEVEL)
(815.22)* GROUNDWATER ELEVATION NOT USED TO GENERATE CONTOURS
812.0 GROUNDWATER CONTOUR

0 100' 200'
GRAPHIC SCALE

RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA
CORRECTIVE MEASURES IMPLEMENTATION WORK PLAN

POTENTIOMETRIC SURFACE - S1 UNIT (MARCH 5, 2021)

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3

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RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA
CORRECTIVE MEASURES IMPLEMENTATION WORK PLAN

TCE GROUNDWATER CONCENTRATION CONTOURS - S1 UNIT (MARCH 29, 2021)

ARCADIS Design & Consultancy for natural and built assets

FIGURE 4

Appendix A

Contract Drawings

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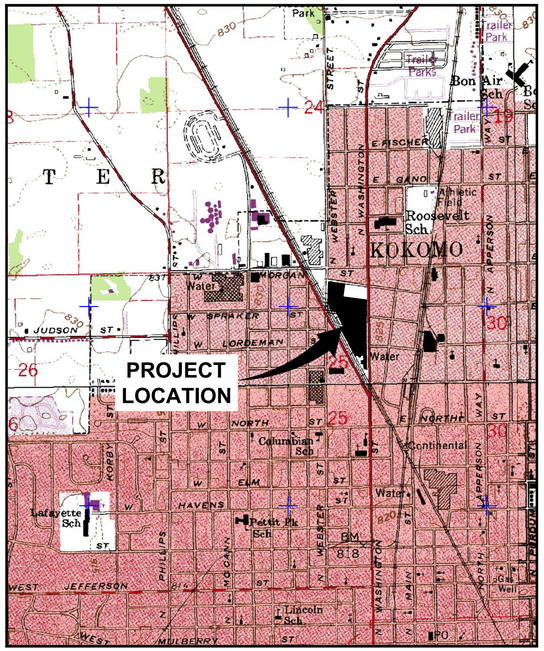
CONTRACT DRAWINGS

PROPOSED REMEDIAL ACTION

FORMER GM DELCO PLANT 5
1723 NORTH WASHINGTON STREET
KOKOMO INDIANA



DATE ISSUED
OCTOBER 2021

RACER TRUST
KOKOMO, INDIANA

DRAFT - NOT FOR CONSTRUCTION

ARCADIS

ARCADIS U.S., INC.

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G-003	TECHNICAL SPECIFICATIONS (2 OF 2)
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G-005	TRAFFIC CONTROL PLAN
G-006	EROSION AND SEDIMENT CONTROL PLAN
G-007	EROSION AND SEDIMENT CONTROL DETAILS AND NOTES

CIVIL

C-101	EXCAVATION PLAN - NORTH AREA
C-102	ISS PLAN - NORTH AREA
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LEGEND:

- PROPERTY BOUNDARY
- ADJOINING PARCEL BOUNDARY
- EXISTING CONTOUR
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- PROPOSED COMPOST SOCK
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- CONTROL POINT – INTERIOR
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- PROPOSED CONTOUR
- PROPOSED GRADE BREAK
- PROPOSED SPOT ELEVATION
- EXCAVATION (CROSS SECTION)
- ISS (CROSS SECTION)
- OVERBURDEN (CROSS SECTION)
- TOPSOIL (CROSS SECTION)
- APPROXIMATE GROUNDWATER ELEVATION
- CONSTRUCTION VEHICLE ROUTE
- PERSONNEL VEHICLE ROUTE
- EXISTING MONITORING WELL
- EXISTING MONITORING WELL TO BE PROTECTED
- EXISTING MONITORING WELL TO BE REMOVED
- EXISTING RAILROAD TRACK
- RAILROAD TRACK – THEORETICAL EMBANKMENT LIMIT

GENERAL NOTES

1. SCALES ARE AS INDICATED ON EACH DRAWING.
2. CONTOUR INTERVAL IS 1 FOOT, UNLESS OTHERWISE INDICATED.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ESTABLISHING SURVEY CONTROL TO VERIFY EXISTING SITE GRADES AND CONDITIONS.
4. ALL EXISTING DIMENSIONS, CONTOUR LINES AND FIELD CONDITIONS SHALL BE VERIFIED BY THE CONTRACTOR AND A LICENSED INDIANA SURVEYOR PRIOR TO START OF ANY CONSTRUCTION. DIFFERENCES NOTED BY THE CONTRACTOR BETWEEN BASE MAP INFORMATION AND ACTUAL SITE CONDITIONS SHALL BE SUBMITTED TO THE FIELD ENGINEER PRIOR TO START OF WORK.
5. CONTRACTOR SHALL NOTIFY INDIANA ONE–CALL (811) AT LEAST FIVE (5) BUSINESS DAYS PRIOR TO COMMENCEMENT OF WORK TO VERIFY UTILITY LOCATIONS AND PERFORM A MARKOUT SURVEY. CONTRACTOR SHALL RE–NOTIFY INDIANA ONE–CALL AND RE–ESTABLISH ACTIVE UTILITY TICKET AS REQUIRED.
6. CONTRACTOR SHALL BE RESPONSIBLE FOR IDENTIFYING AND VERIFYING THE LOCATION OF ALL SITE UTILITIES INDEPENDENTLY WITHIN THE LIMITS OF DISTURBANCE PERFORMED UNDER THE SCOPE OF WORK. EACH CONTRACTOR OR SUBCONTRACTOR IS TOTALLY RESPONSIBLE FOR DETERMINING THE LOCATION OF SUCH UTILITIES, BOTH ON AND ADJACENT TO THE SITE.
7. THE CONTRACTOR SHALL PREPARE, IMPLEMENT, AND BE RESPONSIBLE FOR ALL REQUIREMENTS OF THE HEALTH AND SAFETY PROGRAM THROUGHOUT CONSTRUCTION. CONTRACTOR SHALL COMPLY WITH ALL OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) REQUIREMENTS. THE CONTRACTOR SHALL MAINTAIN AND IMPLEMENT THE SITE HEALTH AND SAFETY PLAN (HASP) IN CONFORMANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL LAWS, RULES, AND REGULATIONS. THE CONTRACTOR SHALL ENSURE THAT THEIR EMPLOYEES AND SUBCONTRACTORS ARE OSHA TRAINED ACCORDING TO CFR 1910:120 AND HAVE THE CAPABILITIES OF IMPLEMENTING THE HASP. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THE HEALTH AND SAFETY OF THE CONTRACTOR'S EMPLOYEES AND SUBCONTRACTORS.
8. THE CONTRACTOR SHALL OBTAIN NECESSARY LOCAL PERMITS THAT MAY BE REQUIRED IN CONJUNCTION WITH VEHICLE USE ON PUBLIC ROADS.
9. THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF CORRECTIVE MEASURE WITHIN THE LIMITS OF DISTURBANCE.

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SCALE(S) AS INDICATED

THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING: _____ USE TO VERIFY FIGURE REPRODUCTION SCALE

No.	Date	Revisions	By	Ckd

THIS DRAWING IS THE PROPERTY OF THE ARCADIS ENTITY IDENTIFIED IN THE TITLE BLOCK AND MAY NOT BE REUSED OR ALTERED IN WHOLE OR IN PART WITHOUT THE EXPRESS WRITTEN PERMISSION OF SAME.

Professional Engineer's Name: -		
Professional Engineer's No.		
State: IN	Date Signed:	Project Mgr.: .
Designed by: .	Drawn by: GS	Checked by: .

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

GENERAL NOTES AND LEGEND

ARCADIS Project No.: 30075940
Date: OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

G-001

1.0 INTRODUCTION

THE ENCLOSED DRAWINGS AND SPECIFICATIONS CONTAIN INFORMATION FOR THE CORRECTIVE MEASURE ASSOCIATED WITH THE FORMER GENERAL MOTORS DELCO PLANT 5 IN KOKOMO, INDIANA.

CLIENT: REVITALIZING AUTO COMMUNITIES ENVIRONMENTAL RESPONSE (RACER) TRUST

ENGINEER: ARCADIS US INC. (ARCADIS)

CONTRACTOR: TO BE DETERMINED

2.0 HEALTH AND SAFETY

2.1 THE CONTRACTOR WILL BE SOLELY RESPONSIBLE FOR ALL SAFETY PROGRAMS FOR THEIR EMPLOYEES, SUBCONTRACTORS, AND ANY OTHER PERSONS WHO MAY BE AFFECTED THEREBY. THE CONTRACTOR WILL PREPARE A SITE–SPECIFIC HEALTH AND SAFETY PLAN (HASP) THAT WILL BE REVIEWED BY THE ENGINEER PRIOR TO THE START OF ANY WORK.

2.2 HASP SHALL INCLUDE THE FOLLOWING:

a. LIST OF EMERGENCY CONTACT INFORMATION.

b. CONTRACTOR'S ORGANIZATIONAL STRUCTURE. ORGANIZATIONAL STRUCTURE TO BE UPDATED, AS NECESSARY, TO REFLECT CURRENT STATUS OF SITE OPERATIONS AND PERSONNEL.

c. HAZARD ANALYSIS FOR EACH TASK AND OPERATION FOUND IN THE CONTRACTOR'S WORK PLAN.

d. SDS FOR ALL CONTRACTOR CONTROLLED MATERIALS KEPT ON SITE.

e. EMPLOYEE TRAINING ASSIGNMENTS INCLUDING COPIES OF OSHA 40–HOUR, 30–HOUR SUPERVISED FIELD ACTIVITIES, 8–HOUR SUPERVISORS, AND 8–HOUR REFRESHER TRAINING CERTIFICATES FOR EACH CONTRACTOR AND SUBCONTRACTOR EMPLOYEE ASSIGNED TO THE PROJECT.

f. PPE TO BE USED BY EMPLOYEES FOR EACH TASK AND OPERATION BEING CONDUCTED.

g. MEDICAL SURVEILLANCE REQUIREMENTS: MEDICAL CLEARANCE CERTIFICATES FOR ALL CONTRACTOR AND SUBCONTRACTOR EMPLOYEES ASSIGNED TO THE PROJECT.

h. FREQUENCY AND TYPES OF AIR AND PERSONNEL MONITORING, INCLUDING METHODS OF MAINTENANCE AND CALIBRATION OF MONITORING EQUIPMENT.

i. SITE CONTROL MEASURES TO PREVENT UNQUALIFIED OR UNPROTECTED WORKERS FROM ENTERING RESTRICTED AREAS.

j. EMERGENCY RESPONSE PLAN FOR COMMUNICATING ROUTES OF ESCAPE AND GATHERING POINTS DURING AN EMERGENCY SITUATION (SEE BELOW).

k. DECONTAMINATION PROCEDURES.

l. SPILL CONTAINMENT PROGRAM.

2.3 ACCIDENT REPORTING AND INVESTIGATION SHALL COMPLY WITH 29 CFR 1904.29, INCLUDING USING OSHA 300, 300–A, AND 301 FORMS (OR EQUIVALENT) TO DOCUMENT ALL ACCIDENTS THAT RESULT IN BODILY INJURY. COPIES OF COMPLETED ACCIDENT REPORTS SHALL BE SUBMITTED TO THE CLIENT AND ENGINEER WITHIN 24 HOURS. BASED UPON RESULTS OF ACCIDENT INVESTIGATION, MODIFY THE HASP AS REQUIRED BY CHANGING TASKS OR PROCEDURES TO PREVENT REOCCURRENCE OF ACCIDENT.

3.0 SUBMITTALS & PROGRESS MEETINGS

3.1 THE CONTRACTOR SHALL CONFIRM A CONSTRUCTION SCHEDULE WITH THE ENGINEER AT LEAST TWO WEEKS (10 BUSINESS DAYS) PRIOR TO ANY WORK AT THE SITE. CONSTRUCTION SCHEDULE SHALL INCLUDE THE ESTIMATED START DATE, DURATION AND COMPLETION TIMES FOR EACH ACTIVITY. ANY DEVIATION FROM THE ORIGINALLY PROPOSED SCHEDULE MUST BE COMMUNICATED TO THE ENGINEER WITHIN 24–HOURS.

3.2 THE CONTRACTOR SHALL MAKE PROPER AND TIMELY NOTIFICATION OF ALL WORK AND INSPECTIONS TO REGULATORY OR GOVERNING AGENCIES AS REQUIRED BY PERMITS.

3.3 PROVIDE SUBMITTALS IN ACCORDANCE WITH THESE NOTES AT LEAST 10 DAYS PRIOR TO PERFORMING THE WORK ASSOCIATED WITH THE SUBMITTAL. SUBMITTALS ANTICIPATED AS PART OF THIS PROJECT INCLUDE, BUT ARE NOT LIMITED TO:

a. SCHEDULE OF VALUES

b. PROJECT SCHEDULE

c. CONTRACTOR'S EXECUTION PLAN

d. HASP

e. SUBMITTAL REGISTER

f. LIST OF SUBCONTRACTORS AND LICENSES

g. INSURANCE CERTIFICATES

h. INDIANA ONE CALL (811) DIGSAFE TICKET

i. PERSONNEL CERTIFICATIONS– HAZWOPER, ETC

j. EROSION CONTROL MATERIALS AND DEVICES

k. TEMPORARY CONTROLS – MATERIAL SPECIFICATIONS

l. ZERO VALENT IRON (ZVI) SUPPLIER INFORMATION AND SPECIFICATIONS

m. BENTONITE AND PORTLAND CEMENT (PC) SUPPLIER INFORMATION AND SPECIFICATIONS

n. AGGREGATE MATERIAL SUPPLIER INFORMATION, ANALYTICAL & GEOTECHNICAL RESULTS

o. TOPSOIL MATERIAL SUPPLIER INFORMATION, ANALYTICAL & GEOTECHNICAL RESULTS

p. SEEDING AND MULCH SUPPLIER INFORMATION

q. DAILY FIELD CONSTRUCTION REPORTS, IN–SITU SOLIDIFICATION AND STABILIZATION (ISS) TRACKING LOGS, WEEKLY REPORTS & UPDATED PROJECT SCHEDULES

r. AS–BUILTS – PRE–CONSTRUCTION, EXCAVATION / ISS LIMITS, AND RESTORED CONDITIONS

s. TREATMENT & DISPOSAL FACILITIES & TRANSPORTERS, IDENTIFICATIONS, PERMITS, ETC

t. WEIGHT TICKETS, MANIFESTS & SHIPPING DOCUMENTATION

u. QUALITY ASSURANCE AND QUALITY CONTROL PROGRAM AND SAMPLING

3.4 BEFORE SUBMITTING EACH SUBMITTAL, THE CONTRACTOR WILL HAVE:

a. REVIEWED AND COORDINATED EACH SUBMITTAL WITH OTHER SUBMITTALS AND WITH THE REQUIREMENTS OF THE PROJECT.

b. DETERMINED AND VERIFIED ALL FIELD MEASUREMENTS, QUANTITIES, DIMENSIONS, INSTALLATION REQUIREMENTS, MATERIALS AND SIMILAR INFORMATION WITH RESPECT THERETO.

c. DETERMINED AND VERIFIED ALL INFORMATION RELATIVE TO THE CONTRACTOR'S RESPONSIBILITIES FOR MEANS, METHODS, TECHNIQUES, SEQUENCES, AND PROCEDURES OF CONSTRUCTION, AND SAFETY PRECAUTIONS AND PROGRAMS INCIDENT THERETO.

3.5 EACH SUBMITTAL WILL BEAR A STAMP OR SPECIFIC WRITTEN CERTIFICATION THAT THE CONTRACTOR HAS SATISFIED THE CONTRACTOR'S OBLIGATIONS WITH RESPECT TO THE CONTRACTOR'S REVIEW AND APPROVAL OF THAT SUBMITTAL.

3.6 EACH SUBMITTAL WILL GIVE THE ENGINEER SPECIFIC WRITTEN NOTICE OF ANY VARIATIONS THAT THE SUBMITTAL MAY HAVE FROM THE REQUIREMENTS OF THE PROJECT. THIS NOTICE WILL BE BOTH A WRITTEN COMMUNICATION SEPARATE FROM THE SUBMITTAL AND BY A SPECIFIC NOTATION MADE ON EACH SUBMITTAL PROVIDED TO THE ENGINEER FOR REVIEW OF EACH SUCH VARIATION.

3.7 PROVIDE A SEPARATE LETTER OF TRANSMITTAL WITH EACH SUBMITTAL, THAT INCLUDES THE FOLLOWING INFORMATION:

a. CONTRACTOR'S NAME.

b. PROJECT NAME.

c. CONTRACT NAME AND NUMBER.

d. SUBMITTAL NUMBER.

e. REFERENCE TO NOTE REQUIRING SUBMITTAL.

f. CONTRACTOR'S STAMP OR SPECIFIC WRITTEN CERTIFICATION.

3.8 ENGINEER WILL PROVIDE TIMELY REVIEW OF SUBMITTALS. THE ENGINEER REVIEW WILL DETERMINE IF THE ITEMS COVERED BY THE SUBMITTALS WILL, AFTER INSTALLATION OR INCORPORATION IN THE WORK, CONFORM TO THE INFORMATION GIVEN AND ARE COMPATIBLE WITH THE DESIGN.

3.9 ENGINEER'S REVIEW WILL NOT EXTEND TO MEANS, METHODS, TECHNIQUES, SEQUENCES, OR PROCEDURES OF CONSTRUCTION OR TO SAFETY PRECAUTIONS OR PROGRAMS INCIDENT THERETO. THE REVIEW OF A SEPARATE ITEM AS SUCH WILL NOT INDICATE APPROVAL OF THE ASSEMBLY IN WHICH THE ITEM FUNCTIONS.

3.10 ENGINEER'S REVIEW WILL NOT RELIEVE THE CONTRACTOR FROM RESPONSIBILITY FOR ANY VARIATION FROM THE REQUIREMENTS OF THE PROJECT DOCUMENTS UNLESS THE CONTRACTOR HAS COMPLIED WITH THE REQUIREMENTS OF SUBMITTAL AND THE ENGINEER HAS GIVEN WRITTEN AGREEMENT OF EACH SUCH VARIATION BY SPECIFIC WRITTEN NOTATION THEREOF INCORPORATED IN OR ACCOMPANYING THE SUBMITTAL.

4.0 UTILITIES

4.1 NOTIFY DIG SAFELY INDIANA (811) AT LEAST 5 DAYS IN ADVANCE OF ANY LAND DISTURBANCE ACTIVITY.

4.2 INFRASTRUCTURE SHOWN ARE COMPILED FROM PLANS OF RECORD AND MUST BE VERIFIED BY THE CONTRACTOR IN THE FIELD PRIOR TO COMMENCING CONSTRUCTION. ADDITIONAL INFRASTRUCTURE INCLUDING UTILITIES MAY BE PRESENT THAT ARE NOT SHOWN. CONTRACTOR SHALL NOTIFY ENGINEER IF UNKNOWN UTILITY IS ENCOUNTERED/IDENTIFIED.

4.3 THE CONTRACTOR IS RESPONSIBLE FOR SUBCONTRACTING/COORDINATING WITH AN APPROPRIATE PRIVATE UTILITY LOCATOR TO LOCATE AND IDENTIFY UNDERGROUND UTILITIES WITHIN PROPERTY LIMITS.

5.0 SURVEY

5.1 BASE MAP CREATED FROM AVAILABLE GIS DATA AND SITE FIGURES. ADDITIONAL DATA DIGITIZED FROM AERIAL IMAGERY. SURFACE TOPOGRAPHY WAS GENERATED FROM SURVEYED GROUND ELEVATIONS AT MONITORING WELLS AND SOIL BORINGS. ALL LOCATIONS APPROXIMATE.

5.2 APPARENT HORIZONTAL DATUM IS NAD83 INDIANA STATE PLANE, EAST ZONE, US FEET.

5.3 VERTICAL DATUM IS UNKNOWN.

5.4 ESTABLISH AND MAINTAIN SURVEY CONTROL DURING THE PERFORMANCE OF WORK.

5.5 DOCUMENT PRE–CONSTRUCTION, EXCAVATION / ISS LIMITS, AND RESTORED CONDITIONS VIA A CERTIFIED PROFESSIONAL LAND SURVEYOR LICENSED IN THE STATE OF INDIANA. CONTRACTOR WILL PROVIDE AN ELECTRONIC COPY OF THE SURVEY (AUTOCAD 2020 OR EARLIER) IN ADDITION TO RECORD DRAWINGS STAMPED BY PROFESSIONAL LAND SURVEYOR LICENSED IN THE STATE OF INDIANA AT PROJECT COMPLETION.

5.6 SURVEY WILL BE ON A MINIMUM 10' X 10' GRID AND INCLUDE ALL ESTABLISHED CONTROL POINTS. CONSISTENT POSITIONS FOR PRE–CONSTRUCTION, EXCAVATION, STAGE 1 – ZVI MIXING LIMITS, STAGE 2 – PORTLAND CEMENT MIXING LIMITS, AND RESTORED CONDITIONS SHALL BE COLLECTED. ADDITIONAL SURVEY WILL ALSO BE PERFORMED AT ABRUPT CHANGES IN GRADE.

5.7 SURVEY CONTROL SHALL BE ESTABLISHED WHICH SHALL BE UTILIZED FOR CELL LOCATION AND DESIGNATION IN THE FIELD. USE THE SAME COORDINATE SYSTEM AND VERTICAL AND HORIZONTAL CONTROLS AS USED BY THE ENGINEER IN DEVELOPING THE CONTRACT DRAWINGS.

a. SURVEY THE DIMENSIONS AND LOCATION OF EACH MIX CELL/COLUMN, USING GPS OR TRANSIT SURVEY FROM ESTABLISHED HORIZONTAL CONTROL POINTS. SURVEY SHALL BE PERFORMED DURING EACH DAY OF SOLIDIFICATION TO ENSURE ACCURATE LOCATION OF MIX CELL/COLUMN, TO DOCUMENT THAT ADEQUATE OVERLAP IS OBTAINED, AND TO PROVIDE FOR WEEKLY ISS REPORTING. ALTERNATIVELY, GPS–ENABLED EQUIPMENT, CALIBRATED TO THE SITE COORDINATE SYSTEM, MAY BE USED TO LOCATE AND TRACK ISS CELL/COLUMN LOCATIONS. DEMONSTRATE CALIBRATION THROUGH LOCATION OF SITE SURVEY CONTROL POINTS ESTABLISHED BY THE ENGINEER AND PROVIDED IN THESE CONTRACT DRAWINGS.

b. FOR EACH MIX CELL/COLUMN, SURVEY STARTING ELEVATION OF ISS (I.E., BEFORE MIXING) AND MEASURE THE TOTAL DEPTH MIXED TO VERIFY THAT THE BOTTOM OF ISS ELEVATION HAS BEEN ACHIEVED.

5.8 THE ACCURACY OF ALL SURVEY LAYOUT DATA SHALL BE PLUS OR MINUS ONE TENTH (0.1) FOOT HORIZONTAL.

5.9 THE ACCURACY OF ALL SURVEY LAYOUT DATA SHALL BE AT OR MINUS 0.1 FOOT VERTICAL.

5.10 TOPOGRAPHY SHALL BE PREPARED WITH 1 FOOT CONTOURS.

6.0 SITE ACCESS & TRAFFIC CONTROL

6.1 THE CONTRACTOR SHALL SECURE THE LIMIT OF DISTURBANCE WITH 6 FT HIGH CHAIN LINK FENCE WITH PRIVACY SCREEN TO PREVENT INTRUSION BY UNAUTHORIZED VEHICLES OR PEDESTRIANS. THE WORK ZONE SHALL BE A HEALTH AND SAFETY RISK TO THE PUBLIC AND SHOULD THEREFORE BE LOCKED AND GUARDED FROM ENTRY BY THE PUBLIC 24 HOURS A DAY, 7 DAYS A WEEK.

6.2 THE CONTRACTOR IS RESPONSIBLE FOR PROVIDING SAFE AND ADEQUATE VEHICLE/EQUIPMENT INGRESS AND EGRESS TO THE SITE TO FACILITATE THE CORRECTIVE MEASURE.

7.0 EROSION AND SEDIMENTATION CONTROL

7.1 THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE INSTALLATION AND MAINTENANCE OF ALL NECESSARY TEMPORARY EROSION AND SEDIMENT CONTROLS THROUGHOUT CONSTRUCTION IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS AND THE SOIL EROSION AND SEDIMENT CONTROL PLAN.

7.2 THE CONTRACTOR IS RESPONSIBLE FOR ANY SEDIMENTATION AND EROSION CONTROL MEASURES REQUIRED BY REGULATORY AUTHORITY REGARDLESS OF WHETHER OR NOT THEY ARE EXPLICITLY STATED HEREIN.

7.3 INSPECT AND REPAIR EROSION CONTROL MEASURES AT LEAST WEEKLY, PRIOR TO EACH ANTICIPATED RAINFALL, AND FOLLOWING RAINFALL EVENTS OF 0.5 INCHES OR MORE. ANY DAMAGE INCURRED BY EROSION WILL BE RECTIFIED IMMEDIATELY.

7.4 NO CONSTRUCTION TRASH OR DEBRIS, ETC. SHALL BE DEPOSITED IN ANY DRAINAGE COURSE NOR HAVE THE ABILITY TO LEAVE THE SITE DUE TO RAINFALL AND/OR RUNOFF.

7.5 MAINTENANCE OF EROSION AND SEDIMENTATION CONTROL MEASURES MUST CONTINUE UNTIL THE SITE IS PERMANENTLY STABILIZED AND THE CONTROLS ARE REMOVED.

8.0 DUST AND ODOR CONTROL

8.1 CONTROL DUST AND VAPORS GENERATED DURING THE PROJECT, AS NECESSARY. ODORS WILL BE CONTROLLED TO THE SATISFACTION OF THE ENGINEER. THE CONTRACTOR IS RESPONSIBLE FOR IMPLEMENTING DUST AND VAPOR CONTROLS TO ADDRESS TOTAL SUSPENDED PARTICULATES (TSP) AND VOLATILE ORGANIC COMPOUNDS (VOCS), RESPECTIVELY. THE CONTRACTOR WILL BE RESPONSIBLE FOR COSTS ASSOCIATED WITH PROJECT DELAYS ASSOCIATED WITH UNCONTROLLED DUST AND VAPOR EMISSIONS.

8.2 THE ENGINEER SHALL MONITOR THE PERIMETER SITE AIR QUALITY. THE ENGINEER WILL NOTIFY THE CONTRACTOR WHEN THERE ARE EXCURSIONS OF TSP AND/OR VOCS ABOVE THE ACTION LEVELS.

8.3 WORK WILL BE SUSPENDED IF VISUAL DUST IS OBSERVED OR IF THE TSP OR VOCS AT THE PERIMETER OF THE SITE ARE EXCEEDED. THESE WORK STOPPAGES ARE THE RESPONSIBILITY OF THE CONTRACTOR AND WILL NOT BE A BASIS FOR AN EXTENSION OF TIME OR ADDITIONAL MONEY FOR DOWN TIME AND IS NOT CONSIDERED TO BE STAND–BY TIME.

8.4 DUST AND ODOR CONTROL MEASURES WILL COMPLY WITH THE FOLLOWING MANAGEMENT PRACTICES:

a. WATERING ACTIVE CONSTRUCTION AREAS, IF NEEDED.

b. COVERING TRUCKS THAT WILL HAUL SOIL AND OTHER LOOSE MATERIALS.

c. CLEANING TRUCKS AND TIRES TO MINIMIZE THE TRACKING OF DRY MATERIALS ONTO LOCAL ROADS.

d. MAINTAINING THE BATCH PLANT AND TEMPORARY STOCKPILE AREA TO ELIMINATE ANY DUST FROM THESE SOURCES.

e. OPERATING A PORTABLE FOAM–GENERATING SYSTEM WITH AIR COMPRESSOR, PUMPS, HOSES AND NOZZLES, SOLUTION TANK. AND SOLUTION (ATMOS SHIELD 645 FOAM OR EQUIVALENT).

8.5 CONTRACTOR SHALL PERFORM AIR MONITORING WITHIN THE WORK ZONES IN ACCORDANCE WITH OSHA GUIDELINES TO ENSURE WORKER SAFETY.

9.0 OVERBURDEN EXCAVATION

9.1 INSTALL TEMPORARY CONCRETE BARRIERS (JERSEY BARRIERS) AND/OR TEMPORARY FENCING AROUND THE PERIMETER OF THE WORK ZONE TO PREVENT ACCESS TO ACTIVE EXCAVATION/ISS TREATMENT AREAS.

9.2 FURNISH ALL LABOR, MATERIALS, TOOLS, EQUIPMENT, ACCESSORIES, AND APPURTENANCES NECESSARY TO PREPARE THE ISS TREATMENT AREA VIA REMOVAL OF OVERBURDEN SOIL.

9.3 SEGREGATE CONSTRUCTION DEBRIS AND ABANDONED MONITORING WELLS UNCOVERED IN THE OVERBURDEN FOR CHARACTERIZATION AND OFFSITE DISPOSAL.

9.4 STAGE THE OVERBURDEN MATERIAL IN A TEMPORARY STOCKPILE AREA TO BE CHARACTERIZED BY OTHERS FOR REUSE ONSITE.

9.5 CAPTURE ALL WATER THAT ACCUMULATES ON–SITE, INCLUDING BUT NOT LIMITED TO: SURFACE WATER AND/OR STORMWATER FROM OPEN EXCAVATIONS; DEWATERING IF NECESSARY; AND DECONTAMINATION OF CONSTRUCTION VEHICLES AND EQUIPMENT. WATER SHALL BE STORED ONSITE IN APPROVED CONTAINERS WITH SECONDARY CONTAINMENT FOR ONSITE REUSE OR OFFSITE DISPOSAL.

9.6 CONTRACTOR IS RESPONSIBLE FOR ALL NECESSARY SLOPING, BENCHING, SHEETING OR SHORING TO SUPPORT THE EXCAVATION WORK. DESIGN OF SUCH SHEETING AND SHORING SHALL BE BY A PROFESSIONAL ENGINEER LICENSED IN THE STATE OF INDIANA.

9.7 EXCAVATION SHALL BE IN ACCORDANCE WITH OSHA CONSTRUCTION STANDARDS (29 CFR – PART 1926, SUBPART P).

9.8 PROJECT EQUIPMENT THAT COMES IN CONTACT WITH EXCAVATED MATERIALS WILL BE APPROPRIATELY DECONTAMINATED.

10.0 MATERIAL HANDLING AND STAGING

10.1 CONTRACTOR IS RESPONSIBLE FOR THE LOADING OF ALL CONSTRUCTION DEBRIS, WASTEWATER AND GENERAL REFUSED GENERATED DURING THE PROJECT AND COORDINATE TRANSPORTATION WITH APPROVED OFFSITE DISPOSAL FACILITIES. MATERIALS DESIGNATED FOR DISPOSAL SHALL BE STORED SEPARATELY ON SITE FROM THE OVERBURDEN MATERIALS FOR REUSE.

10.2 STAGED MATERIALS MUST BE CONTAINED WITH APPLICABLE EROSION AND SEDIMENT CONTROLS AND/OR SECONDARY CONTAINMENT AND COVERED.

10.3 DEPOSITION OF REMOVED MATERIAL IN PLACES OTHER THAN THOSE DESIGNATED OR OTHERWISE PREVIOUSLY APPROVED IS STRICTLY PROHIBITED AND MAY REQUIRE THE CONTRACTOR TO MOVE SUCH MISPLACED MATERIAL AT NO COST TO THE ENGINEER.

10.4 NO MATERIAL SHALL BE REMOVED FROM THE SITE BY THE CONTRACTOR WITHOUT PRIOR NOTIFICATION TO, AND APPROVAL OF, THE ENGINEER.

10.5 MATERIALS REMOVED FROM THE SITE SHALL BE TRANSPORTED BY INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT APPROVED TRANSPORTERS; AND DISPOSED OF AT AN APPROVED DISPOSAL OR TREATMENT FACILITY.

10.6 MATERIALS THAT ARE DISPOSED OF WILL BE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE AND LOCAL LAWS. PROOF OF DISPOSAL WILL BE PROVIDED IN THE FORM OF COPIES OF BILLS OF LADING, DISPOSAL RECEIPTS AND/OR MANIFESTS.

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SCALE(S) AS INDICATED

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Professional Engineer's Name: .

Professional Engineer's No.: .

State	Date Signed	Project Mgr.
IN		.

Designed by: . | Drawn by: GS | Checked by: .

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA

PROPOSED REMEDIAL ACTION

TECHNICAL SPECIFICATIONS (1 OF 2)

ARCADIS Project No. 30075940

Date OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

G-002

11.0 IN–SITU SOLIDIFICATION AND STABILIZATION

11.1 THE CONTRACTOR SHALL FURNISH ALL LABOR, MATERIALS, TOOLS, AND EQUIPMENT AND PERFORM ALL OPERATIONS NECESSARY FOR THE ISS, AS DESCRIBED ON THESE CONSTRUCTION DRAWINGS. ISS MIXING SHALL BE COMPLETED USING EITHER A ROTARY HEAD MIXING HEAD, AUGER MIXING OR BUCKET MIXING AS AN ACCEPTABLE METHOD FOR THIS PROJECT.

11.2 A TWO STEP ISS MIXING APPROACH WILL BE IMPLEMENTED. STEP ONE – ZVI MIXING AND STEP TWO – PC MIXING. ISS WILL NOT BE PERMITTED TO BE PERFORMED DURING PERIODS OF PRECIPITATION WITHOUT APPROVAL OF THE ENGINEER. CONTRACTOR SHALL SCHEDULE THIS WORK ACCORDINGLY AND ACCOUNT FOR WEATHER DELAYS. A MINIMUM OF 28 DAYS SHALL BE ALLOWED TO ELAPSE BETWEEN STABILIZATION WITH ZVI AND SOLIDIFICATION VIA PC TO MEET THE PERFORMANCE REQUIREMENTS.

11.3 MIXING SHALL COVER THE ENTIRE ISS TREATMENT AREA(S) AND MEET ALL TARGET DEPTHS AS DEPICTED ON THE CONTRACT DRAWINGS. THE CONTRACTOR SHALL EVENLY DISTRIBUTE THE ZVI BENTONITE SLURRY MIXTURE OR PC THROUGHOUT THE ISS AREA.

a. THE CONTRACTOR SHALL KEEP ANY STORED SLURRY MIXTURE AGITATED AS REQUIRED TO KEEP ZVI IN SUSPENSION DURING MIXING.

b. THE CONTRACTOR MUST PROVIDE SUFFICIENT OVERLAP BETWEEN MIXED AREAS SUCH THAT NO SOIL WITHIN THE ESTABLISHED ISS AREA LIMITS GOES UNTREATED.

11.4 THE CONTRACTOR SHALL PROVIDE MIX MATERIALS (I.E., REAGENTS AND WATER) IN SUFFICIENT QUANTITIES TO ALLOW FOR UNINTERRUPTED ISS ACTIVITIES BASED ON THE PRODUCTION RATE AS DETERMINED BY THE CONTRACTOR. CONTRACTOR IS RESPONSIBLE FOR THE COORDINATION OF AN APPROPRIATE MATERIAL DELIVERY SCHEDULE TO ACCOMMODATE THIS INDICATED STOCK REQUIREMENT.

11.5 THE CONTRACTOR SHALL CALCULATE AND PROVIDE IN AN ACCEPTABLE FORMAT, THE FOLLOWING ISS MIX PARAMETERS:

a. THE VOLUME OF SOIL BEING TREATED IN EACH ISS AREA, INCLUDING THE VOLUME OF TREATED SOIL AS A RESULT OF OVERLAP FROM ADJACENT AREAS.

b. PROVIDE THE CALCULATIONS THAT INDICATES THE WEIGHT OF SOIL BEING TREATED IN THE ISS AREA.

c. PROVIDE CALCULATIONS THAT INDICATES THE QUANTITY OF MATERIALS REQUIRED FOR THE ISS AREA BY A PERCENTAGE OF THE TOTAL WEIGHT OF TREATED SOIL.

11.6 THE FOLLOWING REAGENTS AND MIX DESIGNS SHALL BE USED FOR ISS IMPLEMENTATION:

a. ZVI SHALL BE ADDED AT 1% BY DRY WEIGHT VIA A BENTONITE SLURRY MIXTURE. ZVI SHALL BE CONNELLY GPM, PRODUCT CC–1200. SLURRY MIXTURE SHALL HAVE A PUMPABLE VISCOSITY. THE WATER TO BE ADDED TO THE BASELINE COMPOSITE SLURRY MIXTURE SHALL BE 0.9 WATER TO BINDER RATIO. OTHER WATER TO BINDER RATIOS MAY BE NECESSARY BASED ON FIELD CONDITIONS ENCOUNTERED AND ARE ACCEPTABLE AS LONG AS THE RATIO USED ALLOWS TO BE EFFECTIVELY PUMPED, ALLOWS EQUIPMENT TO ACHIEVE DESIGN DEPTH, PROVIDES ENOUGH WATER TO BE EFFECTIVELY MIXED, AND MEET ALL OTHER REQUIREMENT OF THE SPECIFICATION. IF THE CONTRACTOR PROPOSES WATER TO BINDER RATIOS OTHER THAN 0.9 THE CONTRACTOR MUST SUBMIT A REQUEST TO THE ENGINEER FOR APPROVAL TO ALTER THE SLURRY MIXTURE WATER QUANTITIES.

b. PC AT 5% BY DRY WEIGHT. PORTLAND CEMENT SHALL BE TYPE I/II, MANUFACTURED BY LAFARGE NORTH AMERICA (OR APPROVED EQUAL). THE CEMENT SHALL BE ADEQUATELY PROTECTED FROM MOISTURE AND CONTAMINATION WHILE IN TRANSIT. CEMENT SHALL BE STORED IN A SILO OR OTHER APPROPRIATE BULK STORAGE CONTAINER. CEMENT SHALL BE FROM AN APPROVED SOURCE AND THE SUPPLIER SHALL PROVIDE A CERTIFICATION OF COMPLIANCE WITH APPLICABLE REQUIREMENTS OF ASTM C150.

c. POTABLE WATER MUST BE PROVIDED FOR SLURRY MIXING BY THE CONTRACTOR. THE CONTRACTOR IS REQUIRED TO ARRANGE FOR AND OBTAIN APPROPRIATE PERMITS FOR THE USE OF HYDRANT WATER OR TEMPORARY HOOKUP OF SITE POTABLE WATER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL FEES ASSOCIATED WITH WATER USAGE. IF AN OFF–SITE SOURCE OF WATER IS USED OTHER THAN CITY–PROVIDED WATER, THE CONTRACTOR MUST SUBMIT DOCUMENTATION OF THE SOURCE OF WATER FOR ENGINEER REVIEW. THE CONTRACTOR SHALL INCORPORATE CONTACT STORMWATER, DEWATERING WATER AND DECONTAMINATION WATER AS PRACTICAL AFTER PRETREATING THE WATER USING NO LARGER THAN 100 MICRON FILTERS TO REMOVE SUSPENDED PARTICLES.

11.7 METERING DEVICES UTILIZED FOR PROPER REAGENT BLENDING MUST BE APPROVED BY THE ENGINEER PRIOR TO THE START OF FULL–SCALE ISS. ALL METERING DEVICES SHALL BE CALIBRATED OR VERIFIED ON–SITE PRIOR TO COMMENCING ON–SITE MIXING OPERATIONS. METERING DEVICES MUST BE CAPABLE OF MEASURING TOTALIZED AND INSTANTANEOUS FLOWS. METERING DEVICES MUST BE CALIBRATED TO WITHIN +/–2 PERCENT TO ACCURATELY MEASURE THE REQUIRED QUANTITY NECESSARY FOR EACH MATERIAL OR SLURRY MIXTURE. THE CONTRACTOR IS REQUIRED TO PROVIDE DOCUMENTATION FOR EQUIPMENT CALIBRATION AND CALIBRATION SCHEDULE.

11.8 MUST PROVIDE ADEQUATE PRESSURE AND FLOW RATE AND A MEANS OF MEASURING PRESSURE AND FLOW SUCH THAT SLURRY IS DELIVERED AT A CONSTANT RATE THROUGHOUT THE ISS AREA. THIS IS APPLICABLE TO INJECTION AND AUGER MIXING/ROTARY HEAD MIXING. IF BUCKET MIXING IS THE METHOD CONTRACTOR MUST DOCUMENT AND RECORD THE APPROPRIATE VOLUME OF ZVI SLURRY HAS BEEN PUMPED TO THE ISS AREA.

11.9 CONTRACTOR IS REQUIRED TO PROVIDE SPARE PARTS/PUMPS/MIXING EQUIPMENT TO BE AVAILABLE ON SITE DURING FULL–SCALE OPERATIONS TO MINIMIZE POTENTIAL DOWNTIME.

11.10 IF THE CONTRACTOR PROPOSES TO USE MIX DESIGNS OTHER THAN THOSE PROVIDED ABOVE, THE CONTRACTOR SHALL CONDUCT BENCH–SCALE TREATABILITY STUDY OR PILOT SCALE TESTING TO DOCUMENT THE PROPOSED MIX DESIGNS' UNCONFINED COMPRESSIVE STRENGTH (UCS).

11.11 UCS OF THE TREATED SOIL MATRIX MUST BE GREATER THAN OR EQUAL TO 20 POUNDS PER SQUARE INCH (PSI), MEASURED AT 14 DAYS AND THE UCS OF THE TREATED SOIL MATRIX MUST BE GREATER THAN OR EQUAL TO 50 POUNDS PER SQUARE INCH (PSI), MEASURED AT 28 DAYS OR SOONER (UNLESS OTHERWISE DIRECTED BY THE ENGINEER), AFTER 28 DAYS WITH NO MORE THAN 20 PERCENT OF THE PERFORMANCE SAMPLES LESS THAN 50 PSI, AND NO SAMPLES LESS THAN 30 PSI.

11.12 THE CONTRACTOR MUST COLLECT VERIFICATION ISS SAMPLES, USING AN IN–SITU WET SAMPLER, AT A FREQUENCY OF ONE SET FOR EVERY 500 CUBIC YARDS (CY) OR DAILY FROM THE ISS AREA AND TEST THE SAMPLES FOR ASTM INTERNATIONAL D1633. EACH SET OF SAMPLES SHALL CONSIST OF FOUR (4) 3–INCH BY 6–INCH SAMPLE SPECIMENS (CYLINDERS) OF HOMOGENIZED SOLIDIFIED SOILS OBTAINED FROM THE ISS MONOLITH. SAMPLES WILL BE COLLECTED AT VARIOUS DEPTHS AND ALTERNATE BETWEEN SURFACE, MID–POINT, AND BOTTOM DEPTH. SAMPLES SHALL BE PREPARED AND CURED IN ACCORDANCE WITH ASTM INTERNATIONAL C31. PRIOR TO FILLING THE CYLINDERS, THE SAMPLE MATERIAL WILL BE PASSED THROUGH A 1/4 INCH–OPENING SIEVE.

a. ISS SAMPLES WILL BE COLLECTED, HANDLED, PACKAGED, AND TESTED BY THE CONTRACTOR AS INDICATED BELOW AND IN ACCORDANCE WITH ASTM D–1362.

1. SAMPLES WILL BE PLACED IN PROPERLY LABELED BOXES (INCLUDING SAMPLE LOCATION, DEPTH, AND COLUMN).
2. SAMPLES WILL BE WRAPPED IN CLEAR PLASTIC WRAP TO PREVENT MOISTURE LOSS.
3. SAMPLES WILL BE STORED IN A COOL, DRY LOCATIONS AND ALLOWED TO CURE AND SOLIDIFY FOR A MINIMUM OF 48 HOURS, BUT NOT MORE THAN 72 HOURS, BEFORE TRANSPORT TO A TESTING LABORATORY.
4. SAMPLES WILL NOT BE ALLOWED TO FREEZE.
5. ONE CYLINDER WILL BE TESTED AFTER 7 DAYS, 14 DAYS AND 28 DAYS (TOTAL OF 3 CYLINDERS) OF CURE FOR UNCONFINED COMPRESSIVE STRENGTH (UCS) OF CYLINDRICAL CONCRETE SPECIMENS (ASTM D1633).
6. THE REMAINING ONE CYLINDER WILL BE STORED AT THE LABORATORY FOR SUBSEQUENT TESTING SHOULD THE TEST CRITERIA NOT BE MET IN THE FIRST TWO SAMPLE CYLINDERS.
7. SAMPLE RESULTS WILL BE REPORTED NO LATER THAN 3 DAYS AFTER TESTING HAS BEEN PERFORMED.

b. IN ADDITION TO LABORATORY COMPLIANCE SAMPLES DESCRIBED ABOVE, FIELD TESTS INCLUDING VISUAL INSPECTION AND SLUMP TESTING (4 TO 7 INCH SLUMP TARGET RANGE) WILL BE PERFORMED.

c. CONTRACTOR MAY ELECT TO COLLECT ADDITIONAL ISS SAMPLES FOR FURTHER TESTING AT CONTRACTORS' DISCRETION.

d. THE ENGINEER WILL BE ON SITE DURING ALL ISS OPERATIONS TO OBSERVE AND DOCUMENT THE OVERALL ISS OPERATION. SLURRY MIXTURE AND IN–SITU STABILIZED MATERIAL SHALL BE VISUALLY OBSERVED TO VERIFY THAT THE MATERIAL HAS BEEN MIXED CREATING A HOMOGENEOUS SOIL MATRIX.

11.13 THE TREATMENT AREA SHALL BE CONSTRUCTED USING ISS TO THE LINES, GRADES, AND CROSS SECTIONS INDICATED ON THESE CONTRACT DRAWINGS. THE VOLUMES PRESENTED ON THESE CONTRACT DRAWINGS ARE NEAT IN–PLACE VOLUMES AND DO NOT INCLUDE OR ACCOUNT FOR OVERLAPPING OR ISS SWELL VOLUMES GENERATED AS A RESULT OF THE ISS MIXING PROCESSES. FOR INSTALLATION PURPOSES, THE ISS STRUCTURE SHALL BE ESSENTIALLY VERTICAL WITH A PATTERN OF OVERLAPPING COLUMNS, CELLS OR TRENCHES AND SHALL EXTEND TO THE MINIMUM ELEVATIONS AND HORIZONTAL LIMITS SHOWN ON THESE CONTRACT DRAWINGS.

11.14 IN–SITU MATERIAL THAT EXCEEDS THE MAXIMUM ALLOWABLE PARTICLE SIZE OF THE ISS MIXING EQUIPMENT AND THAT IS AMENABLE TO TREATMENT SHALL BE REDUCED TO A SIZE THAT THE MIXING EQUIPMENT CAN ACCOMMODATE. OVERSIZE MATERIAL THAT CANNOT BE REDUCED TO AN ACCEPTABLE SIZE SHALL BE REMOVED FOR OFF–SITE DISPOSAL.

11.15 IF AUGER MIXING IS SELECTED, AUGER REFUSAL IS DEFINED AS NO DOWNWARD ADVANCEMENT OF THE AUGER FOR A 15–MINUTE CONTINUOUS DRILLING PERIOD. ENGINEER'S CONSTRUCTION MANAGER SHALL BE CONSULTED DURING ALL AUGER REFUSAL SITUATIONS. ADDITIONAL INVESTIGATION AND REMEDIATION OF AUGER REFUSAL AREAS MAY BE NECESSARY, AT THE DISCRETION OF THE ENGINEER, TO DETERMINE IF PRODUCT REMAINS BENEATH THE INCOMPLETE ISS COLUMN. AUGER REFUSAL CAUSES MAY BE DUE TO PRE–EXISTING OBSTRUCTIONS, EQUIPMENT LIMITATIONS IN PENETRATING DENSE SAND/GRAVEL LAYERS, OVERLAPPING PREVIOUSLY SOLIDIFIED COLUMNS, OR EQUIPMENT MALFUNCTION. CONTRACTOR SHALL ADJUST SLURRY FLOW RATE WHERE FEASIBLE DURING THE 15–MINUTE REFUSAL VERIFICATION PERIOD TO REDUCE THE IMPACT OF INCREASED SLURRY ADDITION WHICH MAY INFLUENCE ADJACENT COLUMN OVERLAP DRILLING.

11.16 IF OBSTRUCTIONS INCLUDING, BUT NOT LIMITED TO, CONCRETE DEBRIS, REMNANT PIPING IN FILL, WOOD PILES, UNKNOWN SUBSURFACE STRUCTURES OR ABANDONED UTILITIES ARE ENCOUNTERED DURING ISS OPERATIONS, THE ISS OPERATOR SHALL STOP MIXING AT THAT LOCATION UNTIL THE NATURE OF THE OBSTRUCTION IS KNOWN OR AS OTHERWISE DIRECTED BY THE ENGINEER. OBSTRUCTIONS WHICH CANNOT BE PENETRATED, MAY BE REMEDIATED BY REMOVAL, GROUTING, OR OTHER ACCEPTABLE MEANS.

a. OBSTRUCTION OCCURRING WITHIN THE EXCAVATION DEPTH RANGE ARE CONSIDERED INCIDENTAL TO THE EXCAVATION WORK AND SHALL BE STAGED FOR OFF–SITE DISPOSAL.

b. DEBRIS OR OBSTRUCTIONS THAT CAN BE REMOVED BY AN EXCAVATOR WITHIN ITS REACH DEPTH RANGE SHALL BE REMOVED. EXCAVATION VOLUME FOR OBSTRUCTION REMOVAL WILL BE DEFINED AS THE THICKNESS OF SOIL FROM THE EXCAVATION ELEVATION TO 1–FT BELOW THE BOTTOM OF THE OBSTRUCTION AND AS THE AREAL EXTENT OF THE OBSTRUCTION EXCAVATION AS DETERMINED IN THE FIELD EITHER BY SURVEY OR FIELD MEASUREMENT. THIS VOLUME WILL BE TRACKED ON A DAILY PROGRESS REPORT. THE DAILY PROGRESS REPORT WILL INCLUDE THE ISS STAND–BY TIME ASSOCIATED WITH THE REMOVAL OF THE OBSTRUCTION. IF ADDITIONAL RETREATING OF SOLIDIFIED SOIL IS REQUIRED, THEN THE VOLUME OF RETREATED SOIL WILL BE DETERMINED IN THE FIELD AND MEASURED FOR PAYMENT AND RECORDED ON THE DAILY PROGRESS REPORT.

c. ALL OBSTRUCTIONS FOR WHICH CONTRACTOR INTENDS TO SEEK ADDITIONAL COMPENSATION IN ACCORDANCE WITH THE ABOVE MUST BE BROUGHT TO THE ATTENTION OF THE ENGINEER'S CONSTRUCTION MANAGER AS SOON AS THE OBSTRUCTION IS ENCOUNTERED SO THAT AN APPROPRIATE APPROACH CAN BE AGREED UPON. AFTER–THE–FACT CLAIMS FOR OBSTRUCTION COMPENSATION WHICH THE ENGINEER'S CONSTRUCTION MANAGER DID NOT WITNESS WILL NOT BE ACCEPTED.

11.17 PLACEMENT OF OVERBURDEN WITHIN THE ISS AREA WILL NOT BE PERMITTED FOR A MINIMUM PERIOD OF 7 DAYS FOLLOWING THE COMPLETION OF STEP 2 – PC MIXING AND RECEIPT OF APPROVED PERFORMANCE RESULTS FROM FIELD QUALITY ASSURANCE/QUALITY CONTROL TESTING PROGRAM INDICATING ISS HAS ACHIEVED THE REQUIRED DESIGN STRENGTH.

11.18 ISS MATERIALS THAT DO NOT PASS THE REQUIRED PERFORMANCE CRITERIA SHALL BE ADDRESSED BY THE CONTRACTOR. RE–MIXING, WITH ADDITIONAL REAGENTS, SHALL BE PERFORMED AT NO ADDITIONAL COST TO THE OWNER/ENGINEER FOR TREATED MATERIAL THAT DOES NOT MEET THE REQUIREMENTS SET FORTH IN THE PERFORMANCE CRITERIA, OR THE SOIL MIXING FAILS TO ACHIEVE THOROUGH HOMOGENOUS MIXING, MIXING TO THE SPECIFIED DEPTHS OR COMPLETE MIXING OVERLAP TO THE DEPTHS SPECIFIED. ISS MATERIALS THAT ARE RE–MIXED SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH THESE SPECIFICATIONS. CONTRACTOR MAY ELECT TO ALTER THE MIX DESIGN FOR RE–MIXING OF THESE AREAS AS NECESSARY TO MEET THE PROJECT PERFORMANCE CRITERIA.

11.19 ISS TRACKING LOGS SHALL BE PREPARED DAILY AND INCLUDE THE FOLLOWING INFORMATION.

a. REQUIRED QUANTITY OF REAGENTS ADDED.

b. TREATED ISS AREA.

1. AREA COORDINATES (I.E. TAKEN AT CENTER OF COLUMN OR PERIMETER OF CELLS).
2. SURFACE ELEVATION AT TOP OF ISS COLUMN.
3. TOTAL INSTALLED DEPTH OF ISS.
4. LOCATION/DEPTH OF POST–MIX REPRESENTATIVE SAMPLE, IF APPLICABLE.
5. START TIME AND FINISH TIME.
6. QUANTITY TREATED.
7. SOIL MIXING TECHNIQUE AND DURATION.
8. DIAGRAM OF ISS AREA DEPICTING LOCATION AND OVERLAP CONFIGURATION.

c. IDENTIFICATION OF ISS OVERLAP AND REDUCTION IN VOLUME DUE TO OVERLAP (WHERE APPLICABLE).

12.0 SITE RESTORATION

12.1 CONTRACTOR SHALL ALLOW TREATED SOILS TO STABILIZE FOR A MINIMUM OF 7 DAYS POST STEP 2 – PC MIXING PRIOR TO PLACEMENT OF OVERBURDEN.

12.2 GEOTEXTILE DEMARCATION FABRIC SHALL BE PLACED OVER THE TREATED SOILS BEFORE BACKFILLING WITH OVERBURDEN.

12.3 OVERBURDEN MATERIALS WILL BE SAMPLED TO VERIFY THAT THE MATERIALS MEET A TRICHLOROETHENE (TCE) CONCENTRATION OF LESS THAN 100 PARTS PER MILLION (PPM) TO BE USED AS BACKFILL. A MINIMUM OF ONE SAMPLE WILL BE COLLECTED FOR EVERY 500 CUBIC YARDS OF OVERBURDEN MATERIAL BY ENGINEER.

12.4 OVERBURDEN MATERIALS WILL BE SAMPLED TO DETERMINE MODIFIED PROCTOR IN ACCORDANCE WITH ASTM INTERNATIONAL D–1557. A MINIMUM OF TWO SAMPLES WILL BE COLLECTED.

12.5 OVERBURDEN SHALL BE PLACED IN 10–INCH LOOSE LIFTS AND COMPACTED WITH A VIBRATORY ROLLER OR EQUIVALENT TO 92 TO 95% OF THE MODIFIED PROCTOR AT A FREQUENCY OF 1 IN–SITU DENSITY TEST FOR EVERY 2,500 SQUARE FEET PER LIFT.

12.6 FINAL RESTORATION WILL CONSIST OF A 4–INCHES OF TOPSOIL. TOPSOIL SHALL BE A LOCALLY AVAILABLE, FERTILE, FRIABLE SOIL OF LOAMY CHARACTER, OBTAINED FROM WELL–DRAINED ARABLE LAND AND REASONABLY FREE FROM SUBSOIL, REFUSE, ROOTS, HEAVY OR STIFF CLAY, ROCKS LARGER THAN 2 INCHES, COARSE SAND, STICKS, BRUSH, LITTER, AND OTHER DELETERIOUS SUBSTANCES.

12.7 TOPSOIL SHALL HAVE A MAXIMUM PARTICLE SIZE, 2 INCHES, WITH MAXIMUM 3 PERCENT RETAINED ON 1/4–INCH SCREEN. THE PH SHALL BE TESTED IN ACCORDANCE WITH AASHTO T289, OR EQUIVALENT. TOPSOIL SHALL CONFORM TO THE FOLLOWING LIMITS:

a. SILT 30% TO 80%
CLAY 5% TO 30%
SAND 5% TO 50%

b. ORGANIC MATERIAL 5% TO 10%

c. PH 6.2 TO 7.4

AT LEAST TWO REPRESENTATIVE SAMPLES SHALL BE SENT TO AN APPROVED LABORATORY FOR PHYSICAL AND FERTILITY TESTING.

12.8 TOPSOIL SHALL BE ANALYZED FOR:

a. VOLATILE ORGANIC COMPOUNDS (BY USEPA SW–846 METHOD 8260)

b. SEMI–VOLATILE ORGANIC COMPOUNDS INCLUDING POLYAROMATIC HYDROCARBONS BY USEPA METHODS 8270

c. POLYCHLORINATED BIPHENYLS BY USEPA METHODS 8082

d. RESOURCE CONSERVATION AND RECOVERY ACT METALS BY USEPA METHOD 6020, AND USEPA METHOD 7471

e. PER– AND POLYFLUOROALKYL SUBSTANCES BY USEPA METHOD 8327

AT LEAST TWO REPRESENTATIVE SAMPLES SHALL BE SENT TO AN APPROVED LABORATORY FOR ANALYTICAL TESTING TO VERIFY THE TOPSOIL MEETS THE INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT REMEDIATION CLOSURE GUIDE – RESIDENTIAL DIRECT CONTACT SOIL EXPOSURE LIMITS.

12.9 SEED MIXTURE SHALL BE A 100 POUND PER ACRE (LB/AC) 4–WAY BLEND OF TURF TYPE TALL FESCUE, 50 LB/AC CREEPING RED FESCUE, 45 LB/AC PERENNIAL RYEGRASS AND 1.6 LB/AC WHITE DUTCH CLOVER. THIS SEED MIXTURE SHALL BE APPLIED AT THE RATE OF 196.5 LB/AC.

12.10 MULCH SHALL BE PROCURED AND APPLIED IN ACCORDANCE WITH SECTION 621 – SEEDING AND SODDING OF THE INDIANA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS 2020.

12.11 ALL AREAS IMPACTED BY OR OTHERWISE DISTURBED DURING THE PROJECT WILL BE RESTORED BY THE CONTRACTOR TO PRE–CONSTRUCTION CONDITIONS, IN A TIMELY MANNER AND PRIOR TO CONTRACTOR DEMOBILIZATION.

12.12 ALL EQUIPMENT OPERATED WITHIN THE PROJECT WORK LIMITS WILL BE DECONTAMINATED IN ACCORDANCE WITH BEST MANAGEMENT PRACTICES PRIOR TO ARRIVING ONSITE AND PRIOR TO LEAVING THE SITE. PROJECT EQUIPMENT THAT COMES IN CONTACT WITH IMPACTED MATERIALS WILL BE APPROPRIATELY DECONTAMINATED PRIOR TO LEAVING THE SITE.

12.13 THE CONTRACTOR WILL PREVENT TRACKING OF SOIL MATERIALS ONTO OFFSITE AREAS. ANY SOIL MATERIALS TRACKED, SPILLED OR DROPPED ONTO OFF–SITE AREAS, WILL BE IMMEDIATELY CLEANED UP BY THE CONTRACTOR AT NO ADDITIONAL COST TO THE ENGINEER.

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SCALE(S) AS INDICATED

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Professional Engineer's No.:

State	Date Signed	Project Mgr.
IN		.

Designed by: - | Drawn by: GS | Checked by: .

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

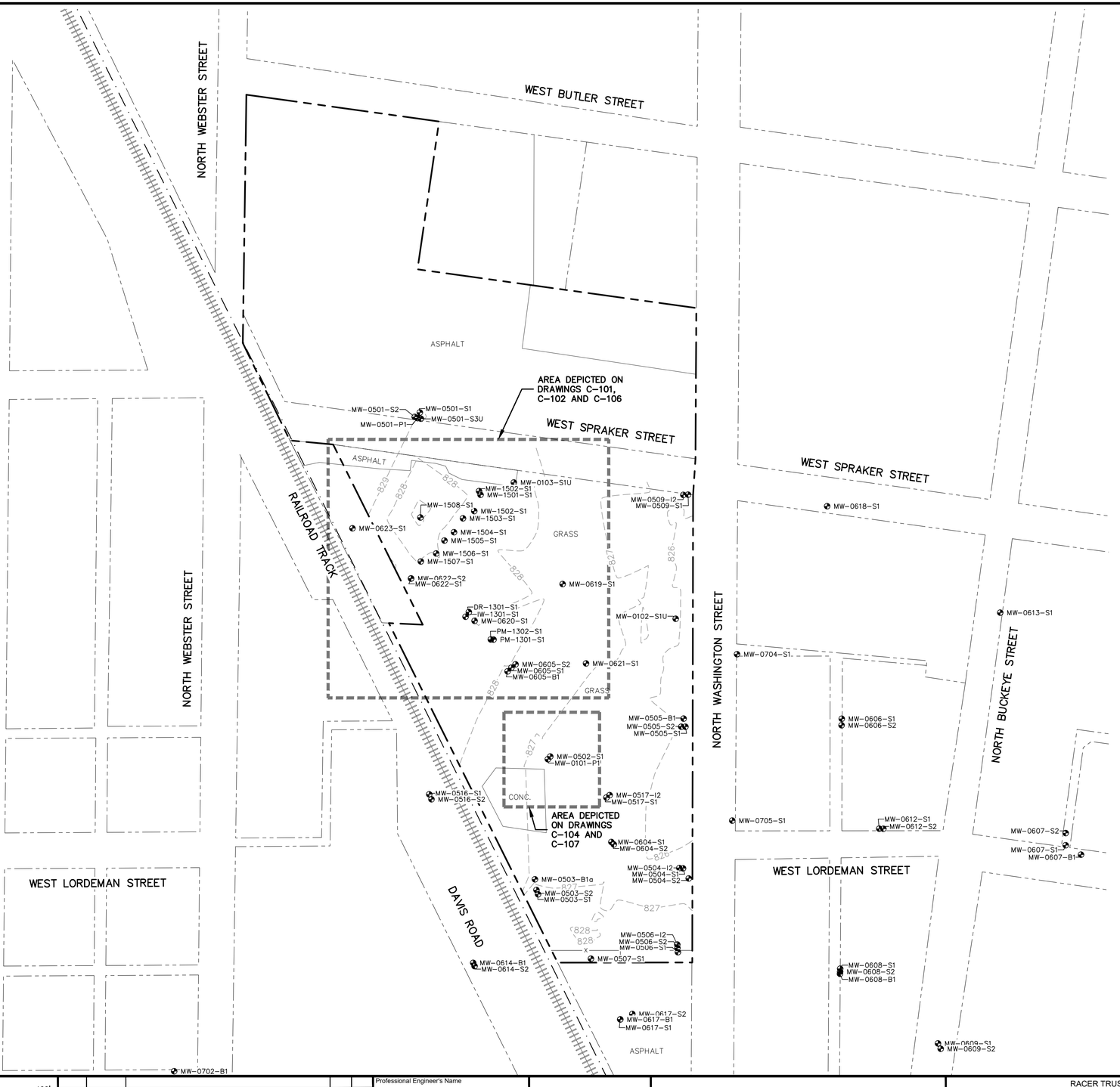
TECHNICAL SPECIFICATIONS (2 OF 2)

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

G-003



LEGEND:

- PROPERTY BOUNDARY
- ADJOINING PARCEL BOUNDARY
- 828 EXISTING CONTOUR
- EXISTING MONITORING WELL
- EXISTING RAILROAD TRACK
- RAILROAD TRACK – THEORETICAL EMBANKMENT LIMIT

NOTES:

1. BASE MAP CREATED FROM AVAILABLE GIS DATA AND SITE FIGURES. ADDITIONAL DATA DIGITIZED FROM AERIAL IMAGERY. SURFACE TOPOGRAPHY WAS GENERATED FROM SURVEYED GROUND ELEVATIONS AT MONITORING WELLS AND SOIL BORINGS. ALL LOCATIONS APPROXIMATE.
2. APPARENT HORIZONTAL DATUM IS NAD83 INDIANA STATE PLANE, EAST ZONE, US FEET. VERTICAL DATUM IS UNKNOWN.
3. VERTICAL DATUM IS UNKNOWN.
4. LOCATIONS OF ALL STRUCTURES/UTILITIES SHOWN ARE APPROXIMATE. INFORMATION RELATED TO SITE CONDITIONS SHOULD BE CONSIDERED AS GENERALLY REPRESENTATIVE AND SHOULD NOT BE RELIED UPON AS A COMPLETE DEPICTION OF SITE CONDITIONS.
5. ADDITIONAL SITE FEATURES MAY BE PRESENT THAT ARE NOT SHOWN. THE CONTRACTOR WILL VERIFY ALL EXISTING CONDITIONS, INCLUDING ABOVE-GRADE AND SUBSURFACE FEATURES.
6. PROMPTLY NOTIFY THE ENGINEER UPON DISCOVERY, AND BEFORE CONDITIONS ARE FURTHER DISTURBED OF PHYSICAL CONDITIONS AT THE SITE THAT DIFFER FROM THOSE INDICATED.

C:\IBM\OneDrive - ARCADIS\IBM 360 Docs\AUS-RACER TRUST-1723 N WASHINGTON ST-KOKOMO Indiana\Project Files\2021\01-In Progress\01-DWG\ISS-DESIGN-DR-G004-EXIST.dwg LAYOUT: G-004 SAVED: 10/22/2021 3:41 PM ACADVER: 24.1S (LMS TECH) PAGESETUP: PDF-D PLOTSTYLETABLE: PLTCONT.CTB PLOTTED: 10/25/2021 2:15 PM BY: STEINBERGER, GEORGE
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ISS-DESIGN-X-BASEMAP

80' 0 80' 160'
1"=80'
SCALE(S) AS INDICATED

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No.	Date	Revisions	By	Ckd

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Professional Engineer's Name: -
Professional Engineer's No.: -

State	Date Signed	Project Mgr.
IN		.
Designed by .	Drawn by GS	Checked by .

DRAFT
NOT FOR CONSTRUCTION

ARCADIS
ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

EXISTING SITE PLAN

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
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Indianapolis IN, 46204
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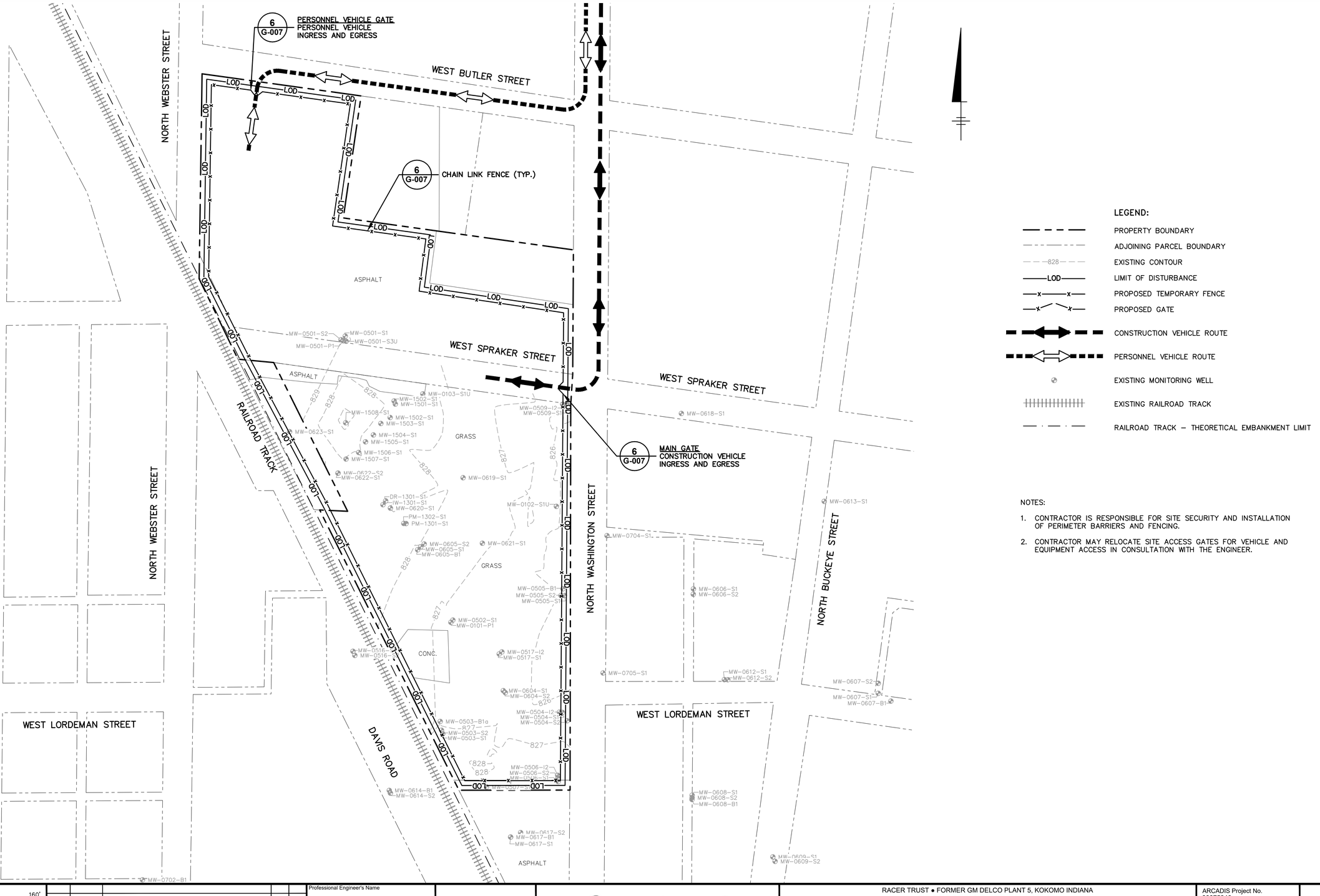
G-004



LEGEND:

- PROPERTY BOUNDARY
- ADJOINING PARCEL BOUNDARY
- 828 EXISTING CONTOUR
- LOD LIMIT OF DISTURBANCE
- PROPOSED TEMPORARY FENCE
- PROPOSED GATE
- CONSTRUCTION VEHICLE ROUTE
- PERSONNEL VEHICLE ROUTE
- EXISTING MONITORING WELL
- EXISTING RAILROAD TRACK
- RAILROAD TRACK – THEORETICAL EMBANKMENT LIMIT

NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR SITE SECURITY AND INSTALLATION OF PERIMETER BARRIERS AND FENCING.
2. CONTRACTOR MAY RELOCATE SITE ACCESS GATES FOR VEHICLE AND EQUIPMENT ACCESS IN CONSULTATION WITH THE ENGINEER.

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ISS-DESIGN-X-TITLE
ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-SESC

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USE TO VERIFY FIGURE REPRODUCTION SCALE

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Professional Engineer's Name		
Professional Engineer's No.		
State	Date Signed	Project Mgr.
IN		
Designed by	Drawn by	Checked by
	GS	

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ARCADIS

ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

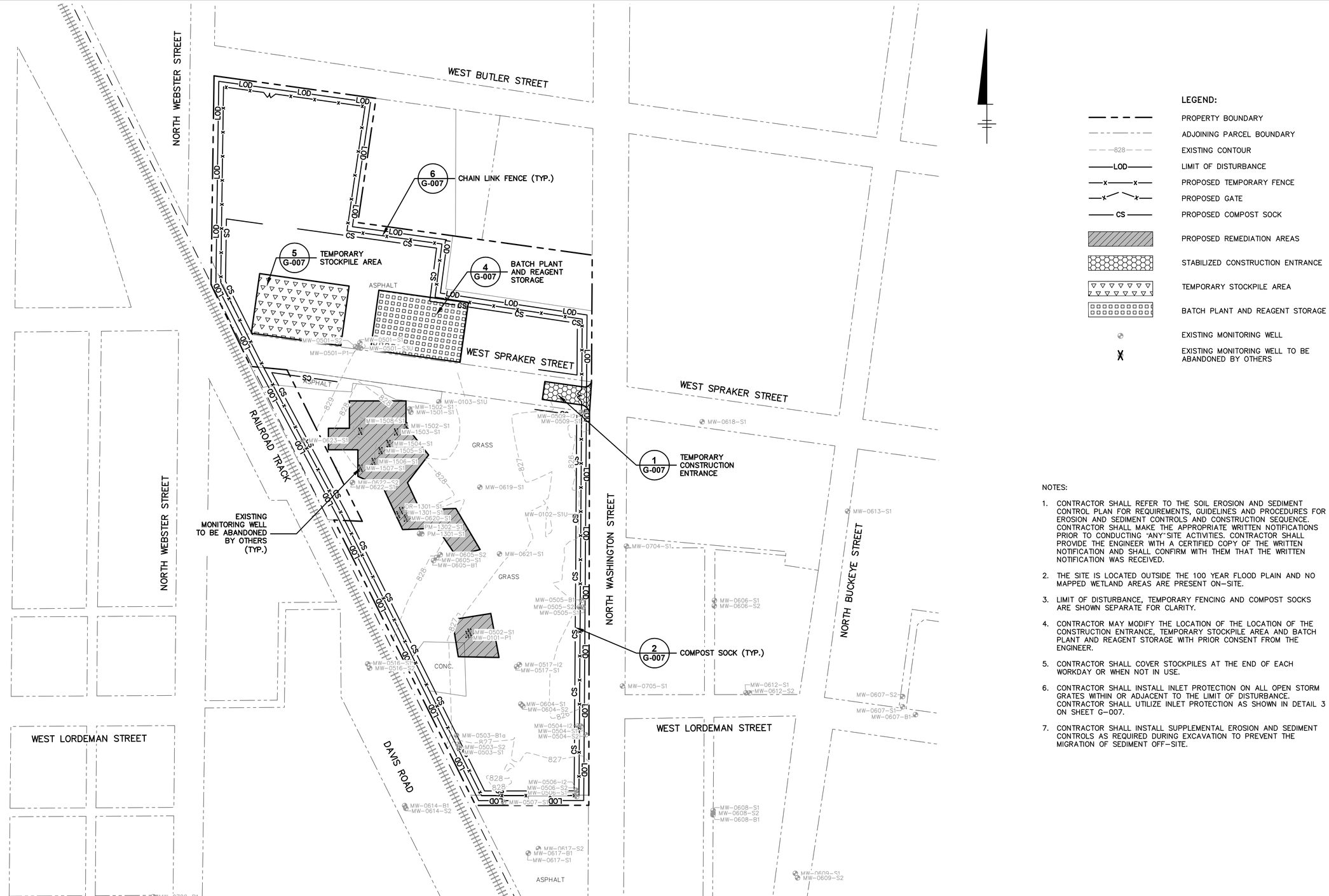
TRAFFIC CONTROL PLAN

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

G-005



NOTES:

1. CONTRACTOR SHALL REFER TO THE SOIL EROSION AND SEDIMENT CONTROL PLAN FOR REQUIREMENTS, GUIDELINES AND PROCEDURES FOR EROSION AND SEDIMENT CONTROLS AND CONSTRUCTION SEQUENCE. CONTRACTOR SHALL MAKE THE APPROPRIATE WRITTEN NOTIFICATIONS PRIOR TO CONDUCTING "ANY" SITE ACTIVITIES. CONTRACTOR SHALL PROVIDE THE ENGINEER WITH A CERTIFIED COPY OF THE WRITTEN NOTIFICATION AND SHALL CONFIRM WITH THEM THAT THE WRITTEN NOTIFICATION WAS RECEIVED.
2. THE SITE IS LOCATED OUTSIDE THE 100 YEAR FLOOD PLAIN AND NO MAPPED WETLAND AREAS ARE PRESENT ON-SITE.
3. LIMIT OF DISTURBANCE, TEMPORARY FENCING AND COMPOST SOCKS ARE SHOWN SEPARATE FOR CLARITY.
4. CONTRACTOR MAY MODIFY THE LOCATION OF THE LOCATION OF THE CONSTRUCTION ENTRANCE, TEMPORARY STOCKPILE AREA AND BATCH PLANT AND REAGENT STORAGE WITH PRIOR CONSENT FROM THE ENGINEER.
5. CONTRACTOR SHALL COVER STOCKPILES AT THE END OF EACH WORKDAY OR WHEN NOT IN USE.
6. CONTRACTOR SHALL INSTALL INLET PROTECTION ON ALL OPEN STORM GRATES WITHIN OR ADJACENT TO THE LIMIT OF DISTURBANCE. CONTRACTOR SHALL UTILIZE INLET PROTECTION AS SHOWN IN DETAIL 3 ON SHEET G-007.
7. CONTRACTOR SHALL INSTALL SUPPLEMENTAL EROSION AND SEDIMENT CONTROLS AS REQUIRED DURING EXCAVATION TO PREVENT THE MIGRATION OF SEDIMENT OFF-SITE.

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ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-SESC
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Professional Engineer's Name: .		
Professional Engineer's No.: .		
State: IN	Date Signed:	Project Mgr.: .
Designed by: .	Drawn by: GS	Checked by: .

DRAFT
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ARCADIS
ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

EROSION AND SEDIMENT CONTROL PLAN

ARCADIS Project No.: 30075940
Date: OCTOBER 2021

ARCADIS
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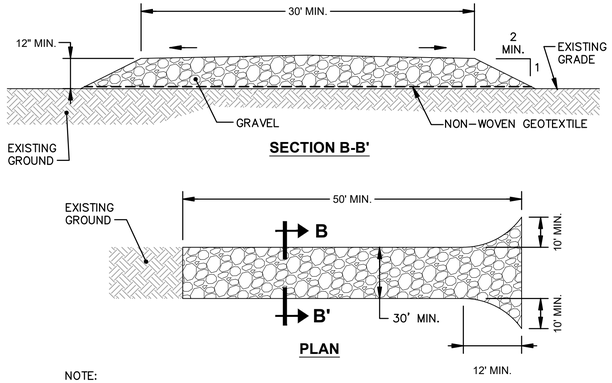
Indianapolis IN, 46204
Tel: 317-231-6500

G-006



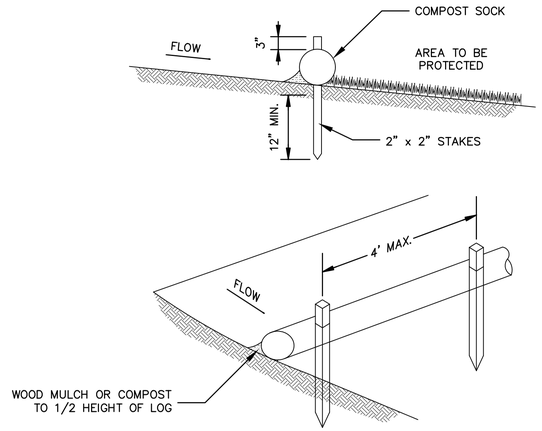
NOTE:

1. CONTRACTOR MAY PROPOSE ALTERNATIVE STABILIZED CONSTRUCTION ENTRANCE OPTIONS FOR APPROVAL BY THE ENGINEER.

STABILIZED CONSTRUCTION ENTRANCE

1 / G-006

NOT TO SCALE



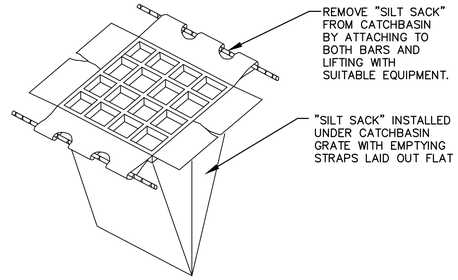
NOTES:

1. 8–INCH DIAMETER COMPOST SOCKS TO BE UTILIZED.
2. PRIOR TO INSTALLATION, CLEAR ALL OBSTRUCTIONS INCLUDING ROCKS, CLODS AND OTHER DEBRIS GREATER THAN ONE–INCH THAT MAY INTERFERE WITH PROPER FUNCTION OF THE COMPOST SOCK.
3. IN THE EVENT THAT STAKING IS NOT POSSIBLE, (I.E. WHEN SOCKS ARE USED ON PAVEMENT) HEAVY CONCRETE BLOCKS OR SAND BAGS SHALL BE USED BEHIND THE SOCK TO HOLD IT IN PLACE DURING RUNOFF EVENTS.

COMPOST SOCK DETAIL

2 / G-006

NOT TO SCALE



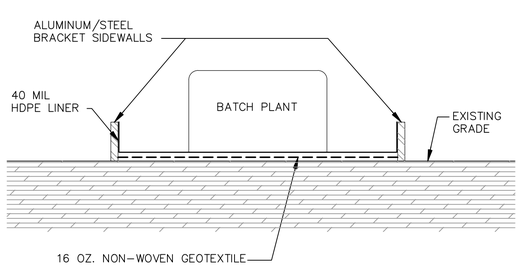
NOTES:

1. REMOVE DRAIN GRATE AND INSERT "SILT SACK" OR EQUIVALENT, MAKING SURE EMPTYING STRAPS ARE LAID FLAT OUTSIDE OF BASIN.
2. REPLACE DRAIN GRATE TO HOLD "SILT SACK" OR EQUIVALENT INTO POSITION.
3. MAINTENANCE – AS "SILT SACK" OR EQUIVALENT BECOMES FULL OF SEDIMENT, REMOVE WITH FRONT END LOADER (OR OTHER SUITABLE EQUIPMENT) AND EMPTY IN AN APPROVED LOCATION.
4. REPLACE EMPTIED "SILT SACK" OR EQUIVALENT BACK INTO CATCH BASIN.

INLET/MANHOLE PROTECTION

3 / G-006

NOT TO SCALE



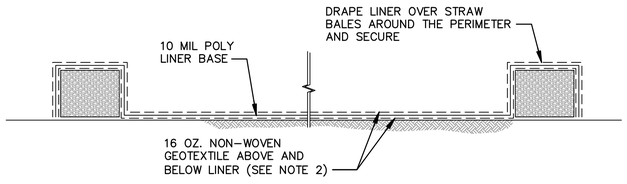
NOTES:

1. CONSTRUCT ON EXISTING GRADE OVER AN AREA SIZED FOR THE AMOUNT OF MATERIAL TO BE STAGED. ENSURE AREA TO BE LINED IS FREE OF DEBRIS, STONES, AND SHARP OBJECTS.
2. PLACE GEOTEXTILE OVERLAIN WITH LINER OVER THE EXISTING SURFACE AND ANCHOR INTO ALUMINUM/STEEL BRACKET SIDEWALLS.
3. THE AREA SHOULD BE SLOPED TO DRAIN TO A LOW POINT SUCH THAT ANY ACCUMULATED WATER CAN BE COLLECTED.
4. WHEN CONSTRUCTION IS COMPLETE, REMOVE ALL MATERIAL ABOVE THE LINER AND DISPOSE OF IT WITH EXCAVATED MATERIALS. REMOVE THE LINER AND DISPOSE OF IT WITH THE COVER MATERIAL.
5. WATER GENERATED DURING THE PROJECT WILL BE COLLECTED AND CONTAINERIZED FOR OFF–SITE TREATMENT AND DISPOSAL BY THE CONTRACTOR.
6. CONTRACTOR MAY SUBMIT ALTERNATIVE BATCH PLANT AND REAGENT STORAGE AREA OPTIONS FOR ENGINEER APPROVAL.

BATCH PLANT AND REAGENT STORAGE

4 / G-006

NOT TO SCALE



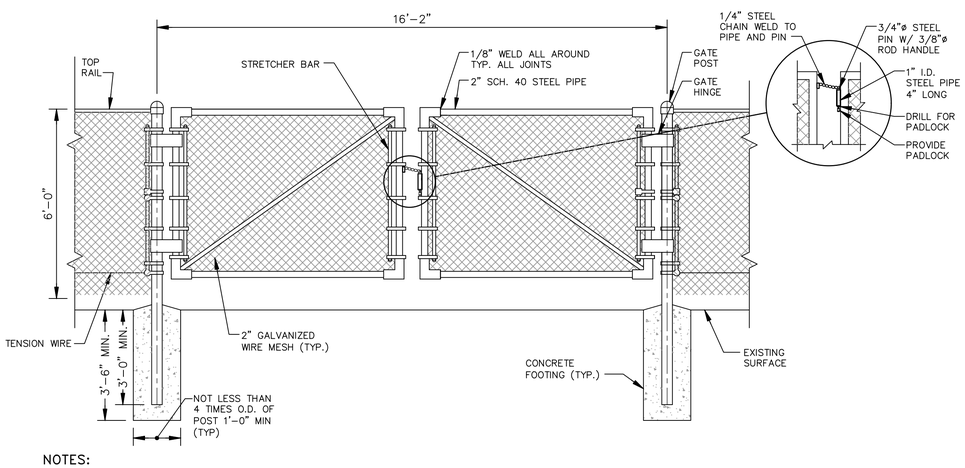
NOTES:

1. COVER TEMPORARY STOCKPILES WITH A PROPERLY ANCHORED PLASTIC COVER (NO LESS THAN 10 MIL), EXCEPT WHILE MATERIAL IS ACTIVELY BEING MANAGED (PLACED OR REMOVED). THE COVER WILL BE PROVIDED TO MINIMIZE POTENTIAL SILTATION/MIGRATION OF SOIL/DEBRIS BEYOND THE STAGING AREAS AND TO MINIMIZE LEACHATE GENERATION.
2. NON–WOVEN GEOTEXTILE SHALL BE 16 OZ./SQ.YD. MINIMUM.
3. TEMPORARY STOCKPILE AREA SHALL BE LOCATED ON ASPHALT/CONCRETE SURFACE AREAS.

TEMPORARY STOCKPILE AREA

5 / G-006

NOT TO SCALE



NOTES:

1. CHAIN LINK FABRIC SHALL BE ONE PIECE OF 9–GAUGE STEEL WIRE FABRIC, WIDTH AS SHOWN ON THE DETAIL, 3– BY 5–INCH CHAIN–LINK WIRE WITH A WOVEN GEOTEXTILE VISUAL BARRIER MEETING THE SPECIFICATIONS OF US FABRIC INC. US 1540 OR EQUIVALENT.
2. STRETCHER BARS WILL BE A MINIMUM OF ½– BY ¾–INCH STEEL AND ATTACHED TO POSTS WITH HEAVY STEEL BANDS.
3. TENSION WIRE WILL BE 7–GAUGE GALVANIZED COIL SPRING STEEL.
4. WIRE TIES OR CLIPS WILL BE A MINIMUM OF 6 GAUGE. HOG RINGS MAY BE USED TO TIE FABRIC TO TENSION WIRE.
5. CONTRACTOR SHALL SECURE POSTS AND FENCING AS REQUIRED TO STABILIZE THE TEMPORARY FENCE PANELS AND POSTS TO ADDRESS SITE SECURITY.

TYPICAL CHAIN LINK FENCE VEHICLE ACCESS GATE DETAIL

6 / G-005 and 6 / G-006

NOT TO SCALE

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Professional Engineer's Name: .
Professional Engineer's No.: .

State	Date Signed	Project Mgr.
IN		.
Designed by	Drawn by	Checked by
.	GS	.

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ARCADIS

ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

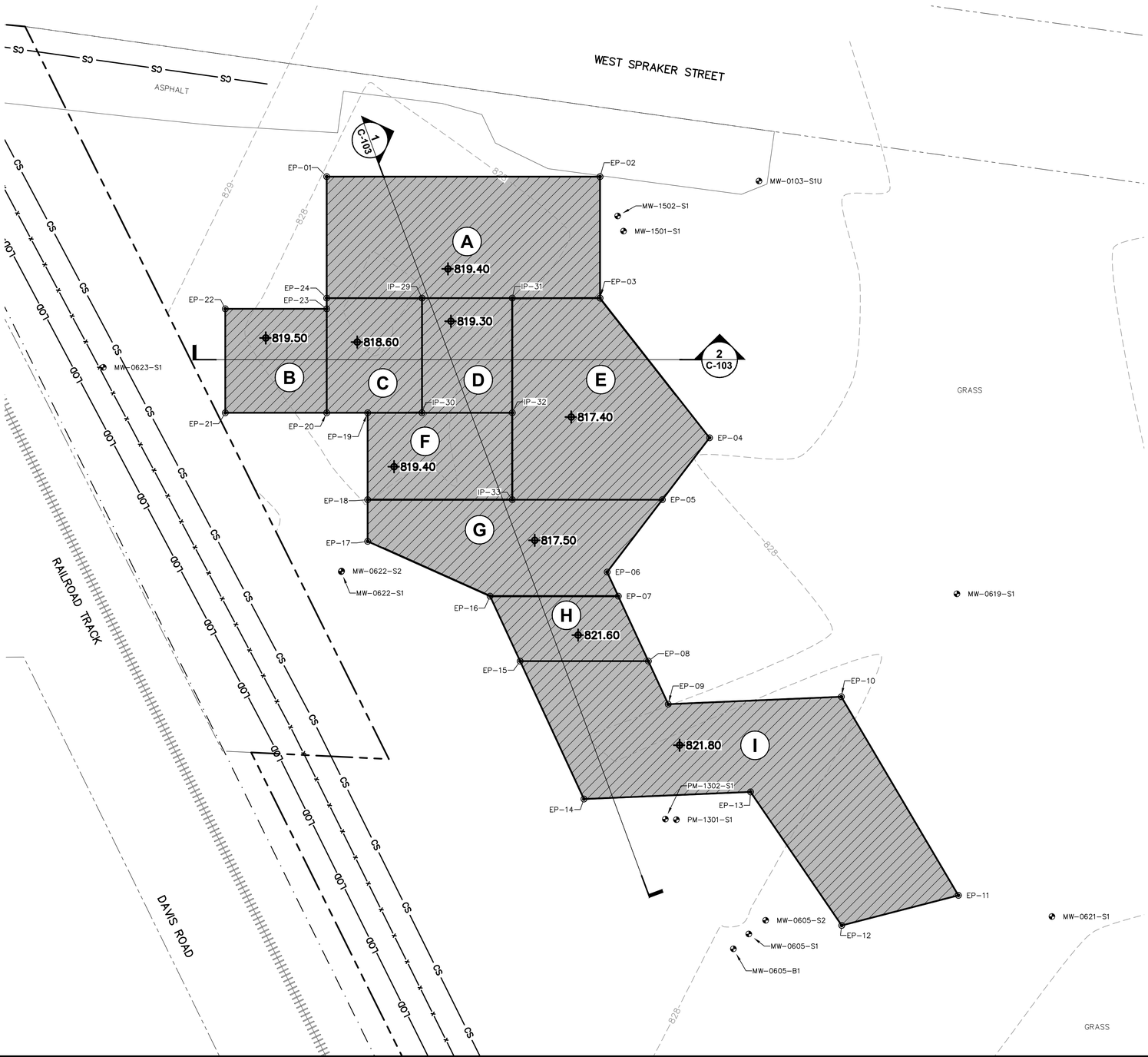
EROSION AND SEDIMENT CONTROL DETAILS AND NOTES

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

G-007



NOTES:

1. CONTRACTOR SHALL DETERMINE THE OPTIMAL SIZE OF THE TEMPORARY STOCKPILE AREA AND BATCH PLANT AND REAGENT STORAGE AREA TO ACCOMMODATE CONTRACTOR'S EXECUTION, OVERALL SITE LOGISTICS AND WORK SEQUENCING.
2. THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF THE EXCAVATION. VOLUMES PROVIDED HEREIN ARE NEAT IN-PLACE VOLUMES AND DO NOT ACCOUNT FOR SLOPING OR OVERLAPPING CELLS/COLUMN.
3. CONTRACTOR SHOULD BE PREPARED TO ENCOUNTER CONSTRUCTION DEBRIS AND ABANDONED MONITORING WELLS WITHIN THE LIMITS OF EXCAVATION. CONTRACTOR SHALL SORT, SIZE AND SEGREGATE CONSTRUCTION DEBRIS FOR STAGING IN A ROLL-OFF OR WITHIN THE TEMPORARY STOCKPILE AREA FOR CHARACTERIZATION AND OFF-SITE DISPOSAL
4. DEWATERING IS NOT ANTICIPATED; HOWEVER, THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF CONSTRUCTION DEWATERING TO FACILITATE EXCAVATION. . WATER SHALL BE STORED ONSITE IN APPROVED CONTAINERS WITH SECONDARY CONTAINMENT FOR ONSITE REUSE OR CHARACTERIZATION AND OFFSITE DISPOSAL.
5. AIR MONITORING SHALL BE IMPLEMENTED WHENEVER INTRUSIVE ACTIVITIES ARE BEING CONDUCTED. CONTRACTOR IS RESPONSIBLE FOR WORK ZONE MONITORING AND ENGINEER WILL MONITOR THE AMBIENT AIR AT THE LIMIT OF DISTURBANCE. CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING DUST AND ODOR CONTROLS WHEN TOTAL SUSPENDED PARTICLES OR VOLATILE ORGANIC COMPOUNDS EXCEED ACTION LEVELS.

CELL ID	AREA (SQ. FT.)	MINIMUM EXCAVATION ELEVATION	IN-PLACE EXCAVATION VOLUME (CU. YD.)
A	3921	819.40	1188
B	1245	819.50	383
C	1290	818.60	410
D	1222	819.30	386
E	3619	817.40	1447
F	1484	819.40	470
G	2584	817.50	1035
H	984	821.60	251
I	6005	821.80	1389

CONTROL POINT	NORTHING	EASTING
EP-01	1914323.80	197766.31
EP-02	1914323.80	197860.27
EP-03	1914282.07	197860.27
EP-04	1914234.09	197897.89
EP-05	1914212.83	197881.68
EP-06	1914187.97	197862.71
EP-07	1914179.68	197866.55
EP-08	1914157.35	197876.88
EP-09	1914142.57	197883.72
EP-10	1914145.12	197943.21
EP-11	1914076.88	197983.44
EP-12	1914066.54	197943.34
EP-13	1914112.43	197911.99
EP-14	1914109.97	197854.73
EP-15	1914157.35	197832.80
EP-16	1914179.68	197822.47
EP-17	1914198.52	197780.39
EP-18	1914212.83	197780.39
EP-19	1914242.68	197780.39
EP-20	1914242.68	197766.31
EP-21	1914242.68	197731.45
EP-22	1914278.40	197731.45
EP-23	1914278.40	197766.31
EP-24	1914282.07	197766.31
IP-29	1914282.07	197799.06
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IP-32	1914242.68	197830.09
IP-33	1914212.83	197830.09

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ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-PROPOSED
ISS-DESIGN-X-PROPOSED-PATT
ISS-DESIGN-X-SESC

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Professional Engineer's Name
-
Professional Engineer's No.
-

State	Date Signed	Project Mgr.
IN		-
Designed by	Drawn by	Checked by
	GS	-

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ARCADIS
ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

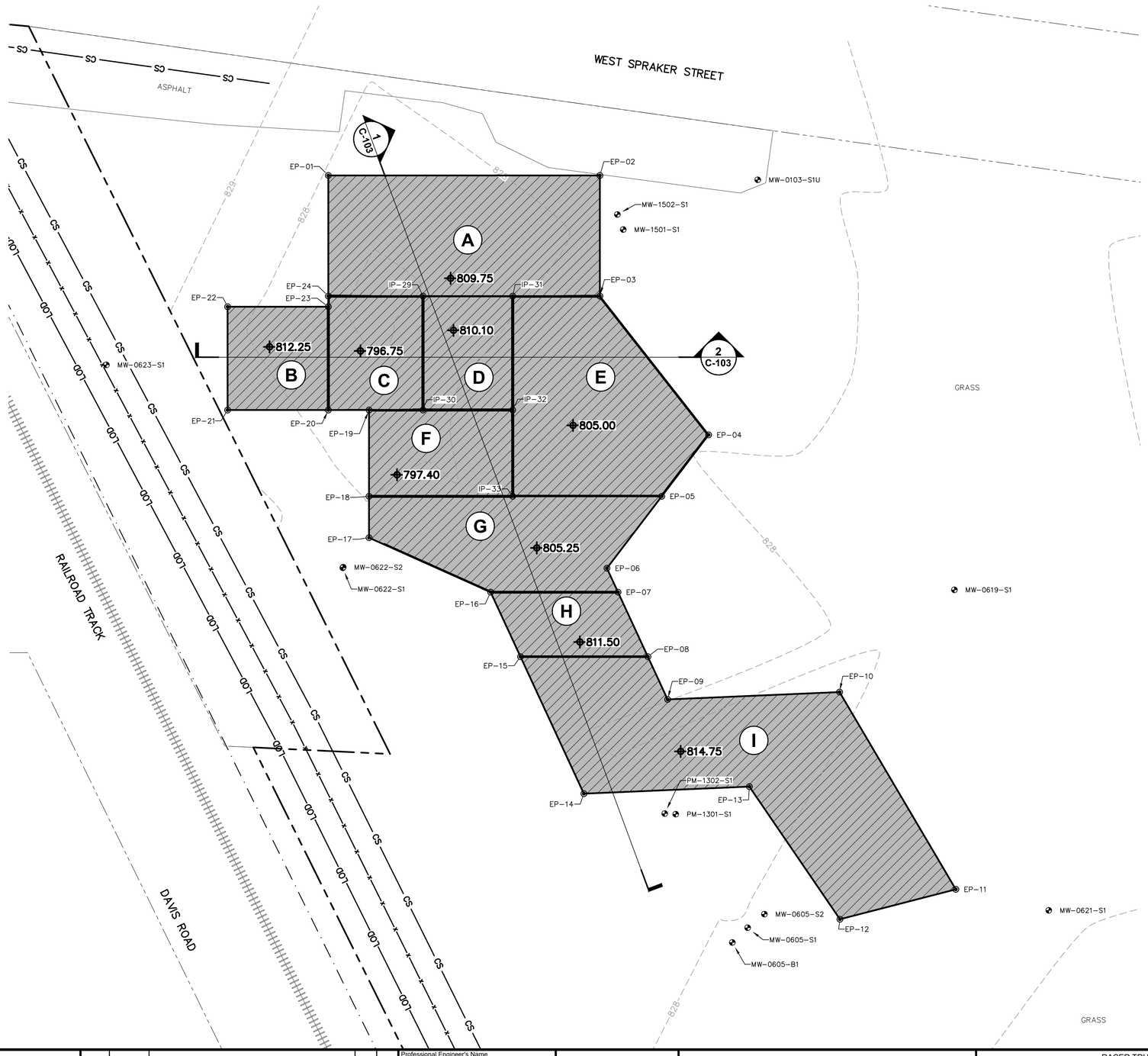
EXCAVATION PLAN - NORTH AREA

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-101



NOTES:

1. THE CONTRACTOR SHALL PROVIDE MIX MATERIALS (I.E., REAGENTS AND WATER) IN SUFFICIENT QUANTITIES TO ALLOW FOR UNINTERRUPTED ISS ACTIVITIES BASED ON THE PRODUCTION RATE AS DETERMINED BY THE CONTRACTOR.
2. THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF ISS. VOLUMES PROVIDED HEREIN ARE NEAT IN-PLACE VOLUMES AND DO NOT ACCOUNT FOR OVERLAPPING CELLS/COLUMN.
3. ZVI SHALL BE ADDED AT 1% BY DRY WEIGHT VIA A BENTONITE SLURRY MIXTURE. THE WATER TO BE ADDED TO THE BASELINE COMPOSITE SLURRY MIXTURE SHALL BE 0.9 WATER TO BINDER RATIO. IF THE CONTRACTOR PROPOSES WATER TO BINDER RATIOS OTHER THAN 0.9 THE CONTRACTOR MUST SUBMIT A REQUEST TO THE ENGINEER FOR APPROVAL TO ALTER THE SLURRY MIXTURE WATER QUANTITIES.
4. MIXING WITH STEP 2 – PORTLAND CEMENT MIXING WILL NOT BE PERMITTED FOR A MINIMUM PERIOD OF 28 DAYS FOLLOWING COMPLETION OF STEP 1 –ZVI MIXING FOR A GIVEN CELL/COLUMN.
5. PORTLAND CEMENT (PC) AT 5% BY DRY WEIGHT.
6. UCS OF THE TREATED SOIL MATRIX MUST BE GREATER THAN OR EQUAL TO 20 POUNDS PER SQUARE INCH (PSI), MEASURED AT 14 DAYS AND THE UCS OF THE TREATED SOIL MATRIX MUST BE GREATER THAN OR EQUAL TO 50 POUNDS PER SQUARE INCH (PSI), MEASURED AT 28 DAYS OR SOONER (UNLESS OTHERWISE DIRECTED BY THE ENGINEER), AFTER 28 DAYS WITH NO MORE THAN 20 PERCENT OF THE PERFORMANCE SAMPLES LESS THAN 50 PSI, AND NO SAMPLES LESS THAN 30 PSI.

CELL ID	AREA (SQ. FT.)	MINIMUM ISS TARGET ELEVATION	ANTICIPATED ISS VOLUME (CU. YD.)
A	3921	809.75	1386
B	1245	812.25	328
C	1290	796.75	1039
D	1222	810.10	419
E	3619	805.00	1654
F	1484	797.40	1200
G	2584	805.25	1164
H	984	811.50	364
I	6005	814.75	1545

CONTROL POINT	NORTHING	EASTING
EP-01	1914323.80	197766.31
EP-02	1914323.80	197860.27
EP-03	1914282.07	197860.27
EP-04	1914234.09	197897.89
EP-05	1914212.83	197881.68
EP-06	1914187.97	197862.71
EP-07	1914179.68	197866.55
EP-08	1914157.35	197876.88
EP-09	1914142.57	197883.72
EP-10	1914145.12	197943.21
EP-11	1914076.88	197983.44
EP-12	1914066.54	197943.34
EP-13	1914112.43	197911.99
EP-14	1914109.97	197854.73
EP-15	1914157.35	197832.80
EP-16	1914179.68	197822.47
EP-17	1914198.52	197780.39
EP-18	1914212.83	197780.39
EP-19	1914242.68	197780.39
EP-20	1914242.68	197766.31
EP-21	1914242.68	197731.45
EP-22	1914278.40	197731.45
EP-23	1914278.40	197766.31
EP-24	1914282.07	197766.31
IP-29	1914282.07	197799.06
IP-30	1914242.68	197799.06
IP-31	1914282.07	197830.09
IP-32	1914242.68	197830.09
IP-33	1914212.83	197830.09

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ISS-DESIGN-X-TITLE
ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-PROPOSED
ISS-DESIGN-X-PROPOSED-PATT
ISS-DESIGN-X-SESC

1"=20' 20' 0 20' 40'
SCALE(S) AS INDICATED

THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING:
USE TO VERIFY FIGURE REPRODUCTION SCALE

No.	Date	Revisions	By	Ckd.

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Professional Engineer's Name: .
Professional Engineer's No.: .

State	Date Signed	Project Mgr.
IN		.
Designed by .	Drawn by GS	Checked by .

DRAFT
NOT FOR CONSTRUCTION

ARCADIS
ARCADIS U.S., INC.

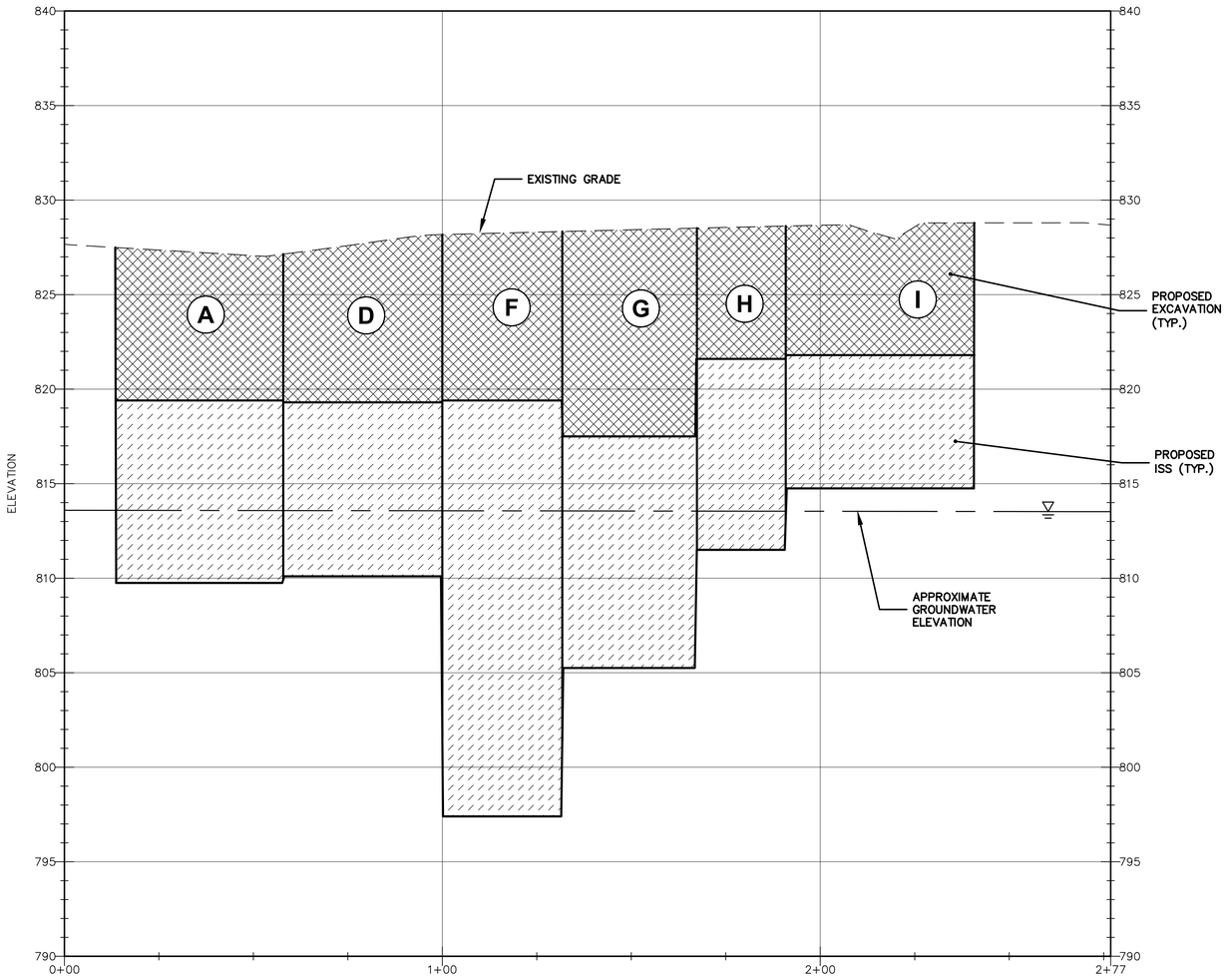
RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

ISS PLAN - NORTH AREA

ARCADIS Project No. 30075940
Date OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-102



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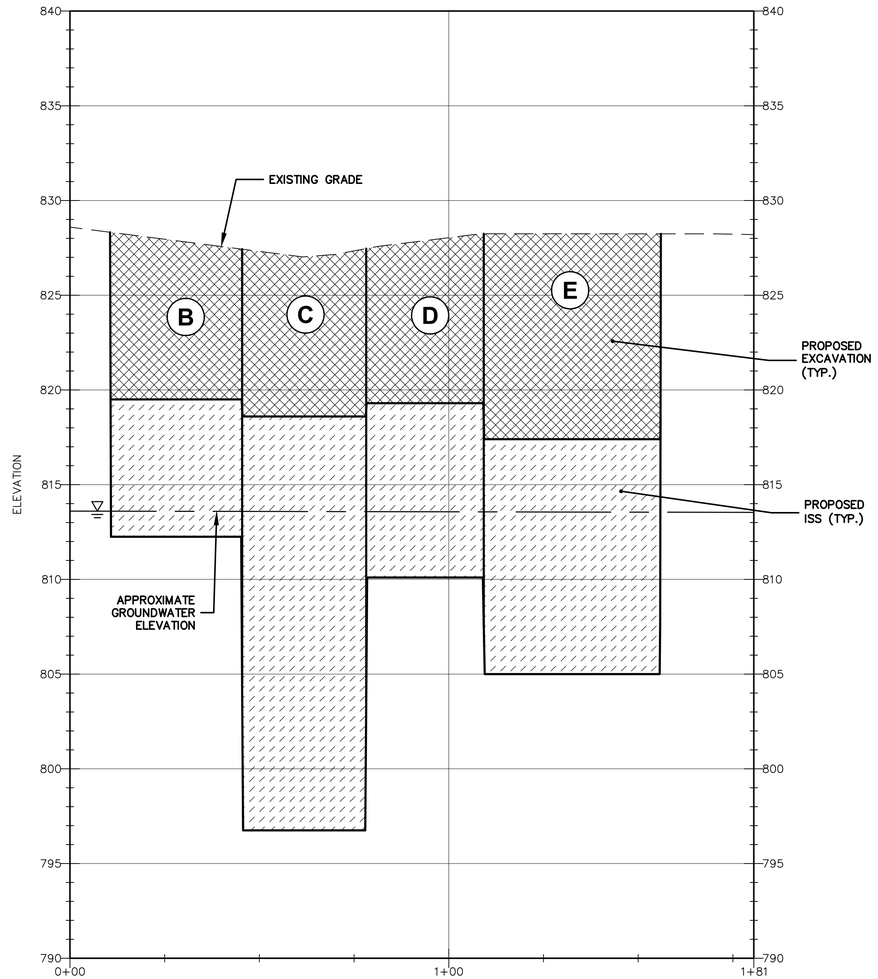
VERTICAL SCALE: 1"=4' (0, 4', 8')



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VERTICAL SCALE: 1"=4' (0, 4', 8')

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ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-PROPOSED
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Professional Engineer's No.: .

State	Date Signed	Project Mgr.
IN		.
Designed by	Drawn by	Checked by
.	GS	.

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

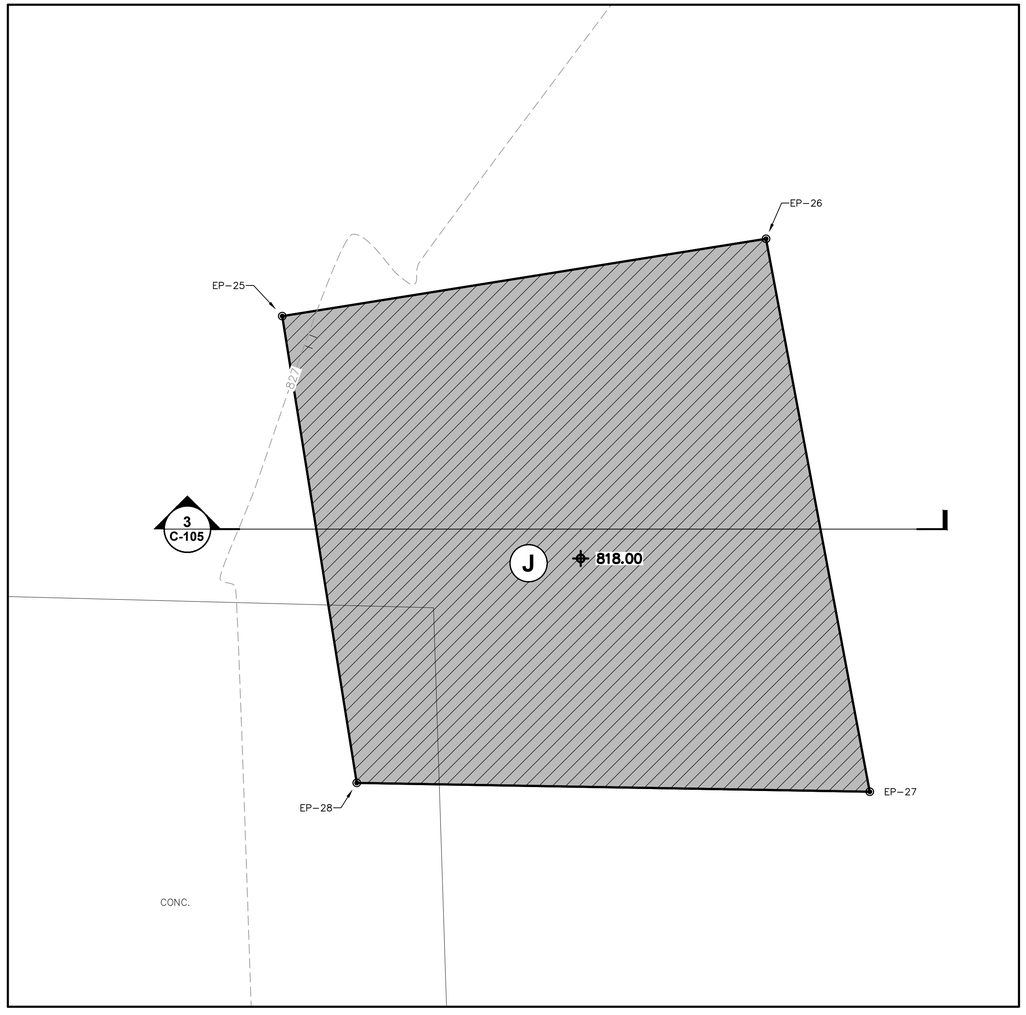
REMEDIATION CROSS-SECTIONS - NORTH AREA

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-103

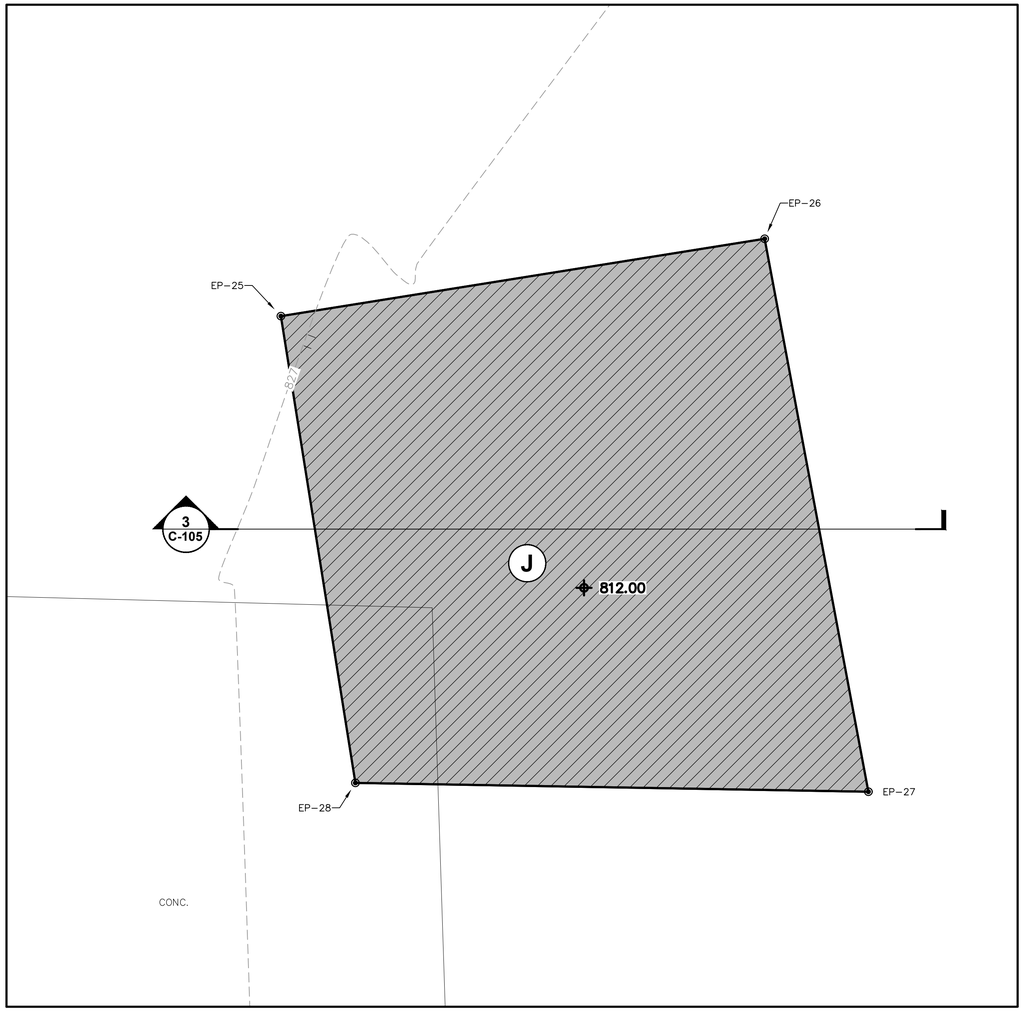


EXCAVATION PLAN

NOTES:

1. CONTRACTOR SHALL DETERMINE THE OPTIMAL SIZE OF THE TEMPORARY STOCKPILE AREA AND BATCH PLANT AND REAGENT STORAGE AREA TO ACCOMMODATE CONTRACTOR'S EXECUTION, OVERALL SITE LOGISTICS AND WORK SEQUENCING.
2. THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF THE EXCAVATION. VOLUMES PROVIDED HEREIN ARE NEAT IN–PLACE VOLUMES AND DO NOT ACCOUNT FOR SLOPING OR OVERLAPPING CELLS/COLUMN.
3. CONTRACTOR SHOULD BE PREPARED TO ENCOUNTER CONSTRUCTION DEBRIS AND ABANDONED MONITORING WELLS WITHIN THE LIMITS OF EXCAVATION. CONTRACTOR SHALL SORT, SIZE AND SEGREGATE CONSTRUCTION DEBRIS FOR STAGING IN A ROLL–OFF OR WITHIN THE TEMPORARY STOCKPILE AREA FOR CHARACTERIZATION AND OFF–SITE DISPOSAL
4. DEWATERING IS NOT ANTICIPATED; HOWEVER, THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF CONSTRUCTION DEWATERING TO FACILITATE EXCAVATION. . WATER SHALL BE STORED ONSITE IN APPROVED CONTAINERS WITH SECONDARY CONTAINMENT FOR ONSITE REUSE OR CHARACTERIZATION AND OFFSITE DISPOSAL.
5. AIR MONITORING SHALL BE IMPLEMENTED WHENEVER INTRUSIVE ACTIVITIES ARE BEING CONDUCTED. CONTRACTOR IS RESPONSIBLE FOR WORK ZONE MONITORING AND ENGINEER WILL MONITOR THE AMBIENT AIR AT THE LIMIT OF DISTURBANCE. CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING DUST AND ODOR CONTROLS WHEN TOTAL SUSPENDED PARTICLES OR VOLATILE ORGANIC COMPOUNDS EXCEED ACTION LEVELS.

CELL ID	AREA (SQ. FT.)	MINIMUM EXCAVATION ELEVATION	IN–PLACE EXCAVATION VOLUME (CU. YD.)
J	4479	818.00	1444



ISS PLAN

NOTES:

1. THE CONTRACTOR SHALL PROVIDE MIX MATERIALS (I.E., REAGENTS AND WATER) IN SUFFICIENT QUANTITIES TO ALLOW FOR UNINTERRUPTED ISS ACTIVITIES BASED ON THE PRODUCTION RATE AS DETERMINED BY THE CONTRACTOR.
2. THE CONTRACTOR IS RESPONSIBLE FOR THE MEANS AND METHODS FOR IMPLEMENTATION OF ISS. VOLUMES PROVIDED HEREIN ARE NEAT IN–PLACE VOLUMES AND DO NOT ACCOUNT FOR OVERLAPPING CELLS/COLUMN.
3. ZVI SHALL BE ADDED AT 1% BY DRY WEIGHT VIA A BENTONITE SLURRY MIXTURE. THE WATER TO BE ADDED TO THE BASELINE COMPOSITE SLURRY MIXTURE SHALL BE 0.9 WATER TO BINDER RATIO. IF THE CONTRACTOR PROPOSES WATER TO BINDER RATIOS OTHER THAN 0.9 THE CONTRACTOR MUST SUBMIT A REQUEST TO THE ENGINEER FOR APPROVAL TO ALTER THE SLURRY MIXTURE WATER QUANTITIES.
4. MIXING WITH STEP 2 – PORTLAND CEMENT MIXING WILL NOT BE PERMITTED FOR A MINIMUM PERIOD OF 28 DAYS FOLLOWING COMPLETION OF STEP 1 –ZVI MIXING FOR A GIVEN CELL/COLUMN.
5. PORTLAND CEMENT AT 5% BY DRY WEIGHT.
6. UCS OF THE TREATED SOIL MATRIX MUST BE GREATER THAN OR EQUAL TO 20 POUNDS PER SQUARE INCH (PSI), MEASURED AT 14 DAYS AND THE UCS OF THE TREATED SOIL MATRIX MUST BE GREATER THAN OR EQUAL TO 50 POUNDS PER SQUARE INCH (PSI), MEASURED AT 28 DAYS OR SOONER (UNLESS OTHERWISE DIRECTED BY THE ENGINEER), AFTER 28 DAYS WITH NO MORE THAN 20 PERCENT OF THE PERFORMANCE SAMPLES LESS THAN 50 PSI, AND NO SAMPLES LESS THAN 30 PSI.

CELL ID	AREA (SQ. FT.)	MINIMUM ISS TARGET ELEVATION	ANTICIPATED ISS VOLUME (CU. YD.)
J	4479	812.00	980

CONTROL POINT	NORTHING	EASTING
EP–25	1913960.39	197937.32
EP–26	1913970.60	198001.16
EP–27	1913897.63	198014.85
EP–28	1913898.79	197947.15

10' 0 10' 20'
1"=10'
SCALE(S) AS INDICATED

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Professional Engineer's Name: .
Professional Engineer's No.: .

State	Date Signed	Project Mgr.
IN		.
Designed by .	Drawn by GS	Checked by .

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ARCADIS
ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

EXCAVATION AND ISS PLAN - SOUTH AREA

ARCADIS Project No. 30075940
Date OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-104

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ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-PROPOSED
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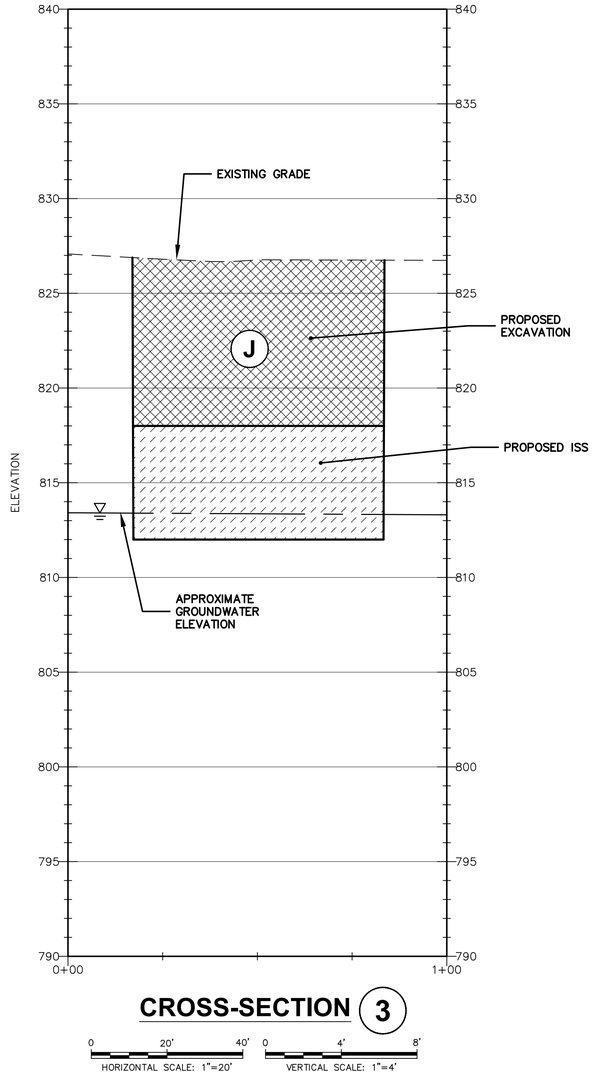

CROSS-SECTION 3

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VERTICAL SCALE: 1"=4' (0, 4', 8')

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ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-PROPOSED
ISS-DESIGN-X-PROPOSED-PATT

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Professional Engineer's Name: .		
Professional Engineer's No.: .		
State: IN	Date Signed:	Project Mgr.: .
Designed by: .	Drawn by: GS	Checked by: .

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

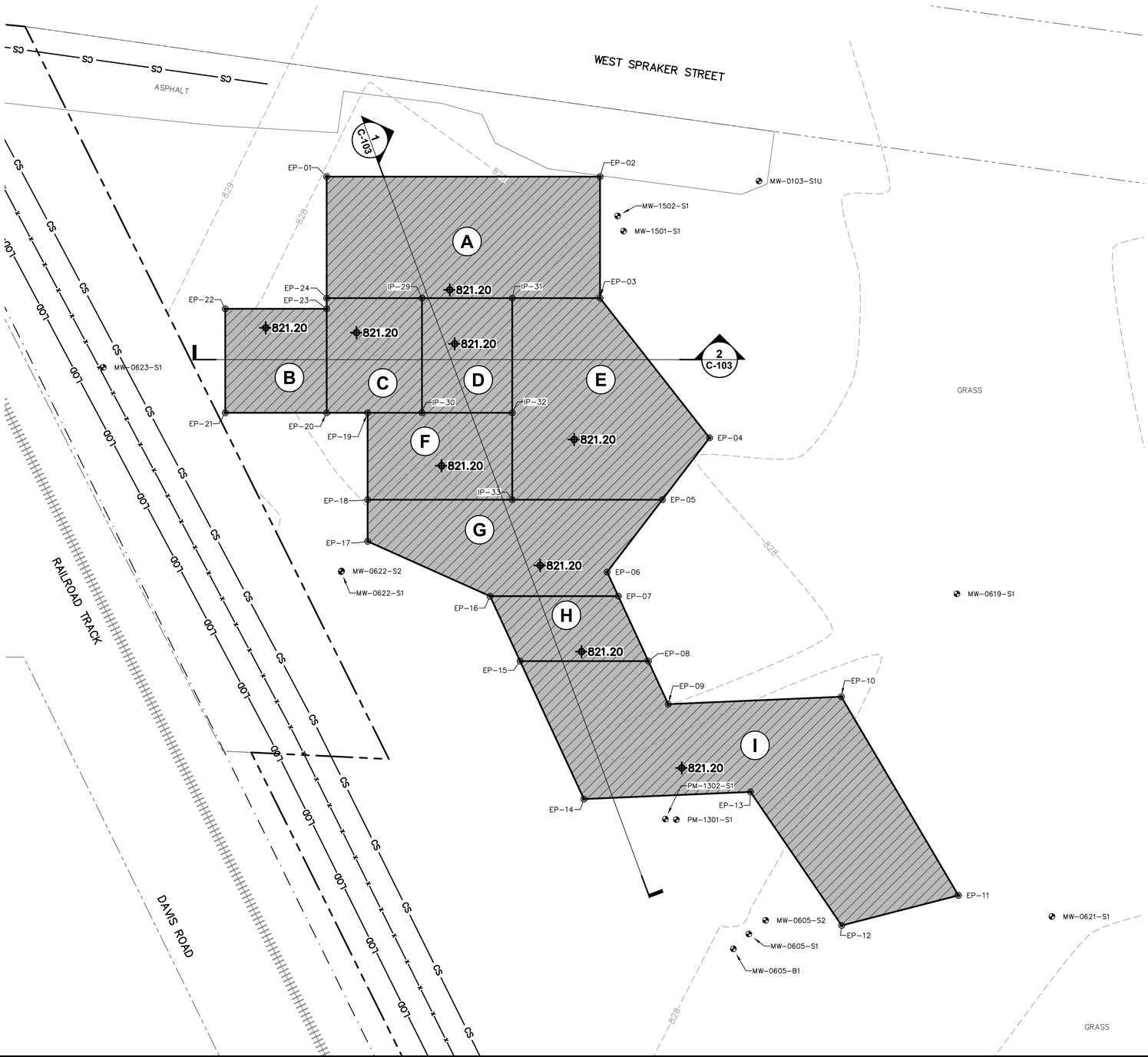
REMEDIATION CROSS-SECTIONS - SOUTH AREA

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-105



NOTES:

1. DURING STEP 2 – PORTLAND CEMENT MIXING, BULKING MAY RESULT IN FINAL ELEVATIONS ABOVE EXISTING GROUND SURFACE. CONTRACTOR SHALL MAKE EVERY EFFORT TO CONTAIN THE MATERIAL DURING MIXING AND RELOCATE THE MATERIAL PRIOR TO HARDENING TO AN ALREADY SOLIDIFIED AREA OF THE SITE WHERE ISS HAS BEEN COMPLETED.
2. MINIMAL REGRADING OF POST SOLIDIFIED MATERIAL, IF NECESSARY, WILL BE ALLOWED WITH ENGINEER'S APPROVAL.
3. ELEVATIONS PRESENTED HEREIN ARE BASED ON EXISTING KNOWLEDGE OF THE ISS TREATMENT ZONE AND WILL BE ADJUSTED BY THE CONTRACTOR IN COORDINATION WITH THE ENGINEER PRIOR TO AND DURING IMPLEMENTATION OF ISS.

CELL ID	AREA (SQ. FT.)	ISS SUBGRADE TARGET ELEVATION
A	3921	821.20
B	1245	821.20
C	1290	821.20
D	1222	821.20
E	3619	821.20
F	1484	821.20
G	2584	821.20
H	984	821.20
I	6005	821.20

CONTROL POINT	NORTHING	EASTING
EP-01	1914323.80	197766.31
EP-02	1914323.80	197860.27
EP-03	1914282.07	197860.27
EP-04	1914234.09	197897.89
EP-05	1914212.83	197881.68
EP-06	1914187.97	197862.71
EP-07	1914179.68	197866.55
EP-08	1914157.35	197876.88
EP-09	1914142.57	197883.72
EP-10	1914145.12	197943.21
EP-11	1914076.88	197983.44
EP-12	1914066.54	197943.34
EP-13	1914112.43	197911.99
EP-14	1914109.97	197854.73
EP-15	1914157.35	197832.80
EP-16	1914179.68	197822.47
EP-17	1914198.52	197780.39
EP-18	1914212.83	197780.39
EP-19	1914242.68	197780.39
EP-20	1914242.68	197766.31
EP-21	1914242.68	197731.45
EP-22	1914278.40	197731.45
EP-23	1914278.40	197766.31
EP-24	1914282.07	197766.31
IP-29	1914282.07	197799.06
IP-30	1914242.68	197799.06
IP-31	1914282.07	197830.09
IP-32	1914242.68	197830.09
IP-33	1914212.83	197830.09

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ISS-DESIGN-X-PROPOSED
ISS-DESIGN-X-SESC
ISS-DESIGN-X-PROPOSED-PATT

20' 0 20' 40'
1"=20'
SCALE(S) AS INDICATED

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Professional Engineer's Name
.
Professional Engineer's No.
.

State	Date Signed	Project Mgr.
IN		.
Designed by	Drawn by	Checked by
.	GS	.

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

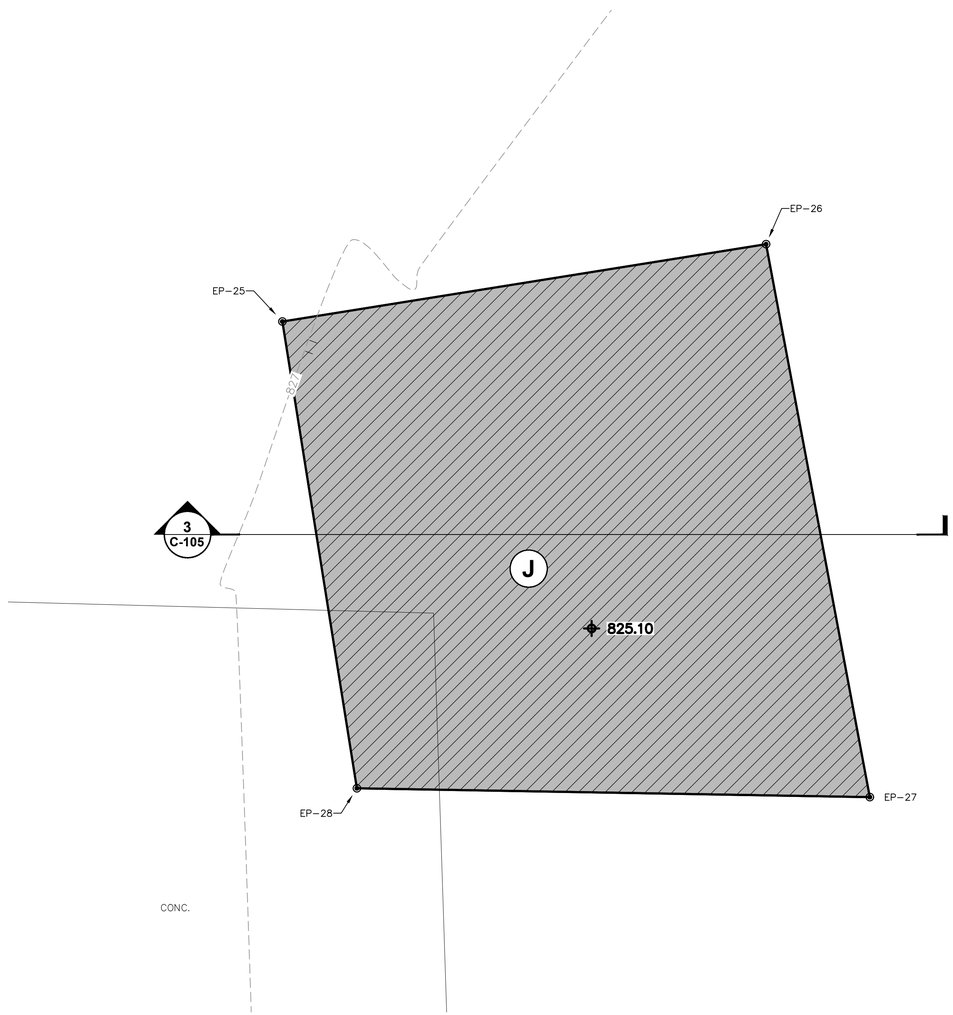
ISS SUBGRADE PLAN - NORTH AREA

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-106



NOTES:

1. DURING STEP 2 – PORTLAND CEMENT MIXING, BULKING MAY RESULT IN FINAL ELEVATIONS ABOVE EXISTING GROUND SURFACE. CONTRACTOR SHALL MAKE EVERY EFFORT TO CONTAIN THE MATERIAL DURING MIXING AND RELOCATE THE MATERIAL PRIOR TO HARDENING TO AN ALREADY SOLIDIFIED AREA OF THE SITE WHERE ISS HAS BEEN COMPLETED.
2. MINIMAL REGRADING OF POST SOLIDIFIED MATERIAL, IF NECESSARY, WILL BE ALLOWED WITH ENGINEER'S APPROVAL.
3. ELEVATIONS PRESENTED HEREIN ARE BASED ON EXISTING KNOWLEDGE OF THE ISS TREATMENT ZONE AND WILL BE ADJUSTED BY THE CONTRACTOR IN COORDINATION WITH THE ENGINEER PRIOR TO AND DURING IMPLEMENTATION OF ISS.

CELL ID	AREA (SQ. FT.)	ISS SUBGRADE TARGET ELEVATION
J	4479	825.10

CONTROL POINT	NORTHING	EASTING
EP-25	1913960.39	197937.32
EP-26	1913970.60	198001.16
EP-27	1913897.63	198014.85
EP-28	1913898.79	197947.15

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ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-PROPOSED
ISS-DESIGN-X-SESC
ISS-DESIGN-X-PROPOSED-PATT

1"=10' 10' 0 10' 20'
SCALE(S) AS INDICATED

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Professional Engineer's No.:

State	Date Signed	Project Mgr.
IN		.
Designed by	Drawn by	Checked by
.	GS	.

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

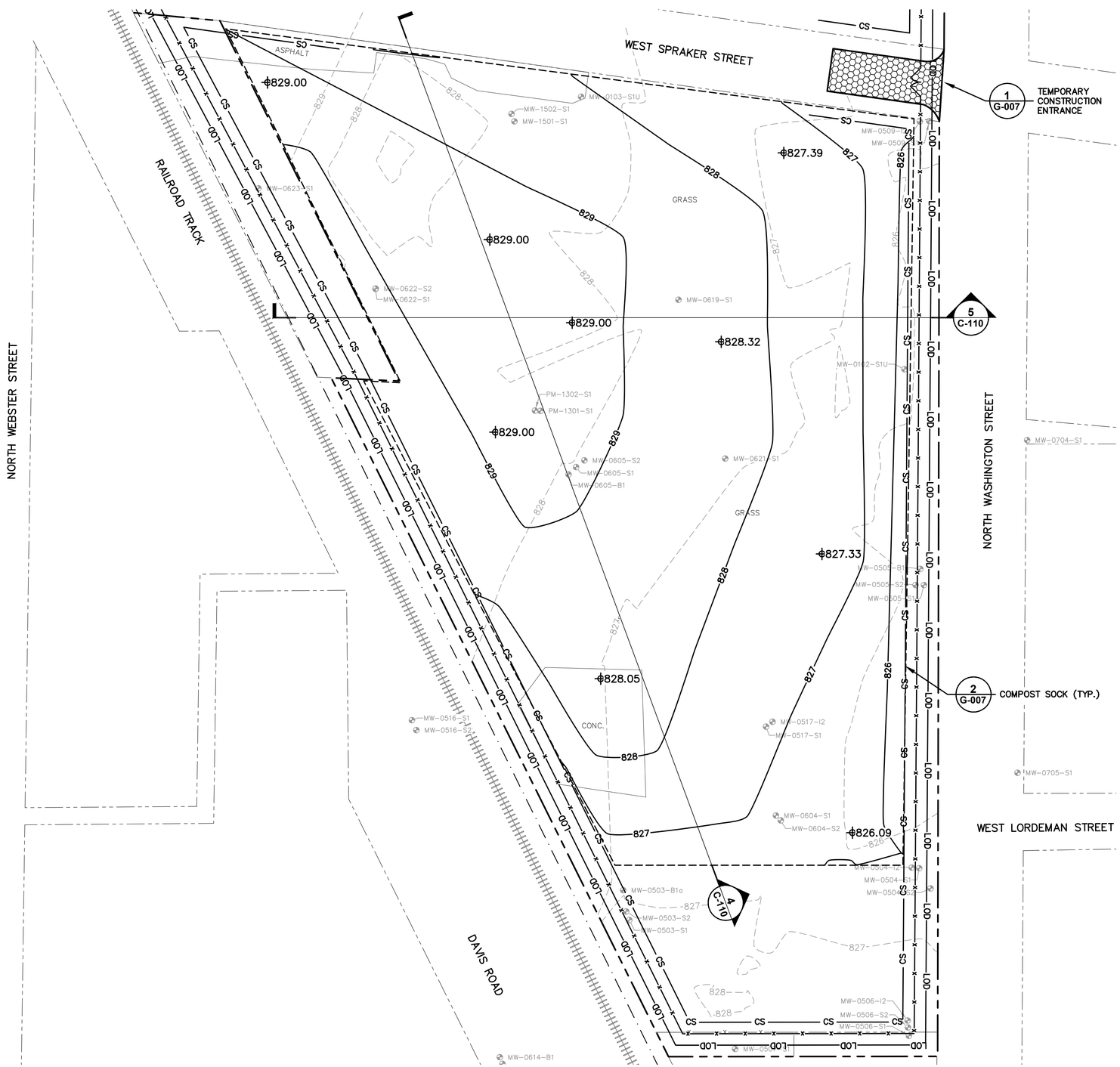
ISS SUBGRADE PLAN - SOUTH AREA

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-107



LEGEND:

- PROPERTY BOUNDARY
- ADJOINING PARCEL BOUNDARY
- EXISTING CONTOUR
- LIMIT OF DISTURBANCE
- PROPOSED TEMPORARY FENCE
- PROPOSED GATE
- PROPOSED COMPOST SOCK
- TEMPORARY CONSTRUCTION ENTRANCE
- PROPOSED CONTOUR
- PROPOSED GRADE BREAK
- EXISTING MONITORING WELL
- EXISTING RAILROAD TRACK
- RAILROAD TRACK – THEORETICAL EMBANKMENT LIMIT

NOTES:

1. PLACEMENT OF OVERBURDEN WITHIN THE ISS AREA WILL NOT BE PERMITTED FOR A MINIMUM PERIOD OF 7 DAYS FOLLOWING THE COMPLETION OF STEP 2 –PC MIXING AND RECEIPT OF APPROVED PERFORMANCE RESULTS FROM FIELD QUALITY ASSURANCE/QUALITY CONTROL TESTING PROGRAM INDICATING ISS HAS ACHIEVED THE REQUIRED DESIGN STRENGTH.
2. A DEMARCATION LAYER SHALL BE PLACED OVER THE ISS AREA TO PROVIDE DEMARCATION BETWEEN THE OVERBURDEN MATERIALS AND TREATED SOILS.
3. OVERBURDEN MATERIALS WILL BE SAMPLED TO VERIFY THAT THE MATERIALS MEET A TRICHLOROETHENE (TCE) CONCENTRATION OF LESS THAN 100 PARTS PER MILLION (PPM) TO BE USED AS BACKFILL.
4. OVERBURDEN MATERIALS WILL BE SAMPLED TO DETERMINE MODIFIED PROCTOR IN ACCORDANCE WITH ASTM INTERNATIONAL D–1557. A MINIMUM OF TWO SAMPLES WILL BE COLLECTED FROM THE TEMPORARY STOCKPILE AREA FOLLOWING EXCAVATION.
5. ELEVATIONS PRESENTED HEREIN ARE BASED ON EXISTING KNOWLEDGE OF THE ISS TREATMENT ZONE AND WILL BE ADJUSTED BY THE CONTRACTOR IN COORDINATION WITH THE ENGINEER PRIOR TO AND DURING IMPLEMENTATION OF ISS.

XREFS: IMAGES: PROJECTNAME: ----
ISS-DESIGN-X-TITLE
ISS-DESIGN-X-BASEMAP
ISS-DESIGN-X-SESC
ISS-DESIGN-X-PROPOSED

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1"=40' — 40' 0 40' 80'
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Professional Engineer's No.: .

State	Date Signed	Project Mgr.
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Designed by	Drawn by	Checked by
	GS	.

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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

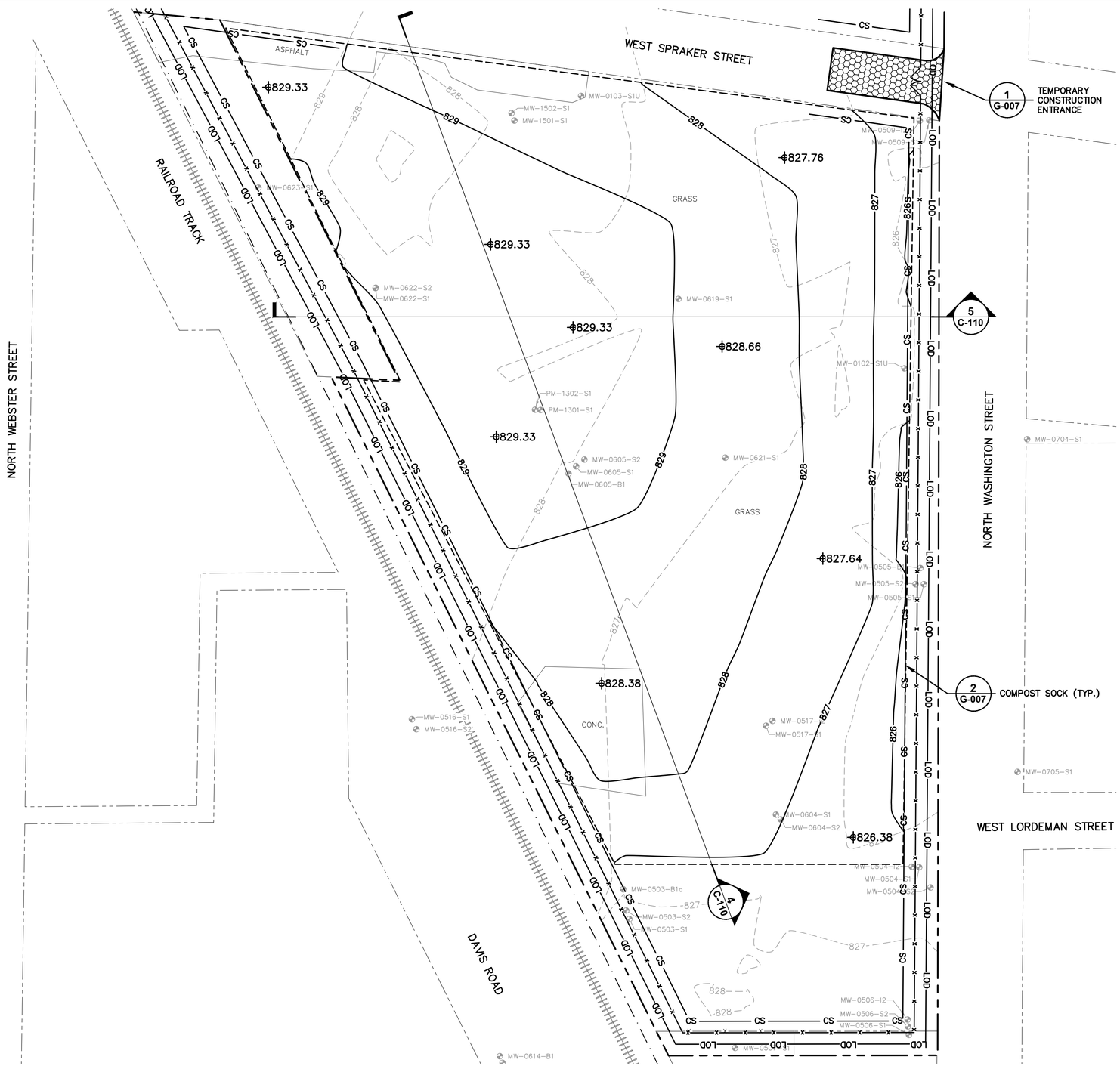
OVERBURDEN SUBGRADE PLAN

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
Indianapolis IN, 46204
Tel: 317-231-6500

C-108



LEGEND:

- PROPERTY BOUNDARY
- ADJOINING PARCEL BOUNDARY
- 828 EXISTING CONTOUR
- LOD LIMIT OF DISTURBANCE
- PROPOSED TEMPORARY FENCE
- PROPOSED GATE
- CS PROPOSED COMPOST SOCK
- TEMPORARY CONSTRUCTION ENTRANCE
- 828 PROPOSED CONTOUR
- PROPOSED GRADE BREAK
- EXISTING MONITORING WELL
- EXISTING RAILROAD TRACK
- RAILROAD TRACK – THEORETICAL EMBANKMENT LIMIT

NOTES:

1. FINAL RESTORATION WILL CONSIST OF A 4–INCHES OF TOPSOIL. TOPSOIL SHALL BE A LOCALLY AVAILABLE.
2. AT LEAST TWO REPRESENTATIVE SAMPLES SHALL BE SENT TO AN APPROVED LABORATORY FOR PHYSICAL, FERTILITY AND ANALYTICAL TESTING OF TOPSOIL.
3. SEED MIXTURE SHALL BE A 4–WAY BLEND OF TURF TYPE TALL FESCUE, 50 LB/AC CREEPING RED FESCUE, 45 LB/AC PERENNIAL RYEGRASS AND 5 LB/AC WHITE DUTCH CLOVER. THIS SEED MIXTURE SHALL BE APPLIED AT THE RATE OF 200 LB/AC CONSISTING OF 100 LB/AC.
4. MULCH SHALL BE PROCURED AND APPLIED IN ACCORDANCE WITH SECTION 621 –SEEDING AND SODDING.
5. ELEVATIONS PRESENTED HEREIN ARE BASED ON EXISTING KNOWLEDGE OF THE ISS TREATMENT ZONE AND WILL BE ADJUSTED BY THE CONTRACTOR IN COORDINATION WITH THE ENGINEER PRIOR TO AND DURING IMPLEMENTATION OF ISS.

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ISS-DESIGN-X-SESC
ISS-DESIGN-X-PROPOSED

1"=40' SCALE(S) AS INDICATED (40' 0 40' 80')

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Professional Engineer's No.		
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State	Date Signed	Project Mgr.
IN		.
Designed by	Drawn by	Checked by
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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

FINAL GRADING PLAN

ARCADIS Project No. 30075940
Date OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
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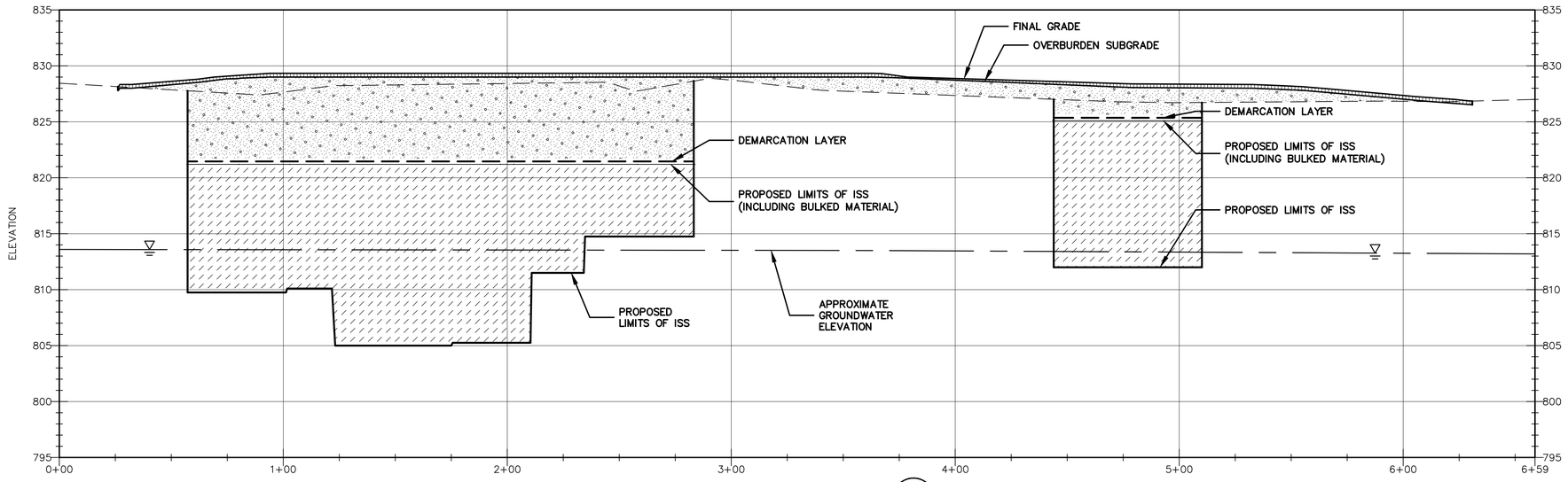
Tel: 317-231-6500

C-109



CROSS-SECTION 4

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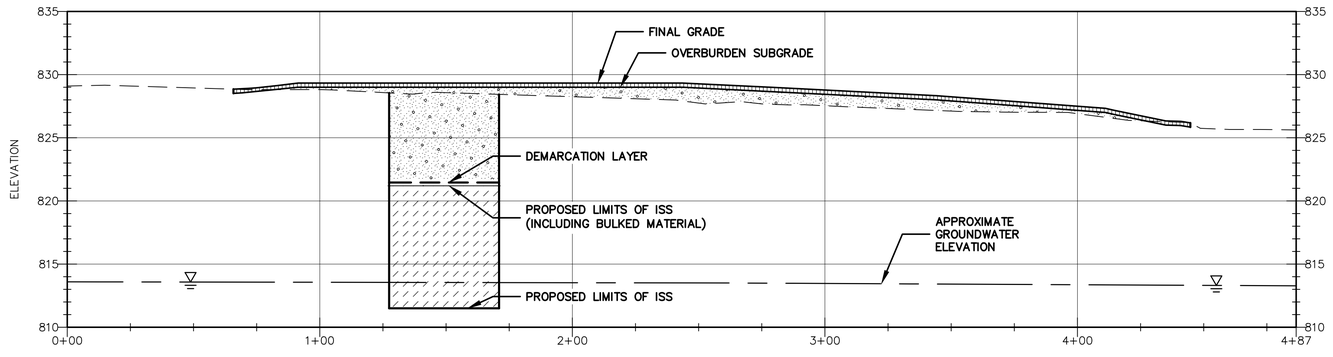
0 6' 12' VERTICAL SCALE: 1"=6'



CROSS-SECTION 5

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SCALE(S) AS INDICATED

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State	Date Signed	Project Mgr.
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ARCADIS U.S., INC.

RACER TRUST • FORMER GM DELCO PLANT 5, KOKOMO INDIANA
PROPOSED REMEDIAL ACTION

RESTORATION CROSS-SECTIONS

ARCADIS Project No.
30075940

Date
OCTOBER 2021

ARCADIS
150 W. Market Street, Suite 728
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Appendix B

Ambient Air Monitoring Plan (AAMP)

RACER Trust

Ambient Air Monitoring Plan

Former GM Delco Plant 5, Kokomo, Indiana

January 10, 2022
Updated July 11, 2022

Ambient Air Monitoring Plan

Former GM Delco Plan 5, Kokomo, Indiana

January 10, 2022
Updated July 11, 2022

Prepared By:
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Our Ref:
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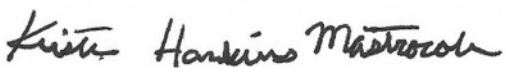

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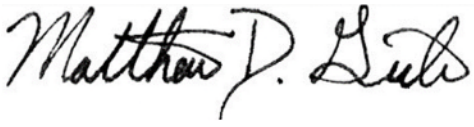

Matthew Griles
Senior Geologist, PG-IN#2398

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Acronyms and Abbreviations

AAMP	Ambient Air Monitoring Plan
ANSI	American National Standards Institute
CMI WP	Corrective Measures Implementation Work Plan
COC	Chemical of Concern
GC	Gas Chromatograph
GM	General Motors
HASP	Health and Safety Plan
ISS	In situ solidification
MMS	Meteorological Monitoring Station
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Levels
PM_{10}	Particulate Matter 10 Micrometers
PID	Photo-ionization detector
QA/QC	Quality Assurance/Quality Control
TCE	Trichloroethene
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds

1 Introduction

Arcadis U.S., Inc (Arcadis) has prepared this Ambient Air Monitoring Plan (AAMP) as a component to the Resource Conservation and Recovery Act (RCRA) Corrective Measures Implementation (CMI) Work Plan (CMI Work Plan) on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust for the former General Motors (GM) Delco Plant 5 site located at 1723 North Washington Street, Kokomo, Indiana (the site; **Figure 1**).

As part of the RCRA Correction Action process, United States Environmental Protection Agency (USEPA) issued a Final Decision and Response to Comments (Final Decision, USEPA 2021) outlining the final corrective measures for the site: In-Situ Solidification and Stabilization (ISS) with Monitored Natural Attenuation (MNA) for Groundwater and Soil, Institutional Controls, and Long-Term Care/Stewardship. As part of the ISS scope of work, USEPA has requested RACER Trust implement an ambient air monitoring program:

- "During the cleanup at the Former GM site, an ambient air monitoring program will be required as part of the EPA approved Corrective Measures Implementation (CMI) Plan. The plan will describe how the air monitoring will take place and must include a contingency plan in the event air quality is being adversely impacted."
- "While the cleanup is underway, RACER and USEPA will establish several lines of communication with the local residents, health department, City of Kokomo, and others to report on air testing results and other progress on the effort. Recognizing not everyone has access to the internet, reporting will include internet-based reporting, and "hard copy" and/or direct reporting, as needed, to keep stakeholders informed."

Corrective measures at the site will involve site preparation, material handling and waste management and site restoration. These corrective measures have the potential to generate dust and fugitive emissions (volatile organic compounds [VOCs], specifically chlorinated VOCs [CVOCs]). This AAMP is designed to minimize the potential impact of these emissions to human health and the environment, with a particular emphasis on the health of site workers and residents.

Air monitoring will be performed during the corrective measure when impacted soils are being disturbed (i.e., removing concrete, sheet pile, or excavation and/or mixing of impacted soils). Monitoring will be performed by using portable direct-reading instruments and by collecting ambient air samples for laboratory analysis. The purpose of the AAMP is to measure airborne concentrations of chemicals of concern (COCs) and particulate emissions and identify if measured concentrations are in excess of applicable action levels.

2 Dust and Odor Control and Mitigation

Corrective measures to be performed at the site have the potential to generate localized impacts to air quality. Remedial components that have the potential to generate air emissions include, but may not be limited to, the following:

- Mobilization and site preparation
- Material handling and waste management
- Site restoration

Emissions resulting from these activities will be controlled using a combination of the following:

- Barriers, wattles and fencing, typically installed at right angles to prevailing winds
- Tracking pads and tire wash stations
- Poly sheeting or equivalent (for covering material stockpiles)
- Speed limits
- Work practices such as limiting the height of backhoe buckets and the size of loads
- Water spray/mist for dust suppression
- Addition of proprietary additives to water spray based on specific dust sources (e.g., Super Tack®, Gorilla Snot®, and FlocLoc™
- High wind speed and wind direction notifications and restrictions of certain activities during high wind periods with consideration for wind direction

These mitigation techniques to prevent emissions will be proactively employed by the Contractor during the work to:

- Prevent exceedances of total VOCs and particulate matter (less than 10 microns [PM_{10}]) above levels specified in Section 4.
- Prevent exceedances of COCs above levels specified in Section 4 as evaluated with a portable gas chromatograph (GC) or a time-integrated air sample collected along site perimeters and analyzed by an off-site laboratory.

3 Air Monitoring Program

Based on the risk assessments completed as part of previous corrective action activities, the only COC in soil for this project is trichloroethene (TCE). Therefore, the target parameters to monitor during excavation, stockpiling, and in-situ mixing of soils include:

- PM_{10} (Real-time);
- Total VOCs (Real-time); and
- TCE (Real-time and laboratory)

Air monitoring will continue until such time that significant material handling and waste management are complete (i.e., solidification of impacted sub-surface soils). The frequency of air monitoring will be relative to the level of site work activities being conducted and may be adjusted as the work proceeds and in consideration of the monitoring results.

3.1 Air Monitoring Locations

The site is situated on a triangular shaped property with Washington Street running north-south on the east side of the property and Davis Road running northwest to southeast on the western side of the property. A railroad is situated between the site and Davis Road. The excavation will be completed in an open grassy area in the central portion of the site. North of the excavation area is a parking lot. No buildings or trees are present on the site. The surrounding property use is a mix of commercial and residential properties. All buildings in the immediate area of the site are single-story, single use buildings. Details on the adjacent receptors and approximate distances from the excavation are detailed in **Table 1** below:

Table 1. Air Monitoring Receptors

Location (with regards to site)	Receptor	Distance from Excavation (ft)
North	Residential Commercial	620 375
West	Residential Commercial	250 150
East	Residential Commercial	200 530
South	Residential	320

Five monitoring locations will be placed at the perimeter of the work zone to evaluate ambient air in the direction of potential receptors, as shown on **Figure 2**. The predominant wind direction for the site from the past four years is from the west/southwest during the months of April through October as depicted on the Wind Rose Plot presented on **Figure 3.** Wind direction during the project will be determined daily based on data from the on-site meteorological monitoring station as presented in Section 3.3. The five monitoring locations will ensure that the ambient air is monitored both upwind (north, west, and south) and downwind (northeast and southeast) of the excavation areas. Air monitoring locations may be adjusted based on daily activities. Air monitoring location changes (if required) will be documented in a field logbook and communicated in the weekly reports.

3.2 Baseline Ambient Air Monitoring

Prior to soil excavation, baseline ambient air conditions will be monitored along the perimeter of the site. Ambient air samples will be collected for real-time PM_{10} and total VOCs as well as a 24-hour sample for TCE from the five monitoring locations identified on **Figure 2** or as adjusted in the field based on the prevailing wind patterns and proximity to potential human receptors adjacent to the site.

- PM_{10} (Real-time) - Real-time monitoring for particulate matter will be collected continuously at each site perimeter monitoring location for the duration of a 10-hour baseline data collection period (reflective of a full work shift or workday). Monitoring will be performed using a calibrated, portable particulate monitor fitted with a 10.0-micron inlet and equipped with electronic data-logging capabilities to calculate a running 15-minute average.
- The monitor will be used to collect PM_{10} data. Monitoring data will be used to determine background ambient particulate levels.
- **Total VOCS (Real-time)** - Real-time monitoring for VOCs will be collected continuously at each site perimeter monitoring location for the duration of a 10-hour baseline data collection period (reflective of a typical work shift period). VOC monitoring will be performed using a calibrated PID or similar equipped with electronic data-logging capabilities to calculate a running 5-minute average and 8-hour time weighted average. Data will be reported as total VOCs.
- **TCE -** Ambient air samples will be collected at each site perimeter monitoring location using SUMMA® canisters, deployed for a 24-hour period. Samples will be analyzed by Pace Analytical for TCE via Method TO-15.

The results of the baseline phase will be used to confirm or adjust the site-specific action level to be implemented during remediation activities based on exposure limits.

3.3 Meteorological Data Monitoring

On-site measurement of meteorological data necessary for the interpretation of the air sampling results, plus quality assurance/quality control (QA/QC) analyses to ensure the accuracy, precision, and scientific defensibility of the data will also be performed during the baseline and remediation phase of work. Meteorological data will be continuously recorded from the beginning to the end of the sampling program using an on-site Davis Vantage Pro2™ meteorological monitoring station (MMS), or equivalent.

The MMS will be located in an area clear of buildings, trees, or other obstructions at a height of approximately 10 feet above ground surface. The following parameters will be recorded by the MMS: wind speed, wind direction, air temperature, relative humidity, barometric pressure, and precipitation. Meteorological data will be reviewed daily and downloaded weekly from the MMS station. Data will be reviewed for consistency and completeness. Wind direction will be recorded periodically (e.g., hourly aligned with a typical work shift) by the sampling technician in the field log concurrent with the ambient air monitoring program.

3.4 Remediation Phase Ambient Air Monitoring

During the remediation activities, the AAMP will be implemented to measure the concentrations of PM_{10} and VOCs at the fenceline of the site. Detected concentrations will be compared to air quality standards, background levels, and action levels developed during the baseline phase of the AAMP.

Air quality monitoring will be completed around the perimeter of the site to evaluate potential off-site and on-site worker exposures associated with concentrations of PM_{10} and VOCs. Perimeter air monitoring will be performed during site activities that disturb soil (i.e., removing concrete, sheet pile, or excavation and/or mixing of impacted soils). Air monitoring may be discontinued during periods of heavy precipitation that would otherwise result in unreliable data or damage to the monitoring equipment. As previously detailed, five ambient air monitoring locations will be established around the perimeter of the site, as illustrated on **Figure 2**.

3.4.1 Real-Time Air Monitoring

Real-time monitoring for PM_{10} and total VOCs will be performed continuously using field samplers at each perimeter monitoring location for the duration of each work shift. Periodic monitoring of TCE will be performed when the VOC measurements exceed the action levels or twice a day, at a minimum. Readings collected during the work shift from the PID and dust monitor will be documented in the field log by the sampling technician or saved in an electronic format from the datalogger.

- **PM_{10} -** Real-time monitoring for particulate matter will be collected continuously at each site perimeter monitoring location for the duration of work shift. The particulate monitor (DataRAM 4000, DustTrak DRX, or similar) will be fitted with a 10.0-micron inlet and equipped with electronic data-logging capabilities to calculate a running 15-minute average. PM_{10} readings will be compared to the action levels presented in **Table 2.** The monitors will be equipped with alarms set to activate if the project action levels presented in **Table 2** are exceeded.
- **Total VOCs -** Real-time monitoring for VOCs will be collected continuously at each site perimeter monitoring location for the duration of work shift (during intrusive and/or dust generating activities). The photoionization detector (PID; ppbRAE 3000, or similar) will be equipped with a 10.6 electron-volt lamp and electronic data-logging capabilities to calculate a running 5-minute average and 8-hour time weighted average. VOC results will be reported as total VOCs. VOC readings will be compared to the action levels presented in **Table 2.** The monitors will be equipped with alarms set to activate if the project action levels presented in **Table 2** are exceeded.
- **TCE** - To evaluate potential on-site worker exposure and off-site residential exposure to TCE (the COC for the site) a portable gas chromatograph (GC) (FROG-4000™ or VOCAM™ manufactured by Defiant, or comparable) will be used periodically to validate PID readings by measuring real-time TCE concentrations or to verify an exceedance of PID action levels. TCE results will be compared to the action levels presented in **Table 2**.

3.4.2 Quantitative Air Monitoring – Specific VOCs

Fenceline air samples will be collected daily for five days during the start of each new phase of remediation (excavation of overburden, mixing with ZVI, mixing with cement). Additionally, if the TCE measurement from the portable GC exceeds action levels, then perimeter air monitoring will be completed at the downwind perimeter locations. Samples will be collected using 6-Liter SUMMA® canisters equipped with 24-hour regulators. Once the collection period has ended, the SUMMA® canisters will be sealed and submitted to Pace Analytical for analysis of TCE by Method TO-15.

Perimeter ambient air results from the TO-15 analysis will initially be compared to fence line screening values listed in **Table 2**. These screening values, one for off-site residents and one for on-site remediation workers, are based on the USEPA Regional Screening Level with a $1x10^{-5}$ target risk and a non-cancer hazard quotient of 1, prorated for an exposure duration of four months, an exposure time of 10 hours per day and an exposure frequency of 5 days per week). After selection of the contractor and review of the contractors phasing, timeline, and safety measures, site-specific fence line action levels for TCE will be calculated and submitted to USEPA.

Risk estimates for off-site receptors will be calculated by summing the ratios of measured concentrations to the site-specific fence line screening values. Site action levels and responses will be reviewed and or modified as needed if the total hazard index estimates exceed 0.8 (total hazard index can be equal to or greater than 1; 0.8 provides an additional margin of safety).

3.4.3 Qualitative Air Monitoring

Qualitative monitoring refers to the recognition of air quality concerns based on observations and familiarity with site conditions. Qualitative monitoring includes visual observations, such as airborne dust. The objectives of qualitative air monitoring vary based on specific circumstances; however, anticipated concerns include migration of dust clouds, particularly when they have the potential to cross site boundaries.

The sampling technician will report incidents of visible dust at risk of reaching or passing the property boundaries to the contractor. Additionally, the sampling technician will notify the contractor of the presence of site-related air quality concerns such as odors.

4 Work Management Decision Criteria and Mitigation Actions

Results from the air quality monitoring will be used to determine when work activities must cease in the remediation area and mitigation procedures must be initiated to ensure the protection of potentially affected on-site workers as well as off-site receptors including residents and non-residential occupants of off-site buildings.

- **Decision Criteria for PM_{10} -** Particulate monitoring results will be compared to site action levels for PM_{10} (**Table 2**). Should the ambient air concentrations of PM_{10} at the fence line not exceed the criteria, assuming no dispersion, further modeling for the off-site resident exposure scenario may not be necessary. A dispersion factor from the site perimeter to downwind off-site locations may be applied to best represent potential off-site concentrations of PM_{10} and then compared to site action levels to assess the significance of dust migration off-site, should that occur during the remediation program.
- **Decision Criteria for VOCs -** PID monitoring results will be compared to the site action level for total VOCs (**Table 2**). If the action level for total VOCs is exceeded, TCE concentrations measured using the portable GC will be collected. If the TCE concentration is lower than the TCE action levels (background plus screening level, **Table 3** below), work will continue and TCE measurements will be collected on an hourly basis for the remainder of the day from that location. Note that the action levels will be updated based on plans submitted by the contractor identifying the phasing and timeline of the ISS work. If the TCE concentration measured using the portable GC is higher than any of the action levels, an air sample will be collected to obtain a laboratory analytical result. If the TO-15 concentrations are less than the fence line screening levels below, no additional evaluation is needed. If the TO-15 concentrations are greater than the fence line screening levels below, the TO-15 concentration will be modeled, along with information on wind direction and any dispersion that may affect the concentrations at off-site locations to determine the potential risk to the receptors.

Table 3. TCE Screening Levels

Exposure Scenario	TCE Fence Line Screening Level ($\mu g/m^3$)	TCE Fence Line Screening Level (ppbv)
off-site resident	2.24	0.4
on-site worker	9.42	1.75

Notes:

Perimeter Fence Line Screening values are calculated based on the USEPA Regional Screening Level for subchronic exposure with a $1x10^{-5}$ target risk and a non-cancer hazard quotient of 1. Site-specific values will be updated when contractor plans are reviewed which will identify the phasing and timeline of the ISS work.

ppbv: parts per billion by volume of air

$\mu g/m^3$: micrograms per cubic meter of air

4.1 Mitigation Measures

If one or more of the PM_{10} or TCE action criteria are exceeded during the remediation activities, the exceedance will be confirmed. If confirmed, the site manager will be notified, and mitigation measures will be implemented. Mitigation measures are presented in Section 2.

If the mitigation is not effective in achieving action criteria, work will be suspended, and the project team will be notified to discuss appropriate actions to mitigate potential exposures and reduce PM_{10} and/or TCE concentrations. Criteria for resuming work are presented in **Table 2** and will consider concentrations of PM_{10} measured using the particulate monitor and/or TCE measured using a portable GC.

4.2 Adaptive Air Monitoring Strategy

Based on the results of initial air monitoring, the frequency and scope of real-time and integrated analytical perimeter monitoring may be decreased to reflect increased understanding of possible air impacts of remedial operations. The plan described is protective of off-site residents under conservatively anticipated conditions.

Potential reductions in the frequency and scope of air monitoring will depend on reviews of initial real-time air monitoring data and knowledge of current and possible future site conditions. The USEPA Project Manager will be contacted and asked to approve any reductions to the frequency and scope of the air monitoring or sampling prior to implementing any changes. The Howard County Health Department will be made aware of any changes to the AAMP.

In some cases, air monitoring or air sampling may be modified for certain constituents of interest (such as VOCs), while other portions of the plan remain unchanged. In general, the decision to reduce the air monitoring/air sampling scope and frequency may depend on the following factors:

- Review of initial air monitoring/air sampling data during remediation activities
- Proximity of off-site receptors to various on-site sources to be monitored
- Changes in site activities
- Excavation progress towards soils with lower known VOC concentrations
- Change in ISS phase (from zero valent iron mixing to Portland cement mixing)
- Prevailing wind direction and wind speed
- Real-time monitoring equipment capabilities.

Other factors not listed above may also be considered in determining whether the air monitoring/air sampling frequency and scope can be decreased.

5 Quality Assurance and Quality Control

The purpose of data quality objectives is to establish a target level that can be measured against to assess whether data collected are of appropriate quality to produce documented, consistent, and technically defensible results. The quality of measurements made, and the data generated will be evaluated in terms of the following characteristics:

- Representativeness;
- Accuracy; and
- Completeness.

5.1 Representativeness

Measurements will be made so that analytical results are as representative as practical, given the field conditions. Proper documentation in the field will be used to assess whether protocols have been followed, and whether data integrity has been preserved. site locations are selected to be representative of the site perimeter based on the premise that the enforcement of air quality standards at the site perimeter are protective of off-site air quality regarding fugitive emissions from the site.

5.2 Accuracy

Measurements will be made so that analytical results are as representative as practical of actual conditions at the Site perimeters. Proper documentation will be prepared weekly in the field and will be used to assess whether protocols have been followed, and whether data integrity has been preserved.

5.3 Completeness

Completeness is a measure of the amount of valid data obtained compared to the amount that was specified to be obtained under normal conditions. Proper documentation will be prepared weekly in the field and document the number of samples collected.

6 Equipment Maintenance

Equipment maintenance in accordance with manufacturer recommendations will be paramount to ensuring data quality. Maintenance activities that occur daily are intended to be completed each day that site operations are underway, but not on weekends or holidays when the site is closed.

If an instrument is found to be inoperative or suspected of giving erroneous readings, the sampling technician must be responsible for immediately removing the instrument from service and obtaining a replacement unit. If the instrument is essential for safe operation during a specific activity, that activity must cease until an appropriate replacement unit is obtained. The sampling technician will be responsible for confirming that a replacement unit is obtained and/or repairs are initiated on the defective equipment.

6.1 Particulate Monitors

The particulate monitors will be inspected daily during work, and each day a zero check will be performed before any intrusive activities occur. Prior to re-zeroing the particulate monitor, it will be inspected for error messages. The air inlet will be inspected for apparent obstructions or contaminants such as spider webs, insect parts, water, and vegetative matter, and the enclosure will be inspected for the presence of water, dust, and debris. Any issues with the air inlet or enclosure such as those described above will be corrected promptly during or daily inspection before the instrument is re-zeroed.

Each particulate monitor will be identified by its serial number on the Weekly Air Monitoring Report. This record will include verification on the most recent calibration by a manufacturer's authorized service provider. Provisions will be made to ensure equipment service and calibrations are completed in a timely manner after replacement units are installed to prevent any lapse in coverage.

Additionally, any calibration, maintenance, or quality control inspections recommended by the manufacturer will be completed on a schedule compliant with manufacturer's recommendations.

6.2 Photoionization detectors (PID)

The PID monitors will be inspected daily during work, all direct-reading instrumentation calibrations should be conducted under the approximate environmental conditions that the instrument will be used. Instruments must be calibrated before and after use, noting the reading(s) and any adjustments that are necessary. The air inlet will be inspected for apparent obstructions or contaminants such as spider webs, insect parts, water, and vegetative matter. All air monitoring equipment calibrations, including the standard used for calibration, must be documented on a calibration log or in the field notebook.

Each PID will be identified by its serial number on the Weekly Air Monitoring Report. This record will include verification on the most recent calibration by a manufacturer's authorized service provider. All air-monitoring equipment will be maintained and calibrated in accordance with the specific manufacturer's procedures. Preventive maintenance and repairs will be conducted in accordance with the respective manufacturer's procedures. When applicable, only manufacturer-trained and/or authorized personnel will be allowed to perform instrument repairs or preventive maintenance.

6.3 Portable GC Monitor

The portable GC monitor (or equivalent) incorporates a micro preconcentrator, micro GC, and miniature PID with 10.6 electron-volt lamp. The portable GC will be calibrated by the manufacturer for the analysis of TCE with a minimum detection of 1 parts per billion volume (ppbv) or 5.37 micrograms per cubic meter ($\mu g/m^3$).

The portable GC monitor will be identified by its serial number on the Weekly Air Monitoring Report. This record will include verification on the most recent calibration by a manufacturer's authorized service provider. The portable GC monitor will be inspected daily during work activities. A blank sample will be run through the instrument at the beginning of each day, prior to remediation activities or after an elevated detection is observed. The air inlet will be inspected for apparent obstructions or contaminants such as spider webs, insect parts, water, and vegetative matter. All air monitoring equipment calibrations, including the standard used for calibration, must be documented on a calibration log or in the field notebook.

7 Program Documentation and Reporting

Air monitoring data will be evaluated on an on-going basis throughout site work, and observations will be recorded regarding activities for the implementation of corrective actions on an immediate basis. Reporting of data collected for the Ambient Air Monitoring Program will have a multiple tiered approach as presented below.

7.1 Daily Summaries

The sampling technician will prepare a daily summary of the air monitoring results (15-minute average for PM_{10} and the 5-minute VOC average). Reporting on perimeter alarm level conditions and response actions may be incorporated into daily reports in an episodic manner. The summary will also include, but not be limited to, a description of community air monitoring exceedances (if any), work activities associated with the exceedances, and corrective actions implemented to address the exceedances.

7.2 Weekly Reports

Weekly reports will be prepared to provide timely information for RACER Trust, Arcadis, the Remedial Contractor and the public to highlight compliance issues and effectiveness of response activities. The weekly reports will summarize program updates, site work activity maps, summarize real-time VOC and PM_{10} data, TCE concentrations from the portable GC, perimeter analytical results, identify issues with equipment operation and maintenance, and summarize any corrective actions taken in response to action level exceedances. Weekly reports will be prepared approximately 3 days after the end of the prior week. Weekly reports will include a dashboard summary, tabular information, and written discussions summarizing the following information:

- Site-Specific Alarm Levels;
- Real-Time VOC and PM_{10} Data Summary inclusive of data collected from air monitoring stations
- Elevated Readings Summary for VOCs and PM_{10}, including the following information:
    - Time of exceedance;
    - Location of exceedance;
    - Cause for exceedance;
    - Relevant meteorological conditions;
    - Background concentrations;
    - Remediation activities; and
    - Documented corrective actions and their effectiveness.
- Meteorological Data; and
- Station Location Map.

7.3 Public Access to Communications

Prior to starting the Corrective Measures, RACER Trust will prepare a Fact Sheet to distribute to the surrounding community and stakeholders which will detail the planned remediation activities and the expected timeline, summarize the Ambient Air Monitoring Plan, and provide details on how the public can access data during the implementation.

After the start of the remedial activities, weekly reports will be placed on a SharePoint that can be viewed by the stakeholders (EPA, IDEM, City of Kokomo, Howard County Health Department, and the public). This website will be identified in the initial factsheet for the project.

Hard copies of the weekly reports will be posted on-site for public viewing and placed in the public repository located at the Kokomo-Howard County Public Library at:

220 North Union Street

Kokomo, IN 46901

Hard copies may also be obtained by submitting a request to:

Arcadis U.S., Inc.

Project Manager: RACER Trust – Former GM Delco Plant 5

150 West Market Street, Suite 728

Indianapolis, Indiana 46204

Or request to be included in a distribution list by submitting an email to:
RACERTrustKokomo@arcadis.com

8 References

USEPA. 2021. Final Decision and Response to Comments for RACER Trust Former GM Delco Plant 5, 1723 North Washington Street, Kokomo, Indiana, EPA ID: IND 000 806 844. June 16.

Tables

Table 2
Ambient Air Sampling Frequency, Action Levels, and Actions
RACER Trust Former GM Delco Plant 5
Kokomo, Indiana

Activity	Parameter	Equipment or Analytical Method	Frequency	Ambient Action Level
Baseline	PM_{10}	PM_{10} Monitor	Continuous, running 15-minute average.	NA
	VOCs	ppbRAE or equivalent	Continuous, running 5-minute average.	
	TCE	Laboratory Sample - TO-15	24-hr sampler.	
ISS Activities (Perimeter Monitoring)	PM_{10}	PM_{10} Monitor	Continuous, running 15-minute average.	**PM_{10} < 75 µg/m^3**: Continue working. **75 µg/m^3 < PM_{10} < 150 µg/m^3**: Levels sustained > 5 minutes, implement dust controls. **PM_{10} > 150 µg/m^3:** Continue to implement dust controls. Suspend site activities until PM_{10} dust emissions are reduced to < 75 µg/m^3.
	VOCs	ppbRAE	Continuous, running 5-minute average.	**VOCs > 0.5 ppm above background** (5-minute average): collect TCE reading with portable GC. Background is determined by upwind location measurement.
	TCE	FROG 4000 or VOCAM™	If total VOC concentrations are higher than Action Level, verify TCE concentration with portable GC. If TCE concentration is lower than Action Level, monitor hourly for remainder of day. Twice a day, at a minimum.	**TCE > 2.24 µg/m^3 above background** (5-minute average): collect air sample for submittal to laboratory. Stop work and implement vapor suppression controls. Suspend site activities until concentrations are < 2.24 µg/m^3 above background. Background is determined by upwind location measurement.

Table 2
Ambient Air Sampling Frequency, Action Levels, and Actions
RACER Trust Former GM Delco Plant 5
Kokomo, Indiana

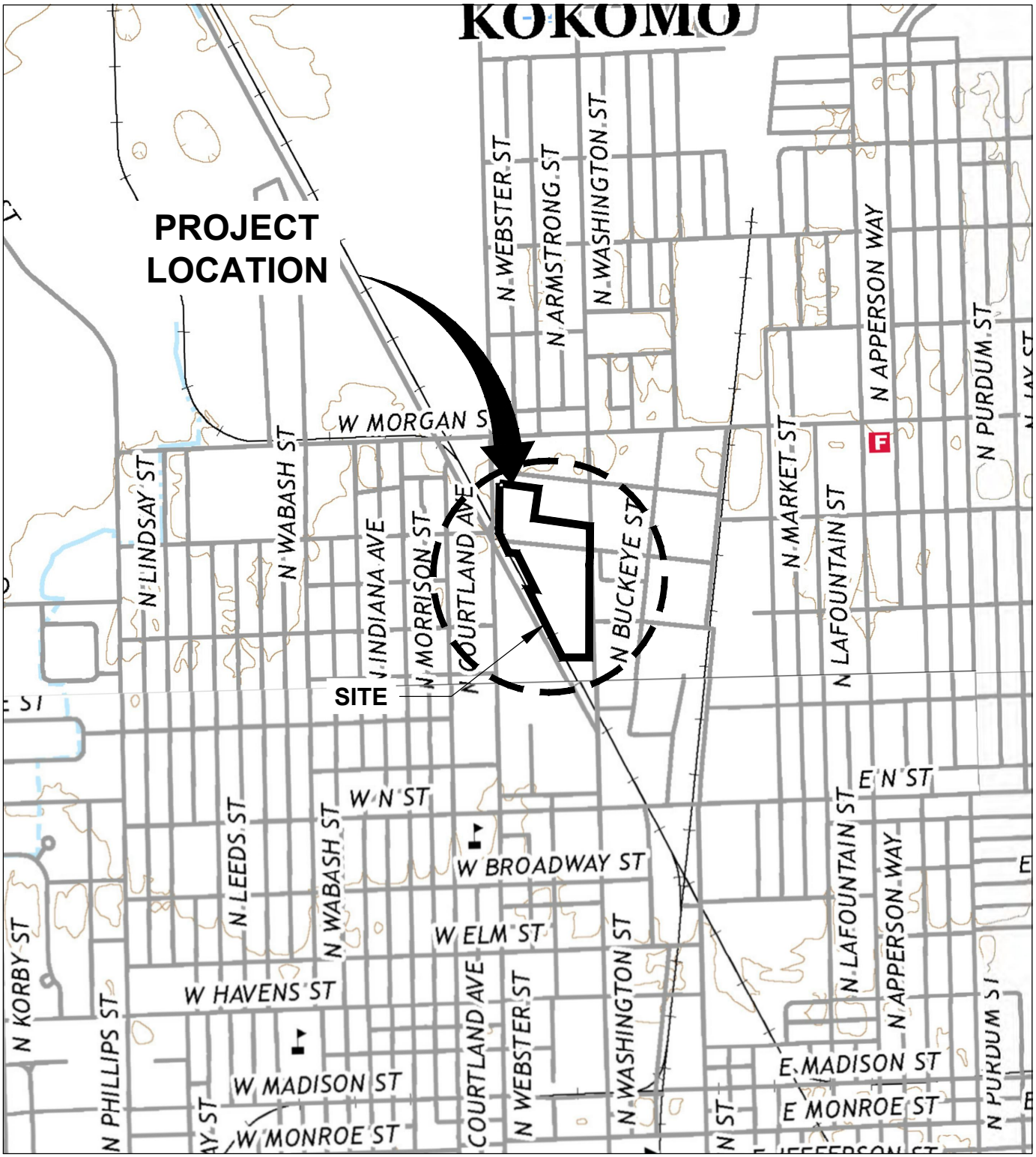
Activity	Parameter	Equipment or Analytical Method	Frequency	Ambient Action Level
ISS Activities (Perimeter Monitoring)	TCE	Laboratory Sample - TO-15	Collect a 24-hr air sample daily for expedited analysis during the first 5 days of each new phase of remediation (i.e., excavation of overburden, initial ZVI mixing, initial cement mixing). If TCE concentration from portable GC is higher than Action Level, collect a 24-hr sample and submit for expedited analysis.	TCE will be compared to site-specific levels and used to calculate risk estimates for off-site receptors. Site-Specific Action Levels and responses will be reviewed and modified if the risk estimates exceed 0.8.
	Qualitative	Visible Dust	Continuously	If visible dust is observed, implement dust control.
ISS Activities (Worker Monitoring)	PM_{10}	PM_{10} Monitor	Continuous, running 15-minute average.	**PM_{10} < 75 µg/m^3**: Continue working. **75 µg/m^3 < PM_{10} < 150 µg/m^3**: Levels sustained > 5 minutes, implement dust controls. **PM_{10} > 150 µg/m^3:** Continue to implement dust controls. Suspend site activities until PM_{10} dust emissions are reduced to < 75 µg/m^3.
	VOCs	ppbRAE	Continuous, running 5-minute average.	**VOCs > 0.5 ppm above background** (5-minute average): collect TCE reading with portable GC. Background is determined by upwind location measurement.
	TCE	FROG 4000 or VOCAM™	If total VOC concentrations are higher than Action Level, verify TCE concentration with portable GC. If TCE concentration is lower than Action Level, monitor hourly for remainder of day. Twice a day, at a minimum.	**TCE > 9.42 µg/m^3 above background** (5-minute average): collect air sample for submittal to laboratory. Stop work and implement vapor suppression controls. Suspend site activities until concentrations are < 9.42 µg/m^3 above background. Background is determined by upwind location measurement.

Table 2
Ambient Air Sampling Frequency, Action Levels, and Actions
RACER Trust Former GM Delco Plant 5
Kokomo, Indiana

Activity	Parameter	Equipment or Analytical Method	Frequency	Ambient Action Level
ISS Activities (Worker Monitoring)	TCE	Laboratory Sample - TO-15	Collect a 24-hr air sample daily for expedited analysis during the first 5 days of each new phase of remediation (i.e., excavation of overburden, initial ZVI mixing, initial cement mixing). If TCE concentration from portable GC is higher than Action Level, collect a 24-hr sample and submit for expedited analysis.	TCE will be compared to site-specific levels and used to calculate risk estimates for on-site workers. Site-Specific Action Levels and responses will be reviewed and modified if the risk estimates exceed 0.8.
	Qualitative	Visible Dust	Continuously	If visible dust is observed, implement dust control.

Notes:
GC - gas chromatograph
$\mu g/m^3$ - micrograms per cubic meter
ppb - parts per billion
ppm - parts per million
PM_{10} - particulate matter, 10 micrometers
TCE - Trichloroethene
VOC - Volatile Organic Compounds

Figures



REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD GALVESTON, IND. 2016, MIAMI, IND. 2016, KOKOMO EAST, IND. 2016, AND KOKOMO WEST, IND. 2016.

0 1000' 2000'

Approximate Scale: 1 in. = 1000 ft.

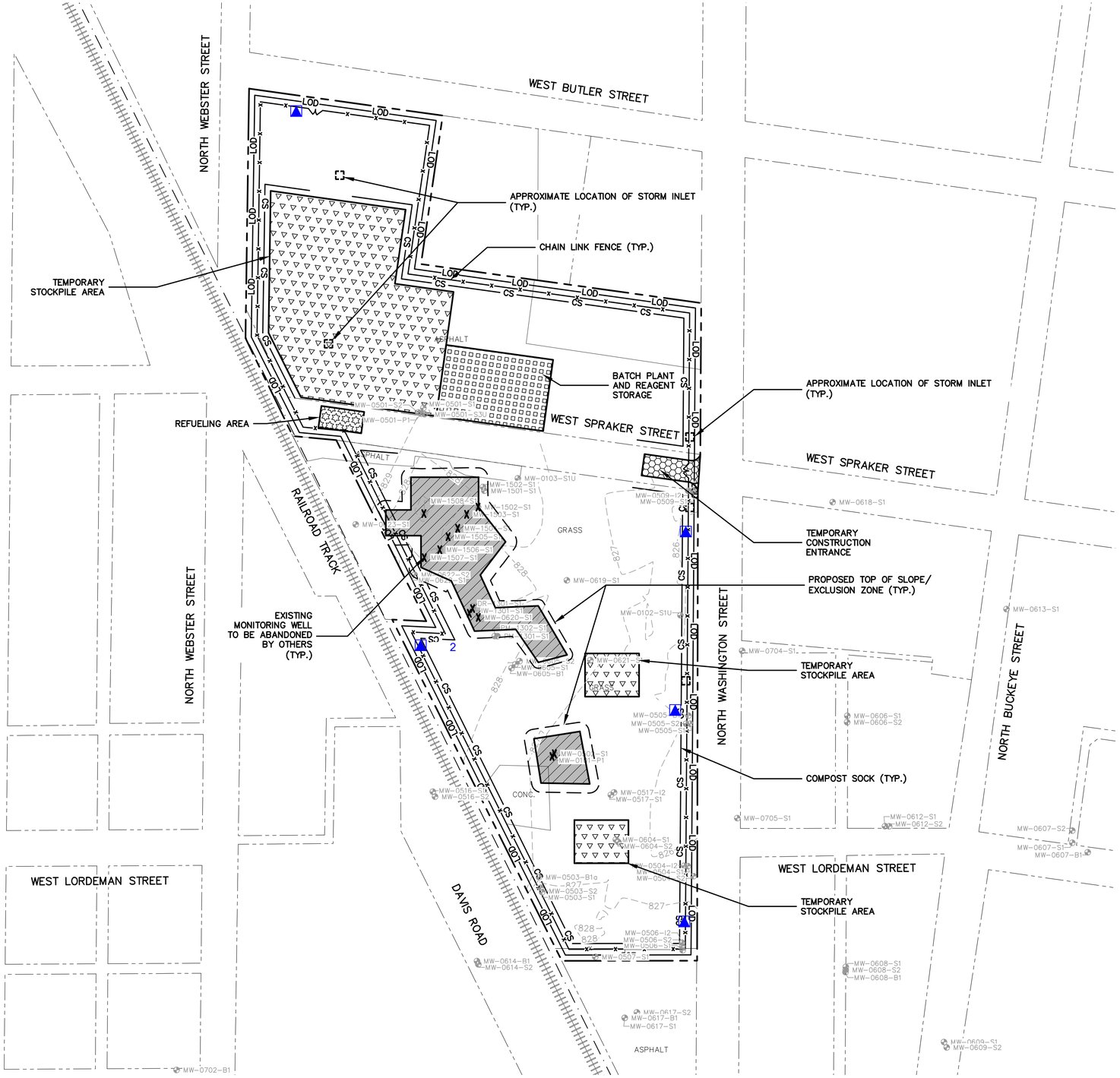
RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

SITE LOCATION MAP

ARCADIS

FIGURE 1

CITY: SYRACUSE DIV/GROUP: ENV DB: G.STOWELL PM:(Reqd) LYR:ON=*;OFF=*REF
C:\Users\aschilling\OneDrive - ARCADIS\BIM 360 Docs\RACER TRUST\FORMER GM DELCO PLANT 5 - KOKO\2018\IN000884.2017\01-DWG\CMP-Fig1-Site Loc.dwg LAYOUT: 1 SAVED: 10/25/2018 1:22 PM ACADVER: 21.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 10/25/2018 1:24 PM BY: SCHILLING, ADAM
XREFS: IMAGES:
CMP-X-PA-TITLEBLOCK.dwg



LEGEND:

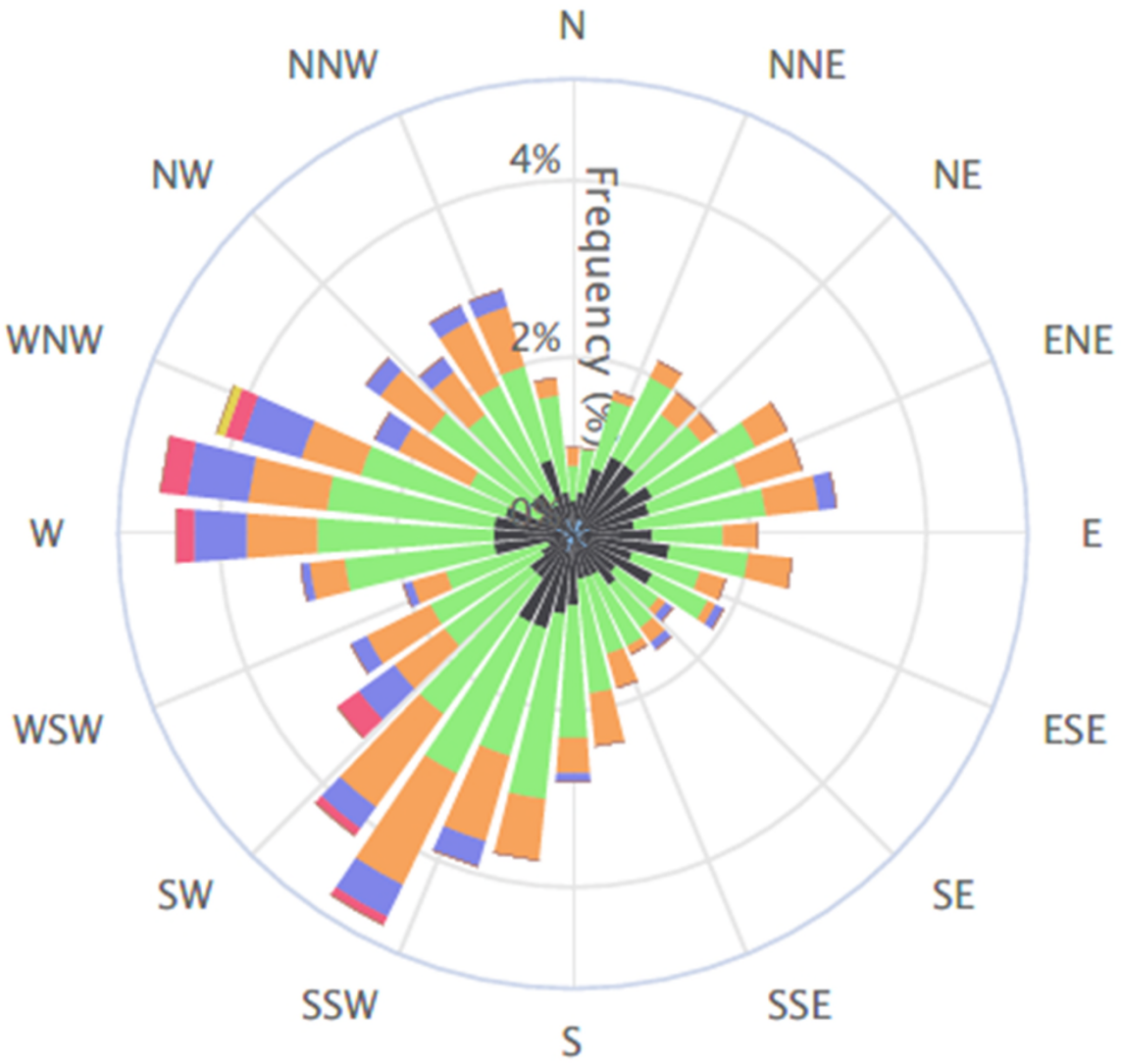
- AMBIENT AIR MONITORING LOCATION
- PROPERTY BOUNDARY
- ADJOINING PARCEL BOUNDARY
- EXISTING CONTOUR
- LIMIT OF DISTURBANCE
- PROPOSED TEMPORARY FENCE
- PROPOSED GATE
- PROPOSED COMPOST SOCK
- PROPOSED INLET/MANHOLE PROTECTION
- PROPOSED REMEDIATION AREAS
- STABILIZED CONSTRUCTION ENTRANCE
- TEMPORARY STOCKPILE AREA
- BATCH PLANT AND REAGENT STORAGE
- REFUELING AREA
- EXISTING MONITORING WELL
- EXISTING MONITORING WELL TO BE ABANDONED BY OTHERS

0 80' 160'
GRAPHIC SCALE

AMBIENT AIR MONITORING PLAN

ARCADIS

2



Wind Speed (mph)

- 1.3 – 4
- 4 – 8
- 8 – 13
- 13 – 19
- 19 – 25
- 25 – 32
- 32 – 39
- 39 – 47
- 47 –

KOKOMO MUNICIPAL AIRPORT Wind Rose
Jan. 1, 2018 - Dec. 31, 2021
Sub-Interval: Apr. 1 - Oct. 31, 7am – 6pm

https://mrcc.purdue.edu/CLIMATE/Hourly/WindRose.jsp

RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

WIND ROSE DIAGRAM

ARCADIS

FIGURE
3

Arcadis U.S., Inc.
150 W. Market Street, Suite 728
Indianapolis
Indiana 46204
Phone: 317 231 6500
Fax: 317 231 6514

Appendix C

Health and Safety Plan (HASP)

Site Specific Health and Safety Plan

Revision 18 b

Project Name:	RACER TRUST CMI Work Plan Oversight (ZVI-Portland Cement-Soil Mixing) Former GM Delco Plant 5 Kokomo, Indiana
Project Number:	30075940
Client Name:	RACER TRUST
Date:	10/20/2021
HASP Expires	10/20/2022
Revision:	

Approvals:

HASP Developer: S. Presswood

Project Manager: Sarah Fisher

HASP Reviewer: Tricia Trommer

HASP Reviewer Name Typed

HASP Reviewer Signature (handwritten or digital signature)

Revised: 2/17/2021

Arcadis Field and Embedded Staff COVID-19 Guidance

Check the Orange Line Daily

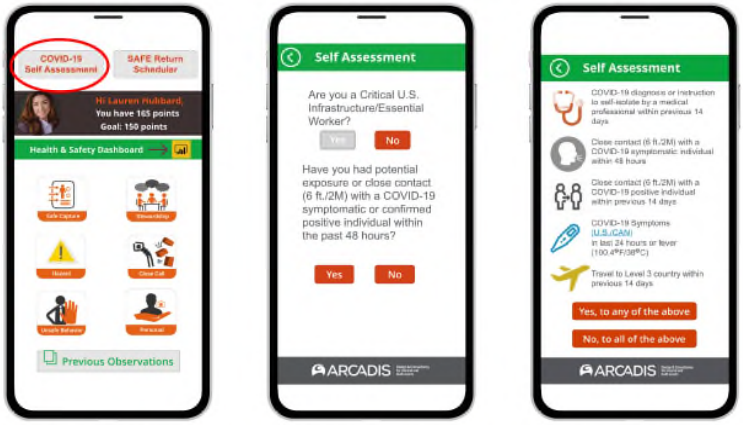
The Arcadis Field and Embedded Staff Covid-19 Guidance document is attached in Attachment A

ARCADIS Design & Consultancy for natural and built assets

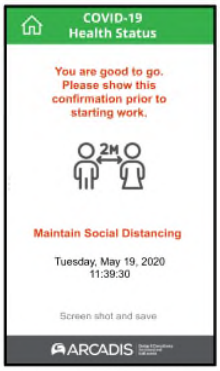
COVID-19 SELF ASSESSMENT

Arcadis staff visiting offices and project sites must complete the COVID-19 Health Screening Self-Assessment Questionnaire prior to each visit. Arcadis staff can now use the H&S App to complete their daily (or multiple times a day, if appropriate) COVID-19 Health Screening Self-Assessment. The data entered into the H&S App COVID-19 Health Screening Self-Assessment form is not stored.

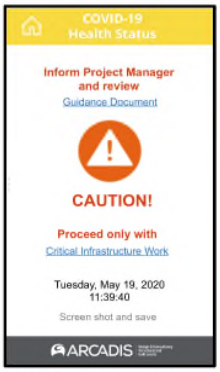
QR Code for daily self-assessment.



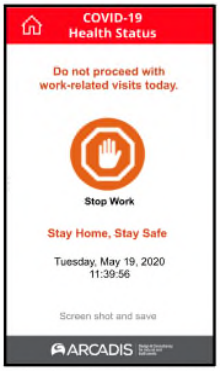
Upon completion of the COVID-19 Health Screening Self-Assessment in the H&S App, the user will receive a green, yellow or red completion message (as shown below).



Green – proceed to the office or project site



Yellow (Caution) – critical infrastructure/essential worker must contact the Project Manager and review the "H&S App Yellow Caution Status Guidance"



Red – do not proceed to the office or project site

Call WorkCare if you have:

- Symptoms consistent with COVID
- Been asked to be tested for COVID
- Tested Positive for COVID
- Been directed by the H&S App to call WorkCare

Calling WorkCare is not required if you have:

- Been in close contact with a person with COVID-related symptoms.
- Been in close contact with a COVID+ person

Arcadis Culture of Caring

Arcadis is committed to a Culture of Caring that ensures each Arcadis employee, part time as needed employee (PTAN), temporary agency employee under Arcadis day to day control, Inexperienced Workers and contractor (cumulatively referred to here as "field staff") goes home at the end of the day free from injury or illness. I certify that the following has been performed with all Arcadis field staff on this project either in person or virtually through Teams:

[X] Reviewed the HASP including a discussion of hazard identification and controls.

[X] If conducting activities deemed by Arcadis to be "High Risk", frontline management has reviewed applicable H&S standards (Job Safety Analysis [JSA] when authorized by H&S) for these activities with field staff.

[ ] If permit to work is required, frontline management has reviewed the permit(s) with field staff.

[X] Reviewed proactive H&S engagement expectations/injury prevention actions.

[X] Reviewed Stop Work Authority.

[X] Reviewed the incident reporting process and expectations including when WorkCare should be contacted by staff (WorkCare incident intervention for all minor, non-emergency injuries) and that the WorkCare phone number is programmed into field team cell phone.

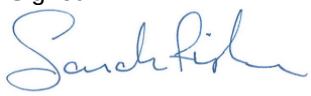
[X] For Inexperienced Workers, a mentor has been assigned for the new task being performed.

For short service employees (SSEs), PTANS* and temporary agency employees* :

[X] Provided coaching and mentoring on Arcadis H&S expectations during project work. Reviewed in detail specific hazards and controls and provided a resource who can be contacted if individual has questions regarding planned or unplanned work tasks.

Mentor/Resource # Matt Griles (Name) 812-325-7504 (Phone Number)

Signed:



Project Manager

* Upon hiring/contracting for the first time.

Emergency Information

Site Address: 1723 North Washington Street
Kokomo, IN 46901

Emergency Phone Numbers:

Emergency (fire, police, ambulance)		911
Emergency (facility specific, if applicable):		
Emergency Other (specify):		
Primary Client Contact:	Bob Hare	419-277-0815
WorkCare (non-life-threatening injury/illness):		1-888-449-7787
Project H&S:	Cameron Stewart	618-237-7488
Task Manager:	William Stephens	317-236-2849
Project Manager:	Sarah Fisher	317-691-4011
H&S Specialist:	Alec MacAdam	720-454-0948
Area H&S Director:	Andrew McDonald	410-200-3752

Hospital Name and Address: St. Vincent Kokomo
1907 West Sycamore Street
Kokomo, IN 46901

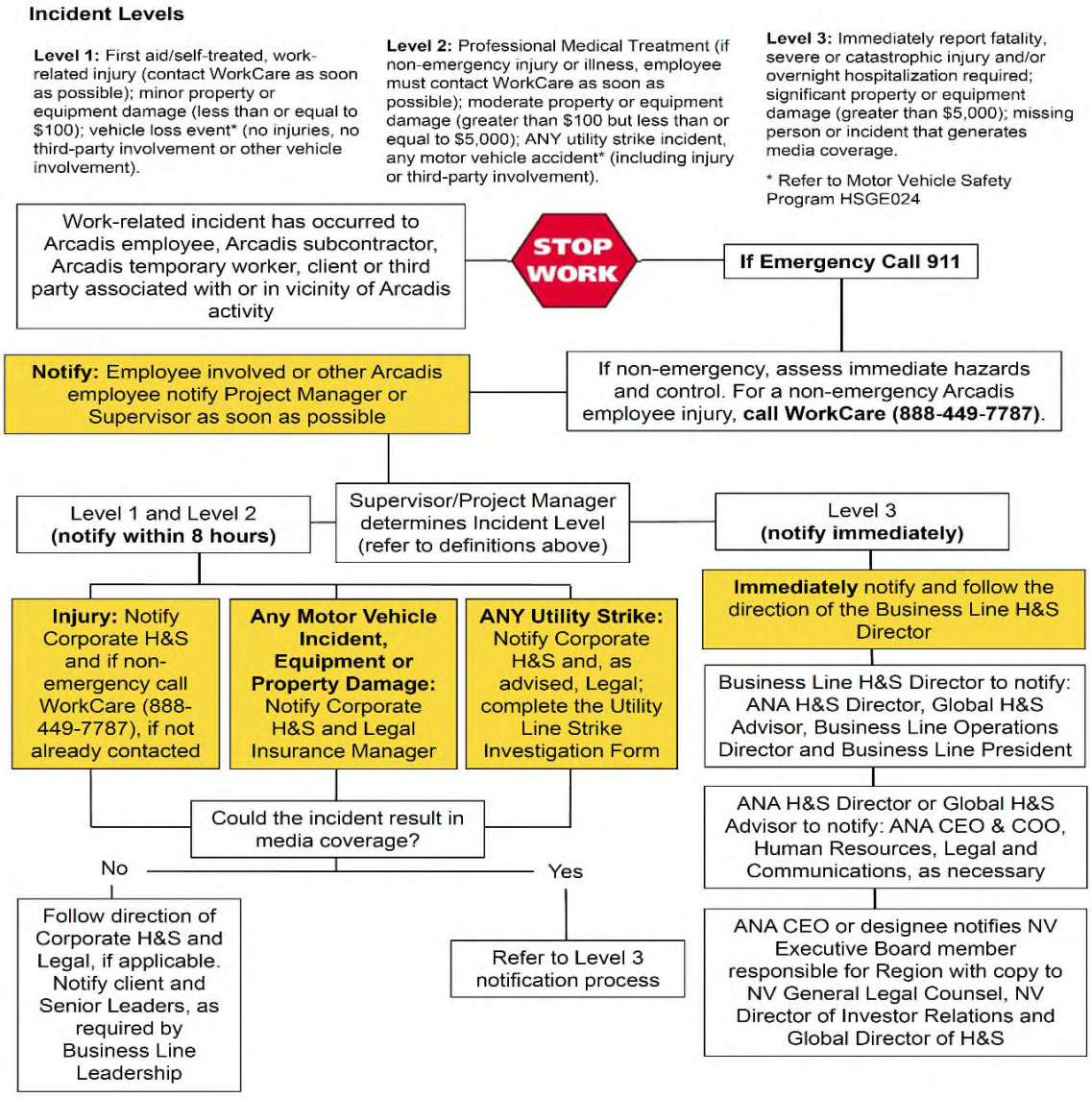
Hospital Phone Number: 765-456-5433

Supplemental Client Contact Information:

Other Important Phone Numbers:

Poison Control Center	1-800-222-1222
Nat. Response Ctr. (spills in reportable quantities)	1-800-424-8802
U.S. Coast Guard (spills to water)	1-800-424-8802

Incident Reporting Protocol Within Arcadis

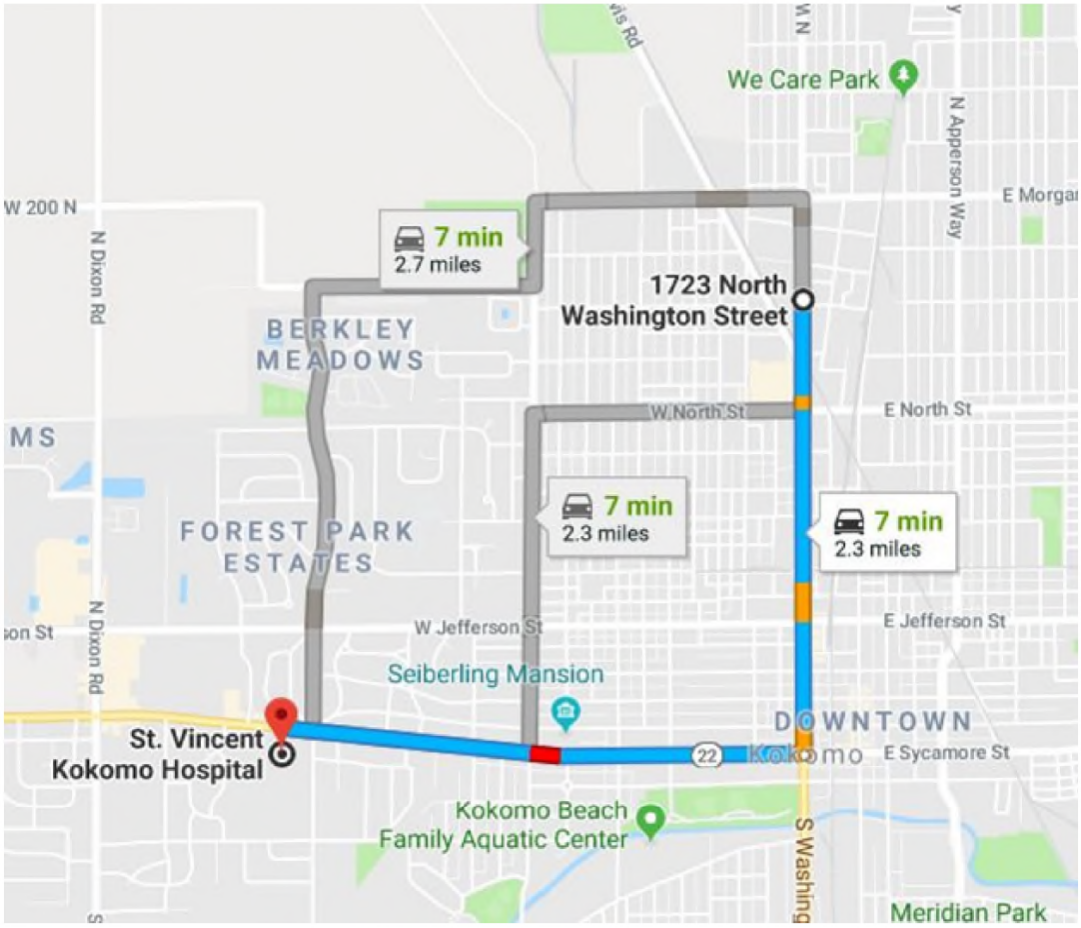


Client Incident Reporting Protocol

Report any incident with injury to the client immediately.
Report any releases or vehicle incidents to the client immediately.
Report any utilities strikes to the client immediately after confirmation of an active utility.
Report any incident without injury to the client within 24-hours.

Sarah Fisher - Project Manager - 317-691-4011
Matt Griles - Associate Project Manager - 812-325-7504
Emma TerBeek - Project Engineer - 616-930-1077
Bob Hare - RACER Trust Cleanup Manager - 419-277-0815

Route to the Hospital



1723 N Washington St

Kokomo, IN 46901

Head south on N Washington St toward W Lordeman St

1.1 mi

Turn right onto W Sycamore St

Destination will be on the left

1.2 mi

St. Vincent Kokomo Hospital

1907 W Sycamore St, Kokomo, IN 46901

Site Type

The project site is an inactive facility which historically had the following attributes:

Industrial	
Roadway (public, including ROW)	
Railroad	

For class I railroads, work within 25 ft of the rails is prohibited unless FRA On-Track Safety and railroad specific trained. For other railroads (i.e. short line railorads), the project or task manager will specify any special training needs. For all rail related work, field staff will have access to the Arcadis Railroad Safety Handbook and/or client rail safety handbook.Work on roadways or in the right of way will require a ROW Traffic Safety Plan.

Surrounding Land Use and Topography

The site is relatively flat with the northern portion pave asphalt. The site is abandoned.

Simultaneous Operations (SimOps)

Planned Arcadis site work will not be in proximity to SimOps work activities performed by non Arcadis employees or subcontractors. Arcadis will initiate stop work and evaluate the work activities through the JSA process if during the course of work a SimOps activity is identified that could reasonably affect health and safety of Arcadis employees and subcontractors.

Site Background

The site was formerly owned by General Motors Corporation prior to bankruptcy. RACER Trust is the current owner. Chlorinated volatile organic compounds (cVOCs) are the main risk factor. The project includes in-situ stabilization and solidification of impacted soil oversight.

Project Tasks

The following tasks are identified for this project:

1	Site Setup and Delivery of Equipment
2	Arcadis Oversight of Excavation and ISS Mixing
3	Arcadis Conducting Perimeter Monitoring During Excavation and ISS
4	Arcadis Oversight of Subcontractor Decontaminating Equipment
5	Arcadis Oversight of Contractor Waste Management
6	Arcadis Oversight of Utility Clearance or Land Surveying Contractor
7	Sampling for waste characterization - Soil sampling using shovel, spade, spoon or trowel
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	0

Supplemental requirements associated with the above task(s):
The Arcadis Utility Clearance Checklist must be used for utility clearance activities.

[X] Required Checklists/Work Forms

- *Tailgate Safety Briefing Form*
- *Vehicle Inspection Checklist*
- *Utility and Structures Checklist*

[ ] Required Permits

- *Not Applicable*

[ ] Required H&S Standards

- *Not applicable*

Short Service Employees (SSEs)

SSEs (employees who are employed with Arcadis for less than 1 year or are Inexperienced Workers) are not anticipated to be working on this project. If staffing changes occur during this project and SSEs are utilized, the project team working in conjunction with the SSE's administrative supervisor will ensure requirements of ARC HSGE019 "Short Service Employees" are completed. SSE's will be identified in the project Tailgate Safety Meeting Form.

Roles and Responsibilities

	Name	Role	Short Service Employee
1	Sarah Fisher	Project Manager (PM)	No
2	Matt Griles	Associate Project Manager (APM)	No
3	William Stephens	Task Manager	No
4	Emma TerBeek	Field Technical Lead	No
5	Emma TerBeek	Site Safety Officer (SSO)	No
6	Various Field Staff	Field Staff	No
7			
8			
9			
10			

Training

All Arcadis employees are required to have the following training to be on site:

H&S Program Orientation (non-certifica
HAZCOM GHS/EAP (non-certificate)
Defensive Driving - Smith On-Line
Hazwoper 40-Hour
Hazwoper 8-Hour Annual Refresher
None
None
None
None
None
None
None
None
Client specific:
Other:

Selected Arcadis employees are required to have the following additional training:

	Names or Numbers from above
First Aid/CPR	4,5,6
DOT HazMat #1	4,5,6
Hazwoper 8-Hour Supervisor	4,5,6
Construction Safety - 10 Hour	4,5,6
Excavation General Awareness	4,5,6
Railroad - FRA Roadway Worker	4,5,6
BBP (Bloodborne Pathogens)	
None	
None	
None	
None	
None	
None	
None	
None	
None	
Other:	

The Arcadis Fundamental H&S Principles

Staff working on any of the task(s) listed above must utilize the six Arcadis Fundamental H&S Principles to ensure work is conducted safely. These principles include: 1) Use of TRACK, 2) H&S Planning, 3) Stop Work Authority, 4) "If Not Me Then Who", 5) Stewardship, and 6) Incident Reporting. Every project team member plays an important role in project health and safety. This is more than just having a HASP, training, or PPE. Proactive staff engagement with these principles is critical to a safe work environment.

General Task Hazard Assessment and Risk Control (HARC)

General:	Hazards Applicable to All Project Tasks

The 12 hazard category HARC ratings are not available in this General THA. The mitigated and unmitigated ratings for the hazards presented are based on the Risk Assessment Matrix below. Modify hazards and ratings as necessary to meet project needs.

Risk Assessment Matrix		Likelihood Ratings			
Consequences Ratings		A	B	C	D
People	Property	0 Almost Impossible	1 Possible but Unlikely	2 Likely to Happen	3 Almost Certain to Happen
1-Slight or No Health Effect	Slight or No Damage	0-Low	1-Low	2-Low	3-Low
2-Minor Health Effect	Minor Damage	0-Low	2-Low	4-Medium	6-Medium
3-Major Health Effect	Local Damage	0-Low	3-Low	6-Medium	9-High
4-Fatalities	Major Damage	0-Low	4-Medium	8-High	12-High

Hazard #1

Driving - On road - Injury or vehicle damage from motor vehicle accident or incident

Suggested FHSHB Ref:	3.4	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	Smith System (on line)
Mitigated Risk:	MEDIUM	JSAs
Comments:	Use Smith System "5-Keys" when driving. See Driving JSA for details.	

Hazard #2

Driving - Driver - Injury, death or property damage due to driver distraction, fatigue, etc.

Suggested FHSHB Ref:	3.4, 3.21	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	Smith System (on line)
Mitigated Risk:	LOW	Driver awareness and use of stop work authority
Comments:	Use route planning. Keep eyes moving while driving. See Driving JSA.	

Hazard #3

Biological - skin/eye irritation or damage from poisonous plants

Suggested FHSHB Ref:	3.17.11	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	LOW	See HASP Tick/Poisonous Plant Section
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Use skin pre-treatment lotions when available.	

Hazard #4

Biological - bites or stings from exposure to insects or arachnids

Suggested FHSHB Ref:	3.17: 2,3,7,8,9,10	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	LOW	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Do body check daily. For ticks see also HASP Tick/Poisonous Plant section	

Hazard #5

Biological - cuts, scrapes, skin/eye puncture from exposure to physically damaging plants

Suggested FHSHB Ref:	3.17.11	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Job Briefing/Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:		

General Task HARC (continued)

Hazard #6		
Environmental - Thermal stress - Injury or illness from heat or cold		
Suggested FHSHB Ref:	3.16	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Field H&S Handbook (see ref. above)
Mitigated Risk:	LOW	JSAs
Comments:	Use job rotation or rest breaks. Stay hydrated and eat regularly.	
Hazard #7		
Environmental - Inclement weather -Injury or equipment damage from inclement weather		
Suggested FHSHB Ref:	3.12	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Weather Monitoring
Mitigated Risk:	LOW	Cont./Emerg. Planning
Comments:	Use 30/30 rule for lightning. See FHSHB for details.	
Hazard #8		
Motion - Musculoskeletal - Injury from lifting, twisting , stooping, or awkward body positions		
Suggested FHSHB Ref:	3.29.1	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Admin. Controls (specify in comments)
Comments:	Use proper lifting techniques. Use job rotation when applicable. See FHSHB for details.	
Hazard #9		
Motion - Musculoskeletal - Injury from repeated work activity or body motion		
Suggested FHSHB Ref:	3.29.2	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Admin. Controls (specify in comments)
Comments:	Use proper lifting techniques. Use job rotation when applicable. See FHSHB for details.	
Hazard #10		
Sound - Noise - Injury or illness due to noise exposure		
Suggested FHSHB Ref:	3.15	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Increase distance from source if possible. Maintain equipment.	
Hazard #11		
Gravity - Falls - Injury due to slips and trips		
Suggested FHSHB Ref:	3.26.4, 4.11	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Site Awareness
Mitigated Risk:	LOW	Housekeeping
Comments:	Use footwear appropriate for site conditions, plan routes and do not hurry while walking.	
Hazard #12		
None		
Suggested FHSHB Ref:	None	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	Not Ranked	Select
Mitigated Risk:	Not Ranked	Select
Comments:		

Task Specific HARC

Task 1:	Site Setup and Delivery of Equipment							
HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low):						FHSHB Ref:		3.9
Biological	-	Chemical	L	Driving	-	Electrical	L	
Environmental	L	Gravity	M	Mechanical	L	Motion	M	
Personal Safety	L	Pressure	L	Radiation	L	Sound	L	

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Cuts and scrapes to hands or skin handling tools, equipment or materials.	

Hazard #2

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Some work locations may expose field workers to traffic using access road. If a traffic hazard exists, Arcadis personnel shall use the relevant TSP configuration based on work task duration. Use vehicles to protect work area. All workers shall wear class 2 high-visibility clothing.	

Task Specific HARC (continued)

Task 2:	Arcadis Oversight of Excavation and ISS Mixing							
HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low):						FHSHB Ref:		4
Biological	L	Chemical	M	Driving	-	Electrical	-	
Environmental	M	Gravity	L	Mechanical	M	Motion	M	
Personal Safety	-	Pressure	L	Radiation	-	Sound	L	

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Cuts and scrapes to hands or skin handling tools, equipment or materials. Wear ANSI Cut 2 or leather work gloves while handling equipment not exposed to site COCs.	

Hazard #2

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref:	3.2, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	See HASP "Monitoring" section
Mitigated Risk:	LOW	Specialized Equipment (specify in comments)
Comments:	Inhalation of site COCs - Chlorinated solvents, breakdown products. Air monitoring shall be conducted in accordance with Ambient Air Monitoring Plan with a calibrated PID.	

Hazard #3

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Some work locations may expose field workers to traffic using access road. If a traffic hazard exists, Arcadis personnel shall use the relevant TSP configuration based on work task duration. Use vehicles to protect work area. All workers shall wear class 2 high-visibility clothing.	

Hazard #4

Gravity - Falls - Injury due to falls from height

Suggested FHSHB Ref:	3.26, 3.34	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	Competent Person Required (designated person)
Mitigated Risk:	LOW	10 hr. Construction Training
Comments:	Large excavations will be present on-site during the construction activities. Contractor will have a compentent person and field staff will have 10-hr construction training. Excavations will have exlusion zones identified with appropriate distance from edge.	

Hazard #5

Chemical - solids/particulates, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	JSAs
Mitigated Risk:	LOW	SDS (see also HASP Hazcom/GHS section)
Comments:	Contractor will be mixing ZVI and Portland Cement. Mixing cement may create dust, which could be an irritant	

Hazard #6

Gravity - Struck by - Injury from falling object

Suggested FHSHB Ref:	3.26.2	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Working around heavy equipment may encounter struck by hazards. Be aware of activities around you as they will change from day to day.	

Task Specific HARC (continued)

Task 3:	Arcadis Conducting Perimeter Monitoring During Excavation and ISS

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 5.7

Biological	L	Chemical	M	Driving	-	Electrical	-
Environmental	M	Gravity	L	Mechanical	L	Motion	L
Personal Safety	L	Pressure	-	Radiation	-	Sound	L

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs
Comments:	Cuts and scrapes to hands or skin handling tools, equipment or materials. Wear ANSI Cut 2 or leather work gloves while handling equipment. Keep out of the exclusion zone during mixing. Signal equipment operator before entering.	

Hazard #2

Chemical - liquids - injury or illness from vapor inhalation

Suggested FHSHB Ref:	3.2, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	See HASP "Monitoring" section
Mitigated Risk:	LOW	Specialized Equipment (specify in comments)
Comments:	Inhalation of site COCs - Chlorinated solvents, breakdown products. Air monitoring shall be conducted in accordance with Ambient Air Monitoring Plan with a calibrated PID.	

Hazard #3

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Some work locations may expose field workers to traffic using (private) access road. If a traffic hazard exists, Arcadis personnel shall use the relevant TSP configuration based on work task duration. Use vehicles to protect work area. All workers shall wear class 2 high-visibility clothing.	

Task Specific HARC (continued)

Task 4:	Arcadis Oversight of Subcontractor Decontaminating Equipment

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.10.4

Biological	L	Chemical	L	Driving	-	Electrical	-
Environmental	L	Gravity	L	Mechanical	L	Motion	L
Personal Safety	L	Pressure	L	Radiation	-	Sound	L

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Cuts and scrapes to hands or skin handling tools, equipment or materials. Wear ANSI Cut 2 or leather work gloves.	

Hazard #2

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	H&S Standards
Comments:	Some work locations may expose field workers to traffic using (private) access road. If a traffic hazard exists, Arcadis personnel shall use the relevant TSP configuration based on work task duration. Use vehicles to protect work area. All workers shall wear class 2 high-visibility clothing.	

Hazard #3

Chemical - liquids, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Job Briefing/Site Awareness
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Arcadis oversight personnel exposed to decon water or overspray. Remain 25' back from decon pad. Continue to wear level D PPE.	

Hazard #4

Pressure - Hydraulic - Injury from hydraulic process or device failure

Suggested FHSHB Ref:	2.5, 4.5, 4.6	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Admin. Controls (specify in comments)
Mitigated Risk:	LOW	PPE (see HASP "PPE" section)
Comments:	Arcadis oversight personnel exposed to pressure washer overspray. Remain 25' back from decon pad. Continue to wear level D PPE.	

Task Specific HARC (continued)

Task 5:	Arcadis Oversight of Contractor Waste Management							
HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low):						FHSHB Ref:		3.31
Biological	L	Chemical	L	Driving	-	Electrical	-	
Environmental	L	Gravity	L	Mechanical	-	Motion	L	
Personal Safety	L	Pressure	L	Radiation	-	Sound	L	

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	JSAs
Comments:	Cuts and scrapes to hands or skin handling tools, equipment or materials. Wear ANSI Cut 2 or leather work gloves.	

Hazard #2

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	H&S Standards
Comments:	Some work locations may expose field workers to traffic using (private) access road. If a traffic hazard exists, Arcadis personnel shall use the relevant TSP configuration based on work task duration. Use vehicles to protect work area. All workers shall wear class 2 high-	

Hazard #3

Environmental - Utilities - Injury or property damage from utility strike/damage

Suggested FHSHB Ref:	3.36	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	HIGH	Admin. Controls (specify in comments)
Mitigated Risk:	MEDIUM	Site Awareness
Comments:	Overhead utilities are running along the former Spraker St. Include signs to warn equipment operators of overhead utilities.	

Task Specific HARC (continued)

Task 6:	Arcadis Oversight of Utility Clearance or Land Surveying Contractor

HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low): FHSHB Ref: 3.36

Biological	L	Chemical	L	Driving	-	Electrical	M
Environmental	L	Gravity	L	Mechanical	M	Motion	M
Personal Safety	L	Pressure	L	Radiation	-	Sound	L

Hazard #1

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Cuts and scrapes to hands or skin while decontaminating tools or equipment. Wear level D, with cut resistant gloves . Avoid sharp edges and pinch points.	

Hazard #2

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	H&S Standards
Comments:	Some work locations may expose field workers to traffic using a (private) access road. If a traffic hazard exists, Arcadis personnel shall use the relevant TSP configuration based on work task duration. Use vehicles to protect work area. All workers shall wear class 2 high-visibility clothing.	

Task Specific HARC (continued)

Task 7:	Sampling for waste characterization - Soil sampling using shovel, spade, spoon or trowel							
HARC Unmitigated Hazard Types (H-High, M-Medium, L-Low):						FHSHB Ref:		3.9
Biological	L	Chemical	L	Driving	-	Electrical	-	
Environmental	M	Gravity	M	Mechanical	-	Motion	M	
Personal Safety	L	Pressure	L	Radiation	-	Sound	L	

Hazard #1

Chemical - solids/particulates, skin or eye irritation/damage/allergy

Suggested FHSHB Ref:	3.9, 3.22, 3.30, 3.33	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	JSAs
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Collecting soil samples from stockpiles or containers may create hazard. Wear appropriate PPE, do not walk on soil piles, do not enter roll-off containers.	

Hazard #2

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	H&S Standards
Comments:	Personnel, vehicles or equipment struck by excavator or debris being moved by excavator. Do not sample soil while machinery is activily working in area.	

Hazard #3

Motion - Struck by - Bodily injury from impact with moving object

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	Engineering Controls (specify in comments)
Mitigated Risk:	LOW	H&S Standards
Comments:	Personnel, vehicles or equipment struck by excavator or debris being moved by excavator. Exclusion zone to be established per long term TSP configuration to isolate work area and swing radius. Ground personnel to remain outside of exclusion zone while equipment is operating. Cell phone usage by operators is forbidden while equipment is operating. Excavator shall be equipped with a backup alarm that is audible over the running equipment. Mirrors, cab glass and cameras will be kept clean and free of debris	

Hazard #4

Motion - Cuts and scrapes - Injury from moving object impacting skin or eye

Suggested FHSHB Ref:	2.5, 3.22	To mitigate this hazard, use TRACK and the following:
Overall Unmitigated Risk:	MEDIUM	PPE (see HASP "PPE" section)
Mitigated Risk:	LOW	Job Briefing/Site Awareness
Comments:	Cuts and scrapes handling tools equipment or materials. Wear leather or ANSI cut 2 or higher cut rated gloves when handling tools equipment or materials.	

Hazard Communication (HAZCOM)/Global Harmonization System (GHS)

☐ HAZCOM/GHS for this project is managed by the client or general contractor

List the chemicals anticipated to be used by Arcadis on this project per HAZCOM/GHS requirements.
(Modify quantities as needed)

	Preservatives	Qty
☐	Not applicable	
x	Hydrochloric acid	<500 ml
☐	Nitric acid	<500 ml
☐	Sulfuric acid	<500 ml
☐	Sodium hydroxide	<500 ml
☐	Zinc acetate	<500 ml
☐	Ascorbic acid	<500 ml
☐	Acetic acid	<500 ml
☐	Isopropyl alcohol	< 4 gal.
☐	Formalin (<10%)	< 4 gal.
☐	Methanol	<500 ml
☐	Sodium bisulfate	<500 ml

	Decontamination	Qty
☐	Not applicable	
x	Alconox	≤ 5 lbs
x	Liquinox	≤ 1 gal
☐	Acetone	≤ 1 gal
☐	Methanol	≤ 1 gal
☐	Hexane	≤ 1 gal
☐	Isopropyl alcohol	≤ 4 gal
☐	Nitric acid	≤ 1 L
☐	Other:	

	Calibration	Qty.
☐	Not applicable	
x	Isobutylene/air	1 cyl
☐	Methane/air	1 cyl
☐	Pentane/air	1 cyl
☐	Hydrogen/air	1 cyl
☐	Propane/air	1 cyl
☐	Hydrogen sulfide/air	1 cyl
☐	Carbon monoxide/air	1 cyl
☐	pH standards (4,7,10)	≤ 1 gal
☐	Conductivity standards	≤ 1 gal
☐	Other:	

	Fuels	Qty.
☐	Not applicable	
☐	Gasoline	≤ 5 gal
☐	Diesel	≤ 5 gal
☐	Kerosene	≤ 5 gal
☐	Propane	1 cyl
☐	Other:	

	Kits	Qty.
x	Not applicable	
☐	Hach (specify):	1 kit
☐	DTECH (specify):	1 kit
☐	Other:	1 kit

	Remediation	Qty.
☐	Not applicable	
x	Zero-Valent Iron ISS Media	
x	Portland cement	
☐		
☐		
☐		

	Other:	Qty.
☐	Not applicable	
x	Spray paint	≤ 6 cans
☐	WD-40	≤ 1 can
☐	Pipe cement	≤ 1 can
☐	Pipe primer	≤ 1 can
☐	Mineral spirits	≤ 1 gal

	DOT(1):	Qty.
☐	MOT eligible soils	
☐	MOT eligible water	
☐	MOT eligible solids	
☐	MOT eligible liquids	
☐		
☐		
☐		

(1) Attach applicable Materials of Trade (MOT) generic shipping determination. SDS not generally applicable to this category.

SDSs for this project will be available in printed form in the company vehicle. All project workers will be notified of the SDS location in their initial safety briefing.

Contractor SDSs will be submitted to Arcadis in advance of work and will be filed with Arcadis SDSs as indicated above.

This project will store materials subject to the HAZCOM Standard in bulk storage. Storage requirements and limitations for this this material is addressed in a supplement attached to the this HASP.

Air Monitoring - ISS Mixing

☐ There are no atmospheric chemical, radiological, or particulate hazards on this project requiring air monitoring.

☐ Air monitoring is the responsibility of the client or subcontractor.

Constituents of Interest:

Time Weighted Averages (TWAs) are ACGIH 8-Hr Threshold Limit Values (TLVs) unless noted.

Trichloroethylene			
TWA	10 ppm	LEL/UEL (%):	8/10.5
STEL	25 ppm	VD (Air = 1):	NA
IDLH	1000 ppm, NIOSH	VP (mmHg):	58
Particulates n.o.s.		Anticipated Breathing Zone Concentration <=	3 mg/m3
TWA	3 mg/m3, respirable	LEL/UEL (%):	NA/NA
STEL	NA	VD (Air = 1):	NA
IDLH	NA	VP (mmHg):	NA
None			0
TWA	NA	LEL/UEL (%):	NA
STEL	NA	VD (Air = 1):	NA
IDLH	NA	VP (mmHg):	NA
None			
TWA	NA	LEL/UEL (%):	NA
STEL	NA	VD (Air = 1):	NA
IDLH	NA	VP (mmHg):	NA
None			
TWA	NA	LEL/UEL (%):	NA
STEL	NA	VD (Air = 1):	NA
IDLH	NA	VP (mmHg):	NA
None			
TWA	NA	LEL/UEL (%):	NA
STEL	NA	RGD (Air = 1):	NA
IDLH	NA	VP (mmHg):	NA

TWA - Time Weighted Average (ACGIH TLV unless noted)
STEL - Short Term Exposure Limit
IDLH - Immediately Dangerous to Life and Health
LEL/UEL - Lower /Upper Explosive Limit
RGD - Relative Gas Density
VP - Vapor Pressure

Notes:

Required Monitoring Instruments, Action Levels and Monitoring Frequency

Gray fields below are not automated. Make necessary selections from drop down menus.

Photoionization Detector — Select Lamp: 10.6 eV

Computed action levels (PID units) (1):			Computed action levels have been manually adjusted.
<	9.3		Continue working
	9.3	18.5	Levels sustained > 5 minutes, monitor continuously and review engineering controls and PPE. Proceed with caution.
>	18.5		Stop work and contact SSO

(1) Computed action levels are for PIDs which have not been programmed to correct TLVs for specific constituents or mixtures.

Particulate/Aerosol monitoring is required.

Action levels are in mg/m3			Computed action levels have been manually adjusted.
<	1.5		Continue working
	1.5	3	Levels sustained > 5 minutes, monitor continuously and review engineering controls and PPE. Proceed with caution.
>	3		Stop work and contact SSO

Breathing zone air monitoring using the above instruments will be performed at the following frequency:
Other (manually enter this field)

Air monitoring shall be conducted continuously, in the breathing space of the ISS operator, as well as at the perimeter of the work area.

Multigas (including LEL/O2 and Hg vapor) monitoring is not required.

LEL/O2 Meter	0-5% LEL	Continue work
LEL/O2 Monitoring Not Required	>5-10% LEL	Continually monitor, review engineering controls, proceed with caution
	>10% LEL	Stop work, evacuate, contact SSO
	19.5%-23.5% O2	Normal, continue work
	<19.5% O2	O2 deficient, stop work, evacuate, contact SSO
	>23.5% O2	O2 enriched, stop work, evacuate, contact SSO

Additional Gas/Vapor Monitoring is Not Required

		1/2 TLV	Stop Work Action Level	Comments
☐	Ammonia	12.5 ppm	25 ppm	
☐	Carbon dioxide	2500 ppm	5000 ppm	
☐	Carbon monoxide	12.5 ppm	25 ppm	
☐	Chlorine	0.05 ppm	0.1 ppm	
☐	Hydrogen cyanide	2.35 ppm (skin)	4.7 ppm* (skin)	
☐	Hydrogen sulfide	0.5 ppm	1 ppm	
☐	Nitrogen dioxide	0.1 ppm	0.2 ppm	
☐	Phosphine	0.025 ppm	0.05 ppm	
☐	Sulfur dioxide	0.125 ppm	0.25* ppm	
☐	Mercury vapor	0.0125 mg/m3	0.025 mg/m3	

* Ceiling or STEL value

All air-monitoring instruments must be calibration checked daily, if used, per manufacturer's instructions. Calibration checks, including calibration gases used, must be documented.

Compound specific monitoring using indicator tubes or chips is not required.

Indicator:		≤TWA	Continue work
☐ Tube	☐ Chip	>TWA	Stop work, review engineering controls and PPE, contact SSO
Compound(s):			

Indicator tube/chip monitoring frequency: Not applicable

Tick and Poisonous Plant Hazards

For all projects with outdoor work, biological hazards must be addressed in the tailgate safety meeting each day. The following controls must be used to mitigate biological hazards while working and must also be discussed in the tailgate safety meeting. For low risk situations, the discussion must include exposure to weeds/vegetation near fences, buildings, etc.

Controlling Tick Hazards

Risk Guide for Ticks:

Low	Paved areas; parking lots; well manicured lawns and fields; no work taking place within 15 feet of vegetated areas; work in REGIONS with no tick populations; sub-freezing temperatures, snow or ice cover on ground.*
Medium	Brush hogged fields, wetlands, and grasslands; forested areas with little undergrowth; weeds less than knee height; moderately dense foliage; sporadic or moderately vegetated shaded areas; average leaf accumulation and decaying material on the ground; work taking place in fields after application of insecticide; work in REGIONS with a recognized moderate tick populations; outdoor work during spring, summer and fall months.*
High	Uncut fields, wetlands, forested areas, and grasslands; weeds taller than knee height; heavy dense foliage; heavily vegetated shaded areas; excessive accumulations of leaves and decaying material on the ground; work in REGIONS with recognized heavy tick populations; areas with posted tick hazard warnings; outdoor work during spring, summer and fall months.*

*Cold weather does not eliminate risk of exposure to deer ticks as they may be active all year in areas that experience subfreezing temperatures.

Ticks are ranked as a **Low** risk for this project

Care should be taken to avoid walking through or working in tall grasses, overgrown or bushy vegetation to the extent reasonable and practical. No single control is effective against ticks.

Select required controls below:

Engineering Controls x

- [ ] Mowing of work area
- [x] Clearing overgrown vegetation
- [ ] Pesticide application
- [ ] Other: _____

Administrative Controls

- [x] Complete tick check morning/evening
- [ ] Scheduled tick check: _____
- [x] Inspect backpacks, equipment cases, etc. daily
- [x] Vehicle cab - maintain good housekeeping
- [ ] Other: _____

Personal Protective Equipment

- [ ] Light colored clothing
- [ ] Light colored hat/hardhat
- [ ] Pants tucked in boots
- [ ] Shirt tucked into pants
- [ ] Long sleeved shirt and long pants
- [ ] White Tyvek pants
- [ ] White coveralls/Tyvek
- [ ] Taped cuffs/pant legs
- [ ] Tick gators
- [ ] Double sided tape/duct tape sticky side out
- [ ] Insect mesh/netting for face/head or whole body suit
- [ ] Other: _____

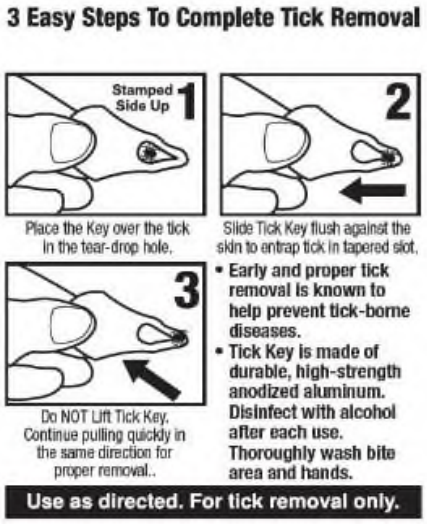
Repellents

- [ ] Repellents will not be used
- [ ] Permethrin impregnated clothing (purchased)
- [ ] Permethrin (0.5% self applied/treated to clothing)
- [x] Deet 20-40% applied to skin
- [ ] Other: _____

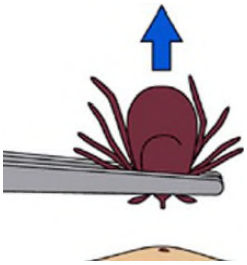
Tick Removal and First Aid

Ticks removed within 24 hours of embedment represent a very low risk for adverse outcomes. Perform tick checks as directed above. To properly remove a tick:

Using a Tick Removal Tool



Using Tweezers



1) Use point tip tweezers, if available, to reduce potential of crushing the ticks body
2) Grasp the tick as close to skin as possible
3) Pull upward with even pressure.

Do not crush tick with fingers

After removal, wash affected area with alcohol or iodine. Wash hands thoroughly after removal.
Document date/time of the removal in field notes, field form or H&S app.
If rash or fever develops, call WorkCare

Poisonous Plants (Poison Ivy, Poison Oak, Poison Sumac)

All work outdoors, regardless of time of year, must address poisonous plant hazards and controls in the tailgate safety meeting. For low risk projects, the discussion should consider potential vegetation exposure near fences, buildings, work near trees, etc.

Controlling Exposure to Poisonous Plants

Poisonous Plants are ranked as a **Low** risk on this project

Select required controls below:

Engineering Controls

	Not applicable
	Mowing of work area
x	Clearing overgrown vegetation
	Herbicide application
	Other: _____

Administrative Controls

x	Identify and avoid (see ID Quick Guide below)
x	Watch for signs or symptoms of exposure
x	Vehicle cab - maintain good housekeeping
	Other: _____

A specific JSA is required that must address controls to be used to prevent exposure to poisonous plants during mowing/cutting/removal activities. Burning cleared vegetation not recommended.

Personal Protective Equipment

x	Gloves
	Hat/hardhat/head covering
	Pants tucked in boots
	Shirt tucked into pants
	Long sleeved shirt and long pants

	White coveralls/Tyvek
	Taped cuffs/pant legs
	Dust mask (during burning activities, etc.)
	Other: _____

Repellents

x	Repellents will not be used
	Barrier creams
	Other: _____

Skin Decontamination

x	Wash with post-exposure soap and water
x	Wash with soap and water (use hot water if available)
x	Hot shower at end of day
	Other: _____

Equipment Decontamination

Due to the low risk associated with poisonous plants on this project, portable equipment and tools may still have a potential to be contaminated with urushiol (the oil that causes allergic reactions and dermatitis in poisonous plants covered by this plan). It is recommend to decontaminate handles, grips, and hand holds of tools and equipment with post-exposure soap and water or alcohol spray (if safe to do so for the equipment/tool being decontaminated) as a best practice.

Clothing Decontamination

Wash work clothing in hot water separate from other clothing. Even though there is a low risk for poisonous plants on this project, work boots should be considered potentially contaminated with urushiol. Decontaminate with post-exposure soap and water or hot soap and water. If safe for the boot, consider spraying with alcohol spray of post exposure soap is not available.

First Aid

If skin irritation or other signs of allergic reaction develops contact WorkCare for assistance. Document date and time of exposure, if known, in field notes, field form or H&S app.

Identification Quick Guide

Ticks:

American Dog Tick

Blacklegged (Deer) Tick

Brown Dog Tick

Groundhog Tick

Gulf Coast Tick

Lone Star Tick

Rocky Mountain Wood Tick

Soft Tick

Poison Ivy:

Poison Oak:

Poison Sumac:

For other biological hazards, address the hazards and controls in the JSA for the work task.

Personal Protective Equipment (PPE)

See JSA or Permit for the task being performed for required PPE. If work is not conducted under a JSA or Permit, refer to the governing document for PPE requirements. At a minimum, the following checked PPE is required for all tasks during field work (outside of field office trailers and vehicles) not covered by a JSA or Permit on this project:

Minimum PPE required to be worn by all staff on project:						Specify Type:
X	Hard hat		Snake chaps/guards		Coveralls:	
X	Safety glasses		Briar chaps		Apron:	
	Safety goggles		Chainsaw chaps		Chem. resistant gloves:	
	Face shield		Sturdy boot		Gloves other:	
	Hearing protection	X	Steel or comp. toe boot		Chemical boot:	
	Rain suit		Metatarsal boot		Boot other:	
	Other:			X	Traffic vest, shirt or coat:	Class II
					Life vest:	

Task specific PPE: Reference JSAs for task-specific PPE; use ANSI Cut 2 or Leather when handling equipment.

Comments:

See Biological section for important PPE information.

Medical Surveillance

All Arcadis employees performing field work will be required to be current in HAZWOPER medical surveillance.

Hazardous Materials Shipping and Transportation

A shipping determination package has been prepared, reviewed and is attached to this HASP.

Traffic Safety and Traffic Safety Plans (TSPs)

On-site traffic control will be addressed in the contractors work plan or HASP. A TSP may be required based on traffic patterns or work zones.

Arcadis Commercial Motor Vehicles (CMVs)

CMVs operated by Arcadis employees on public roadways will not be utilized on this project. Arcadis defines a CMV as any single vehicle with a gross vehicle weight rating (GVWR) ≥10,001 pounds or a truck and trailer combination with a combined GVWR ≥10,001 pounds (GVWR of truck + GVWR of trailer = ≥10,001 pounds).

Site Control

Site control will consist of a permeter fence. Additional controls for internal work zones will be prepared by contractor and presented in their work plan or HASP.

Decontamination

Decontamination protocols are addressed in the applicable task JSA(s) for this project. The applicable JSAs are attached to this HASP.

Sanitation

Restroom facilities and potable water will be provided by an Arcadis contractor for this project. Unless alternate requirements are stipulated in a plan supplement (i.e. Heat Injury and Illness Prevention Plan), permit or JSA, temporary restroom facilities will be provided with one toilet for every 20 project workers and bottled or non-plumbed potable water will be provided to project workers at 1 gallon/worker/day.

Safety Briefings

Arcadis field staff will attend safety briefings provided by the client. The content of the safety briefing will be documented by at least one Arcadis employee on a Tailgate Safety Briefing Form or logbook. If the client does not perform routine safety briefings (i.e. once daily), Arcadis employee(s) on the project site will perform a daily safety briefing or safety review and document the briefing/review on a Tailgate Safety Briefing Form or logbook.

Employee Health and Safety Engagement

The CPM or APM is responsible for reviewing and establishing H&S engagement goals for the project. These goals are summarized below.

Hazard Observations (via H&S App or TIP) required at the following frequency on this project:
observations will be recorded daily, Arcadis will obtain observations submitted by contractor
Close Call reporting (via H&S app) goals for this project:
as appropriate
Other (specify):
Project H&S Assessment will be completed once, at a minimum

Safety Equipment and Supplies

Safety equipment/supply requirements are addressed in the JSA or Permit for the task being performed. If work is not performed under a JSA or Permit, the following safety equipment is required to be present on site in good condition unless otherwise noted (Check all that apply):

X	First aid kit	X	Insect repellent: DEET, as needed
X	Bloodborne pathogens kit	X	Sunscreen
X	Fire extinguisher		Air horn
	Eyewash (ANSI compliant)	X	Traffic cones
X	Eyewash (bottle)		2-way radios
X	Drinking water		Heat stress monitor
X	Other: spill kit	X	See Tick and Poisonous Plant Hazards section for addtional equipment/supply information.

International Travel

International travel is not required for this project.

Spill Control and Containment

Spill control and containment planning and implementation, if required, is the responsibility of another contractor working with Arcadis. Arcadis will validate the contractor has the necessary equipment and supplies on site to control and contain spills prior to start of work.

Use of Electronic Devices in Areas of Increased Safety Risk

The intent of this section is to ensure use of standard computer tablets, laptops, or cell phones (collectively referred to in this HASP as a digital device) is performed in a manner that is effective in preventing or mitigating injury to the user of the digital device.

Use of electronic devices within 25 ft of a railroad track requires approval of the railroad owning or operating on the track. Railroad On-Track Safety rules for use of electronic devices must be followed without exception even if not under contract to the railroad (Arcadis policy). Refer to the Arcadis Railroad Safety Handbook for more information.

Use of electronic devices on an active roadway must be addressed in the ROW TSP. Device user should face traffic when recording data or rely on a spotter. Use the company vehicle as a shield on roadway when practical.

Electronic device use and distractions to be discussed and documented in the job briefing/safety briefing.

Signatures

I have read, understand and agree to abide by the requirements presented in this health and safety plan. I understand that I have the absolute right to stop work if I recognize an unsafe condition affecting my work until corrected.

Printed Name	Signature	Date

Add additional sheets if necessary

You have an absolute right to STOP WORK if unsafe conditions exist!

Attachments

Attachment A - Job Safety Analyses (JSAs)

- Driving
- Site Inspection
- Use of Hand or Power Tools
- Excavation Oversight
- Air Monitoring
- Drum Sampling-Handling
- Cooler Handling
- Decontamination

Attachment B - Safety Data Sheets (SDSs)

- Hydrochloric Acid
- Alconox
- Liquinox
- Isobutylene
- Iron Aggregate 2020
- Portland Cement
- Spray Paint

Attachment C - Field Forms

- Visitor Acknowledgement
- Tailgate Meeting Form
- Task Improvement Process (TIP) General
- Vehicle Inspection Form
- Utility and Structures Checklist
- Bloodborne Pathogen Exposure Control Plan
- Air Monitoring Documentation Form
- PID Calibration Log

Attachment D - Shipping Determination

- Soil Waste Characterization

Attachment E - COVID-19 Field and Embedded Guidance

Attachment A - Job Safety Analyses (JSAs)

Driving
Site Inspection
Use of Hand or Power Tools
Excavation Oversight
Air Monitoring
Drum Sampling-Handling
Cooler Handling
Decontamination

Job Safety Analysis

General

JSA ID	8121	**Status**	(3) Completed
Job Name	General Industry-Driving - passenger vehicles	**Created Date**	8/24/2012
Task Description	Driving a car, van, or truck on public roadways.	**Completed Date**	05/30/2013
Template	True	**Auto Closed**	False

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role			Completed Date	Supervisor	Active
Developer					☑
HASP Reviewer					☑
Quality Reviewer					☐

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Pre-Trip Inspection	1	Failing to perform pre-trip inspections may cause mechanical failure, accident or injury	Perform walk around of vehicle with particular attention to tire inflation and condition. Check lights, wipers, seatbelts for proper operating condition. Properly adjust seat and mirrors prior to vehicle operation. Use or review vehicle inspection checklist as required under the MVSP.	ARC HSGE024 Motor Vehicle Safety Standard (MVSP)
		2	Scrapes, cuts, burns to hand if inspecting engine fluids and/or tires. Eye splash hazard if inspecting engine fluids. Pinch or crush hazards when opening or closing hood, trunk or tailgate.	Wear protective gloves and safety glasses as described below when checking under hood or tires. Use TRACK and keep hands clear when opening/closing hood, trunk, or tailgate to avoid crush or pinch hazard.	
		3	Improperly secured cargo may dislodge creating injury, property damage or road hazard.	Ensure all cargo is properly secured to prevent movement while the vehicle is in opertation. This includes cargo in the cab of the vehicle.	
2	Driving a motor vehicle on public streets	1	Failing to observe traffic flow ahead increases risk of hard braking resulting in potential impact of vehicle ahead, being struck by another vehicle from behind and decreases decision making time.	Use Smith System Key #1, "Aim High in Steering". **Look ahead (15 seconds if possible) to observe traffic flow and traffic signals.** Adjust speed accordingly to keep vehicle moving and avoid frequent braking. Select lane of least traffic and adjust speed based on observed signal timing when possible. Avoid following directly behind large vehicles that obscure view ahead.	Smith System "5-Keys" is a registered trademark of Smith System Driver Improvement Institute, Inc.
		2	Failing to observe vehicles, pedestrians, bicyclists and other relevant objects in vicinity of your vehicle increases risk of side swipes, rear ending, and third party injury.	Use Smith System Key #2, "Get the Big Picture". **Maintain 360 degrees of awareness around vehicle.** Check a mirror every 6-8 seconds, maintain space around the vehicle, choose a lane that avoids being boxed in. Look for pedestrian activity ahead in crosswalks or sidewalks. Watch for construction zone approach signs and act early by executing lane changes and reducing speed.	

2	Driving a motor vehicle on public streets	3	Failing to keep your eyes moving increases risk of not seeing relevant vehicles, pedestrians and objects in your vicinity that may impair your ability to make timely and appropriate driving decisions and also increases risk of accident.	Use Smith System Key #3, "Keep Your Eyes Moving". **Move your eyes every 2 seconds and avoid staring while evaluating relevant objects.** Scan major and minor intersections prior to entering them. Check mirrors.	
		4	Failing to maintain space around and in front of your vehicle increases risk of striking another vehicle or being struck by another vehicle. Insufficient space shortens time for effective driving decision making resulting in increased accident risk.	Use Smith System #4, "Leave Yourself an Out". **Use 4 second rule when following a vehicle.** Avoid driving in vehicle clusters by adjusting speed and using lanes that permit maximum space and visibility. When stopped, keep one car length space in front of vehicle ahead or white line.	
		5	Failing to communicate with other drivers and pedestrians increases risk of striking vehicles, pedestrians, or being struck by other vehicles, especially from the rear.	Use Smith System Key #5, "Make Sure They See You". **Brake early and gradually when stopping to reduce potential of being rear ended.** Keep foot on brake while stopped. Use turn signals and horn effectively. Establish eye contact with other drivers and pedestrians to extent practical. Use vehicle positioning that promotes being seen.	
		6	Distractions within the vehicle takes focus off driving, increases risk of accident decreases time for making effective driving decisions.	**Cell phone use (any type or configuration) is prohibited while the vehicle is in motion.** Familiarize yourself with vehicle layout and controls (radio, temperature controls, etc.) prior to operating unfamiliar vehicles. Set controls prior to operating vehicle. Use GPS in unfamiliar areas to avoid use of paper maps/directions while driving. Set GPS prior to vehicle operation. Pull over and stop to modify GPS functions. Avoid consuming food or drink while driving.	
3	Parking	1	Parking vehicle in areas of clustered parked vehicles or near facility entrance may impair visibility to oncoming traffic in lot and increase exposure to pedestrian traffic.	**Use pull through parking or back into parking space when permitted or practical.** When practical and safe to do so, park away from other vehicles and avoid parking near the facility entrance or loading docks. If available, use a spotter to aid in backing activity. Back no further than necessary and back slowly. Get out and look (GOAL) if uncertain of immediate surroundings. Tap horn prior to backing.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Eye Protection	safety glasses	While checking engine or tires	Required
Hand Protection	work gloves (specify type)	Leather or equivalent checking engine or tires	Required

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone		Required
	other	Vehicle kit (applies to company trucks)	Required
Miscellaneous	fire extinguisher	Applies to company trucks	Required
	first aid kit	Applies to company trucks	Required

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Santaniello, Julie HASP Reviewer Revise 9/6/2012	Revise per suggested mark-ups
Employee: **Role** **Review Type** **Completed Date**	Santaniello, Julie HASP Reviewer Approve 5/30/2013	
Employee: **Role** **Review Type** **Completed Date**	Lujan, Teresa Quality Reviewer NA 6/17/2013	Very good write up. The reminder of the 5 Key Smith Driving rules are essential in everyday driving. The practice of these has and will make you a better driver and keep you safe.

Job Safety Analysis

General

JSA ID	4079	**Status**	(3) Completed
Job Name	General Industry-Site inspection/walkover - undeveloped	**Created Date**	12/9/2010
Task Description	Site Inspection	**Completed Date**	12/14/2010
Template	True	**Auto Closed**	False

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role			Completed Date	Supervisor	Active
Developer					☐
HASP Reviewer					☐
Quality Reviewer					☑

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Undeveloped Site Walk (Winter Conditions)	1	Slippery/icy conditions	Use caution and proper footwear with traction	
		2	Eye/face injury	Use caution when walking through trees and brush. Wear proper eye protection to avoid eye injury	
		3	Hypothermia/frostbite	Assess weather conditions and wear proper clothing to avoid hypothermia/frostbite and freezing	
		4	Falling ice/snow	Assess the site for falling ice/snow from trees/powerlines. Use caution when walking around trees and powerlines. Wear hard hat	
		5	Stray animals	Make lots of noise while walking through the site. Carry repellent in the event of encountering stray animals. If a dangerous or aggravated animal is spotted, leave the area, return to your vehicle and contact animal control.	
		6	Vehicular traffic	Asses the site and the surrounding area for vehicle traffic. Use caution when walking near busy roadways. Wear type II or III traffic vest.	
2	Undeveloped Site Walk (Summer Conditions)	1	Slips/trips/falls	Use caution when walking on un-even surfaces. Use proper footwear with traction	
		2	Eye injury	Use caution when walking through areas of trees and brush. Wear proper eye protection to avoid eye injury from tree limbs	
		3	Dehydration	Drink plenty of water and avoid long periods of direct sun exposure	
		4	Sunburn	Wear sunscreen. Avoid long periods of direct sun exposure. Work in the shade if possible.	
		5	Vehicular traffic	Assess the site and the surrounding area for vehicular traffic. Use caution when walking near busy roadways. Wear type II or III traffic vest.	
		6	Stray animals, ticks, bugs	Make lots of noise when traveling through the site and carry repellent spray. If a dangerous or aggravated animal is spotted, leave the area and return to your vehicle and contact animal control. Wear long pants/long sleeve shirt and use insect repellent as necessary	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	long sleeve shirt/pants		Required
Foot Protection	steel-toe boots		Required

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone		Required
Miscellaneous	first aid kit		Required
Personal	eye wash (specify type)		Required
	insect repellent		Recommended
	sunscreen		Recommended

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Tremblay, Tony HASP Reviewer Revise 12/10/2010	Please refer to JLA 1602 and use the exterior site walk information as a template for this JLA. Thanks Ahren
Employee: **Role** **Review Type** **Completed Date**	Tremblay, Tony HASP Reviewer Approve 12/14/2010	
Employee: **Role** **Review Type** **Completed Date**	Brien, Jason Quality Reviewer NA 12/14/2010	Well thought out. Appropriate hazards and critical actions have been identified.

Job Safety Analysis

General

JSA ID	17186	**Status**	(3) Completed
Job Name	General Industry-Other	**Created Date**	11/7/2019
Task Description	Using Hand-Operated Power Tools	**Completed Date**	12/05/2019
Template	False	**Auto Closed**	True

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role			Completed Date	Supervisor	Active
Developer					☑
HASP Reviewer					☑
Quality Reviewer					☑

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Check condition of the blade, if applicable.	1	Lacerations.	Avoid contact with blade teeth. Be sure the tool is unplugged.	
2	Check that the guard is in working condition and in the proper position, if applicable.	1	Lacerations.	Avoid contact with blade teeth. Be sure the tool is unplugged.	
3	Plug in power tool.	1	• Injuries from starting tool when in the "on" position. • Potential electrocution from cord in poor condition.	• Ensure tool is in the "off" position before plugging in. • Inspect condition of cord before plugging in. • If cord is in poor condition, do not use the tool until the cord has been repaired.	
4	Operating power tool.	1	Lacerations and other injuries.	• Always wear correct PPE • Evaluate surroundings before turning on power tool and be aware of others. • Make sure that cutting will not come into contact with any utilities. • Make sure that blade or bit is not binding, cease operation of the tool and evaluate reasons for binding. • Ensure that material being operated on is secured.	
5	Unplugging power tool.	1	Lacerations.	Ensure tool is in the "off" position before unplugging.	
6	Changing blade/bit/other tool parts.	1	Lacerations.	Ensure tool is unplugged before changing any part of the tool.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	long sleeve shirt/pants		Recommended
Eye Protection	faceshield	when necessary	Required
	safety glasses		Required
Foot Protection	steel-toe boots		Required
Head Protection	hard hat		Required
Hearing Protection	ear plugs		Recommended

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone		Required
Miscellaneous	fire extinguisher		Required
	first aid kit		Required
Personal	eye wash (specify type)	16oz bottle	Required

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Guillen, Antonio Quality Reviewer NA 12/6/2019	Good analysis and itemization of requirement and recommendations

Job Safety Analysis

General

JSA ID	2796	**Status**	(3) Completed
Job Name	Construction-Oversight - excavation and construction	**Created Date**	6/14/2010
Task Description	Excavation/Trenching Oversight (Outdoors)	**Completed Date**	06/17/2010
Template	True	**Auto Closed**	False

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role			Completed Date	Supervisor	Active
Developer					☐
HASP Reviewer					☐
Quality Reviewer					☐

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Utility Clearance	1	Contact with utilities can cause injury, property damage, and cause releases of hazardous substances to the environment.	Establish a minimum of three lines of evidence, and obtain additional lines of evidence as needed for site specific conditions. Maintain utility markings, perform detailed site inspections, and keep open and constant communication between operators, onsite staff, and project management. Always Use Stop Work Authority if there is a question or concern about the location of a utility.	ARCHSFS019 - Utility Clearance HS Standard
		2	Slip trip and falls while performing site clearance activities	Focus on task at hand and do not hurry through task. Avoid reading maps/drawings while walking, stop walking when looking up for overhead utilities.	
2	Excavation/Trenching and Backfilling Oversight	1	Slips trips and falls from poor housekeeping around trench or excavation.	Maintain work area and minimize clutter near excavation. Place excavated material properly and at least 2 feet away from the edge of excavation. Remove potential hazards when possible. Mark hazards when it cannot be removed. Create and maintain awareness of hazard. Maintain barriers, fall hazard warning signage and traffic controls properly. Do not cross over caution tape, safety fencing etc. Follow Project specific STAR Plan	FHSHB IV(D)
		2	Excavation or trench collapse trapping workers or creating falls.	Excavation/Trench greater than five (5) feet deep in which subcontractor, employees or others will be entering must be properly sloped, benched, shored or have a trench box in place. Sloping, benching, shoring or use of trench box is not required IF an excavation is less than five (5) feet in depth and examination of the ground by a competent person provides no indication of a potential cave-in. Ensure a Competent Person is on site to inspect and oversee excavation/ trenching activities. Where feasible, stay six (6) feet from edge of excavation/trench. A safe means of egress, such as a stairway, ladder, or ramp, shall be located so that no more than twenty-five (25) feet of lateral travel is necessary for site workers conducting activities in trenches exceeding four (4) feet in depth.	

2	Excavation/Trenching and Backfilling Oversight	3	Potential high level of dust, fumes, vapors or particulates creating visibility or inhalation/contact hazards could result in exposure above occupational exposure limit or create an IDLH atmosphere.	Visually monitor air for dust, and wet excavated soil as needed to control dust. Monitor for chemical vapors if hazard exists. The atmosphere must be tested in excavations greater than four (4) feet in depth where oxygen deficiency or toxic or flammable gases are likely to be present, before workers will be permitted to enter. Ensure downwind and perimeter monitoring also performed, if atmospheric hazards exists.	
		4	Excessive noise from excavating equipment or pumps.	Make sure all authorized personnel including subcontractors are wearing hearing protection (ear plugs/muffs) when working around noisy equipment. Increase distance from noise hazard when practical.	
		5	Potential Leaks of Petroleum Fluids and Lubricants from excavating equipment and support equipment.	Make sure all authorized personnel including subcontractors perform equipment inspections looking for leaks, cracked hoses, and loose fittings. Promptly and properly repair all leaks.	
		6	Open Excavation, Unauthorized Entry, or Property Damage	Make sure all authorized personnel including subcontractors mark open excavation with demarcation tape, orange fencing, orange cones, etc. to prevent unauthorized / accidental entry. Make sure controls are adequate for traffic protection after dark or when the site is unstaffed. Backfill excavation area as soon as possible and fence off any excavation not backfilled at the end of the work day.	
		7	Contact with potentially impacted groundwater and soil.	Conduct task in a calm, cautious manner. Wear appropriate PPE. Ensure equipment is in working conditions before start of work every day. Stop work immediately and report to the site manager, if any life threatening conditions exist.	
		8	Working Around Heavy Machinery	Where feasible, maintain distance from excavation equipment in excess of the swing radius. Maintain eye contact with operators at all time. Ensure equipment is in good working condition before work begins. Wear appropriate PPE, including safety vest. Do not wear loose clothing and pull back long hair. Be aware of and avoid standing in red zones (equipment operator "blind-spots"). No personnel are permitted to stand underneath suspended loads.	
3	Stockpile Maintenance and Sampling	1	Falls climbing on or during covering of stockpile.	Avoid climbing on stockpiles when possible, keep hands free, do not hurry trough tasks such as pulling plastic sheeting up onto or over piles.	
		2	Overexertion placing plastic sheeting, weight, and straw bales.	Use proper lifting techniques, avoid twisting of body, and forceful pulling/pushing. Do not hurry through task.	
		3	Cuts, scrapes, impalement from debris in stockpiles.	Have excavation contractor remove/isolate large chunks of concrete, exposed rebar etc. from stockpile to extent practical. Inspect areas prior to kneeling or placing hands when sampling upon stockpile.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	long sleeve shirt/pants		Required
Eye Protection	safety glasses		Required
Foot Protection	steel-toe boots		Required
Hand Protection	chemical resistant gloves (specify type)	When sampling groundwater	Required
	work gloves (specify type)	Leather when hand hazard exists; nitrile for soil/	Required
Head Protection	hard hat		Required
Hearing Protection	ear plugs	When working near heavy equipment	Required
Miscellaneous PPE	traffic vest--Class II or III		Required

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone	Remote area, check reception	Required
Decontamination	Decon supplies (specify type)		Required
Miscellaneous	fire extinguisher		Required
	first aid kit		Required
	flashlight		Required
Personal	eye wash (specify type)		Required
	insect repellent		Recommended
Traffic Control	Other	Cones/tape to delineate trenches prior to backfill	Required

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Tremblay, Tony HASP Reviewer Approve 6/17/2010	
Employee: **Role** **Review Type** **Completed Date**	Crandall, James M. Quality Reviewer NA 6/25/2010	No additional comments. Very well done.

Job Safety Analysis

General

JSA ID	18226	**Status**	(3) Completed
Job Name	Environment-Other	**Created Date**	5/18/2021
Task Description	Air Monitoring - heavy equipment handling and equipment charging	**Completed Date**	06/29/2021
Template	False	**Auto Closed**	False

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role			Completed Date	Supervisor	Active
Developer					☑
HASP Reviewer					☑
Reviewer					☑

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Load/upload equipment to field vehicle.	1	Lifting bulky and heavy equipment into vehicle	Prepare vehicle to make space before storing equipment. Use proper lifting technique (use legs, not back) to lift. If needed, use second person to help. Use handles/straps on equipment to help gripping. Wear gloves if equipment have sharp edges.	
		2	Secure equipment to avoid flying while driving	Pack and place equipment to avoid loose items flying while driving Secure with bungee cords or ropes if needed. Avoid putting light weight items in the bed of pickup trucks to avoid items flying off the bed, or tie down before driving.	
2	Set up equipment at the monitoring locations	1	Carry equipment to monitoring locations by hands. Heave equipment can cause hand or back or shoulder injury.	For heavy and bulky equipment, drive to monitoring location to minimize hand carrying. If needed, carry one equipment at a time. Wear gloves to avoid sharp edges cutting into hands. Use shoulder pads if carrying over shoulder. Use tools/ pully to help move equipment if available. If needed, use second person to help. Can use garden wagons, folding tables, and ballast to facilitate work at air monitoring stations.	
		2	Equipment fall to cause damage on equipment or body injury on personnel.	Inspect monitoring location and place equipment on even ground. If tripod is used and placed on grass, step on each foot of the tripod to ensure stability. If windy or equipment is placed on uneven ground or concrete where foot of tripod can not be inserted into ground for stability, consider use bungee cords or rope to secure equipment to a fixture (i.e. fence, light pole etc).	
		3	Struck by vehicle or other moving equipment in the same area	Be aware of activities in the surrounding area. Choose locations in less active areas to avoid being struck by traffic or moving equipment to provide personnel and equipment. Use traffic cones to identify monitoring equipment. Communicate with subcontractors working in the same area about CAMP monitoring locations to raise awareness.	

2	Set up equipment at the monitoring locations	4	Slip, trip and falls; biological hazards	Personnel should be mindful of general ground condition. Look out for depression and holes including animal holes for potential trip hazards. When work in vegetated area, watch out for bees, wasps, ticks and spiders, along with other poisonous plants. Wear and use proper protection accordingly.	
		5	Damage to Equipment due to elements (e.g. rain, flooding).	1. Routine inspection of equipment enclosures. 2. Apply waterproofing to the equipment enclosures as warranted. 3. Avoid outdoor deployment of equipment during heavy or wind-driven rain.	
3	Charge equipment overnight	1	Electric shock when plug in equipment	Don't touch the prong of the plug when plugging in equipment. Exam equipment plug for wear and tear. Replace worn parts or equipment as a whole if needed. Avoid charging equipment outside. Always leave equipment in a secured, indoor place.	
		2	Overload extension cord	If multiple equipment are to be charged, avoid overloading extension cords with all the equipment. Use multiple wall plugs instead.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	long sleeve shirt/pants		Required
Eye Protection	safety glasses		Required
Foot Protection	steel-toe boots		Required
Hand Protection	work gloves (specify type)		Recommended
Miscellaneous PPE	traffic vest--Class II or III		Required

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Held, Daniel HASP Reviewer Revise 5/22/2021	Please remove the word community from the title to make it a JSA for Air Monitoring Program. Recommendations can include use of garden wagons, folding tables, and ballast to facilitate work at air monitoring stations . Personnel should be mindful of animal holes (trip hazards), ticks and spiders. This is a good JSA.
Employee: **Role** **Review Type** **Completed Date**	Held, Daniel HASP Reviewer Revise 6/4/2021	Thank you for making changes. Just two more recommendations. 1. We should change the title (task name) so it is just 'Air Monitoring.' 2. We should add a potential hazard under step 2. The new potential hazard should be Damage to Equipment due to elements (e.g. rain, flooding). Critical Actions include i. Routine inspection of equipment enclosures, ii. Apply waterproofing to the equipment enclosures as warranted. iii. Avoid outdoor deployment of equipment during heavy or wind-driven rain.
Employee: **Role** **Review Type** **Completed Date**	Held, Daniel HASP Reviewer Approve 6/16/2021	
Employee: **Role** **Review Type** **Completed Date**	Decarr, Wayne Reviewer Approve 6/29/2021	This JSA is fine as is. We will be providing equipment to facilitate setting up and breaking down the CAMP equipment each day.

Job Safety Analysis

General

JSA ID	7983	**Status**	(3) Completed
Job Name	Environment-Drum sampling/handling	**Created Date**	7/26/2012
Task Description	Drum Handling, Sampling and Transfer of Drum Contents	**Completed Date**	07/26/2012
Template	True	**Auto Closed**	False

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role			Completed Date	Supervisor	Active
Developer					☐
HASP Reviewer					☑
Quality Reviewer					☑

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Inspect Drums for signs of Bulging, Leaking, Crystals, Temperature, and Odor	1	Exposure to chemicals stored in drum or container.	Read drum labels for information about contents. Review all relevant MSDSs about chemical contents. If labels are not attached, call PM or Local H&S Representative.	None
		2	Contents of the drum can cause fire/explosion hazard.	Use air monitoring meters to screen drums. % LEL and VOCs (PPM). If either of the values are above the action levels described in the HASP or MSDS then Stop Work, move away from the area, and reassess the situation. Call PM and H&S staff for support.	
2	Remove lids or bungs from Drums	1	Hand Injuries can occur from sharp edges, pinch points, and from use of hand tools.	Wear appropriate work gloves. When removing ring from drum, fingers can get pinched between ring and drum. Keep fingers clear of this space. Select proper tool for task. If large amount of drums will be encountered, use a speed or drum wrench.	Employee H&S Field book, Section III Subpart II, page 104. Also Section III Subpart L, page 38.
		2	Rapid depressurization from empty or partially full drums can cause flying parts or volatile COCs releasing on staff.	Do not handle or open bulging drums (contact Corp H&S for assistance). Bleed any built up pressure by carefully loosening bung prior to removing ring. Keep face and arms away from bung opening when loosening. Slightly lift lid, insert end of air monitoring device to monitor air inside drum.	
		3	Use of mechanical tools to remove bolts from drum lids causes excessive noise.	Wear hearing protection.	
		4	Splashing can occur if filling drum, or collecting samples.	Wear eye and face protection. Pour liquids into drum slowly to minimize splashing.	
		5	When working with COCs that have fire/explosive properties, sparking or heat could cause fire/explosion.	Use brass or non Spark Hand Tools if such a hazard exists or is suspected.	
3	Sample Contents from Drums	1	Exposure to COCs can occur by contacting impacted contents.	Select proper dermal protection for task, at a minimum nitrile gloves should be worn. Wear appropriate eye face and body protection as outlined in the HASP.	
		2	Staff can be exposed to chemical vapors/fumes when sampling.	Conduct air monitoring as outlined in the HASP, and if required, select appropriate respiratory protection for the task.	
		3	Sharp edges and broken sample containers can cause lacerations.	Discard any broken sample ware or glass properly. Do not over tighten sample containers.	

3	Sample Contents from Drums	4	Chemical burns or skin irritation can occur from contact with sample preservatives.	Wear chemical protective gloves when collecting samples, or when handling damaged sample containers.	
4	Replace drum lids	1	Hand Injuries can occur from sharp edges, pinch points, and from use of hand tools.	see step 2 above	
5	Moving and Storing Drums	1	Drum storage areas can be accessed by the general public, or may not be secure.	Calculate how many drums will be stored in new location. Ensure that drums are not easily accessed by the general public. Do not store such that drums impede pedestrian or vehicular traffic.	
		2	Muscle strain can occur when lifting/pulling/pushing drums.	Drums that are full can weigh as much as 800 lbs. Use a lift assist device whenever possible, and use a team lift approach. When moving soil drum generated by drilling, have drillers use their equipment to move the drums. Using dolly, slightly lift drum away from dolly to install forks under drum. Slowly let drum come back down and rest on dolly. Using hook on top of dolly, ensure it latches on top of drum bung.	
		3	Body parts can be pinched between lift device, or drum and the ground.	Be aware of hand and foot placement during drum staging. Do not hurry through task.	
		4	When moving, the drum can tip or the dolly could become unstable from uneven ground surface.	Plan travel route with drum prior to moving. With drum secure on dolly, have one employee pull back on dolly, and other employee slowly push back on drum toward dolly. Have second worker act as spotter for traffic, pedestrians, and any trip hazards along the way.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	chemical protective suit (specify type)		Required
Eye Protection	faceshield		Required
	safety goggles		Required
Hand Protection	chemical resistant gloves (specify type)	Nitrile	Required
	work gloves (specify type)		Required
Hearing Protection	ear plugs		Required

Supplies

Type	Supply	Description	Required
Miscellaneous	Other	dolly	Required

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Hubbard, Lauren HASP Reviewer Approve 7/26/2012	
Employee: **Role** **Review Type** **Completed Date**	Hubbard, Lauren Quality Reviewer NA 7/27/2012	Reviewed by Corporate H&S Department

Job Safety Analysis

General

JSA ID	166	**Status**	(3) Completed
Job Name	Environment-Sample cooler handling	**Created Date**	5/1/2009
Task Description	Sample cooler handling	**Completed Date**	05/13/2009
Template	True	**Auto Closed**	False

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role	Employee	Due Date	Completed Date	Supervisor	Active
Developer					☐
HASP Reviewer					☑

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Transfer field samples to sample packing area	1	Lifting heavy coolers may result in muscle strain especially to lower back.	Use proper lifting techniques and keep back straight. Use buddy system for large coolers, Use mechanical aids like hand trucks if readily available to move coolers. Do not over fill coolers with full sample containers for temporary movement to the sample prep area. Ensure an adequate supply of sample coolers are in field.	
		2	Hazards to hands from broken glass caused by over tightening lids or improper placement in cooler	Inspect all bottles and bottle caps for cracks/leaks before and after filling container. Do not over tighten sample lids. Clean up any broken bottles immediately, avoid contact with sample preservatives. Wear leather gloves when handling broken glass.	
		3	Exposure to chemicals (acid preservatives or site contaminants) on the exterior of sample bottles after filling.	Wear protective gloves for acid preservatives and safety glasses with side shields during all sample container handling activities (before and after filling), Once filled follow project specific HASP PPE requirements for skin and eye protection.	
		4	Samples containing hazardous materials may violate DOT/IATA HazMat shipping regulations	All persons filling a sample bottle or preparing a cooler for shipment must have complete ARCADIS DOT HazMat shipping training. Compare the samples collected to the materials described in the Shipping Determination for the Project and ensure consistent. Re-perform all Shipping determinations if free product is collected and not anticipated during planning.	
2	Sample cooler selection	1	Sample coolers with defective handles, lid hinges, lid hasps cracked or otherwise damaged may result in injury (cuts to hands, crushing of feet if handle breaks etc)	Only use coolers that are new or in like new condition, No rope handled coolers unless part of the manufacturer's handle design.	ARCADIS Shipping Guide US-001
		2	Selection of excessively large coolers introduces lifting hazards once the cooler is filled.	Select coolers and instruct lab to only provide coolers of a size appropriate for the material being shipped. For ordinary sample shipping sample coolers should be 48 quart capacity or smaller to reduce lifting hazards.	
3	Pack Samples	1	Pinch points and abrasions to hands from cooler lid closing unexpectedly	Beware that lid could slam shut; block/brace if needed; be wary of packing in strong winds. New coolers may be more prone to self closing, tilt cooler back slightly to facilitate keeping lid open.	

3	Pack Samples	2	Awkward body positions and contact stress to legs and knees when preparing coolers on irregular or hard ground surfaces.	Plan cooler prep activities. Situate cooler where neutral body positions can be maintained if practical, like truck tailgate. Avoid cooler prep on rough gravel surfaces unless knees and legs protected during kneeling.	
		3	Frostbite or potential for oxygen deficiency when packing with dry ice. Contact cold stress to fingers handling blue ice or wet ice	Dry ice temperature is -109.30F. Wear thermal protective gloves. DO NOT TOUCH with bare skin! Dry ice sublimates at room temp and could create oxygen deficiency in closed environment. Maintain adequate ventilation! Do not keep dry ice in cab of truck. Wear gloves when handling blue ice or gaging wet ice. Dry Ice is DOT regulated for air shipping, follow procedures in Shipping Determination.	
4	Sealing, labeling and Marking Cooler	1	Cuts to hands and forearms from strapping tape placement or removing old tape and labels	Do not use a fixed, open-blade knife to remove old tags/labels, USE SCISSORS or other safety style cutting device. Only use devices designed for cutting. Do not hurry through task.	
		2	Lifting and awkward body position hazards from taping heavy coolers, dropping coolers on feet during taping.	Do not hurry through the taping tasks, ensure samples in cooler are evenly distributed in cooler to reduce potential for overhanging cooler falling off edge of tailgate/table when taping.	
		3	Improper labeling and marking may result in violation of DOT/IATA HazMat shipping regulations delaying shipment or resulting in regulatory penalty	Do not deviate from ARCADIS Shipping Guide or Shipping Determination marking or labeling requirements.	
5	Offering sample cooler to a carrier or lab courier for shipment.	1	Lifting heavy coolers may result in muscle strain especially to lower back.	See lifting hazard controls above.	
		2	Carrier refusal to accept cooler may cause shipping delay and/or result in violation of DOT HazMat shipping regulations.	Promptly report all rejected and refused shipments to the ARCADIS DOT Program Manager. Do Not re-offer shipment if carrier requires additional labels markings or paperwork inconsistent with your training or Shipping Determination without contacting the ARCADIS DOT Compliance Manager.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Eye Protection	safety glasses		Required
Hand Protection	chemical resistant gloves (specify type)	nitrile	Required
	work gloves (specify type)	leather	Required

Supplies

Type	Supply	Description	Required
Miscellaneous	Other	Scissors	Required

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Moyers, Samuel HASP Reviewer Revise 5/11/2009	Kevlar is required? Leather work gloves are listed. i suggest just leather gloves.
Employee: **Role** **Review Type** **Completed Date**	Moyers, Samuel HASP Reviewer Approve 5/13/2009	

Job Safety Analysis

General

JSA ID	17061	**Status**	(3) Completed
Job Name	Environment-Other	**Created Date**	8/14/2019
Task Description	Decontamination of Equipment	**Completed Date**	11/14/2019
Template	False	**Auto Closed**	True

Client / Project

Client	RACER Trust
Project Number	
Project Name	Former GM Delco Plant 5, Kokomo, IN
PIC	
Project Manager	

User Roles

Role	Employee	Due Date	Completed Date	Supervisor	Active
Developer					☑
HASP Reviewer					☑
Quality Reviewer					☑

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Setting up decontamination area	1	Slip, trip and fall caused by uneven surfaces	Check decontamination area for slip/trip/fall hazards (i.e., vegetation, rocks, potholes). Identify and remove trip hazards from walking path. If not possible to remove hazards, flag them. Maintain good housekeeping of equipment. Verbally communicate location of flagged hazard to other field personnel working in the area.	
		2	Pinch points or sharp edges	Prior to starting work, identify pinch points and sharp edges on equipment and avoid those areas when handling. Wear leather work gloves to protect hands and fingers during loading and unloading.	
		3	Back/neck strains/sprains from lifting equipment	Lift with legs and not back. Use two field personnel to lift if the load is over 50 pounds. Load items using 2 people to minimize awkward positions and prevent strain.	
		4	Dropping equipment on self or others	Do not carry wet equipment. If equipment is wet, wipe off excess moisture to prevent dropping it and causing a struck-by injury. Carry fewer items in more trips to maintain balance. Do not stack equipment above chest height to maintain visibility of the ground and avoid slips, trips and falls. If stacking, make sure items are secured together before carrying. Maintain clear path while walking. Wear steel-toed boots to protect feet.	
2	Decontamination of tools and equipment	1	Exposure to or contact with contaminated media	Establish and enforce a minimum 10-ft exclusion zone around decontamination area to prevent splashing on and exposure of decon water to others. Pour contaminated media from smaller temporary storage containers (i.e., buckets) into drums slowly to prevent splashing onto self. Close and secure drums with affected media immediately after use to prevent exposure to affected soils or decon water. Do not handle contaminated media with bare hands to prevent dermal irritation. Wear nitrile gloves over work gloves when handling contaminated equipment to protect hands from dermal exposure.	EFH&SH Part III, Section F; EFH&SH Part III, Section G; EFH&SH Part III, Section R

2	Decontamination of tools and equipment	2	Splashing face/skin with decon fluids in spray bottles	When cleaning equipment, minimize over-spraying to prevent backsplash. make sure nozzle is adjusted properly as to not overspray. Shut nozzles on spray bottles when not in use to prevent dripping/leaking. Spray equipment down into dedicated container. Never spray equipment into the wind. Handle all decon fluids slowly and spray deliberately. Wear face shield over safety glasses if necessary. Always handle decon cleaning bottles wearing nitrile gloves.	
		3	Slip/trip/fall hazards in walking path	Maintain good housekeeping. Keep work area neat with all unnecessary equipment stored to avoid trip hazards. Do not walk on plastic sheeting around decontamination area. Do not rush through tasks.	
		4	Spilling buckets of decontamination water on the ground	Do not place buckets or drums on unlevel ground to prevent contents from spilling and causing a release. Immediately empty any intermediate or temporary storage containers of decon water or affected media into drums that can be lidded securely when not in use to prevent contents from spilling and causing a release. Securely close lid on decon bucket/drum when not in use.	
		5	Potential recontamination	Place decontaminated equipment separate from contaminated equipment. If possible, use clean plastic bag/sheeting to transport decontaminated equipment before next use.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	long sleeve shirt/pants		Required
Eye Protection	faceshield		Recommended
	safety glasses		Required
Foot Protection	steel-toe boots		Required
Hand Protection	chemical resistant gloves (specify type)	Nitrile	Required
	work gloves (specify type)	Leather or cut resistant	Required

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone		Required
	walkie talkie		Recommended
Decontamination	Decon supplies (specify type)	Alconox or liquinox, water	Required
Miscellaneous	fire extinguisher		Required
	first aid kit		Required
Personal	eye wash (specify type)	Personal - bottle	Required
	sunscreen		Recommended

Review Comments

Reviewer		Comments
Employee: **Role** **Review Type** **Completed Date**	Goldberg Day, Amy Quality Reviewer NA 12/2/2019	solid evaluation of potential hazards

Attachment B - Safety Data Sheets (SDSs)

Hydrochloric Acid
Alconox
Liquinox
Isobutylene
Iron Aggregate 2020
Portland Cement
Spray Paint

SAFETY DATA SHEET

Preparation Date: 10/15/2013 **Revision Date:** 4/27/2017 **Revision Number:** G4

1. IDENTIFICATION

Product identifier

Product code: H1135
Product Name: HYDROCHLORIC ACID, ULTRATRACE

Other means of identification

Synonyms: Muriatic Acid;
Chlorohydric acid;
Spirits of salt
Acide chlorhydrique (French)
CAS #: 7647-01-0
RTECS # MW4025000
CI#: Not available

Recommended use of the chemical and restrictions on use

Recommended use: In the production of chloride; refining ore in the production of tin and tantalum; for the neutralization of basic systems; as a laboratory reagent; as a catalyst and solvent in organic synthesis; for oil and gas-well treatment; in removing scale from boilers and heat exchange equipment; pharmaceutic aid (acidifier); in the manufacture of phosphoric acid and in the production of ammonium chloride; metal treating agent (steel pickling); in food processing as a startch modifier; in the manufacturer of sodium glutamate; in the manufacturer of gelatin; in the conversion of cornstartch to syrup; in the brewing industry; in sugar refining; in the manufacture of fertilizers, dyes and dyestuffs, artifical silks, pigments for paints; in electroplating, leather tanning, the photographic industry, in soap refining, in the textile industry, in the rubber industry; in petroleum activation; metal cleaning operations; recovery of zinc from galvanized iron scrap.
Uses advised against No information available

Supplier: Spectrum Chemical Mfg. Corp
14422 South San Pedro St.
Gardena, CA 90248
(310) 516-8000.
Order Online At: https://www.spectrumchemical.com
Emergency telephone number Chemtrec 1-800-424-9300
Contact Person: Martin LaBenz (West Coast)
Contact Person: Ibad Tirmiz (East Coast)

2. HAZARDS IDENTIFICATION

Classification

This chemical is considered hazardous according to the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Considered a dangerous substance or mixture according to the Globally Harmonized System (GHS)

Acute toxicity - Oral	Category 4
Acute toxicity - Inhalation (Gases)	Category 4

Skin corrosion/irritation	Category 1 Sub-category A
Serious eye damage/eye irritation	Category 1
Specific target organ toxicity (single exposure)	Category 3

Label elements

Danger

Hazard statements
Harmful if swallowed
Harmful if inhaled
Causes severe skin burns and eye damage
May cause respiratory irritation

Hazards not otherwise classified (HNOC)
Not Applicable

Other hazards
Not available

Precautionary Statements - Prevention
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product
Use only outdoors or in a well-ventilated area
Do not breathe dust/fume/gas/mist/vapors/spray
Wear protective gloves/protective clothing/eye protection/face protection

Precautionary Statements - Response
Immediately call a POISON CENTER or doctor/physician
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a POISON CENTER or doctor/physician.
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower
Wash contaminated clothing before reuse
IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER or doctor/physician if you feel unwell. Immediately call a POISON CENTER or doctor/physician.
IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
Rinse mouth
Do NOT induce vomiting

Precautionary Statements - Storage
Store locked up
Store in a well-ventilated place. Keep container tightly closed

Precautionary Statements - Disposal
Dispose of contents/container to an approved waste disposal plant

3. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS-No.	Weight %
Water	7732-18-5	62-80
Hydrogen chloride	7647-01-0	20-38

4. FIRST AID MEASURES

First aid measures

General Advice: National Capital Poison Center in the United States can provide assistance if you have a poison emergency and need to talk to a poison specialist. Call 1-800-222-1222. Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves. First aider needs to protect himself.

Skin Contact: Wash off immediately with soap and plenty of water. Continue flushing with plenty of water for at least 15 minutes. Remove all contaminated clothes and shoes. Immediate medical attention is required. Call a physician immediately.

Eye Contact: Flush eyes with water for 15 minutes. Immediate medical attention is required. Call a physician immediately.

Inhalation: Move to fresh air. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. WARNING! It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled or ingested material is toxic, infectious or corrosive. Do not use mouth-to-mouth resuscitation if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Immediate medical attention is required. Call a physician immediately.

Ingestion: Do not induce vomiting without medical advice. Do not give Sodium Bicarbonate (Baking Soda). Never give anything by mouth to an unconscious person. If victim is conscious, give water or milk. Immediate medical attention is required. Call a physician or Poison Control Center immediately.

Most important symptoms and effects, both acute and delayed

Symptoms Severe skin and eye irritation or burns. Irritating to respiratory system. Burning sensation of the respiratory tract. Coughing. Hoarseness of the voice. Choking sensation. Dyspnea (Shortness of breath and difficulty breathing). Shallow respiration. Can burn mouth, throat, and stomach. May cause perforation of the digestive tract. May cause salivation. Thirst. May cause difficulty swallowing. May cause abdominal pain, nausea, vomiting, diarrhea. Shock. It may affect the kidneys. Discoloration and excessive decay of teeth. Weak, rapid pulse or rapid heart rate (Tachycardia). May cause inflammation of the lungs (pneumonitis). May cause chemical burns to the respiratory tract.

Indication of any immediate medical attention and special treatment needed

Notes to Physician: Treat symptomatically.

Protection of first-aiders
First-Aid Providers: Avoid exposure to blood or body fluids. Wear gloves and other necessary protective clothing. Dispose of contaminated clothing and equipment as bio-hazardous waste.

5. FIRE-FIGHTING MEASURES

Extinguishing Media

Suitable Extinguishing Media: The product is not flammable. If it is involved in a fire, extinguish the fire using an agent suitable for the type of

surrounding fire.

Unsuitable Extinguishing Media: No information available.

Specific hazards arising from the chemical

Hazardous Combustion Products: No information available.

Specific hazards: Contact with metals may evolve flammable hydrogen gas. Calcium carbide reacts with hydrogen chloride gas with incandescence. Uranium phosphide reacts with hydrochloric acid to release spontaneously flammable phosphine. Rubidium acetylene carbide burns with slightly warm Hydrochloric acid. Lithium silicide in contact with hydrogen chloride becomes incandescent. When dilute hydrochloric acid is used, gas that is spontaneously flammable in air is evolved. Magnesium boride treated with concentrated hydrochloric acid produces spontaneously flammable gas. Cesium acetylene carbide burns in hydrogen chloride gas. Cesium carbide ignites in contact with Hydrochloric acid unless acid is dilute. Hydrogen chloride in contact with the following can cause an explosion, ignition on contact, or other violent/vigorous reaction: Acetic anhydride AgClO + CCl4 Alcohols + hydrogen cyanide, Aluminum Aluminum-titanium alloys (with HCl vapor), 2-Amino ethanol, Ammonium hydroxide, Calcium carbide Ca3P2 Chlorine + dinitroanilines (evolves gas), Chlorosulfonic acid Cesium carbide Cesium acetylene carbide, 1,1-Difluoroethylene Ethylene diamine Ethylene imine, Fluorine, HClO4 Hexalithium disilicide H2SO4 Metal acetylides or carbides, Magnesium boride, Mercuric sulfate, Oleum, Potassium permanganate, beta-Propiolactone Propylene oxide Rubidium carbide, Rubidium, acetylene carbide Sodium (with aqueous HCl), Sodium hydroxide Sodium tetraselenium, Sulfonic acid, Tetraselenium tetranitride, U3P4 , Vinyl acetate. Silver perchlorate with carbon tetrachloride in the presence of hydrochloric acid produces trichloromethyl perchlorate which detonates at 40 deg. C.

Special Protective Actions for Firefighters

Specific Methods: No information available.

Special Protective Equipment for Firefighters: As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Personal Precautions: Keep people away from and upwind of spill/leak. Ensure adequate ventilation. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Use personal protective equipment. Avoid contact with skin, eyes and clothing.

Environmental precautions Prevent further leakage or spillage if safe to do so. Should not be released into the environment. Do not let product enter drains. Do not flush into surface water or sanitary sewer system. Prevent entry into waterways, sewers, basements or confined areas.

Methods and material for containment and cleaning up

Methods for containment Stop leak if you can do it without risk.

Methods for cleaning up Neutralize with Sodium carbonate or Sodium bicarbonate. Dilute with water. Absorb spill with inert material (e.g. vermiculite, dry sand or earth), then place in a suitable chemical waste container. Clean contaminated surface thoroughly.

7. HANDLING AND STORAGE

Precautions for safe handling

Technical Measures/Precautions:
Use only in area provided with appropriate exhaust ventilation. Keep away from incompatible materials.

Safe Handling Advice
Wear personal protective equipment. Avoid contact with skin, eyes and clothing. Do not ingest. Do not breathe vapors or spray mist. Handle in accordance with good industrial hygiene and safety practice.

Conditions for safe storage, including any incompatibilities

Technical Measures/Storage Conditions:
Keep container tightly closed in a dry and well-ventilated place. Store at room temperature in the original container. May corrode metallic surfaces. Do not store in uncoated metallic containers. Store in a segregated and approved area. Store away from incompatible materials.

Incompatible Materials:
Oxidizing agents
Metals
Alkalis
Organic materials
Water

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

National occupational exposure limits

United States

Components	CAS-No.	OSHA	NIOSH	ACGIH	AIHA WHEEL
Water	7732-18-5	None	None	None	None
Hydrogen chloride	7647-01-0	5 ppm Ceiling 7 mg/m³ Ceiling	5 ppm Ceiling 7 mg/m³ Ceiling	2 ppm Ceiling	None

Canada

Components	CAS-No.	**Canada - Alberta**	**Canada - British Columbia**	**Canada - Ontario**	**Canada - Quebec**
Water	7732-18-5	None	None	None	None
Hydrogen chloride	7647-01-0	2 ppm Ceiling 3 mg/m³ Ceiling	2 ppm Ceiling	2 ppm Ceiling	5 ppm Ceiling 7.5 mg/m³ Ceiling

Australia and Mexico

Components	CAS-No.	**Australia**	**Mexico**
Water	7732-18-5	None	None
Hydrogen chloride	7647-01-0	None	5 ppm Ceiling 7 mg/m³ Ceiling

Appropriate engineering controls

Engineering measures to reduce exposure: Ensure adequate ventilation. Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors and mist below their respective threshold limit value.

Individual protection measures, such as personal protective equipment

Personal Protective Equipment

Eye protection: Face-shield and Goggles

Skin and body protection: Chemical resistant protective suit
Gloves
Boots

Respiratory protection: Vapor respirator. Be sure to use an approved/certified respirator or equivalent.

Hygiene measures: Avoid contact with skin, eyes and clothing. When using, do not eat, drink or smoke. Wash hands before breaks and immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:
Liquid

Appearance:
No information available.

Color:
Colorless. Light yellow.

Odor:
Pungent. Irritating.

Taste
No information available.

Formula:
HCl

Molecular/Formula weight:
No information available

Flammability:
No information available

Flashpoint (°C/°F):
No information available.

Flash Point Tested according to:
Not available

Autoignition Temperature (°C/°F):
No information available

Lower Explosion Limit (%):
No information available

Upper Explosion Limit (%):
No information available

Melting point/range(°C/°F):
-62.25°C (-80°F) (20.69% HCl in water)
-46.2 C (31.24% HCl in water)
-25.4 C (39.17% HCl in water)

Decomposition temperature(°C/°F):
No information available

Boiling point/range(°C/°F):
108.58 C @ 760 mm Hg (for 20.22% HCl in water)
83 C @ 760 mm Hg (for 31% HCl in

Bulk density:
No information available

water)
50.5 C (for 37% HCl in water)

Density (g/cm3):
No information available

Specific gravity:
1.1- 1.19 (Water = 1)
1.10 (20%and 22% HCl solutions)
1.12 (24% HCl solution)
1.15 (29.57% HCl solution)
1.16 (32% HCl solution)
1.186 - 1.19 (37% and 38%HCl solutions)

pH:
No information available

Vapor pressure @ 20°C (kPa):
No information available

Evaporation rate:
No information available

Vapor density:
1.267

VOC content (g/L):
No information available

Odor threshold (ppm):
0.25 to 10 ppm

Partition coefficient (n-octanol/water):
No information available

Viscosity:
No information available

Miscibility:
No information available

Solubility:
Soluble in Ether
Soluble in Water

10. STABILITY AND REACTIVITY

Reactivity

For Hydrogen chloride or concentrated Hydrochloric Acid:
Reacts with most metals to produce flammable Hydrogen gas.
Sodium reacts very violently with gaseous hydrogen chloride.
Calcium phosphide and Hydrochloric acid undergo a very energetic reaction.
Hydrogen chloride reacts with oxidizers releasing chlorine gas.
Hydrogen chloride gas is emitted when Hydrochloric acid comes in contact with Sulfuric acid.
Adsorption of Hydchloric acid onto Silicon dioxide results in exothermic reaction.
Hydrogen chloride causes aldehydes and epoxides to violently polymerize.
Reacts violently with bases, oxidizers forming toxic chlorine gas.
Reacts, often violently or vigorously or exothermically, with acetic anhydride, active metals, aliphatic amines, alkanolamines, alkylene oxides, aromatic amines, amides, 2-aminoethanol, ammonia, ammonium hydroxide, calcium phosphide, chlorosulfonic acid, ethylene diamine, ethyleneimine, epichlorohydrin, isocyanates, metal acetylides, oleum, organic anhydrides, perchloric acid, 3-propiolactone, uranium phosphide, sulfuric acid, vinyl acetate, vinylidene fluoride, alcohols + hydrogen cyanide, Aluminum phosphide, Aluminum-titanium alloys, 2-Amino ethanol, Ammonium hydroxide, Ammonium, 1,4-Benzoquinone diimine, Cesium telluroacylated, Chlorine + dinitroanilines, Chloroacetaldehyde oxime, Cyanogen chloride, 1,1-Difluoroethylene, dinitroanilines, Ethylene, Ethyl 2-formylpropionate oxime, Hexalithium disilicide, Hydrogen peroxide, Methyl vinyl ether, Nitric acid + glycerol, Potassium, Potassium permanganate, beta-Propiolactone, Propylene oxide, Rubidium acetylide, Silver chlorite, Sodium 2-allyloxy-6-nitrophenylpyruvate oxime, Sodium hydroxide, Sodium teranitride, 2,4,6-Tri(2-acetylhydrazino)-1,3,5-trinitrobenzene, Sulfonic acid, Cesium cyanotridecahydrodecarborate(2-), Potassium ferricyanide, Vinylidene fluoride, Potassium ferrocyanide, Ammonium hexacyanoferrate (II).
Reaction with oxidizers such as permanganates, chlorates, chlorites, and hypochlorites may produce chlorine or bromine gas.
Reacts vigorously with alkalies and with many organic materials.
Cesium acetylene carbide burns in hydrogen chloride gas.
Lithium silicide in contact with hydrogen chloride becomes incandescent.
Magnesium boride in contact with concentrated hydrochloric acid produces spontaneously flammable gas.
Rubidium acetylene carbide burns with slightly warm hydrochloric acid.
Rubidium carbide ignites in contact with hydrochloric acid unless acid is dilute.
Uranium phosphide reacts with hydrochloric acid to release spontaneously flammable phosphine.
Calcium carbide reacts with hydrogen chloride gas with incandescence.
Absorption of gaseous hydrogen chloride on mercuric sulfate becomes violent @ 125 deg C.
Reaction of silver perchlorate with carbon tetrachloride in presence of small amount of hydrochloric acid produces trichloromethyl perchlorate, which detonates @ 40 deg C.
Cesium carbide ignites in contact with hydrochloric acid unless acid is dilute.
Hydrochloric acid in the presence of alcohol and glycols results in dehydration reactions.
Hydrogen chloride gas can react with formaldehyde to form bis(chloromethyl)ether, a human carcinogen.
Exothermic reaction with water
Attacks some plastics, rubber, and coatings.

Chemical stability

Stability: Stable under recommended storage conditions.

Possibility of Hazardous Reactions: Hazardous polymerization does not occur

Conditions to avoid: Stable at normal conditions.

Incompatible Materials: Oxidizing agents
Metals
Alkalis
Organic materials
Water

Hazardous decomposition products: Hydrogen chloride gas. Hydrogen. Hydrogen, by reaction with metals.

Other Information
Corrosivity: Severe corrosive effect on 304 Stainless Steel
Severe corrosive effect on 316 Stainless Steel
Severe corrosive effect on Copper and copper alloys
Severe corrosive effect on Bronze
Severe corrosive effect on Brass

Special Remarks on Corrosivity: No information available

11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Principal Routes of Exposure:
Skin. Inhalation. Ingestion.

Acute Toxicity

The following values are calculated based on chapter 3.1 of the GHS document
ATEmix (inhalation-gas) 4115-7810 ppm; (4-hr)

Component Information

Water	
CAS-No.	7732-18-5

LD50/oral/rat = > 90 mL/kg Oral LD50 Rat
LD50/oral/mouse = No information available
LD50/dermal/rabbit = No information available
LD50/dermal/rat = No information available
LC50/inhalation/rat = No information available
LC50/inhalation/mouse = No infomation available
Other LD50 or LC50information = No information available

Hydrogen chloride	
CAS-No.	7647-01-0

LD50/oral/rat = 238 - 277 mg/kg Oral LD50 Rat
700 mg/kg Oral LD50 Rat (test substance: 31.5% hydrochloric acid solution)
LD50/oral/mouse = No information available
LD50/dermal/rabbit = >5010 mg/kg (Test substance: 31.5% hydrochloric acid solution - from European Chemicals Bureau IUCLID dataset)

LD50/dermal/rat = No information available
LC50/inhalation/rat = 3124 ppm Inhalation LC50 Rat 1 h
1562 ppm 4 h
1.68 mg/L Inhalation LC50 Rat 1h
LC50/inhalation/mouse = 1108 ppm 1 h
Other LD50 or LC50information = 900 mg/kg oral LD50 Rabbit (no information on test substance)

Product Information

LD50/oral/rat =
VALUE- Acute Tox Oral = 700 mg/kg

LD50/oral/mouse =
Value - Acute Tox Oral = No information available

LD50/dermal/rabbit
VALUE-Acute Tox Dermal = > 5010 mg/kg

LD50/dermal/rat
VALUE -Acute Tox Dermal = No information available

LC50/inhalation/rat
VALUE-Vapor = No information available
VALUE-Gas = No information available
VALUE-Dust/Mist = No information available

LC50/Inhalation/mouse
VALUE-Vapor = No information available
VALUE - Gas = No information available
VALUE - Dust/Mist = No information available

Symptoms

Skin Contact:	Causes severe irritation and burns.
Eye Contact:	Causes severe irritation and burns.
Inhalation	Harmful by inhalation. Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract. Inhalation of hydrochloric acid fumes produces nose, throat, and laryngeal irritation, and burning, pain and inflammation, coughing, sneezing, choking sensation, hoarseness, laryngeal spasms, upper respiratory tract edema, chest pains, as well has headache, and palpitations. Inhalation of high concentrations can result in corrosive burns, necrosis of bronchial epithelium, constriction of the larynx and bronchi, nasoseptal perforation, glottal closure, dyspnea, bronchitis. Chemical pneumonitis and pulmonary edema can also occur, particularly if exposure is prolonged. May affect the liver.
Ingestion	Harmful if swallowed. Causes irritation and burning, ulceration, or perforation of the gastrointestinal tract and resultant peritonitis, gastric hemorrhage and infection. Can also cause nausea, vomitting (with "coffee ground" emesis), diarrhea, thirst, difficulty swallowing, salivation, chills, fever, uneasiness, shock, strictures and stenosis (esophogeal, gastric, pyloric). May affect behavior (excitement), the cardiovascular system (weak rapid pulse, tachycardia), respiration (shallow respiration), and urinary system (kidneys- renal failure, nephritis). Acute ingestion can also cause erosion of tooth enamel.
Aspiration hazard	No information available.

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Chronic Toxicity Prolonged or repeated inhalation and/or ingestion may affect liver, and cause bleeding of nose and gums, nasal and oral mucosal ulceration, conjunctivitis. It may also affect respiratory tract (changes in pulmonary function, chronic bronchitis, overt respiratory tract abnormalities), teeth (yellowing of teeth and erosion of tooth enamel), kidneys, and behavior/central nervous system (muscle contraction or spasticity).Prolonged or repeated skin contact may cause dermatitis.Prolonged or repeated eye contact with vapor/mist can cause conjunctivitis.

Sensitization: No information available.

Mutagenic Effects: Animal experiments showed mutagenic effects
Cytogenetic Analysis - chromosome aberration test (Chinese Hamster ovary): Genotoxic effects were observed

Carcinogenic effects: Not considered carcinogenic.

Components	CAS-No.	IARC	ACGIH - Carcinogens	NTP	OSHA HCS - Carcinogens	Australia - Notifiable Carcinogenic Substances	Australia - Prohibited Carcinogenic Substances
Water	7732-18-5	Not listed	Not listed	Not listed	Not listed	Not listed	Not listed
Hydrogen chloride	7647-01-0	Group 3 - Not Classifiable - Monograph 54 [1992]	A4 Not Classifiable as a Human Carcinogen	Not listed	Not listed	Not listed	Not listed

ACGIH (American Conference of Governmental Industrial Hygienists)

IARC (International Agency for Research on Cancer)

NTP (National Toxicology Program)

OSHA (Occupational Safety and Health Administration of the US Department of Labor)

Reproductive toxicity No data is available

Reproductive Effects: No information available
Developmental Effects: No information on developmental toxicity effects on humans was found
An increase in postnatal mortality was seen in experiments where rats were exposed to Hydrogen Chloride for 1 hour
Teratogenic Effects: No information available

Specific Target Organ Toxicity

STOT - single exposure No information available.
STOT - repeated exposure No information available.
Target Organs: Skin. Eyes. Respiratory system.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Ecotoxicity effects: Aquatic environment.

Hydrogen chloride - 7647-01-0
Freshwater Fish Species Data: 282 mg/L LC50 Gambusia affinis 96 h
862 mg/L LC50 Leuciscus idus

Water Flea Data: <56 mg/L LC50 Daphnia magna 72h

Persistence and degradability: No information available

Bioaccumulative potential: No information available.

Mobility: No information available.

13. DISPOSAL CONSIDERATIONS

Disposal Methods

Waste from residues / unused products:
Waste must be disposed of in accordance with Federal, State and Local regulation.

Contaminated packaging:
Empty containers should be taken for local recycling, recovery or waste disposal

Components	CAS-No.	RCRA - F Series Wastes	RCRA - K Series Wastes	RCRA - P Series Wastes	RCRA - U Series Wastes
Water	7732-18-5	None	None	None	None
Hydrogen chloride	7647-01-0	None	None	None	None

14. TRANSPORT INFORMATION

DOT

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Subsidiary Class	No information available
Packing group:	II
Emergency Response Guide Number	157
Marine Pollutant	No data available
DOT RQ (lbs):	No information available
Special Provisions	A3, A6, B3, B15, IB2, N41, T8, TP2
Symbol(s):	[DOT]: (R5) - Identifies a material that is a hazardous substance that has a reportable quantity (RQ) of 5000 pounds (2270 Kilograms).
Description:	UN1789, Hydrochloric acid solution, 8, II

TDG (Canada)

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Subsidiary Risk:	No information available
Packing Group:	II
Marine Pollutant	No Information available
Description:	UN1789, Hydrochloric acid solution, 8, II

ADR

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Packing Group:	II
Subsidiary Risk:	No information available
Special Provisions	520
Description:	UN1789, Hydrochloric acid solution, 8, II

IMO / IMDG

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Subsidiary Risk:	No information available
Packing Group:	II
Marine Pollutant	No information available
EMS:	F-A
Description	UN1789, Hydrochloric acid solution, 8, II

RID

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Subsidiary Risk:	8
Packing Group:	II
Special Provisions	520
Description:	UN1789, Hydrochloric acid solution, 8, II

ICAO

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Subsidiary Risk:	No information available
Packing Group:	II
Description:	UN1789, Hydrochloric acid solution, 8, II
Special Provisions	A3

IATA

UN-No:	UN1789
Proper Shipping Name:	Hydrochloric acid solution
Hazard Class:	8
Subsidiary Risk:	No information available
Packing Group:	II
ERG Code:	8L
Special Provisions	No information available
Description:	UN1789, Hydrochloric acid solution, 8, II

15. REGULATORY INFORMATION

International Inventories

Components	CAS-No.	U.S. TSCA	KOREA KECL	Philippines (PICCS)	Japan ENCS	CHINA	Australia (AICS)	EINECS-No.
Water	7732-18-5	Present	Present KE-35400	Present	Not present	Present	Present	Present 231-791-2
Hydrogen chloride	7647-01-0	Present	Present KE-20189	Present	Present (1)-215	Present	Present	Present 231-595-7

U.S. Regulations

Hydrogen chloride

Massachusetts RTK: Present
Massachusetts EHS: extraordinarily hazardous
New Jersey RTK Hazardous Substance List: 1012
New Jersey (EHS) List: 1012 500 lb TPQ
2909 500 lb TPQ
New Jersey - Discharge Prevention - List of Hazardous Substances: Present

New Jersey TCPA - EHS: 15000lbTQ
5000lbTQ
5600lbTQ
2000lbTQ
Pennsylvania RTK: Environmental hazard
Pennsylvania RTK - Environmental Hazard List Present
Michigan PSM HHC: = 5000 lb TQ
Minnesota - Hazardous Substance List: Present
New York Release Reporting - List of Hazardous Substances:
5000 lb RQ
100 lb RQ
Louisana Reportable Quantity List for Pollutants: 5000lbfinal RQAs listed in 40 CFR 117.3 Table 117.3 and 40 CFR 302.4 Table 302.4
2270kgfinal RQAs listed in 40 CFR 117.3 Table 117.3 and 40 CFR 302.4 Table 302.4
5000lbRQAs listed in Louisiana Administrative Code, Title 33, Part 1, Subpart 2, Chapter 39, Subchapter E. Applies to unauthorized emissions based on total mass emitted into or onto all media within any consecutive 24-hour period
1000lbRQAs listed in Louisiana Administrative Code, Title 33, Part 1, Subpart 2, Chapter 39, Subchapter E. Applies to unauthorized emissions based on total mass emitted into the atmosphere
California Directors List of Hazardous Substances: Present
FDA - Food Additives Generally Recognized as Safe (GRAS): 21 CFR 182.1057
FDA - 21 CFR - Total Food Additives 133.129, 155.191, 155.194, 160.105, 160.185, 172.560, 172.892, 182.1057

California Prop. 65: Safe Drinking Water and Toxic Enforcement Act of 1986.

Chemicals Known to the State of California to Cause Cancer:
This product does not contain a chemical requiring a warning under California Prop. 65. (See table below)

Chemicals Known to the State of California to Cause Reproductive Toxicity:
This product does not contain a chemical requiring a warning under California Prop. 65. (See table below)

Components	CAS-No.	Carcinogen	Developmental Toxicity	Male Reproductive Toxicity	Female Reproductive Toxicity:
Water	7732-18-5	Not Listed	Not Listed	Not Listed	Not Listed
Hydrogen chloride	7647-01-0	Not Listed	Not Listed	Not Listed	Not Listed

CERCLA/SARA

Components	CAS-No.	CERCLA - Hazardous Substances and their Reportable Quantities	Section 302 Extremely Hazardous Substances and TPQs	Section 302 Extremely Hazardous Substances and RQs	Section 313 - Chemical Category	Section 313 - Reporting de minimis
Water	7732-18-5	None	None	None	None	None
Hydrogen chloride	7647-01-0	5000 lb final RQ 2270 kg final RQ	500 lb TPQ 5000 lb EPCRA RQ	None	None	1.0 % de minimis concentration

U.S. TSCA

Components	CAS-No.	TSCA Section 5(a)2 - Chemicals With Significant New Use Rules (SNURS)	TSCA 8(d) -Health and Safety Reporting
Water	7732-18-5	Not Applicable	Not Applicable
Hydrogen chloride	7647-01-0	Not Applicable	Not Applicable

Canada

WHIMIS 2015 - GHS Classifications

WHMIS 2015 Hazard Classification Information: .

Component
Water
7732-18-5 (62-80)
Hydrogen chloride
7647-01-0 (20-38)

WHMIS 2015 Hazard Classification
Not a dangerous product according to HPR classification criteria

Gases under pressure - Liquefied gas: H280 Contains gas under pressure, may explode when heated.; Corrosive to Metals -

Category 1: H290 May be corrosive to metals. (potentially corrosive to metals; the supplier should be contacted for more information); Acute toxicity - Inhalation - Category 3: H331 Toxic if inhaled.; Health Hazard Not Otherwise Classified - Category 1: Causes severe damage to the respiratory tract; Skin corrosion/irritation - Category 1: H314 Causes severe skin burns and eye damage.; Serious Eye Damage/Eye Irritation - Category 1: H318 Causes serious eye damage.

Canada Hazardous Products Regulation This product has been classified according to the hazard criteria of the HPR (Hazardous Products Regulation) and the SDS contains all of the information required by the HPR

WHMIS 1988 Hazard Class
D1A Very toxic materials
D1B Toxic materials
E Corrosive material

Components

	WHMIS 1988
Water	Uncontrolled product according to WHMIS classification criteria
Hydrogen chloride	A,D1A,E D1A,E E 0.036% in aqueous solution, 0.36% in aqueous solution, 3.6% in aqueous solution D1B,E 28% in aqueous solution D1A,E 31.45% in aqueous solution, 35.2% in aqueous solution

Canada Controlled Products Regulation:
This product has been classified according to the hazard criteria of the CPR (Controlled Products Regulation) and the MSDS contains all of the information required by the CPR.

Components	**WHMIS Ingredient Disclosure List -**
Hydrogen chloride	1 %

Inventory

Components	CAS-No.	Canada (DSL)	Canada (NDSL)
Water	7732-18-5	Present	Not Listed
Hydrogen chloride	7647-01-0	Present	Not Listed

Components	CAS-No.	CEPA Schedule I - Toxic Substances
Water	7732-18-5	Not listed
Hydrogen chloride	7647-01-0	Not listed
Components	CAS-No.	CEPA - 2010 Greenhouse Gases Subject to Mandatory Reporting
Water	7732-18-5	Not listed
Hydrogen chloride	7647-01-0	Not listed

EU Classification

EU GHS - SV - CLP 172/2008

Components	CAS-No.	EU GHS - SV - CLP (172/2008)
Water	7732-18-5	
Hydrogen chloride	7647-01-0	Gases under pressure: H280 Contains gas under pressure, may explode when heated.; Acute toxicity - Inhalation - Acute Tox. 3: H331 Toxic if inhaled. (Minimum classification); Skin corrosion/irritation - Skin Corr. 1A: H314 Causes severe skin burns and eye damage.017-002-00-2

EU - CLP (1272/2008)

R-phrase(s)
R34 - Causes burns.
R37 - Irritating to respiratory system.

S -phrase(s)
S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S45 - In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 1/2 - Keep locked up and out of the reach of children.

Components	CAS-No.	**Classification**	**Concentration Limits:**	**Safety Phrases**
Water	7732-18-5		No information	
Hydrogen chloride	7647-01-0	Hydrogen Chloride T; R23 C; R35 Hydrochloric Acid: + hydrochloric acid ... % C; R34 - Xi; R37 Concentration Limit(s): C >= 25 % C; R34-37 10 % <= C < 25 % Xi; R36/37/38	Hydrogen Chloride: 0.02%<=C<0.2% Xi;R36/37/38 0.2%<=C<0.5% C;R34 0.5%<=C<1% C;R20-34 1%<=C<5% C;R20-35 5%<=C T;C;R23-35	For Hydrogen Chloride: S1/2 S9 S26 S36/37/39 S45 Hydrochloric Acid: S(1/2)-S26-S45

The product is classified in accordance with Annex VI to Directive 67/548/EEC

Indication of danger:
C - Corrosive.
Xi - Irritant.

16. OTHER INFORMATION

Preparation Date: 10/15/2013
Revision Date: 4/27/2017
Prepared by: Sonia Owen

Disclaimer: All chemicals may pose unknown hazards and should be used with caution. This Safety Data Sheet (SDS) applies only to the material as packaged. If this product is combined with other materials, deteriorates, or becomes contaminated, it may pose hazards not mentioned in this SDS. The physical properties reported in this SDS are obtained from the literature and do not constitute product specifications. Information contained herein does not constitute a warranty, whether expressed or implied, as to the safety, merchantability or fitness of the goods for a particular purpose. Spectrum Chemicals & Laboratory Products, Inc. assumes no responsibility for results obtained or for incidental or consequential damages, including lost profits, arising from the use of these data. No warranty against infringement of any patent, copyright or trademark is made or implied. It shall be the user's responsibility to develop proper methods of handling and personal

protection based on the actual conditions of use. While this SDS is based on technical data judged to be reliable, Spectrum assumes no responsibility for the completeness or accuracy of the information contained herein.

End of Safety Data Sheet

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), and GHS

Printing date 25.05.2012 Revision: 24.05.2012

1 Identification of the substance/mixture and of the company/undertaking

· **1.1 Product identifier**

· **Trade name: ALCONOX**
· **Application of the substance / the preparation** Cleaning material/ Detergent

· **1.3 Details of the supplier of the Safety Data Sheet**
· **Manufacturer/Supplier:**
Alconox, Inc.
30 Glenn St., Suite 309
White Plains, NY 10603
Phone: 914-948-4040

· **Further information obtainable from:** Product Safety Department
· **1.4 Emergency telephone number:**
ChemTel Inc.
(800)255-3924, +1 (813)248-0585

2 Hazards identification

· **2.1 Classification of the substance or mixture**
· **Classification according to Regulation (EC) No 1272/2008**

GHS05 corrosion

Eye Dam. 1 H318 Causes serious eye damage.

GHS07

Skin Irrit. 2 H315 Causes skin irritation.

· **Classification according to Directive 67/548/EEC or Directive 1999/45/EC**

Xi; Irritant

R38-41: Irritating to skin. Risk of serious damage to eyes.
· **Information concerning particular hazards for human and environment:**
The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.
· **Classification system:**
The classification is according to the latest editions of the EU-lists, and extended by company and literature data.

· **2.2 Label elements**
· **Labelling according to Regulation (EC) No 1272/2008**
The product is classified and labelled according to the CLP regulation.
· **Hazard pictograms**

GHS05

· **Signal word** Danger

· **Hazard-determining components of labelling:**
Benzenesulfonic Acid, Sodium Salts

(Contd. on page 2)

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), and GHS

Printing date 25.05.2012 Revision: 24.05.2012

Trade name: ALCONOX

(Contd. of page 1)

· **Hazard statements**
H315 Causes skin irritation.
H318 Causes serious eye damage.
· **Precautionary statements**

P280	Wear protective gloves/protective clothing/eye protection/face protection.
P264	Wash thoroughly after handling.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310	Immediately call a POISON CENTER or doctor/physician.
P321	Specific treatment (see on this label).
P362	Take off contaminated clothing and wash before reuse.
P332+P313	If skin irritation occurs: Get medical advice/attention.
P302+P352	IF ON SKIN: Wash with plenty of soap and water.

· **Hazard description:**
· **WHMIS-symbols:**
D2B - Toxic material causing other toxic effects

· **NFPA ratings (scale 0 - 4)**

Health = 1
Fire = 0
Reactivity = 0

· **HMIS-ratings (scale 0 - 4)**

Health = 1
Fire = 0
Reactivity = 0

· **2.3 Other hazards**
· **Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.

3 Composition/information on ingredients

· **3.2 Mixtures**
· **Description:** Mixture of substances listed below with nonhazardous additions.

· **Dangerous components:**

CAS: 68081-81-2	Benzenesulfonic Acid, Sodium Salts Xi R38-41 Eye Dam. 1, H318 Skin Irrit. 2, H315	10-25%
CAS: 497-19-8 EINECS: 207-838-8 Index number: 011-005-00-2	sodium carbonate Xi R36 Eye Irrit. 2, H319	2,5-10%

(Contd. on page 3)

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), and GHS

Printing date 25.05.2012 Revision: 24.05.2012

Trade name: ALCONOX

(Contd. of page 2)

CAS: 7722-88-5 EINECS: 231-767-1	tetrasodium pyrophosphate substance with a Community workplace exposure limit	2,5-10%
CAS: 151-21-3 EINECS: 205-788-1	sodium dodecyl sulphate Xn R21/22; Xi R36/38 Acute Tox. 4, H302; Acute Tox. 4, H312; Skin Irrit. 2, H315; Eye Irrit. 2, H319	2,5-10%

· **Additional information:** For the wording of the listed risk phrases refer to section 16.

4 First aid measures

· **4.1 Description of first aid measures**
· **After inhalation:** Supply fresh air; consult doctor in case of complaints.
· **After skin contact:**
Immediately wash with water and soap and rinse thoroughly.
If skin irritation continues, consult a doctor.
· **After eye contact:**
Remove contact lenses if worn.
Rinse opened eye for several minutes under running water. If symptoms persist, consult a doctor.
· **After swallowing:**
Do not induce vomiting; call for medical help immediately.
Rinse out mouth and then drink plenty of water.
· **4.2 Most important symptoms and effects, both acute and delayed**
No further relevant information available.
· **4.3 Indication of any immediate medical attention and special treatment needed**
No further relevant information available.

5 Firefighting measures

· **5.1 Extinguishing media**
· **Suitable extinguishing agents:**
CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.
· **5.2 Special hazards arising from the substance or mixture**
No further relevant information available.
· **5.3 Advice for firefighters**
· **Protective equipment:**
Wear self-contained respiratory protective device.
Wear fully protective suit.

6 Accidental release measures

· **6.1 Personal precautions, protective equipment and emergency procedures**
Product forms slippery surface when combined with water.
· **6.2 Environmental precautions:** Do not allow to enter sewers/ surface or ground water.
· **6.3 Methods and material for containment and cleaning up:**
Pick up mechanically.
Clean the affected area carefully; suitable cleaners are:
Warm water
· **6.4 Reference to other sections**
See Section 7 for information on safe handling.

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See Section 8 for information on personal protection equipment.
See Section 13 for disposal information.

7 Handling and storage

· **7.1 Precautions for safe handling**
Prevent formation of dust.
Keep receptacles tightly sealed.
· **Information about fire - and explosion protection:** No special measures required.

· **7.2 Conditions for safe storage, including any incompatibilities**
· **Storage:**
· **Requirements to be met by storerooms and receptacles:** No special requirements.
· **Information about storage in one common storage facility:** Not required.
· **Further information about storage conditions:** Protect from humidity and water.
· **7.3 Specific end use(s)** No further relevant information available.

8 Exposure controls/personal protection

· **Additional information about design of technical facilities:** No further data; see item 7.

· **8.1 Control parameters**

· **Ingredients with limit values that require monitoring at the workplace:**	
7722-88-5 tetrasodium pyrophosphate	
REL (USA)	5 mg/m³
TLV (USA)	TLV withdrawn
EV (Canada)	5 mg/m³

· **Additional information:** The lists valid during the making were used as basis.

· **8.2 Exposure controls**
· **Personal protective equipment:**
· **General protective and hygienic measures:**
Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing
Wash hands before breaks and at the end of work.
Avoid contact with the skin.
Avoid contact with the eyes and skin.
· **Respiratory protection:**
In case of brief exposure or low pollution use respiratory filter device. In case of intensive or longer exposure use self-contained respiratory protective device.
· **Protection of hands:**

Protective gloves

The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.
Due to missing tests no recommendation to the glove material can be given for the product/ the preparation/ the chemical mixture.
Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation

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· **Material of gloves**
Butyl rubber, BR
Nitrile rubber, NBR
Natural rubber, NR
Neoprene gloves
The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer. As the product is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application.
· **Penetration time of glove material**
The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.
· **Eye protection:**

Safety glasses

· **Body protection:** Protective work clothing

9 Physical and chemical properties

· **9.1 Information on basic physical and chemical properties**	
· **General Information**	
· **Appearance:**	
Form:	Powder
Colour:	White
· **Odour:**	Odourless
· **Odour threshold:**	Not determined.
· **pH-value (10 g/l) at 20°C:**	9,5 (- NA for Powder form)
· **Change in condition**	
Melting point/Melting range:	Undetermined.
Boiling point/Boiling range:	Undetermined.
· **Flash point:**	Not applicable.
· **Flammability (solid, gaseous):**	Not determined.
· **Ignition temperature:**	
Decomposition temperature:	Not determined.
· **Self-igniting:**	Product is not selfigniting.
· **Danger of explosion:**	Product does not present an explosion hazard.
· **Explosion limits:**	
Lower:	Not determined.
Upper:	Not determined.
· **Vapour pressure:**	Not applicable.
· **Density at 20°C:**	1,1 g/cm³
· **Relative density**	Not determined.
· **Vapour density**	Not applicable.

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· **Evaporation rate**	Not applicable.
· **Solubility in / Miscibility with water:**	Soluble.
· **Segregation coefficient (n-octanol/water):**	Not determined.
· **Viscosity:**	
Dynamic:	Not applicable.
Kinematic:	Not applicable.
· **Solvent content:**	
Organic solvents:	0,0 %
Solids content:	100 %
· **9.2 Other information**	No further relevant information available.

10 Stability and reactivity

· **10.1 Reactivity**
· **10.2 Chemical stability**
· **Thermal decomposition / conditions to be avoided:**
No decomposition if used according to specifications.
· **10.3 Possibility of hazardous reactions**
Reacts with acids.
Reacts with strong alkali.
Reacts with strong oxidizing agents.
· **10.4 Conditions to avoid** No further relevant information available.
· **10.5 Incompatible materials:** No further relevant information available.
· **10.6 Hazardous decomposition products:**
Carbon monoxide and carbon dioxide
Phosphorus compounds
Sulphur oxides (SOx)

11 Toxicological information

· **11.1 Information on toxicological effects**
· **Acute toxicity:**
· **Primary irritant effect:**
· **on the skin:** Irritant to skin and mucous membranes.
· **on the eye:** Strong irritant with the danger of severe eye injury.
· **Sensitization:** No sensitizing effects known.
· **Additional toxicological information:**
The product shows the following dangers according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version:
Irritant
Swallowing will lead to a strong caustic effect on mouth and throat and to the danger of perforation of esophagus and stomach.

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12 Ecological information

· **12.1 Toxicity**
· **Aquatic toxicity:** No further relevant information available.
· **12.2 Persistence and degradability** No further relevant information available.
· **12.3 Bioaccumulative potential** Not worth-mentioning accumulating in organisms
· **12.4 Mobility in soil** No further relevant information available.
· **Additional ecological information:**
· **General notes:**
Water hazard class 2 (German Regulation) (Self-assessment): hazardous for water
Do not allow product to reach ground water, water course or sewage system.
Danger to drinking water if even small quantities leak into the ground.
· **12.5 Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.
· **12.6 Other adverse effects** No further relevant information available.

13 Disposal considerations

· **13.1 Waste treatment methods**
· **Recommendation**
Smaller quantities can be disposed of with household waste.
Small amounts may be diluted with plenty of water and washed away. Dispose of bigger amounts in accordance with Local Authority requirements.
The surfactant used in this product complies with the biodegradability criteria as laid down in Regulation (EC) No. 648/2004 on detergents. Data to support this assertion are held at the disposal of the competent authorities of the Member States and will be made available to them, at their direct request or at the request of a detergent manufacturer.

· **Uncleaned packaging:**
· **Recommendation:** Disposal must be made according to official regulations.
· **Recommended cleansing agents:** Water, if necessary together with cleansing agents.

14 Transport information

· **14.1 UN-Number**	
· **DOT, ADR, ADN, IMDG, IATA**	N/A
· **14.2 UN proper shipping name**	
· **DOT, ADR, ADN, IMDG, IATA**	N/A
· **14.3 Transport hazard class(es)**	
· **DOT, ADR, ADN, IMDG, IATA**	
· **Class**	N/A
· **14.4 Packing group**	
· **DOT, ADR, IMDG, IATA**	N/A
· **14.5 Environmental hazards:**	
· **Marine pollutant:**	No

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· **14.6 Special precautions for user**	Not applicable.
· **14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code**	Not applicable.
· **UN "Model Regulation":**	N/A

15 Regulatory information

· **15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture**
· **United States (USA)**
· **SARA**

· **Section 355 (extremely hazardous substances):**
None of the ingredients is listed.

· **Section 313 (Specific toxic chemical listings):**
None of the ingredients is listed.

· **TSCA (Toxic Substances Control Act):**
All ingredients are listed.

· **Proposition 65 (California):**

· **Chemicals known to cause cancer:**
None of the ingredients is listed.

· **Chemicals known to cause reproductive toxicity for females:**
None of the ingredients is listed.

· **Chemicals known to cause reproductive toxicity for males:**
None of the ingredients is listed.

· **Chemicals known to cause developmental toxicity:**
None of the ingredients is listed.

· **Carcinogenic Categories**

· **EPA (Environmental Protection Agency)**
None of the ingredients is listed.

· **TLV (Threshold Limit Value established by ACGIH)**
None of the ingredients is listed.

· **NIOSH-Ca (National Institute for Occupational Safety and Health)**
None of the ingredients is listed.

· **OSHA-Ca (Occupational Safety & Health Administration)**
None of the ingredients is listed.

· **Canada**

· **Canadian Domestic Substances List (DSL)**
All ingredients are listed.

· **Canadian Ingredient Disclosure list (limit 0.1%)**
None of the ingredients is listed.

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· **Canadian Ingredient Disclosure list (limit 1%)**	
497-19-8	sodium carbonate
7722-88-5	tetrasodium pyrophosphate
151-21-3	sodium dodecyl sulphate

· **15.2 Chemical safety assessment:** A Chemical Safety Assessment has not been carried out.

16 Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· **Relevant phrases**
H302 Harmful if swallowed.
H312 Harmful in contact with skin.
H315 Causes skin irritation.
H318 Causes serious eye damage.
H319 Causes serious eye irritation.

R21/22 Harmful in contact with skin and if swallowed.
R36 Irritating to eyes.
R36/38 Irritating to eyes and skin.
R38 Irritating to skin.
R41 Risk of serious damage to eyes.

· **Abbreviations and acronyms:**
ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
IMDG: International Maritime Code for Dangerous Goods
DOT: US Department of Transportation
IATA: International Air Transport Association
GHS: Globally Harmonized System of Classification and Labelling of Chemicals
ACGIH: American Conference of Governmental Industrial Hygienists
NFPA: National Fire Protection Association (USA)
HMIS: Hazardous Materials Identification System (USA)
WHMIS: Workplace Hazardous Materials Information System (Canada)

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1 Identification of the substance/mixture and of the company/undertaking

· **1.1 Product identifier**

· **Trade name: LIQUINOX**
· **Application of the substance / the preparation** Hand detergent

· **1.3 Details of the supplier of the Safety Data Sheet**
· **Manufacturer/Supplier:**
Alconox, Inc.
30 Glenn St., Suite 309
White Plains, NY 10603
Phone: 914-948-4040

· **Further information obtainable from:** Product Safety Department
· **1.4 Emergency telephone number:**
ChemTel Inc.
(800)255-3924, +1 (813)248-0585

2 Hazards identification

· **2.1 Classification of the substance or mixture**
· **Classification according to Regulation (EC) No 1272/2008**

GHS07

Skin Irrit. 2 H315 Causes skin irritation.
Eye Irrit. 2 H319 Causes serious eye irritation.

· **Classification according to Directive 67/548/EEC or Directive 1999/45/EC**

Xi; Irritant

R36/38: Irritating to eyes and skin.
· **Information concerning particular hazards for human and environment:**
The product has to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.
· **Classification system:**
The classification is according to the latest editions of the EU-lists, and extended by company and literature data.

· **2.2 Label elements**
· **Labelling according to Regulation (EC) No 1272/2008**
The product is classified and labelled according to the CLP regulation.
· **Hazard pictograms**

GHS07

· **Signal word** Warning

· **Hazard-determining components of labelling:**
Benzenesulfonic Acid, Sodium Salts
· **Hazard statements**
H315 Causes skin irritation.
H319 Causes serious eye irritation.
· **Precautionary statements**
P280 Wear protective gloves/protective clothing/eye protection/face protection.

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P264	Wash thoroughly after handling.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P321	Specific treatment (see on this label).
P362	Take off contaminated clothing and wash before reuse.
P332+P313	If skin irritation occurs: Get medical advice/attention.
P337+P313	If eye irritation persists: Get medical advice/attention.
P302+P352	IF ON SKIN: Wash with plenty of soap and water.

· **Hazard description:**
· **WHMIS-symbols:**
D2B - Toxic material causing other toxic effects

· **NFPA ratings (scale 0 - 4)**

Health = 1
Fire = 0
Reactivity = 0

· **HMIS-ratings (scale 0 - 4)**

Health = 1
Fire = 0
Reactivity = 0

· **2.3 Other hazards**
· **Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.

3 Composition/information on ingredients

· **3.2 Mixtures**
· **Description:** Mixture of substances listed below with nonhazardous additions.

· **Dangerous components:**

CAS: 68081-81-2	Benzenesulfonic Acid, Sodium Salts Xi R38-41 Eye Dam. 1, H318 Skin Irrit. 2, H315	10-25%
CAS: 1300-72-7 EINECS: 215-090-9	sodium xylenesulphonate Xi R36/37/38 Skin Irrit. 2, H315; Eye Irrit. 2, H319; STOT SE 3, H335	2,5-10%
CAS: 84133-50-6	Alcohol Ethoxylate Xi R36/38 Skin Irrit. 2, H315	2,5-10%
CAS: 68603-42-9 EINECS: 271-657-0	Coconut diethanolamide Xi R36/38	2,5-10%
CAS: 17572-97-3 EINECS: 241-543-5	Ethylenediaminetetraacetic acid, tripotassium salt Xi R36/37/38	2,5-10%

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· **Additional information:** For the wording of the listed risk phrases refer to section 16.

4 First aid measures

· **4.1 Description of first aid measures**
· **General information:** Take affected persons out into the fresh air.
· **After inhalation:** Supply fresh air; consult doctor in case of complaints.
· **After skin contact:**
Immediately wash with water and soap and rinse thoroughly.
If skin irritation continues, consult a doctor.
· **After eye contact:**
Remove contact lenses if worn.
Rinse opened eye for several minutes under running water. If symptoms persist, consult a doctor.
· **After swallowing:**
Do not induce vomiting; call for medical help immediately.
Rinse out mouth and then drink plenty of water.
A person vomiting while laying on their back should be turned onto their side.
· **4.2 Most important symptoms and effects, both acute and delayed**
No further relevant information available.
· **4.3 Indication of any immediate medical attention and special treatment needed**
No further relevant information available.

5 Firefighting measures

· **5.1 Extinguishing media**
· **Suitable extinguishing agents:**
CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.
· **5.2 Special hazards arising from the substance or mixture**
No further relevant information available.
· **5.3 Advice for firefighters**
· **Protective equipment:**
Wear self-contained respiratory protective device.
Wear fully protective suit.

6 Accidental release measures

· **6.1 Personal precautions, protective equipment and emergency procedures**
Ensure adequate ventilation
Particular danger of slipping on leaked/spilled product.
· **6.2 Environmental precautions:**
Dilute with plenty of water.
Do not allow to enter sewers/ surface or ground water.
· **6.3 Methods and material for containment and cleaning up:**
Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).
Clean the affected area carefully; suitable cleaners are:
Warm water
· **6.4 Reference to other sections**
See Section 7 for information on safe handling.
See Section 8 for information on personal protection equipment.

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See Section 13 for disposal information.

7 Handling and storage

· **7.1 Precautions for safe handling** No special measures required.
· **Information about fire - and explosion protection:** No special measures required.

· **7.2 Conditions for safe storage, including any incompatibilities**
· **Storage:**
· **Requirements to be met by storerooms and receptacles:** No special requirements.
· **Information about storage in one common storage facility:** Not required.
· **Further information about storage conditions:** None.
· **7.3 Specific end use(s)** No further relevant information available.

8 Exposure controls/personal protection

· **Additional information about design of technical facilities:** No further data; see item 7.

· **8.1 Control parameters**
· **Ingredients with limit values that require monitoring at the workplace:**
The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.
· **Additional information:** The lists valid during the making were used as basis.

· **8.2 Exposure controls**
· **Personal protective equipment:**
· **General protective and hygienic measures:**
Keep away from foodstuffs, beverages and feed.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes and skin.
· **Respiratory protection:** Not required.
· **Protection of hands:**

Protective gloves

The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.
Due to missing tests no recommendation to the glove material can be given for the product/ the preparation/ the chemical mixture.
Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation
· **Material of gloves**
Natural rubber, NR
Nitrile rubber, NBR
Neoprene gloves
The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer. As the product is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application.

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· **Penetration time of glove material**
The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.
· **Eye protection:**

Safety glasses

Goggles recommended during refilling

9 Physical and chemical properties

· **9.1 Information on basic physical and chemical properties**	
· **General Information**	
· **Appearance:**	
Form:	Liquid
Colour:	Light yellow
· **Odour:**	Odourless
· **Odour threshold:**	Not determined.
· **pH-value at 20°C:**	8,5
· **Change in condition**	
Melting point/Melting range:	Undetermined.
Boiling point/Boiling range:	100°C
· **Flash point:**	Not applicable.
· **Flammability (solid, gaseous):**	Not applicable.
· **Ignition temperature:**	
Decomposition temperature:	Not determined.
· **Self-igniting:**	Product is not selfigniting.
· **Danger of explosion:**	Product does not present an explosion hazard.
· **Explosion limits:**	
Lower:	Not determined.
Upper:	Not determined.
· **Vapour pressure at 20°C:**	23 hPa
· **Density at 20°C:**	1,08 g/cm³
· **Relative density**	Not determined.
· **Vapour density**	Not determined.
· **Evaporation rate**	Not determined.
· **Solubility in / Miscibility with water:**	Fully miscible.
· **Segregation coefficient (n-octanol/water):**	Not determined.
· **Viscosity:**	
Dynamic:	Not determined.
Kinematic:	Not determined.

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· **9.2 Other information** No further relevant information available.

10 Stability and reactivity

· **10.1 Reactivity**
· **10.2 Chemical stability**
· **Thermal decomposition / conditions to be avoided:**
No decomposition if used according to specifications.
· **10.3 Possibility of hazardous reactions**
Reacts with strong oxidizing agents.
Reacts with strong acids.
· **10.4 Conditions to avoid** No further relevant information available.
· **10.5 Incompatible materials:** No further relevant information available.
· **10.6 Hazardous decomposition products:**
Carbon monoxide and carbon dioxide
Sulphur oxides (SOx)
Nitrogen oxides

11 Toxicological information

· **11.1 Information on toxicological effects**
· **Acute toxicity:**
· **Primary irritant effect:**
· **on the skin:** Irritant to skin and mucous membranes.
· **on the eye:** Strong irritant with the danger of severe eye injury.
· **Sensitization:** No sensitizing effects known.
· **Additional toxicological information:**
The product shows the following dangers according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version:
Irritant

12 Ecological information

· **12.1 Toxicity**
· **Aquatic toxicity:** No further relevant information available.
· **12.2 Persistence and degradability** No further relevant information available.
· **12.3 Bioaccumulative potential** No further relevant information available.
· **12.4 Mobility in soil** No further relevant information available.
· **Additional ecological information:**
· **General notes:**
Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water
Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.
· **12.5 Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.

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· **12.6 Other adverse effects** No further relevant information available.

13 Disposal considerations

· **13.1 Waste treatment methods**
· **Recommendation**
Smaller quantities can be disposed of with household waste.
Small amounts may be diluted with plenty of water and washed away. Dispose of bigger amounts in accordance with Local Authority requirements.
The surfactant used in this product complies with the biodegradability criteria as laid down in Regulation (EC) No. 648/2004 on detergents. Data to support this assertion are held at the disposal of the competent authorities of the Member States and will be made available to them, at their direct request or at the request of a detergent manufacturer.

· **Uncleaned packaging:**
· **Recommendation:** Disposal must be made according to official regulations.
· **Recommended cleansing agents:** Water, if necessary together with cleansing agents.

14 Transport information

· **14.1 UN-Number** · **DOT, ADR, ADN, IMDG, IATA**	N/A
· **14.2 UN proper shipping name** · **DOT, ADR, ADN, IMDG, IATA**	N/A
· **14.3 Transport hazard class(es)** · **DOT, ADR, ADN, IMDG, IATA** · **Class**	N/A
· **14.4 Packing group** · **DOT, ADR, IMDG, IATA**	N/A
· **14.5 Environmental hazards:** · **Marine pollutant:**	No
· **14.6 Special precautions for user**	Not applicable.
· **14.7 Transport in bulk according to Annex II of MARPOL73/78 and the IBC Code**	Not applicable.
· **UN "Model Regulation":**	-

15 Regulatory information

· **15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture**
· **United States (USA)**
· **SARA**

· **Section 355 (extremely hazardous substances):**
None of the ingredients is listed.

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· **Section 313 (Specific toxic chemical listings):**
None of the ingredients is listed.

· **TSCA (Toxic Substances Control Act):**
All ingredients are listed.

· **Proposition 65 (California):**

· **Chemicals known to cause cancer:**
None of the ingredients is listed.

· **Chemicals known to cause reproductive toxicity for females:**
None of the ingredients is listed.

· **Chemicals known to cause reproductive toxicity for males:**
None of the ingredients is listed.

· **Chemicals known to cause developmental toxicity:**
None of the ingredients is listed.

· **Carcinogenic Categories**

· **EPA (Environmental Protection Agency)**
None of the ingredients is listed.

· **TLV (Threshold Limit Value established by ACGIH)**
None of the ingredients is listed.

· **NIOSH-Ca (National Institute for Occupational Safety and Health)**
None of the ingredients is listed.

· **OSHA-Ca (Occupational Safety & Health Administration)**
None of the ingredients is listed.

· **Canada**

· **Canadian Domestic Substances List (DSL)**
All ingredients are listed.

· **Canadian Ingredient Disclosure list (limit 0.1%)**
None of the ingredients is listed.

· **Canadian Ingredient Disclosure list (limit 1%)**
None of the ingredients is listed.

· **15.2 Chemical safety assessment:** A Chemical Safety Assessment has not been carried out.

16 Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· **Relevant phrases**
H315 Causes skin irritation.
H318 Causes serious eye damage.
H319 Causes serious eye irritation.
H335 May cause respiratory irritation.

R36/37/38 Irritating to eyes, respiratory system and skin.
R36/38 Irritating to eyes and skin.
R38 Irritating to skin.
R41 Risk of serious damage to eyes.

(Contd. on page 9)

Safety Data Sheet
according to 1907/2006/EC (REACH), 1272/2008/EC (CLP), and GHS

Printing date 25.05.2012 Revision: 24.05.2012

Trade name: LIQUINOX

(Contd. of page 8)

· **Abbreviations and acronyms:**
ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
IMDG: International Maritime Code for Dangerous Goods
DOT: US Department of Transportation
IATA: International Air Transport Association
GHS: Globally Harmonized System of Classification and Labelling of Chemicals
ACGIH: American Conference of Governmental Industrial Hygienists
NFPA: National Fire Protection Association (USA)
HMIS: Hazardous Materials Identification System (USA)
WHMIS: Workplace Hazardous Materials Information System (Canada)

SAFETY DATA SHEET

Nonflammable Gas Mixture: Isobutylene / Nitrogen / Oxygen

Airgas
an Air Liquide company

Section 1. Identification

GHS product identifier : Nonflammable Gas Mixture: Isobutylene / Nitrogen / Oxygen

Other means of identification : Not available.

Product use : Synthetic/Analytical chemistry.

SDS # : 002103

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

24-hour telephone : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : GASES UNDER PRESSURE - Compressed gas

GHS label elements

Hazard pictograms :

Signal word : Warning

Hazard statements : Contains gas under pressure; may explode if heated.

Precautionary statements

General : Read and follow all Safety Data Sheets (SDS'S) before use. Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Close valve after each use and when empty. Use equipment rated for cylinder pressure. Do not open valve until connected to equipment prepared for use. Use a back flow preventative device in the piping. Use only equipment of compatible materials of construction.

Prevention : Not applicable.

Response : Not applicable.

Storage : Protect from sunlight when ambient temperature exceeds 52°C/125°F. Store in a well-ventilated place.

Disposal : Not applicable.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Not available.

CAS number/other identifiers

CAS number : Not applicable.

Product code : 002103

Section 3. Composition/information on ingredients

Ingredient name	%	CAS number
Nitrogen	75 - 80.5	7727-37-9
oxygen	19.5 - 23.5	7782-44-7
Isobutylene	0.0001 - 1.13	115-11-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband. In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : As this product is a gas, refer to the inhalation section.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : As this product is a gas, refer to the inhalation section.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use an extinguishing agent suitable for the surrounding fire.

Unsuitable extinguishing media : None known.

Specific hazards arising from the chemical : Contains gas under pressure. In a fire or if heated, a pressure increase will occur and the container may burst or explode.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide
nitrogen oxides

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Contact supplier immediately for specialist advice. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Avoid breathing gas. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Ensure emergency procedures to deal with accidental gas releases are in place to avoid contamination of the environment. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Immediately contact emergency personnel. Stop leak if without risk.

Large spill : Immediately contact emergency personnel. Stop leak if without risk. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Contains gas under pressure. Avoid contact with eyes, skin and clothing. Avoid breathing gas. Empty containers retain product residue and can be hazardous. Do not puncture or incinerate container. Use equipment rated for cylinder pressure. Close valve after each use and when empty. Protect cylinders from physical damage; do not drag, roll, slide, or drop. Use a suitable hand truck for cylinder movement.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Section 7. Handling and storage

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store away from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10). Keep container tightly closed and sealed until ready for use. Cylinders should be stored upright, with valve protection cap in place, and firmly secured to prevent falling or being knocked over. Cylinder temperatures should not exceed 52 °C (125 °F).

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Nitrogen	Oxygen Depletion [Asphyxiant]
oxygen	None.
Isobutylene	**ACGIH TLV (United States, 3/2015).** TWA: 250 ppm 8 hours.

Appropriate engineering controls : Good general ventilation should be sufficient to control worker exposure to airborne contaminants.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state	:	Gas.
Color	:	Not available.
Melting/freezing point	:	-140.7°C (-221.3°F) This is based on data for the following ingredient: isobutylene. Weighted average: -211.14°C (-348.1°F)
Critical temperature	:	Lowest known value: -146.95°C (-232.5°F) (nitrogen).
Odor	:	Not available.
Odor threshold	:	Not available.
pH	:	Not available.
Flash point	:	Not available.
Burning time	:	Not applicable.
Burning rate	:	Not applicable.
Evaporation rate	:	Not available.
Flammability (solid, gas)	:	Not available.
Lower and upper explosive (flammable) limits	:	Not available.
Vapor pressure	:	Not available.
Vapor density	:	Highest known value: 1.94 (Air = 1) (isobutylene). Weighted average: 1.01 (Air = 1)
Gas Density (lb/ft ^{3})	:	Weighted average: 0.07
Relative density	:	Not applicable.
Solubility	:	Not available.
Solubility in water	:	Not available.
Partition coefficient: n-octanol/water	:	Not available.
Auto-ignition temperature	:	Not available.
Decomposition temperature	:	Not available.
SADT	:	Not available.
Viscosity	:	Not applicable.

Section 10. Stability and reactivity

Reactivity	:	No specific test data related to reactivity available for this product or its ingredients.
Chemical stability	:	The product is stable.
Possibility of hazardous reactions	:	Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid	:	No specific data.
Incompatible materials	:	No specific data.
Hazardous decomposition products	:	Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Hazardous polymerization	:	Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
Isobutylene	LC50 Inhalation Vapor	Rat	550000 mg/m³	4 hours

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Contact with rapidly expanding gas may cause burns or frostbite.

Inhalation : No known significant effects or critical hazards.

Skin contact : Contact with rapidly expanding gas may cause burns or frostbite.

Ingestion : As this product is a gas, refer to the inhalation section.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Section 11. Toxicological information

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
Nitrogen	0.67	-	low
oxygen	0.65	-	low
Isobutylene	2.34	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Empty Airgas-owned pressure vessels should be returned to Airgas. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Do not puncture or incinerate container.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1956	UN1956	UN1956	UN1956	UN1956
UN proper shipping name	COMPRESSED GAS, N.O.S. (nitrogen, oxygen)	COMPRESSED GAS, N.O.S. (nitrogen, oxygen)	COMPRESSED GAS, N.O.S. (nitrogen, oxygen)	COMPRESSED GAS, N.O.S. (nitrogen, oxygen)	COMPRESSED GAS, N.O.S. (nitrogen, oxygen)
Transport hazard class(es)	2.2	2.2	2.2	2.2	2.2
Packing group	-	-	-	-	-
Environment	No.	No.	No.	No.	No.
Additional information	-	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.13-2.17 (Class 2). **Explosive Limit and Limited Quantity Index** 0.125 **Passenger Carrying Road or Rail Index** 75	-	-	-

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined

United States inventory (TSCA 8b): All components are listed or exempted.

Clean Air Act (CAA) 112 regulated flammable substances: isobutylene

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

Section 15. Regulatory information

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Sudden release of pressure

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Nitrogen	75 - 80.5	No.	Yes.	No.	No.	No.
oxygen	19.5 - 23.5	No.	Yes.	No.	No.	No.
Isobutylene	0.0001 - 1.13	Yes.	Yes.	No.	No.	No.

State regulations

Massachusetts : The following components are listed: NITROGEN; OXYGEN (LIQUID); 2-METHYLPROPENE

New York : None of the components are listed.

New Jersey : The following components are listed: NITROGEN; OXYGEN; ISOBUTYLENE; 1-PROPENE, 2-METHYL-

Pennsylvania : The following components are listed: NITROGEN; OXYGEN; 1-PROPENE, 2-METHYL-

International regulations

International lists

National inventory

Australia : All components are listed or exempted.

Canada : All components are listed or exempted.

China : All components are listed or exempted.

Europe : All components are listed or exempted.

Japan : Not determined.

Malaysia : Not determined.

New Zealand : All components are listed or exempted.

Philippines : All components are listed or exempted.

Republic of Korea : All components are listed or exempted.

Taiwan : All components are listed or exempted.

Canada

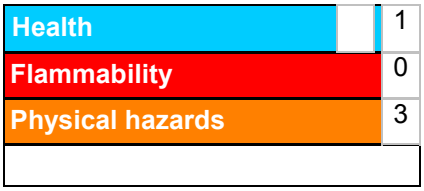
WHMIS (Canada) : Class A: Compressed gas.

CEPA Toxic substances: None of the components are listed.
Canadian ARET: None of the components are listed.
Canadian NPRI: The following components are listed: Butene (all isomers)
Alberta Designated Substances: None of the components are listed.
Ontario Designated Substances: None of the components are listed.
Quebec Designated Substances: None of the components are listed.

Section 16. Other information

Canada Label requirements : Class A: Compressed gas.

Hazardous Material Information System (U.S.A.)



Section 16. Other information

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)

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Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

Procedure used to derive the classification

Classification	Justification
Press. Gas Comp. Gas, H280	On basis of test data

History

Date of printing : 6/24/2016

Date of issue/Date of revision : 6/24/2016

Date of previous issue : 1/26/2016

Version : 0.02

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

CONNELLY – GPM, INC.

ESTABLISHED 1875
3154 SOUTH CALIFORNIA AVENUE CHICAGO, ILLINOIS 60608-5176
PHONE: (773) 247-7231 • www.ConnellyGPM.com • FAX: (773) 247-7239

SAFETY DATA SHEET Date Prepared: 2/14/2017 Last Revision: 2/14/2017 Date Printed: 02/14/2017

1. CHEMICAL PRODUCT & COMPANY IDENTIFICATION

MATERIAL IDENTITY:
Iron Aggregate, Ground Cast Iron

INFORMATION TELEPHONE:
INFORMATION: (773) 247-7231

EMERGENCY TELEPHONE:
EMERGENCY: (773) 247-7231

COMPANY:
Connelly-GPM, Inc.
3154 S. California Ave
Chicago, IL 60608

Trade Name:	Common Name of Synonyms:	Ductile Irons
Chemical Name:	Iron	
Form:	Granular	

2. HAZARDS IDENTIFICATION

General Hazard Statement: Cast iron products in their natural state do not present inhalation, ingestion or contact hazards. However, dust or fumes from machining, cutting, grinding, welding, brazing, flame cutting and arc gouging will release contaminants into the air, with inhalation as the primary route of entry. Since the castings are primarily iron, the dust and fume generated from the working of these castings will be primarily iron or iron oxide. Flame cutting, arc gouging or welding on these castings may convert a fraction of the chromium to a water insoluble hexavalent (Carcinogenic) form. However, the chromium content of these castings is very low and the dust from handling does not contain Chromium VI

.

EMERGENCY OVERVIEW REPRESENTS HAZARDOUS COMPONENTS THAT CAN BE RELEASED DURING PROCESSING.

OSHA HAZARDOUS

Target Organ	Target Organ Effect:
Eye	Irritant
Skin	Irritant/Sensitizer
Respiratory	Irritant/Sensitizer
Kidney, Respiratory, Skin	Target Organ Effect

GHS LABEL ELEMENTS, INCLUDING PRECAUTIONARY STATEMENTS

Health		Environmental	Physical
Acute Toxicity, Oral	Category 2	Acute Aquatic Toxicity Category 1	Not Classified

Skin Irritant	Category 2	Chronic Aquatic Toxicity Category 1
Serious Eye Irritant	Category 2B	
Respiratory Sensitization	Category 1	
Carcinogenicity	Category 2	
Reproductive	Category 1B	
Target Organ Toxicity (kidney, respiratory, skin)	Category 1	

Pictogram:

Hazard Statements

H303 Maybe harmful if swallowed
H315 Causes skin irritation
H320 Causes eye irritation
H334 May cause allergy or asthma symptoms or breathing difficulties if inhaled
H317 May cause an allergic skin reaction
H341 Suspected of genetic defects
H351 Suspected of causing cancer
H370 Causes damage to organs (kidneys, respiratory)
H401 Toxic to Aquatic Life

Precautionary Statements

P281 Wear protective gloves/protective clothing/eye protection/face protection
P260 Do not breath dust/fume/gas/mist/vapors/spray
P285 In case of inadequate ventilation wear respiratory protection
P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P273 Avoid release to the environment

Potential Health Effects of Acute Exposure

Inhalation: Inhalation of high concentrations of metal dust or fume for short periods of time can cause irritation to the eyes, nose and throat. Metal fume fever can also occur, with symptoms of metallic taste, dryness of the mouth, throat irritation and chills and fever, which usually lasts for 12 to 48 hours.

Potential Health Effects of Chronic Exposure by Principle Elements

Carbon: Prolonged and repeated over-exposure (Inhalation) may lead to benign pneumoconiosis.
Chromium: In some workers, chromium compounds act as allergens and my cause dermatitis and may also produce pulmonary sensitization. Chromium and chromium compounds have been identified as carcinogenic substances.
Copper: Fumes may cause metal fume fever, with flu-like symptoms and hair and skin discoloration. Keratinization of the hands and feet has been reported. Systemically, dust and fume cause irritation of the upper respiratory tract, metallic taste and nausea.
Iron: Iron oxide dust or fumes may cause benign pneumoconiosis (siderosis). This disease may make x-ray diagnosis of other lung conditions difficult or impossible, but causes little or no disability.

Manganese: Chronic manganese poisoning may result from inhalation of dust and fume. The central nervous system is the chief site of injury. This is not a fatal disease, although it is extremely disabling. Some persons may be hypersusceptable to manganese. Freshly formed manganese fume has caused fever and chills, similar to metal fume fever.

Nickel: The most common ailment arising from contact with nickel or its compounds is an allergenic dermatitis known as "nickel itch", which occurs usually when the skin is moist. Generally, nickel and most salts of nickel do not cause systemic poisoning, but nickel and some nickel compounds have been identified as suspected carcinogens.

Silicon: Accumulation in lungs can cause benign pneumoconiosis, but is not considered to be responsible for pulmonary functional impairment or respiratory symptoms.

Molybdenum: Particulate affects the eyes and respiratory system and may also damage the liver and kidneys.

Tin: Prolonged or repeated skin contact may cause dermatitis. Chronic exposure to tin oxide dusts and fume may result in stannosis (benign pneumoconiosis).

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Characterization:

Ingredient(s)	**CAS Number**	**% (by weight)**
Base Metal		
Iron (Fe)	7439-89-6	Remainder
Principle Alloying Elements		
Carbon (C)	7440-44-0	2.5-4.3
Chromium (Cr)	7440-47-3	0.01-2.0
Copper (Cu)	7440-50-8	0.01-1.5
Manganese (Mn)	7439-96-5	0.01-2.0
Nickel (Ni)	7440-02-0	0.01-3.0
Molybdenum (Mo)	7439-98-7	0.01-0.5
Silicon (Si)	7440-21-3	1.0-4.0
Tin (Sn)	7440-31-5	0.01-0.30
Titanium (Ti)	7440-32-6	0.01-0.50

Note: The above listing is a summary of the principle elements. Various grades of iron will contain varying amounts or combinations of these elements. Other elements may also be present in minute amounts.

4. FIRST AID MEASURES

Cast iron in the final manufactured state does not present inhalation, ingestion, or contact hazards. The following recommendations are for overexposure to dust or fumes generated by machining, grinding, welding or thermal cutting of castings.

Eyes Contact: Exposure to high concentrations of metal dust and fume can cause irritation to the eyes. Immediately flush eyes gently with large amounts of water for at least 15 minutes. Retract eyelids often. Check for and remove any contact lenses. Get medical aid.

Skin Contact: Dust may cause irritation. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists. Wash clothing before reuse.

Ingestion: Not expected to occur. If significant amounts of metal are ingested, seek medical attention.

Inhalation: Inhalation of fume or dust from machining, cutting, grinding, welding, brazing and flame cutting is the primary route of exposure. Exposure to fume and particulate may produce irritation of the eyes and respiratory system. Inhalation of high concentrations of freshly formed oxides of the metals iron, manganese or copper may cause metal fume fever characterized by metallic taste in the mouth, dryness and irritation of the throat and influenza-like symptoms. This material may contain trace concentrations of nickel, chromium that may be released during processing. Nickel and chromium compounds have been identified as carcinogenic substances. Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Carcinogenicity: This material may contain trace concentrations of components that have been listed as carcinogens by ACGIH, IARC, NTP or CA Prop 65 including nickel and chromium.

5. FIRE FIGHTING MEASURES Conditions of Flammability

These castings will not burn or explode. However, metal working dusts present a moderate fire and explosion hazard, when exposed to heat, flames, chemical reaction or in contact with powder oxidizers. To extinguish, use mixtures of dry chemical or sand. Fire fighters should wear self-contained breathing apparatus and protective clothing.

Suitable Extinguishing Media

Use Class D agent to extinguish a particulate fire, of small chips and fines. DO NOT use halogenated extinguishing media. DO NOT use water on fires involving ignited particulate or molten metal. These extinguishing agents may react with burning metal resulting in an explosion.

Hazardous Decomposition Products

Hot processes such as welding and burning may generate metal fumes. Mechanical action, grinding, cutting, machining may generate metal fumes and dust leading to a release of irritating gases and vapors (See Section 10). In the event of fire and/or explosion do not breath fumes. May cause sensitization by inhalation and skin contact.

Fire Fighting Instructions

Do not enter fire area without proper protection. Wear self contained breathing apparatus (pressure-demand MSHA/NIOSH) approved or equivalent. See Section 10 - decomposition products possible. Fight fire from safe distance/protected location. To extinguish, use mixtures of dry chemical or sand.

6. ACCIDENTAL RELEASE MEASURES Personal Precautions

Cast iron in formed state is not expected to pose a hazard. For fumes and dusts follow exposure controls in Section 8.

Environmental Precautions

Cast iron in formed state is not expected to pose a release hazard.

Methods and Materials for Containment and Cleaning Up

Avoid dust formation. Collect scrap for recycling. If product is molten contain the flow using dry sand or salt flux as a dam. Allow spill to cool before remelting as scrap.

See section 1 for emergency contact information and section 13 for waste disposal.

Environmental Precautions

Cast iron in formed state is not expected to pose a release hazard.

Methods and Materials for Containment and Cleaning Up

Avoid dust formation. Collect scrap for recycling. If product is molten contain the flow using dry sand or salt flux as a dam. Allow spill to cool before remelting as scrap.

See section 1 for emergency contact information and section 13 for waste disposal.

7. HANDLING AND STORAGE

Precautions for Safe Handling

Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Use with adequate ventilation. Minimize dust generation and accumulation. Avoid contact with skin and eyes. Avoid contact with sharp edges or heated material.

Conditions for Safe Storage

Store away from chemicals or oxidizers.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure Limits

Hazardous Component	OSHA PEL		ACGIH TLV		OTHER
Iron (Fe) 7439-89-6	10 mg/m3	fume	5 mg/m3	fume	
Carbon (C) 7440-44-0	N/E		N/E		
Chromium (Cr) 7440-47-3	0.5 mg/m3		0.5 mg/m3		
Copper (Cu) 7440-50-8	0.1 mg/m3	fume	0.2 mg/m3	fume	
	1 mg/m3	dust	1 mg/m3	dust	
Manganese (Mn) 4739-96-5	5 mg/m3	ceiling	0.2 mg/m3	fume	
Nickel (Ni) 7440-02-0	1 mg/m3		0.1 mg/m3	fume	
Molybdenum (Mo) 7439-98-7	15 mg/m3		10 mg/m3		
Silicon (Si) 7440-21-3	5 mg/m3		5 mg/m3	dust	
Tin (Sn) 7440-31-5	2 mg/m3	metal oxide	2 mg/m3	metal oxide	
Titanium (Ti) 7440-32-6	N/E			N/E	

N/E means none established

Engineering Controls

Ductile iron casting in its final manufactured state does not present inhalation, ingestion, or contact hazards. However, operations such as welding, burning, flame or laser cutting, brazing, grinding, sanding or sawing may release fume and other particulate, which should be captured with adequate local exhaust ventilation such as a fume extractor or vented down draft table. Evaluate jobs done on this product and meet requirements of all OSHA and environmental standards.

Respiratory Protections

No respiratory protection is needed unless processing releases fume or particulate. Where exposures cannot be adequately controlled through exhaust ventilation provide respiratory protection in accordance with OSHA and NIOSH recommendations. A NIOSH approved respirator should be used when cutting, grinding, welding or burning if a PEL or TLV is exceeded.

Eye Protection

Goggles or safety glasses with side shields and face shields should be used for protection against flying particulate and fume during processing of cast iron products. Provide appropriate welding helmet with eye protection during welding.

Skin and Body Protection

Protective clothing including long sleeves and long pants are recommended for protection during processing. Sturdy cut-resistant gloves should be worn when handling solid materials. Provide welding gloves, aprons or jackets, and other skin protection when welding, cutting, brazing or banding.

Other hygienic practices

Hands and face should be washed before eating or smoking. Fume and other particulate should be removed from clothing by HEPA vacuuming. Compressed air MUST NOT be used for particulate removal. Contaminated clothing should not be worn off the job site.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Solid
Form	Grey or Brown
Color pH	Not applicable
Melting/Freezing Temperature	> 2,750 ^{o}F for iron
Boiling Point	Nonflammable
Flash Point	Nonflammable
Ignition Temperature	Not applicable
Autoignition Temperature	Not applicable
Lower explosive limit: Not applicable	Upper explosive limit: Not applicable
Vapor Pressure	Not applicable
Vapor Density (air=1)	Not applicable
Specific Gravity (water=1 @39.2F)	7.86 for iron
Evaporation Rate (Bac=1)	Not applicable
Solubility	Not applicable
Odor	Odorless
Odor threshold	Not applicable
Percent Volatile	Not applicable

10. STABILITY AND REACTIVITY Chemical Stability

Stable

Possibility of Hazardous Reactions Will not occur **Conditions to Avoid**

Metal working dusts present a moderate fire and explosion hazard, when exposed to heat, flames, chemical reaction or in contact with powder oxidizers. May cause violent decomposition of hydrogen peroxide (52% by weight or greater).

Materials to Avoid

Chemicals and oxidizers

Hazardous Decomposition Products

Hazardous decomposition products can include hazardous metallic dust (particulate) and fume may be generated from welding, brazing, cutting, burning, grinding, sanding, sawing and machining.

Toxic metal oxides and carbon and nitrogen oxides may be produced during a fire involving metal alloys. Alloys with nickel may also produce poisonous nickel carbonyl.

11. TOXICOLOGY INFORMATION Toxicity Data

Cast iron in a solid state does not present a toxicity hazard. The following represents toxicity of components if released as a fume or dust.

Acute Toxicity

Iron	(7439-89-6)	Oral LD50	Rat	984 mg/kg
Carbon	(7440-44-0)	Oral LD50	Rat	> 1,000 mg/kg
Silicon	(7440-21-3)	Oral LD50	Rat	3,160 mg/kg
Manganese	(7439-96-5)	Oral LD50	Rat	9 g/kg
Nickel	(7440-02-0)	Oral LD50	Rat	9,000 mg/kg
Chromium	(7440-47-3)	Oral LD50	Rat	80 mg/kg
Molybdenum	7439-98-7)	Oral LD50	Rat	4,233mg/kg

Skin Irritation/Sensitizer

Skin (fume and dust) Irritant/Sensitizer May cause allergic reaction.

Serious Eye Irritation

Eye (fume and dust) Irritant

Respiratory

Respiratory (fume and dust) Irritant/Sensitizer Inhalation may cause metal fume fever see section 4.

Mutagenicity

Some components are suspected of causing genetic defects.

Carcinogenicity

This material may contains trace concentrations of components that have been listed as carcinogens by ACGIH, IARC, NTP or CA Prop 65 including nickel and chromium.

12. ECOLOGICAL INFORMATION

Cast iron in a solid state does not present an ecological hazard. The following represents toxicity of components if released as a fume or dust. **Aquatic Ecotoxicity**

Iron	(7439-89-6)	96 hr Semi static LC50	Fish	> 0.56 mg/l
Nickel	(7440-02-0)	96 hour LC50	Fish	0.4 mg/l
		96 Semi static LC50	Fish	1.3 mg/l
Copper	(7440-50-8)	96 hr LC50	Fish	0.0068 - 0.0156 mg/l
Molybdenum	(7439-98-7)	96 hr LC50	Fish	609 mg/l

Biodegradability

Persistent. Not readily biodegradable - Metal powders may cause ecological damage through silting or sediment effects.

Mobility in soil

Metal powder is immobile in soils but may be transported with ground water.

13. DISPOSAL CONSIDERATIONS Waste Disposal

When recycled cast iron is not regulated. When disposed it is not a RCRA (Resource Conservation and Recovery Act) hazardous waste. Dispose of per local, state and federal requirements.

14. TRANSPORTATION INFORMATION

DOT (US)

Cast iron products in their final manufactured state are not a U.S. Department of Transportation (DOT) regulated hazardous material requiring labeling or a placard.

IMDG

Not Regulated

TDG

Not Regulated

IATA

Not Regulated

UNECE Dangerous Goods

Not Regulated

15. REGULATORY INFORMATION

TSCA INVENTORY STATUS

TSCA: All components of this product are listed, or excluded from listing, on the United States Environmental Protection Agency Toxic Substances Control Act (TSCA) inventory.

OSHA HAZARDS

Solid cast iron products are classified as "articles and do not constitute an OSHA hazardous material in a solid form.

OSHA Standards for General Industry (29 CFR 1910), Shipyard Standard (29 CFR 1915), and Construction Standards (29 CFR 1926) apply to processing of cast iron products

	HMIS Classification	NFPA Rating
Health Hazard;	0	0
Flammability	0	0
Physical Hazards	0	0

SARA TITLE III: Section 311/312 Hazard Class

Solid metallic products are classified as "articles and are not subject to Section 311 and Section 312. **SARA TITLE III: Section 313 (40CFR370)**

This product contains the following materials at or above the de minimus concentrations that may be subject to SARA Section 313 Reporting: chromium, copper, manganese, nickel. **CERCLA Information (40CFR302.4)**

This material contains chromium, copper and nickel at or above the de minimus concentrations as defined by CERCLA or SARA Title III.

Clean Air Act

Manganese, Nickel, Chromium

CLEAN WATER ACT

Chromium, copper, nickel **California Proposition 65 Information:**

This material may contains trace concentrations of components that have been listed as carcinogens by ACGIH, IARC, NTP or CA Prop 65 including nickel and chromium.

16. OTHER INFORMATION

Some of the information presented and conclusions drawn herein are from sources other than direct test data on the product itself. The information in this SDS was obtained from sources, which we believe are reliable. However, the information is provided without any warranty, express or implied, regarding its correctness. The conditions or methods of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of the product. This SDS was prepared and is to be used only for this product. If the product is used as a component in another product, this SDS information may not be applicable. This SDS has been prepared in accordance with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Lehigh Hanson
HEIDELBERGCEMENT Group

Safety Data Sheet Portland Cement

Section 1. Identification

GHS product identifier: Portland Cement

Chemical name: Calcium compounds, calcium silicate compounds, and other calcium compounds containing iron and aluminum make up the majority of this product.

Other means of identification: Cement, ASTM Type I, II, III, V, Portland Limestone Cement, Plastic Cement, Hydraulic Cement, Oilwell Cement, Well Cement, Class G Cement, InterCem, Type L, CSA Type GU, GUb, GUL, MS, MH, MHL, HE, HEL, LH, LHL, HS

Relevant identified uses of the substance or mixture and uses advised against: Building materials, construction, a basic ingredient in concrete.

Supplier's details: 300 E. John Carpenter Freeway, Suite 1645
Irving, TX 75062
(972) 653-5500

Emergency telephone number (24 hours): **CHEMTREC: (800) 424-9300**

Section 2. Hazards Identification

Overexposure to portland cement can cause serious, potentially irreversible skin or eye damage in the form of chemical (caustic) burns, including third degree burns. The same serious injury can occur if wet or moist skin has prolonged contact exposure to dry portland cement.

OSHA/HCS status: This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture:
SKIN CORROSION/IRRITATION – Category 1
SERIOUS EYE DAMAGE/EYE IRRITATION – Category 1
SKIN SENSITIZATION – Category 1
CARCINOGENICITY/INHALATION – Category 1A
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE)
[Respiratory tract irritation] – Category 3

GHS label elements

Hazard pictograms:

Signal word: Danger

Hazard statements:
Causes severe skin burns and eye damage.
May cause an allergic skin reaction.
May cause respiratory irritation.
May cause cancer.

Precautionary statements:

Prevention: Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Do not breathe dust. Use outdoors in a well ventilated area. Wash any exposed body parts thouroughly after handling. Wear protective gloves/protective clothing/eye protection/face protection.Contaminated clothing must not be allowed out of the workplace.

Response: If exposed or concerned: Immediately get medical advice/attention if you feel unwell or irritation or rash occurs.If on skin: Wash with plenty of water. Take off contaminated clothing and wash it before reuse. If in eyes: Rinse continuously with water for several minutes. Remove contact lenses, if present and easy to do.If inhaled: Remove person to fresh air and keep comfortable for breathing. If swallowed: Rinse mouth. Do not induce vomiting.

Storage: Restrict or control access to stockpile areas (store locked up). Engulfment hazard: To prevent burial or suffocation, do not enter a confined space, such as a silo, bulk truck or other storage container or vessel that stores or contains cement without an effective procedure for assuring

safety. Store in a well ventilated area. Keep container tightly closed.

Disposal: Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazards not otherwise classified (HNOC): None known

Supplemental Information: Respirable Crystalline Silica (RCS) may cause cancer. Repeated inhalation of respirable crystalline silica (quartz) may cause lung cancer according to IARC and NTP; ACGIH states that it is a suspected cause of cancer. Other forms of RCS (e.g., tridymite and cristobalite) may also be present or formed under certain industrial processes.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Chemical Name: Calcium compounds, calcium silicate compounds, and other calcium compounds containing iron and aluminum make up the majority of this product.

CAS number/other identifiers

Ingredient name	%	CAS number
Portland Cement	100%	65997-15-1
The structure of Portland cement may contain the following in some concentration ranges:		
Calcium oxide	A-B	1305-78-8
Quartz	C-D	14808-60-7
Hexavalent chromium*	E-F	18450-29-9
Portland cement also contains gypsum, limestone and magnesium oxide in various concentrations. However, because these components are not classifiable as a hazard under Title 29 Code of Federal Regulations 1910.1200, they are not required to be listed in this section.		
Gypsum	G-H	13397-24-5
Limestone	I-J	1317-65-3
Magnesium oxide	K-L	1309-48-4

Any concentration shown as a range is to protect confidentiality or is due to process variation.
*Hexavalent chromium is included due to dermal sensitivity associated with the component.

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye Contact: Get medical attention immediately. Call a poison center or physician. Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Chemical burns must be treated promptly by a physician.

Inhalation: Seek medical help if coughing or other symptoms persist. Inhalation of large amounts of portland cement requires immediate medical attention. Call a poison center or physician. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If the individual is not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. If unconscious, place in a recovery position and get medical attention immediately. Maintain an open airway.

Skin Contact: Get medical attention immediately. Heavy exposure to portland cement dust, wet concrete or associated water requires prompt attention. Quickly remove contaminated clothing, shoes, and leather goods such as watchbands and belts. Quickly and gently blot or brush away excess portland cement. Immediately wash thoroughly with lukewarm, gently flowing water and non-abrasive pH natural soap. Seek medical attention for rashes, burns, irritation, dermatitis and prolonged unprotected exposure to wet cement, cement mixtures or liquids from wet cement. Burns should be treated as caustic burns. Portland cement causes skin burns with little warning. Discomfort or pain cannot be relied upon to alert a person to

a serious injury. You may not feel pain or the severity of the burn until hours after the exposure Chemical burns must be treated promptly by a physician. In the event of any complaints or symptoms, avoid further exposure.

Ingestion: Get medical attention immediately. Call a poison center or physician. Have victim rinse mouth thoroughly with water. DO NOT INDUCE VOMITING unless directed to do so by medical personnel. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Have victim drink 60 to 240 mL (2 to 8 oz.) of water. Stop giving water if the exposed person feels sick as vomiting may be dangerous. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Chemical burns must be treated promptly by a physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway.

Most important symptoms/effects, acute and delayed potential acute health effects

Eye contact: Causes serious eye damage.
Inhalation: May cause respiratory irritation.
Skin contact: Causes severe burns. May cause an allergic skin reaction.
Ingestion: May cause burns to mouth, throat and stomach.

Over-exposure signs/symptoms

Eye contact: Adverse symptoms may include the following: pain, watering and redness.
Inhalation: Adverse symptoms may include the following: respiratory tract irritation and coughing.
Skin contact: Adverse symptoms may include the following: pain or irritation, redness and blistering may occur, skin burns, ulceration and necrosis may occur.
Ingestion: Adverse symptoms may include the following: stomach pains.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician: Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments: Not applicable.
Protection of first-aiders: No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media: Use an extinguishing agent suitable for the surrounding fire.
Unsuitable extinguishing media: Do not use water jet or water-based fire extinguishers.
Specific hazards arising from the chemical: No specific fire or explosion hazard.
Hazardous thermal decomposition Products: Decomposition products may include the following materials: carbon dioxide, carbon monoxide, sulfur oxides and metal oxide/oxides.
Special protective actions for fire-fighters: Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel: No action shall be taken involving any personal risk or without suitable training. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Do not

	breathe dust. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.
For emergency responders:	For personal protective clothing requirements, please see Section 8.
Environmental precautions:	Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has entered the environment, including waterways, soil or air. Materials can enter waterways through drainage systems.

Methods and materials for containment and cleaning up

Small spill:	Move containers from spill area. Avoid dust generation. Do not dry sweep. Vacuum dust with equipment fitted with a HEPA filter and place in a closed, labeled waste container. Place spilled material in a designated, labeled waste container. Dispose of waste material by using a licensed waste disposal contractor.
Large spill:	Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Avoid dust generation. Do not dry sweep. Vacuum dust with equipment fitted with a HEPA filter and place dust in a closed, labeled waste container. Avoid creating dusty conditions and prevent wind dispersal. Large spills to waterways may be hazardous due to alkalinity of the product. Dispose of waste material using a licensed waste disposal contractor. Note: see section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures:	Put on appropriate personal protective equipment (see Section 8). Persons with a history of skin sensitization problems should not be employed in any process in which this product is used. Avoid exposure by obtaining and following special instructions before use. Do not handle until all safety precautions have been read and understood. Do not get in eyes or on skin or clothing. Do not breathe dust. Do not ingest. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material and keep the container tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.
Advice on general occupational hygiene:	Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.
Conditions for safe storage, including any incompatibilities:	A key to using the product safely requires the user to recognize that portland cement reacts chemically with water to produce calcium hydroxide which can cause severe chemical burns. Every attempt should be made to avoid skin and eye contact with cement. Do not get portland cement inside boots, shoes or gloves. Do not allow wet, saturated clothing to remain against the skin. Promptly remove clothing and shoes that are dusty or wet with cement mixtures. Launder/clean clothing and shoes before reuse. Do not enter a confined space that stores or contains portland cement unless appropriate procedures and protection are available. Portland cement can build up or adhere to the walls of a confined space and then release or fall suddenly (engulfment).

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
Cement, portland, chemicals	**ACGIH TLV (United States, 3/2012)** TWA: 1 mg/m³ 8hours. Form: Respirable fraction **NIOSH REL (United States, 6/2009)** TWA: 5 mg/m³ 10 hours. Form: Respirable fraction TWA: 10 mg/m³ 10 hours. Form: Total **OSHA PEL (United States, 6/2010)** TWA: 5mg/m³. 8 hours. Form: Respirable fraction TWA: 15 mg/m³. 8 hours. Form: Total dust
Calcium oxide	**ACGIH TLV (United States, 3/2012)** TWA: 2 mg/m³ 8 hours **NIOSH REL (United States, 6/2009)** TWA: 2mg/m³ 10 hours. **OSHA PEL (United States, 6/2010)** TWA: 5 mg/m³ 8 hours.
Limestone	**NIOSH REL (United States, 6/2009)** TWA: 5 mg/m³ 10 hours. Form: Respirable fraction TWA: 10 mg/m³ 10 hours. Form: Total **OSHA PEL (United States, 6/2010)** TWA: 5 mg/m³ 8 hours. Form: Respirable fraction TWA: 15 mg/m³ 8 hours. Form: Total dust
Magnesium oxide	**ACGIH TLV (United States, 3/2012)** TWA: 10 mg/m³ 8 hours. Form: Inhalable fraction **OSHA PEL (United States, 6/2010)** TWA: 15 mg/m³ 8 hours. Form: Total particulates
Crystalline Silica (Quartz) (CAS 14808-60-7)	**OSHA PEL (United States, 9/2017)** TWA: 0.3 mg/m³. Form: Total dust (1,2) TWA: 0.05 mg/m³. Form: Respirable (1,2,3) **ACGIH TLV (United States, 3/2012)** TWA: 0.025 mg/m³. Form: Respirable fraction **NIOSH REL (United States, 6/2009)** TWA: 0.05 mg/m³. Form: Respirable dust
Calcium sulfate (gypsum)	**ACGIH TLV (United States, 3/2012)** TWA: 10 mg/m³ 8 hours. Form: Respirable fraction **NIOSH REL (United States, 6/2009)** TWA: 5 mg/m³ 8 hours. Form: Respirable fraction TWA: 10 mg/m³ 8 hours. Form: Total dust **OSHA PEL Z-1 (United States, 2/2006)** TWA: 5 mg/m³ 8 hours. Form: Respirable fraction TWA: 15 mg/m³ 8 hours. Form: Total dust

Appropriate engineering controls: Use only with adequate ventilation. If user operations generate dust, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation.

Individual protection measures

Hygiene measures: Clean water should always be readily available for skin and (emergency) eye washing. Periodically wash areas contacted by portland cement with a pH neutral soap and clean, uncontaminated water. If clothing becomes saturated with portland cement, garments should be removed and replaced with clean, dry clothing.

Eye/face protection: To prevent eye contact, wear safety glasses with side shields, safety goggles or face shields when handling dust or wet cement. Wearing contact lenses when working with cement is not recommended.

Skin protection

Hand protection: Use impervious, waterproof, abrasion and alkali-resistant gloves. Do not rely on barrier creams in place of impervious gloves. Do not get portland cement inside gloves.

Body protection: Use impervious, waterproof, abrasion and alkali-resistant boots and protective long-sleeved and long-legged clothing to protect the skin from contact with wet portland cement. To reduce foot and ankle exposure, wear impervious boots that are high enough to prevent portland cement from getting inside them. Do not get portland cement inside boots, shoes, or gloves. Remove clothing and protective equipment that becomes saturated with cement and immediately wash exposed areas of the body.

Other skin protection: Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved. .

Respiratory protection: Use properly fitted, particulate filter respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product, and assigned protection factor of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical State:	Solid. [Powder]	**Lower and Upper explosive flammable limits**	Not applicable
Color:	Gray or white	**Vapor pressure:**	Not applicable
Odor:	Odorless	**Vapor density:**	Not applicable
Odor threshold:	Not available	**Relative density:**	2.3 to 3.1
pH:	>11.5 [Conc. (% w/w): 1%]	**Solubility:**	Slightly soluble in water
Melting point:	Not available	**Solubility in water:**	0.1 to 1%
Boiling point:	>1000°C (>1832°F)	**Partition coefficient: n-octanol/water:**	Not applicable
Flash point:	Not flammable. Not combustible	**Auto-ignition temperature:**	Not applicable
Burning time:	Not available	**Decomposition temperature:**	Not available
Burning rate:	Not available	**SADT:**	Not available
Evaporation Rate:	Not applicable	**Viscosity:**	Not applicable
Flammability (solid, gas):	Not applicable		

Section 10. Stability and reactivity

Reactivity: Reacts slowly with water forming hydrated compounds, releasing heat and producing a strong alkaline solution until reaction is substantially complete.

Chemical Stability: The product is stable.

Possibility of hazardous reactions: Under normal circumstances of storage and use, hazardous reactions will not occur.

Conditions to avoid: No specific data.

Incompatible materials: Reactive or incompatible with the following materials: oxidizing materials, acids, aluminum and ammonium salt. Portland cement is highly alkaline and will react with acids to produce a violent, heat-generating reaction. Toxic gases or vapors may be given off depending on the acid involved. Reacts with acids, aluminum metals and ammonium salts. Aluminum powder and other alkali and alkaline earth elements will react in wet mortar or concrete, liberating hydrogen gas. Limestone ignites on contact with fluorine and is incompatible with acids, alum, ammonium salts, and magnesium. Silica reacts violently with powerful oxidizing agents such as fluorine, boron trifluoride, chlorine trifluoride, manganese trifluoride, and oxygen difluoride yielding possible fire and/or explosions. Silicates dissolve readily in hydrofluoric acid producing a corrosive gas-silicon tetrafluoride.

Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity: Portland Cement LD50/LC50 = Not available
Irritation/Corrosion: **Skin:** May cause skin irritation. May cause serious burns in the presence of moisture.
Eyes: Causes serious eye damage. May cause burns in the presence of moisture.
Respiratory: May cause respiratory tract irritation.
Sensitization: May cause sensitization due to the potential presence of trace amounts of hexavalent chromium.
Mutagenicity: There are no data available.

Carcinogenicity:
Classification below:

Product/ingredient name	OSHA	IARC	ACGIH	NTP
Cement, portland, chemicals	-	-	A4	-
Crystalline Silica (Quartz) (CAS 14808-60-7)	-	1	A2	Known to be a human carcinogen.

Reproductive toxicity: There are no data available.
Teratogenicity: There are no data available.

Specific target organ toxicity (single exposure)

Name	Category	Route of Exposure	Target Organs
Calcium oxide	Category 3	Inhalation and skin contact	Respiratory tract irritation, skin irritation
Cement, portland, chemicals	Category 3	Inhalation and skin contact	Respiratory tract irritation, skin irritation

Specific target organ toxicity (repeated exposure)

Name	Category	Route of Exposure	Target Organs
Crystalline Silica (Quartz) (CAS 14808-60-7)	Category 1	Inhalation	Respiratory tract and kidneys

Aspiration hazard: There are no data available.

Information on the likely routes of exposure

Potential acute health effects:
Eye contact: Causes serious eye damage.
Inhalation: May cause respiratory irritation.
Skin contact: Causes severe burns. May cause an allergic skin reaction.
Ingestion: May cause burns to mouth, throat and stomach.

Symptoms related to the physical, chemical and toxicological characteristics:
Eye contact: Adverse symptoms may include the following: pain, watering, redness.
Inhalation: Adverse symptoms may include the following: respiratory tract irritation, coughing
Skin contact: Adverse symptoms may include the following: pain or irritation, redness, blistering may occur, skin burns, ulcerations and necrosis may occur
Ingestion: Adverse symptoms may include the following: stomach pains

Delayed and immediate effects and also chronic effects from short and long term exposure:
Short term exposure
Potential immediate effects: No known significant effects or critical hazards.
Potential delayed effects: No known significant effects or critical hazards.

Long term exposure
Potential immediate effects: No known significant effects or critical hazards.
Potential delayed effects: No known significant effects or critical hazards.

Potential chronic health effects:

General: Repeated or prolonged inhalation of dust may lead to chronic respiratory irritation. If sensitized to hexavalent chromium, a severe allergic dermal reaction may occur when subsequently exposed to very low levels.

Carcinogenicity: Portland cement is not classifiable as a human carcinogen. Crystalline silica is considered a hazard by inhalation. IARC has classified crystalline silica as a Group 1 substance, carcinogenic to humans. This classification is based on the findings of laboratory animal studies (inhalation and implantation) and epidemiology studies that were considered sufficient for carcinogenicity. Excessive exposure to crystalline silica can cause silicosis, a non-cancerous lung disease.

Mutagenicity: No known significant effects or critical hazards.

Teratogenicity: No known significant effects or critical hazards.

Developmental effects: No known significant effects or critical hazards.

Fertility effects: No known significant effects or critical hazards.

Numerical measures of toxicity: Acute toxicity estimates: There are no data available.

Section 12. Ecological Information

Toxicity

Product/ingredient name	Result	Species	Exposure
Calcium oxide	Chronic NOEC 100 mg/L Fresh water	Fish-Oreochromis niloticus-Juvenile (Fledgling, Hatchling, Weanling)	46 days

Persistence and degradability: There are not data available.
Bioaccumulative potential: There are not data available.
Mobility in soil: Soil/water partition coefficient (Koc): Not available.
Other adverse effects: No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods: The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Untreated waste should not be released to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe manner. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff, and contact with soil, waterways, drains and sewers.

Section 14. Transportation information

	DOT Classification	IMDG	IATA
UN number	Not regulated	Not regulated	Not regulated
UN proper shipping name	-	-	-
Transport hazard class(es)	-	-	-
Packing group	-	-	-
Environmental hazards	None	None	None
Additional information	-	-	-

Special precautions for user: Transport within user's premises: always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available.

Section 15. Regulatory Information

TSCA 6 final risk management: Chromium, ion (Cr6+)
United States inventory (TSCA 8b): Cements are considered to be statutory mixtures under TSCA. CAS 65997-15-1 is included on the TSCA inventory.
CERCLA: This product is not listed as a CERCLA substance
Clean Air Act Section 112 (b): Hazardous Air Pollutants (HAPs) – Not listed
Clean Air Act Section 602: Class I Substances - Not listed
Clean Air Act Section 602: Class II Substances - Not listed
DEA List I Chemicals: (Precursor Chemicals) – Not listed
DEA List II Chemicals: (Essential Chemicals) – Not listed

SARA 311/312

Classification: Immediate (acute) health hazard
Delayed (chronic) health hazard

Composition/information on ingredients

Name	%	Fire Hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
Calcium oxide	A-B	No	No	No	Yes	No
Quartz	>0.1	No	No	No	No	Yes
Chromium, ion (Cr6+)	<0.1	No	No	No	Yes	Yes

SARA 313

	Product name	CAS number	%
Form R-Report requirements	Chromium, ion (Cr6+)	8540-29-9	<0.1

State regulations

Massachusetts: The following components are listed: cement, portland, chemicals, limestone
New York: None of the components are listed.
New Jersey: The following components are listed: cement, portland, chemicals, gypsum, limestone
Pennsylvania: The following components are listed: cement, portland, chemicals, gypsum, limestone

California Prop. 65

WARNING: This product contains crystalline silica and chemicals (trace metals) known to the State of California to cause cancer, birth defects or other reproductive harm. California law requires the above warning in the absence of definitive testing to prove the defined risks do not exist.

Ingredient name	Cancer	Reproductive	No significant risk level	Maximum acceptable dosage level
Quartz	Yes	No	No	No
Chromium, ion (Cr6+)	Yes	Yes	0.001µg/day (inhalation)	8.2 micrograms/day (ingestion)

International regulations

International lists: **Canadian Domestic Substances List (DSL):** Portland cement is included on the DSL.
Mexico Inventory (INSQ): All components are listed or exempted.

Section 16. Other Information

Date of issue: 07/01/2018
Replaces: 06/01/2015
Revised Section(s): Section 8

Notice to reader

While the information provided in this safety data sheet is believed to provide a useful summary of the hazards of portland cement as it is commonly used, the sheet cannot anticipate and provide all of the information that might be needed in every situation. Inexperienced product users should obtain proper training before using this product. In particular, the data furnished in this sheet do not address hazards that may be posed by other materials mixed with portland cement to produce portland cement products. Users should review other relevant material safety data sheets before working with this portland cement or working on portland cement products, for example, portland cement concrete.

SELLER MAKES NO WARRANTY, EXPRESS OR IMPLIED, CONCERNING THE PRODUCT OR THE MERCHANTABILITY OR FITNESS THEREOF FOR ANY PURPOSE OR CONCERNING THE ACCURACY OF ANY INFORMATION PROVIDED BY Lehigh Hanson, except that the product shall conform to contracted specifications. The information provided herein was believed by the Lehigh Hanson to be accurate at the time of preparation or prepared from sources believed to be reliable, but it is the responsibility of the user to investigate and understand other pertinent sources of information to comply with all laws and procedures applicable to the safe handling and use of product and to determine the suitability of the product for its intended use. Buyer's exclusive remedy shall be for damages and no claim of any kind, whether as to product delivered or for non-delivery of product, and whether based on contract, breach of warranty, negligence, or otherwise shall be greater in amount than the purchase price of the quantity of product in respect of which damages are claimed. In no event shall Seller be liable for incidental or consequential damages, whether Buyer's claim is based on contract, breach of warranty, negligence or otherwise.

Abbreviations

ACGIH — American Conference of Governmental Industrial Hygienists
CAS — Chemical Abstract Service
CERCLA — Comprehensive Emergency Response and Comprehensive Liability Act
CFR — Code of Federal Regulations
DOT — Department of Transportation
GHS — Globally Harmonized System
HEPA — High Efficiency Particulate Air
IATA — International Air Transport Association
IARC — International Agency for Research on Cancer
IMDG — International Maritime Dangerous Goods
NIOSH — National Institute of Occupational Safety and Health
NOEC — No Observed Effect Concentration
NTP — National Toxicology Program
OSHA — Occupational Safety and Health Administration
PEL — Permissible Exposure Limit
REL — Recommended Exposure Limit
RQ — Reportable Quantity
SARA — Superfund Amendments and Reauthorization Act
SDS — Safety Data Sheet
TLV — Threshold Limit Value
TPQ — Threshold Planning Quantity
TSCA — Toxic Substances Control Act
TWA — Time-Weighted Average
UN — United Nations

Safety Data Sheet

RUST-OLEUM CORPORATION
* Trusted Quality Since 1921 *
www.rustoleum.com

1. Identification

Product Name: PRO LSPR 6PK MARK FLUORESCENT ORANGE

Revision Date: 6/5/2015

Product Identifier: 2554838

Supercedes Date: New SDS

Product Use/Class: Marking Paint/Aerosols

Supplier: Rust-Oleum Corporation
11 Hawthorn Parkway
Vernon Hills, IL 60061
USA

Manufacturer: Rust-Oleum Corporation
11 Hawthorn Parkway
Vernon Hills, IL 60061
USA

Preparer: Regulatory Department

Emergency Telephone: 24 Hour Hotline: 847-367-7700

2. Hazard Identification

Classification

Symbol(s) of Product

Signal Word
Danger

Possible Hazards
60% of the mixture consists of ingredient(s) of unknown acute toxicity

GHS HAZARD STATEMENTS

Flammable Aerosol, category 1	H222	Extremely flammable aerosol.
Acute Toxicity, Dermal, category 4	H312	Harmful in contact with skin.
Germ Cell Mutagenicity, category 1B	H340	May cause genetic defects . Classified as mutagenic Category 1 if one ingredient is present at or above 0.1% Applies to liquids, Solids (w/w units) and gases (v/v). The substance may also have its own exposure limit. Routes of exposure are dependant on ingredient form.
Carcinogenicity, category 1B	H350	May cause cancer. Classified as carcinogenic Category 1 on the basis of epidemiological and/or animal data. Mixtures are classified as carcinogenic when at least 1 ingredient has been classified as carcinogenic and is present at 0.1% or above Routes of exposure are dependant on ingredient form.

GHS LABEL PRECAUTIONARY STATEMENTS

P201	Obtain special instructions before use.
P211	Do not spray on an open flame or other ignition source.
P251	Do not pierce or burn, even after use.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P281	Use personal protective equipment as required.
P308+P313	IF exposed or concerned: Get medical advice/attention.
P312	Call a POISON CENTER or doctor/physician if you feel unwell.
P410+P412	Protect from sunlight. Do no expose to temperatures exceeding 50°C/ 122°F.

3. Composition/Information On Ingredients

HAZARDOUS SUBSTANCES

Chemical Name	CAS-No.	Wt.% Range	GHS Symbols	GHS Statements
Aliphatic Hydrocarbon	64742-89-8	10-25	GHS08	H304-340-350
Propane	74-98-6	10-25	No Information	No Information
Limestone	1317-65-3	10-25	No Information	No Information
Hydrous Magnesium Silicate	14807-96-6	2.5-10	No Information	No Information
n-Butane	106-97-8	2.5-10	No Information	No Information
Acetone	67-64-1	2.5-10	GHS02-GHS07	H225-319-336
n-Butyl Acetate	123-86-4	2.5-10	GHS02-GHS07	H226-336
Hydrotreated Light Distillate	64742-47-8	2.5-10	GHS06-GHS08	H304-331
Naphtha, Petroleum, Hydrotreated Light	64742-49-0	1.0-2.5	GHS08	H304-340-350
Organoclay	68911-87-5	1.0-2.5	No Information	No Information
Stoddard Solvent	8052-41-3	0.1-1.0	GHS08	H304-340-350-372
Ethylbenzene	100-41-4	0.1-1.0	GHS02-GHS07	H225-332

The text for GHS Hazard Statements shown above (if any) is given in the "16. Other Information" section.

4. First-aid Measures

FIRST AID - EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes holding eyelids open. Get medical attention. Do NOT allow rubbing of eyes or keeping eyes closed.

FIRST AID - SKIN CONTACT: Wash skin with soap and water. Remove contaminated clothing. Get medical attention if irritation develops or persists.

FIRST AID - INHALATION: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get immediate medical attention. Do NOT use mouth-to-mouth resuscitation. If you experience difficulty in breathing, leave the area to obtain fresh air. If continued difficulty is experienced, get medical assistance immediately.

FIRST AID - INGESTION: Aspiration hazard: Do not induce vomiting or give anything by mouth because this material can enter the lungs and cause severe lung damage. Get immediate medical attention. If swallowed, get medical attention.

5. Fire-fighting Measures

EXTINGUISHING MEDIA: Alcohol Film Forming Foam, Carbon Dioxide, Dry Chemical, Dry Sand, Water Fog

UNUSUAL FIRE AND EXPLOSION HAZARDS: FLASH POINT IS LESS THAN 20°F. EXTREMELY FLAMMABLE LIQUID AND VAPOR!Water spray may be ineffective. Closed containers may explode when exposed to extreme heat due to buildup of steam. Closed containers may explode when exposed to extreme heat. Vapors may form explosive mixtures with air. Vapors can travel to a source of ignition and flash back. Keep containers tightly closed. Isolate from heat, electrical equipment, sparks and open flame. Perforation of the pressurized container may cause bursting of the can. No unusual fire or explosion hazards noted.

SPECIAL FIREFIGHTING PROCEDURES: Water may be used to cool closed containers to prevent pressure buildup and possible autoignition or explosion. Full protective equipment including self-contained breathing apparatus should be used. Evacuate area and fight fire from a safe distance. Use water spray to keep fire-exposed containers cool. Containers may explode when heated.

6. Accidental Release Measures

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Contain spilled liquid with sand or earth. DO NOT use combustible materials such as sawdust. Isolate the hazard area and deny entry to unnecessary and unprotected personnel. Remove all sources of ignition, ventilate area and remove with inert absorbent and non-sparking tools. Dispose of according to local, state (provincial) and federal regulations. Do not incinerate closed containers. Ventilate area, isolate spilled material, and remove with inert absorbent. Dispose of contaminated absorbent, container, and unused contents in accordance with local, state, and federal regulations.

7. Handling and Storage

HANDLING: Wash thoroughly after handling. Wash hands before eating. Remove contaminated clothing and launder before reuse. Use only in a well-ventilated area. Use only with adequate ventilation. Follow all MSDS/label precautions even after container is emptied because it may retain product residues. Avoid breathing fumes, vapors, or mist. Avoid contact with eyes, skin and clothing.

STORAGE: Store in a dry, well ventilated place. Keep container tightly closed when not in use. Keep containers tightly closed. Isolate from heat, electrical equipment, sparks and open flame. Contents under pressure. Do not store above 120 ° F. Store large quantities in buildings designed and protected for storage of NFPA Class I flammable liquids. Keep away from heat, sparks, flame and sources of ignition. Contents under pressure. Do not expose to heat or store above 120 ° F. Avoid excess heat. Product should be stored in tightly sealed containers and protected from heat, moisture, and foreign materials.

8. Exposure Controls/Personal Protection

Chemical Name	CAS-No.	Weight % Less Than	ACGIH TLV-TWA	ACGIH TLV-STEL	OSHA PEL-TWA	OSHA PEL-CEILING
Aliphatic Hydrocarbon	64742-89-8	20.0	N.E.	N.E.	N.E.	N.E.
Propane	74-98-6	20.0	1000 ppm	N.E.	1000 ppm	N.E.
Limestone	1317-65-3	20.0	N.E.	N.E.	15 mg/m3	N.E.
Hydrous Magnesium Silicate	14807-96-6	10.0	2 mg/m3	N.E.	N.E.	N.E.
n-Butane	106-97-8	10.0	N.E.	1000 ppm	N.E.	N.E.
Acetone	67-64-1	10.0	500 ppm	750 ppm	1000 ppm	N.E.
n-Butyl Acetate	123-86-4	5.0	150 ppm	200 ppm	150 ppm	N.E.
Hydrotreated Light Distillate	64742-47-8	5.0	N.E.	N.E.	N.E.	N.E.
Naphtha, Petroleum, Hydrotreated Light	64742-49-0	5.0	N.E.	N.E.	N.E.	N.E.
Organoclay	68911-87-5	5.0	N.E.	N.E.	N.E.	N.E.
Stoddard Solvent	8052-41-3	1.0	100 ppm	N.E.	500 ppm	N.E.
Ethylbenzene	100-41-4	1.0	20 ppm	N.E.	100 ppm	N.E.

PERSONAL PROTECTION

ENGINEERING CONTROLS: Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Use explosion-proof ventilation equipment. Provide general dilution of local exhaust ventilation in volume and pattern to keep TLV of hazardous ingredients below acceptable limits. Prevent build-up of vapors by opening all doors and windows to achieve cross-ventilation.

RESPIRATORY PROTECTION: A respiratory protection program that meets OSHA 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use. A NIOSH/MSHA approved air purifying respirator with organic vapor cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits.

SKIN PROTECTION: Use gloves to prevent prolonged skin contact. Use impervious gloves to prevent skin contact and absorption of this material through the skin. Nitrile or Neoprene gloves may afford adequate skin protection.

EYE PROTECTION: Use safety eyewear designed to protect against splash of liquids.

OTHER PROTECTIVE EQUIPMENT: Refer to safety supervisor or industrial hygienist for further guidance regarding types of personal protective equipment and their applications. Refer to safety supervisor or industrial hygienist for further information regarding personal protective equipment and its application.

HYGIENIC PRACTICES: Wash thoroughly with soap and water before eating, drinking or smoking. Remove contaminated clothing immediately and launder before reuse.

9. Physical and Chemical Properties

Appearance:	Aerosolized Mist	**Physical State:**	Liquid
Odor:	Solvent Like	**Odor Threshold:**	N.E.
Relative Density:	0.871	**pH:**	N.A.
Freeze Point, °C:	N.D.	**Viscosity:**	N.D.
Solubility in Water:	Slight	**Partition Coefficient, n-octanol/ water:**	N.D.
Decompostion Temp., °C:	N.D.		
Boiling Range, °C:	-24 - 537	**Explosive Limits, vol%:**	0.9 - 13.0
Flammability:	Supports Combustion	**Flash Point, °C:**	-96
Evaporation Rate:	Faster than Ether	**Auto-ignition Temp., °C:**	N.D.
Vapor Density:	Heavier than Air	**Vapor Pressure:**	N.D.

(See "Other information" Section for abbreviation legend)

10. Stability and Reactivity

CONDITIONS TO AVOID: Avoid temperatures above 120 °F (49°C)Avoid contact with strong acid and strong bases. Avoid all possible sources of ignition.

INCOMPATIBILITY: Incompatible with strong oxidizing agents, strong acids and strong alkalies.

HAZARDOUS DECOMPOSITION: By open flame, carbon monoxide and carbon dioxide. When heated to decomposition, it emits acrid smoke and irritating fumes. Contains solvents which may form carbon monoxide, carbon dioxide, and formaldehyde.

HAZARDOUS POLYMERIZATION: Will not occur under normal conditions.

STABILITY: This product is stable under normal storage conditions.

11. Toxicological information

EFFECTS OF OVEREXPOSURE - EYE CONTACT: Causes Serious Eye Irritation

EFFECTS OF OVEREXPOSURE - SKIN CONTACT: Substance may cause slight skin irritation. May cause skin irritation. Allergic reactions are possible. Prolonged or repeated contact may cause skin irritation.

EFFECTS OF OVEREXPOSURE - INHALATION: Harmful if inhaled. High gas, vapor, mist or dust concentrations may be harmful if inhaled. Avoid breathing fumes, spray, vapors, or mist. High vapor concentrations are irritating to the eyes, nose, throat and lungs. Prolonged or excessive inhalation may cause respiratory tract irritation.

EFFECTS OF OVEREXPOSURE - INGESTION: Harmful if swallowed. Aspiration hazard if swallowed; can enter lungs and cause damage.

EFFECTS OF OVEREXPOSURE - CHRONIC HAZARDS: May cause central nervous system disorder (e.g., narcosis involving a loss of coordination, weakness, fatigue, mental confusion, and blurred vision) and/or damage. High concentrations may lead to central nervous system effects (drowsiness, dizziness, nausea, headaches, paralysis, and blurred vision) and/or damage. Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. IARC lists Ethylbenzene as a possible human carcinogen (group 2B).

PRIMARY ROUTE(S) OF ENTRY: Eye Contact, Ingestion, Inhalation, Skin Absorption, Skin Contact

ACUTE TOXICITY VALUES

The acute effects of this product have not been tested. Data on individual components are tabulated below:

CAS-No.	Chemical Name	Oral LD50	Dermal LD50	Vapor LC50
64742-89-8	Aliphatic Hydrocarbon	N.I.	3000 mg/kg Rabbit	N.I.
74-98-6	Propane	N.I.	N.I.	658 mg/L Rat
123-86-4	n-Butyl Acetate	N.I.	>17600 mg/kg Rabbit	N.I.
64742-47-8	Hydrotreated Light Distillate	>5000 mg/kg Rat	>2000 mg/kg Rabbit	>5.2 mg/L Rat
64742-49-0	Naphtha, Petroleum, Hydrotreated Light	>5000 mg/kg Rat	>3160 mg/kg Rabbit	N.I.
100-41-4	Ethylbenzene	3500 mg/kg Rat	15354 mg/kg Rabbit	17.2 mg/L Rat

N.I. - No Information

12. Ecological Information

ECOLOGICAL INFORMATION: Product is a mixture of listed components. Product is a mixture of listed components.

13. Disposal Information

DISPOSAL INFORMATION: Dispose of material in accordance to local, state, and federal regulations and ordinances. Do not allow to enter waterways, wastewater, soil, storm drains or sewer systems.

14. Transport Information

	Domestic (USDOT)	International (IMDG)	Air (IATA)	TDG (Canada)
UN Number:	N.A.	1950	1950	N.A.
Proper Shipping Name:	Paint Products in Limited Quantities	Aerosols	Aerosols	Paint Products in Limited Quantities
Hazard Class:	N.A.	2.1	2.1	N.A.
Packing Group:	N.A.	N.A.	N.A.	N.A.
Limited Quantity:	Yes	Yes	Yes	Yes

15. Regulatory Information

U.S. Federal Regulations:

CERCLA - SARA Hazard Category

This product has been reviewed according to the EPA 'Hazard Categories' promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

Fire Hazard, Pressure Hazard, Acute Health Hazard, Chronic Health Hazard

Sara Section 313:

This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendment and Reauthorization Act of 1986 and 40 CFR part 372:

Chemical Name	CAS-No.
Ethylbenzene	100-41-4

Toxic Substances Control Act:

This product contains the following chemical substances subject to the reporting requirements of TSCA 12(b) if exported from the United States:

No TSCA 12(b) components exist in this product.

16. Other Information

HMIS RATINGS

Health:	2*	**Flammability:**	4	**Physical Hazard:**	0	**Personal Protection:**	X

NFPA RATINGS

Health:	2	**Flammability:**	4	**Instability**	0

VOLATILE ORGANIC COMPOUNDS, g/L: 522

MSDS REVISION DATE: 6/5/2015

REASON FOR REVISION:

Legend: N.A. - Not Applicable, N.E. - Not Established, N.D. - Not Determined

Text for GHS Hazard Statements shown in Section 3 describing each ingredient:

H225	Highly flammable liquid and vapour.
H226	Flammable liquid and vapour.
H304	May be fatal if swallowed and enters airways.
H319	Causes serious eye irritation.
H331	Toxic if inhaled.
H332	Harmful if inhaled.
H336	May cause drowsiness or dizziness.
H340	May cause genetic defects.
H350	May cause cancer.
H372	Causes damage to organs through prolonged or repeated exposure.

Icons for GHS Pictograms shown in Section 3 describing each ingredient:

GHS02

GHS06

GHS07

GHS08

Rust-Oleum Corporation believes, to the best of its knowledge, information and belief, the information contained herein to be accurate and reliable as of the date of this safety data sheet. However, because the conditions of handling, use, and storage of these materials are beyond our control, we assume no responsibility or liability for personal injury or property damage incurred by the use of these materials. Rust-Oleum Corporation makes no warranty, expressed or implied, regarding the accuracy or reliability of the data or results obtained from their use. All materials may present unknown hazards and should be used with caution. The information and recommendations in this material safety data sheet are offered for the users' consideration and examination. It is the responsibility of the user to determine the final suitability of this information and to comply with all applicable international, federal, state, and local laws and regulations.

Attachment C - Field Forms

Visitor Acknowledgement
Tailgate Meeting Form
Task Improvement Process (TIP) General
Vehicle Inspection Form
Utility and Structures Checklist
Bloodborne Pathogen Exposure Control Plan
Air Monitoring Documentation Form
PID Calibration Log

Arcadis Visitor Acknowledgement and Acceptance of HASP Signature Form

By signing below, I waive, release and discharge the owner of the site and Arcadis and their employees from any future claims for bodily and personal injuries which may result from my presence at, entering, or leaving the site and in any way arising from or related to any and all known and unknown conditions on the site.

Printed Name	Signature	Company	Date/Time On Site	Date/Time Off Site

Control Number: TSM-30006250-

TSM + project number plus date as follows: xxxxxxxx.xxxx.xxxxx - dd/mm/year

ARCADIS Design & Consultancy for natural and built assets

TAILGATE HEALTH & SAFETY MEETING FORM

Project Name:			**Project Location:**
Date:	**Time:**	**Conducted by:**	**Signature/Title:**

Issues or concerns from previous day's activities:

Task anticipated to be performed today:

☐ Additional permits/checklists attached

USE TRACK! Evaluate the hazards (h) for the tasks being performed today and rank as Low (L), Medium (M) or High (H). Use relevant JSAs, FHSHB, permit or other work standard to communicate controls (c) to be used to eliminate or mitigate identified hazards.

☐ Gravity (i.e., ladder, trips) (L M H) h: c:	☐ Motion (i.e., traffic, machinery) (L M H) h: c:	☐ Mechanical (i.e., augers, motors) (L M H) h: c:
☐ Electrical (i.e., utilities) (L M H) h: c:	☐ Pressure (i.e., gas cyl., wells) (L M H) h: c:	☐ Environment (i.e., heat, cold) (L M H) h: c:
☐ Chemical (i.e., fuel, acid, paint) (L M H) h: c:	☐ Biological (i.e., ticks, poison ivy) (L M H) h: c:	☐ Radiation (i.e., alpha, sun, laser) (L M H) h: c:
☐ Sound (i.e., machinery) (L M H) h: c:	☐ Personal (i.e. alone, night) (L M H) h: c:	☐ Driving (i.e. car, ATV, boat) (L M H) h: c:

☐ Refer to the attached Hazard Analysis Sheet(s) or JSA

Comments:

Signature and Certification: I have read and understand the project specific HASP for this project.

SSE Employee*

Non-Life Threatening Injury or Illness
Call WorkCare 1-888-449-7787

	Printed Name/Signature/Company	Sign In Time	Sign Out Time

***Short Service Employee (SSE) working for Arcadis <1 year.**

I will STOP the job any time anyone is concerned or uncertain about health & safety or if anyone identifies a hazard or additional mitigation not recorded in the site, project, job or task hazard assessment.

I will be alert to any changes in personnel, conditions at the work site or hazards not covered by the original hazard assessments.

If it is necessary to **STOP THE JOB,** I will perform **TRACK**; and then amend the hazard assessments or the HASP as needed.

I will not assist a subcontractor or other party with their work unless it is absolutely necessary and then only after I have done TRACK and I have thoroughly controlled the hazard.
All site staff should arrive fit for work. If not, they should report to the supervisor any restrictions or concerns.

In the event of an injury, employees will call **WorkCare at 1.888.449-7787** and then notify the field supervisor.

Utility strike, motor vehicle accident or 3rd party property damage - field supervisor will immediately notify the Project or Task Manager

Task Improvement Process

General

Observed Company:
Observation Type:
TIP Form: H&S Field Multi-Task (General)
Task Observed:
Observee Name:
Observer Name:
Observation Date:
Project Number: I30006250
Project Name: GEneral Electric Decatur
Supervisor:
Equipment On Site:
Pertinent Information:

Observation

Task	Correct	Questionable	Comments
General			
PPE worn according to HASP/JLA specifications and inspected before use?			
STOP work authority used where appropriate?			
Body Use/Positioning			
Proper lifting/pushing / pulling techniques used (no awkward positions/posture; no twisting or excessive reaching; no straining; no excessive weight; load under control/stable; etc.)?			
Body parts away from pinch points (clear or protected from being caught between objects/equipment or from contacting sharp objects/edges, etc.)?			
Body parts not in the Line of Fire (protected from being struck by traffic, equipment, falling/flying objects, etc.)?			
Work Procedures/Environment			
Correct type and number of barricades/warning devices/cones?			

Communication with others when necessary (hand signals, flags, etc.)?			
Right tools and equipment selected for the job and inspected before use?			
Tools and equipment used properly?			
Housekeeping performed (work areas and pathways clear of hazards, uneven surfaces addressed, etc.)?			
Slip/trip/fall hazards addressed (path selected and cleared, eyes on path, speed footing, etc.)?			
Proper energy control (electrical systems grounded, lock out/tag out performed, isolated, cords/fixtures in good condition, GFCI inspected and utilized when appropriate and used properly, etc.)?			
Protected from overhead/underground utilities (proper clearance, properly marked, spotters as necessary, etc.)?			
Safe work on/near water (appropriate flotation device, appropriate boat for body of water and operation of boat, etc.)?			
Chemical/Radiation protection (decontamination zones set up properly, air monitoring, completed, and logged, etc.)?			
Fall from elevated height prevention (maintains 3-points of contact, appropriate ladder, mounting/dismounting vehicle/equipment, fall arrest system, etc.)?			
Any additional safety issues identified:			

Tip Summary **Enter details of the TIP and follow up discussion provide details on how any questionable items were resolved.**

Discussion following the TIP led by: _____

Date of follow-up discussion: _____

Positive Comments:

Discussion Summary Completed:

- ☐ Supervisor Led
- ☐ Peer to Peer
- ☐ Arcadis Employee to Subcontractor

Summary of Questionable Items

Action Items (Optional) Assign appropriate action items based on the observations made. You can add more than one action item if needed.

Item #	Action Item	Responsible Person	Due Date	Comp. Date
1				
2				
3				

Standard Review

Reviews to be performed after entry of this TIP into 4-Sight.

Quality Review

Quality Reviews to be performed after entry of this TIP into 4-Sight.

Field Validation and Verification

Use the 4-Sight generated copy of this TIP to perform field V&V activities.

Arcadis Weekly Vehicle Inspection Form

Vehicle # / License Plate # | **Lease Plan # / Last 6 of Vin #**

	Inspection Date												
	Odometer reading												
	Driver / Inspector Name												
	Check the appropriate box and enter repair date for identified repairs:	OK	Needs Repair	Repair Date	OK	Needs Repair	Repair Date	OK	Needs Repair	Repair Date	OK	Needs Repair	Repair Date
Interior	Horn operational												
	Door Locks operational												
	Seat Belts in good repair												
	Seats and Seating Controls												
	Steering Wheel - No Excessive Play												
	Interior Lights and Light Controls												
	Instrument Panel/Gauges												
	Wiper Controls operational												
	Heat/Defrost/Air Conditioning working												
	Rear View Mirror present												
	Backup Camera/Sensors working												
	Jack and Lug Wrench present												
Exterior[1]	Lights and Signals operational												
	Tires properly inflated/good tread depth												
	Spare Tire properly inflated												
	Doors operational												
	Windows Not Cracked/Damaged												
	Side View Mirrors												
	Body Panels and Bumpers												
Engine & Brakes	Engine Start & Running Smoothly												
	Fluid Levels, No Noticeable Leaks												
	Belts tight, no cracks												
	Brakes operational, no squeaking												
Emergency Equipment[2]	First Aid Kit, inspected weekly												
	Fire Extinguisher properly secured												
	Fire Extinguisher inspected weekly												
	Orange/Yellow emergency warning light												
	Roadside Assistance Information												
	Recommend spotter cones available												
Cargo	Cargo Secure and Properly Distributed												
	Securing Devices in Good Condition												
Registration	License Plate /Tags												
	Registration and Insurance												
	City/State Inspection Decal												
	Lease Plan information/Fuel Card												

[1] Note all damages to the vehicle on the back of this page

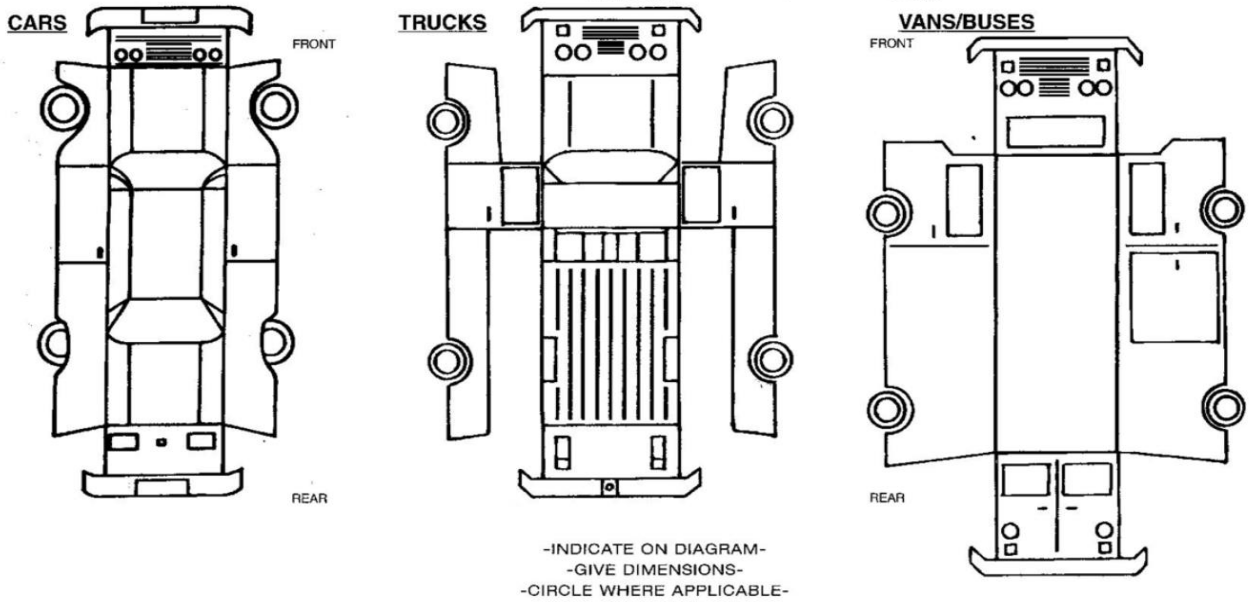
[2] Emergency Equipment required per Motor Vehicle Standard ARC HSGE024

Note All Vehicle Damage Below

All Vehicle Damage must be reported to Sue Berndt (Corporate Legal), Andrew McDonald (Corporate H&S), and Roger Elliot (Corporate Fleet Manger)

CODES:

B-BENT
BR-BROKEN
BU-BULGE
C-CHAFED
CH-CHIPPED
CPM-COVERED WITH PROTECTIVE MATERIAL-UNABLE TO DETERMINE DEFECTS IF ANY
CSA-CHAFED AND SCRATCHED ALL OVER
CR-CRACKED
D-DENTED
DMC-DUST AND MUD COVERED UNABLE TO DETERMINE OTHER DEFECTS IF ANY
G-GOUGED OR CUT
GC-GLASS CRACKED
HS-HAIRLINE SCRATCH
M-MISSING
P-PUNCTURED
R-RUSTY
S-SCRATCHED
SC-SCRAPED
SM-SMASHED
ST-STAINED AND/OR SOILED
T-TORN



Notes:

Tread guide: If a tread gauge is not available coins may be used to determine remaining tread. 2/32” is the minimum by law in most states (top of Lincoln’s head on penny), 4/32” is minimum recommended for wet surfaces (top of Washington’s head on quarter), 6/32” is minimum recommended for snowy surfaces (top of Lincoln Memorial on penny).Vehicle tires should be replaced if the tread depth is less than 6/32”.

2/32” remaining 4/32” remaining 6/32” remaining

Reference JSA 10907 For Weekly Vehicle Inspection

THIS FORM MUST BE ENTIRELY COMPLETED PRIOR TO BEGINNING ANY INTRUSIVE WORK

Project Name: RACER TRUSTCMI Work Plan Oversigh Start Date:

Project #: 30075940 End Date:

Utility markings valid for 15 days. Initiate clearance renewal 5 days prior to expiration for ongoing work

PRE-FIELD WORK REQUIREMENTS

DigSafe 811 notified 48-72 hrs. in advance of work? [ ] DigSafe Ticket #:

Ticket Expiration Date: State Utility Laws: www.commongroundalliance.com/map

Ticket(s) Attached(Y/N)? [ ] List utility owners notified via DigSafe 811 & response status:

List addt'l. utilities requiring notification not included in DigSafe811 Notice:

Review task details w/ private utility location subcontractor. ID work areas, clearance equipment needed, depth of clearance needed, types of features, utilities, anticipated/known/unknown. Verify DigSafe 811 markings to confirm public utility clearance.

Private Utility Locator Name, if used: AUS onsite meeting (Y/N)? [ ]

FIELD WORK REQUIREMENTS

This portion of the checklist must be completed on site. AUS staff must have a minimum of one year of field experience in identifying utilities to complete the checklist. Field staff will review the completed checklist with PM or designee prior to beginning intrusive work.

Heavy equipment/mechanized intrusive work w/in the Arcadis Tolerance Zone (utility or structure present within 30-in. of point of work) REQUIRES pre-approval by Corporate H&S prior to working at all such locations. STOP WORK if the Arcadis Tolerance Zone work has not been approved.

List work type & locations for utility location and clearance as applicable to this checklist:

3 Reliable Lines of Evidence are REQUIRED for EACH INTRUSIVE LOCATION prior to starting any subsurface intrusive work. Check corresponding boxes below to document utility clearance efforts.

[ ] OneCall/DigSafe 811 Public Utility Locate (required by State law for subsurface work)

811 is only reliable as a Line of Evidence when working in/adjacent to a public ROW or easement.

Marking type: [ ] Paint [ ] Pin Flags/Stakes [ ] Other: [ ] None

[ ] Client provided maps/drawings (Y/N)? [ ] Maps/drawings not provided (Y/N)?

[ ] Client Clearance (Y/N)? Name(s)/Affiliation(s):

[ ] Interviews (Y/N)? Name(s)/Affiliation(s):

[ ] Specific subsurface feature types and depths provided by person interviewed (Y/N)?

Details provided:

[ ] Site Inspected (Y/N)? (document on Pg. 2.) Photo Document Marked Utilities & Structures

[ ] Public records/Client Dwgs/As-Builts (Y/N)? Type:

List private locator tools used: [ ] Radio Freq. Detection [ ] Electromagnetic [ ] GPR

[ ] Metal Detector [ ] Acoustic Pipe Locator [ ] Downhole sonde Other:

[ ] Soft Dig Methods used (Y/N)? [ ] Hand auger [ ] Probing [ ] Hand tools (shovel/rake)

[ ] Air knife [ ] Hydro Knife [ ] Potholing/Vacuum extraction

[ ] Other soft dig tools used (Y/N)? If Yes, list here:

ALL BOXES BELOW MUST BE COMPLETED BEFORE PROCEEDING

Site inspection also requires investigating vicinity outside of the work area for structures and utilities. Noting "YES" requires addt'l. investigation. Utilities must be field marked prior to intrusive work.

Is the utility present (Y/N)?		Utility Color Code
	Utilities entering/exiting structures?	No Color
	Intrusive work area marked out?	White
	Structural features above or below?	White
	Public natural gas line or meter?	Yellow
	Private natural gas laterals/feeders?	Yellow
	Public electrical service?	Red
	Conduit from meter or on wall?	Red
	Conduit from poles into ground?	Red
	Poles/devices w/ no visible lines?	Red
	Overhead electrical lines?	Red
	Solar arrays or wind turbines?	Red
	Public water line(s)?	Blue
	Private water line(s) or lateral(s)?	Blue
	Water meter onsite?	Blue
	Fire hydrants/post indicator valves?	Blue
	Irrigation system control box/valve?	Blue
	Sprinkler heads, drip lines, vaults?	Blue
	Water dispensers, fill stations?	Blue
	Telecomm. overhead or buried?	Orange
	Telecomm. ground box or relays?	Orange
	Telecomm./security CCTV devices?	Orange
	Public sanitary sewer pipes?	Green
	Combined sanitary/storm pipes?	Green
	Private sanitary laterals/clean outs?	Green
	Restrooms, kitchens, wash bays?	Green

Is the utility present (Y/N)?		Utility Color Code
	Evidence of stormwater network?	Green
	Curb drains/catch basins/manholes?	Green
	Stormwater culverts, outfalls?	Green

ABOVEGROUND Features Present?

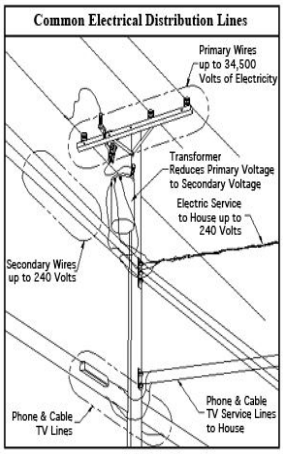
	Transportation tunnels/structures/markers present?	
	Overhead electrical lines?	Red
	< 50 kV w/in 10 ft of work area?	Red
	>50-200 kV w/in 15 ft of work area?	Red
	>200-350 kV w/in 20 ft of work area?	Red
	>350-500 kV w/in 25 ft of work area?	Red
	>500-750 kV w/in 35 ft of work area?	Red
	>750-1000 kV w/in 45 ft of work area?	Red
	Aboveground fire suppression?	Blue
	Aboveground communications?	Orange
	Aboveground chases/racks/trays?	Orange
	Private/Remediation system lines?	Various
	Unclassed utilities/anomalies?	Pink
	Warning signs/stakes/markers present?	
	Heavy Equipment: Mark travel route for overhead, next to route, and/or under route (e.g. crush risk) utilities.	

Signs of other utilities/ground disturbance

	Signs of asphalt or concrete disturbance/repair?
	Any ground subsidence or change in vegetation?
	Unknown manholes or valve covers in work area?

Tips for Thorough Utility Location (HSS Section 5.6):

1. Don't forget to look up for utilities
2. Be on-site with Private Utility Locators.
3. Ask Private Locators to "confirm" other's markings.
4. Also clear alternate/backup locations
5. Mark all known utilities.
6. No hammering, no pickaxes, no digging bars, no shortcutting.
7. No excessive turning or downward force of hand tools, especially hand augers.
8. Utilities may run in or directly under asphalt/concrete
9. Heavy equipment may damage shallow utilities. Especially during clearing and grubbing.
10. Use spotter for heavy equipment near aboveground utilities?



☐ Utilities & Structures Checklist reviewed by the PM or Designee (Y/N)? *If no, STOP WORK call PM*

PM or Designee Name: _____

Name and Signature of person completing the checklist: _____

Date of checklist review / update: _____

ALL SUSPECT UTILITY STRIKES REQUIRE CORPORATE H&S NOTIFICATION WITHIN 24 hrs. OF KNOWLEDGE OF STRIKE WITH A CONFIRMED RESPONSE FROM CORPORATE H&S.

BLOODBORNE PATHOGEN EXPOSURE CONTROL PLAN

(HASP Template 7/9/2021)

ARCADIS OFFICE/PROJECT: RACER Trust Kokomo	
WRITTEN BY: Sarah Fisher	**DATE WRITTEN: 10/8/2021**
REVISED BY:	**DATE REVISED:**

Purpose:

Each Arcadis field office or project site that designates employees to render first aid as part of their job duties, are required to develop a written Bloodborne Pathogen Exposure Control Plan ("ECP"). The plan may be used in this format or incorporated in another way into the project HASP.

The purpose of the ECP is to eliminate or minimize employee exposure to bloodborne pathogens. It will be accessible to all employees and reviewed at least once per year. The ECP does not apply to employees who have not been designated to render first aid.

Definitions:

Bloodborne Pathogens ("BBP") are microorganisms present in human blood including, but not limited to, HBV (Hepatitis B virus) and HIV (human immunodeficiency virus).

BBP Exposure is a specific eye, mouth, mucous membrane, or non-intact skin (e.g., bites, cuts, abrasions) contact with another person's blood or other body fluid contaminated with blood.

Employees, for purposes of this ECP, are employees who have been designated to render first aid as part of their job duties.

First Aid, for purposes of Arcadis employees, includes rendering basic first aid and adult CPR, but does not include injections, intravenous interventions or any other invasive procedure, technique or treatment.

Victim is the person who is being given first aid.

Exposure Determination

The following employees have the potential for occupational exposure to BBPs because they have been designated to render first aid as part of their job responsibilities:

EMPLOYEE NAME & JOB TITLE

1. To Be Determined during Kickoff Meeting or in Tailgate Safety Meetings
2.
3.
4.
5.

Methods of Compliance
To help prevent exposure, we will follow “Universal Precautions”. That is, the victim’s blood and other bodily fluids will be treated as if known to be infectious for BBPs.

Materials and equipment detailed below may be kept in a first aid kit if that kit will be available to the employee at sites where he/she is expected to render first aid.

Engineering and work practice controls will be used to minimize the risk of employee exposure, and they are:

- o Employees will wash their hands and other potentially contaminated skin with antiseptic soap and water as soon as possible after removal of PPE.
- o Employees will flush mucous membranes with water as soon as possible after contact with potentially infectious materials.
- o If hand washing facilities are or may not be available, employees will be given an antiseptic hand cleanser to use immediately, and will wash their hands and other potentially contaminated skin with antiseptic soap and water as
- o Employees will try and minimize splashing, spraying, or spattering of blood or body fluids.

Personal protective equipment will be provided and employees are expected to have this equipment with them on any job site at which they are expected to render first aid. If an employee refuses to wear PPE, the manager will investigate and document the circumstances and any action taken.

Employees will be given and instructed on the proper use, maintenance and disposal of the following PPE:

- o Disposable gloves (non-latex gloves are preferred)
- o Eye protection (goggles with adjustable straps or face shields)
- o Mouth guard for mouth-to-mouth resuscitation
- o Disposable mask

If required to clean a surface that has been potentially contaminated with BBPs, the employee will wear gloves and will clean the area with disinfectant. Gloves and cleaning items will be discarded as noted below.

Any sharp object that has been contaminated (e.g., broken glass, piece of metal) will be picked up with a brush/dust pan rather than the hands and discarded as noted below.

Items contaminated with a victims blood or other body fluids will be placed in a closable and puncture/leak resistant biohazard trash bag labeled with the below red/red-orange symbol:

o The bag will be disposed of at or by [check with local resources on how to dispose of these bags – a local clinic, hospital or your trash local clinic, hospital or your trash pick-up company should be able to advise you – and note it here]:

If contaminated sharps (e.g., needles, metal or glass) or other contaminated material is an expected/potential hazard at a project site, the HASP will include instruction for its removal by a professional company/service. If such items are unexpectedly found at a site, Stop Work, isolate the area in question, contact the client and discuss with the client options for contracting with a professional company service for cleanup and removal.

Hepatitis B Vaccination Series

Employees who are designated to render first aid as part of their job duties will be offered the Hepatitis B vaccination series after they've received the required BBP training. The vaccination series is offered without cost to the employee and consists of three injections.

Employees who decline the injection will be asked to sign a Hepatitis B Declination form (Appendix 1- from the Arcadis Bloodborne Pathogens Exposure Control Plan Template) which will be placed in the employee's Corporate Health and Safety file. If an employee later decides to have the vaccination and is still designated to provide first aid, the vaccination will be made available at no cost to the employee.

Post Exposure Evaluation and Follow-Up

If an employee feels that he/she has had an exposure to a BBP, the employee will be sent for a medical evaluation if the employee so chooses. The employee's supervisor or a manager will complete the medical provider information form (Attachment 1) and send it with the employee to the evaluation.

The employee will receive a detailed report from the medical provider, and Arcadis will receive notification that the employee has been informed of the results of the evaluation and any recommended treatment.

The incident will also be reported to Corporate Health and Safety.

Training

All employees who are designated to render first aid will be given BBP training upon initial designation and annually thereafter. The training will be provided before the employee is offered the Hepatitis B vaccination.

Record Keeping

Medical records regarding an exposure to a BBP and Hepatitis B vaccination information will be maintained by the healthcare provider. Records provided to Arcadis will be maintained by Corporate Health and Safety permanently, and will be kept confidential and not disclosed without an employee's written consent except as required by law.

BBP exposure training records will be maintained in the Arcadis training database.

Attachment 1

INFORMATION TO THE MEDICAL PROVIDER FOLLOWING THE REPORT OF A BBP EXPOSURE

(To be completed by the employee's supervisor or manager or the project manager and sent with the employee to the medical evaluation)

Job Duties as They Relate To The Exposure Incident: The Employee is a designated first aid responder.

Route of Exposure: _____

(e.g., absorption through the skin, splashed in eyes, mouth or nose, etc.)

Circumstances Under Which Exposure Occurred: _____

(explain why the employee thinks he/she was exposed/came in contact with another person's blood or other bodily fluids)

Results of Source Individual's/Victim's Blood Test: _____

(if unavailable, if the blood hasn't been tested, if the source refused testing or the source is not known, note this)

The employee's medical records, including Hepatitis B vaccination status, should be sent with the employee if not already available to the medical provider.

A copy of the OSHA Bloodborne Pathogen Regulation will also be submitted to the medical provider if not already available to the provider.

Revised 7/9/2021

Air Monitoring Documentation Form

PID Model: _____ Monitor Frequency: _____

LEL/O_2 Model: _____

CIT Model: _____

Dust Mon. Model: _____

Air Monitoring Results

Date	Time	PID (units)	O_2 (%)	LEL (% LEL)	CIT (ppm)	Dusts (mg/m^3)	Location

CIT = Colorimetric Indicator Tube
LEL = Lower Explosive Limit
mg/m3 = Milligram per cubic meter
O2 = Oxygen
ppm = Part per million
% = Percent
PID = Photoionization Detector

PID Calibration Log

ARCADIS

Zero Gas Source: _____ Instrument Type: _____ PAGE ____ of ____

Lot Number/Expiration Date: _____ Serial Number: _____

Calibration Gas Source: _____ Instrument Type: _____

Lot Number/Expiration Date: _____ Serial Number: _____

Concentration: _____ _____

Instrument Number	Date	Time	Zero Cal. OK (Y/N)	Calibration Gas Reading	Comments	Calibration w/in 2% (Y/N)?	Alarms Set (Yes/No)?	User Initials

Attachment D - Shipping Determination

Soil Waste Characterization

Materials of Trade Quick Form 11/14/2019

Date:	10/8/2021
Project Name:	RACER Trust Former GM Delco Plant 5
Project Number:	0
Supplemental Information:	MSDS/SDS

Description of the Material to be Transported or Shipped:

Checked materials in the HAZCOM/GHS worksheet, Monitoring worksheet, Safety Supplies and Equipment section and Level C Supplement (if applicable) of the Standard Excel HASP Template for this project and samples will be transported under the Materials of Trade Exception (49 CFR 143.6) in Arcadis owned, leased or rented vehicles and/or lab courier (employee of the lab), and/or requipment rental vendor (employee of the vendor). Eligible samples must meet qualifying criteria in the Limitations section below.

Special Instructions:

1) All containers will be maintained in an upright condition with lids or other openings secure. Containers will be protected against movement during transport and have adequate cushioning for protection.
2) Cylinders will have regulators removed and protective caps in place during transport. Cylinders will be secure in the vehicle. Vertical transport should be utilized as a best practice.
3) Batteries regardless of type or size, will have terminal protected and each battery will be protected from crushing, pressure or other condition that may affect the integrity of the battery.
4) ChemTel 24 hr. phone number and registration is not required.
5) Fire extinguishers, when considered as part of vehicle equipment, will be mounted and secure in company owned or leased vehicles.
6) Fuels will be transported in DOT or OSHA approved metal or plastic containers (ie. **safety cans**).
7) For HSSPs listed below, use the HSSP designed for ground transport unless transport is related to an air shipment.

Limitations

1) No more than 440 pounds (combined gross weight) of materials subject to this shipping determination are permitted on a transport vehicle and individual container limits are specified in the chart below.
2) Materials that are radioactive or explosive are not eligible for MOT Exception and separate shipping determinations will be required for those materials.
3) Flammable gases not transported in a specification cylinder are not eligible for the MOT Exception and must be prepared in accordance with HSSP-004 or HSSP-005 (attach applicable HSSP).
4) Gasoline transported in glass containers (samples) are not eliglible for MOT Exception. Follow HSSP-001 or HSSP-003 (attach applicable HSSP) for transport of gasoline in glass containers.
5) Div. 6.2 materials are not covered by this MOT Quick Form.
6) Self-reactive materials, poisonous by inhalation materials, and hazardous wastes are not permitted under MOT Exception.

Material Hazard	Packing Group	Limit per Package
High hazard	I	0.5 kg (1 pound) for solids 0.5 L (1 pint) for liquids
Medium/Low hazard (excluding Div 4.3) or ORM-D	II or III	30 kg (66 pounds) for solids 30 L (8 gallons) for liquids
Div. 4.3	II and III only	30 ml
Div 2.1 or 2.2 cylinder	N/A	100 kg (220 pounds) gross weight
Dilute Class 9 (<2% concentration)	N/A	Tank capacity <1500L (<400 gallons)

References and Rationale for the Determination:

49 CFR 173.6
These materials are used in support of Arcadis work.

Determination performed by: Sarah Fisher

Attachment E - COVID-19 Field and Embedded Guidance

Arcadis Field and Embedded Staff COVID-19 Guidance

10 September 2021

Version Control

Revision No.	Date Issued	Description
1	3/17/20	Original document.
2	3/20/20	Added guidance for multiple occupants traveling in the same vehicle.
3	3/24/20	Updated introduction to include links to Orange Line information; added requirement of Arcadis COVID-19 Health Screening Self-Assessment Questionnaires; moved client questionnaire section forward in the document; and made minor updates to the social distancing, vehicle/transportation, lodging and equipment sections.
4	3/30/20	Updated social distancing section to include CDC “close contact” definition; added section for work in team settings; added AirBnB to lodging discussion.
5	4/2/20	Document template updated and sections rearranged; updated Hand Hygiene section; updated Cleaning of Frequently Touched Surfaces section; updated close contact definition; added section on PPE; added section for Traveling Between States, Provinces and Territories; added section for Construction/Construction Management; added section on Post-Shift Work
6	4/3/20	Added Appendix D – Interim Guidance for the Use of Face Coverings; Updated links, Section 2.3 added bullet to avoid sharing tools and equipment unless cleaned; Section 4.7.2 updated with a bullet for maintaining social distancing at choke points; Section 4.8 added section for Face Coverings and guidance in Appendix D.
7	4/10/20	Added Section 2.8 Other Considerations for journey and emergency action planning; Section 4.6 updated with current information regarding COVID-19 in sewage; Section 4.8 and Appendix D updated to include CDC’s recommends of wearing cloth face coverings in public settings where other social distancing measures are difficult to maintain.
8	4/13/20	Revised Section 2.6 by adding information about gloves being required in some jurisdictions; revised Section 4.8 and Appendix D with latest CDC and Health Canada guidance information.
9	4/20/20	Revised Section 2.1 to discuss both digital and hardcopy COVID-19 Health Screening Self-Assessment Questionnaires; revised Section 2.3.1 to include instructions on alcohol-based hand sanitizer use.
10	4/26/20	Revised Section 2.1 by adding the definition of fever and process for elevated temperature; revised section 2.4 by adding a reminder to understand the appropriate uses and limitations of the disinfectant; revised Section 2.6 by adding link to PPE request form and email address; Section 3.1 added link to “Locations with Travel Restrictions”

Revision No.	Date Issued	Description
		dashboard; revised Section 3.2 to consider face coverings when multiple occupants are riding in a single vehicle; revised Section 4.2 adding critical infrastructure/essential worker language; updated hyperlinks
11	5/1/20	Section 1 revised with latest symptoms of COVID-19; Section 2.5 reinforced Stop Work Authority and reporting where social distancing is not being practiced; inserted Interim Guidelines for Cardiopulmonary Resuscitation as Section 2.8 and moved “Other Considerations” to Section 2.9; added a bullet referencing Continuity Plan in Section 2.9
12	5/4/20	Revised Appendix C per jurisdictional updates.
13	6/16/20	Updated symptom list per CDC guidance; revised CDC close contact definition notes (Section 2.4); added plan for breaks bullets in Section 4.2; added Section 4.9 KN95; updated CDC’s face covering laundering recommendations in Appendix D.
14	8/14/20	Updated footnotes for “close contact” definition (Section 2.5); updated Sections 3.1 and 3.3 to reflect current travel recommendations; updated Section 4.8 and Appendix D to indicate exhalation valves or vents should NOT be worn; added links to the Face Covering Guide in Section 4.8.
15	10/23/20	Added Appendix E with additional signage that may be used; added reference to signage (Section 2.3.1); updated social distancing and close contact definitions (Section 2.5); added Yellow Guidance sub bullet (Section 2.7); updated order hyperlink (Section 3.1); added airline and other transportation (Section 3.2); added reporting requirement documentation (Section 4.3); updated Section 4.7.1 to clarify occupancy and documentation of visitors for contact tracing; added guidance to hold meetings outside (Section 4.7.2); minor edits to Section 4.8 and Appendix D.
16	11/13/20	Section 3.2 updated protocol to only one person in a vehicle; Section 3.3 updated protocol regarding room sharing and dining; Sections 4.2 through 4.7 added a face covering bullet; Section 4.8 and Appendix D added information from recent study that face coverings provide protection to the wearer.
17	12/4/20	Revised the reporting process in Section 2.7 to contact WorkCare instead of Brian Kundert. Added Section 2.7.1 describing WorkCare’s risk stratification and return to work process.
18	1/29/21	Updated all hyperlinks to new Intranet; added COVID-19 vaccine to Section 2.3; moved the Face Covering and KN95 section from 4.8 and 4.9, respectively, to Section 2.6; renumbered all sections; Section 2.9 clarified the continuity plan is required by the jurisdiction or client and is

Revision No.	Date Issued	Description
		recommended for all projects; revised poster in Appendix B; Appendix D updated with current CDC language and added CDC graphics.
19	2/25/21	Updated links in Section 2.1.2; updated Section 2.6 and Appendix D with revised face covering and KN95 guidance.
20	5/18/21	Added U.S. quarantine exemptions in Section 2.8; updated U.S. ridesharing requirements in Section 3.2; updated U.S. dining protocol in Section 3.3; updated face covering bullets in Section 4.0 work-specific situations; template update.
21	7/23/2021	Updated Section 2.1 and 2.8.1 to reflect the revised WorkCare Daily Screen and risk stratification process; removed outdated Section 2.6.1; updated U.S. vehicle sharing protocol in Section 3.2; Section 4.7 updated with guidance for vaccinated and unvaccinated employees.
22	8/13/21	Removed “Jurisdictional Social Distancing” template from Appendix C and renumber appendices; changed temperature at which individuals will not visit an office or project site to 100.0°F (37.8°C) in Section 2.1; updated face covering protocol for indoor spaces in Section 2.6 and Appendix C; updated U.S. vehicle sharing protocol in Section 3.2.
23	9/10/21	Added Section 2.3 Vaccine Policy and renumbered sections; Section 2.8 removed reference to retired “Yellow Caution Status” flowchart; Section 3.2 updated Canada ridesharing; Section 3.3 updated Canada and U.S. dining protocol; Section 4.7.1 removed reference to unvaccinated employees.

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Acronyms and Abbreviations

AED	Automated external defibrillators
CDC	U.S. Centers for Disease Control and Prevention
CPR	Cardiopulmonary resuscitation
HC	Health Canada
PPE	Personal protective equipment
SDS	Safety Data Sheet

1 Introduction

Currently Arcadis is following CDC and Health Canada guidelines, as well as applicable government directives. The health and safety of our people is of utmost importance to us. Arcadians are empowered to use TRACK to evaluate individual situations and Stop Work Authority anytime safety is at risk. Employees will not come to work if exhibiting any respiratory illness symptoms, including but not limited to COVID-19.

It is recommended that all field and embedded staff review and have access to the current version of this document. The most current version can be viewed and downloaded from the ANA H&S COVID-19 Resources intranet page. COVID-19 symptoms may appear 2-14 days after exposure to the virus. People with these symptoms or combinations of symptoms may have COVID-19:

- Fever or chills
- Cough
- Shortness of breath or difficulty breathing
- Fatigue
- Muscle or body aches
- Headache
- New loss of taste or smell
- Sore throat
- Congestion or runny nose
- Nausea or vomiting
- Diarrhea

This list is not all inclusive. Please consult your medical professional for any other symptoms that are severe or concerning to you.

2 Guidance for Project Activities

Employees should complete the following for all project activities.

2.1 Arcadis COVID-19 Health Screening Self-Assessment Questionnaires

All employees going to an Arcadis office, a project site, or a client site will be required to complete a Daily Screening through WorkCare, regardless of vaccination status. Individuals should continuously monitor for signs and symptoms of COVID-19 and, if not feeling well, complete the WorkCare Daily Screen Process again.

When individuals take their own temperature to evaluate whether they have a fever, the temperature measurements will be completed without the use of fever-reducing medicines that contains ibuprofen or acetaminophen and not within 30 minutes of exercise. The CDC defines a fever as a temperature of 100.4°F (38°C) or greater. If the individual's temperature is between 99°F (37.2°C) and 99.9°F (37.7°C) it is recommended the individual pay close attention for signs and symptoms of COVID-19 and complete the WorkCare COVID-19 Daily Screen Process more frequently. Individuals with temperatures of 100.0°F (37.8°C) or greater should not

visit an office or project site. You may also contact WorkCare's COVID-19 services if you are experiencing symptoms consistent with COVID-19 and are concerned it may be COVID-19.

2.1.1 COVID-19 Daily Screen Process

Arcadis staff can use the WorkCare WorkMatters app once a day (or multiple times a day, if appropriate) to complete their COVID-19 health screening self-assessment using the Daily Screen Survey.

Upon completion of the COVID-19 Daily Screen Process in the WorkMatters app, the user will receive a green or red completion message:

- Green – Proceed to the office or project site.
- Red – Do not proceed to the office or project site. Complete Survey 2 and follow end guidance. You and your supervisor will receive an email that you have not been cleared to work. You will need to conduct contact tracing with Corporate Health & Safety, if necessary. You must to log into the URL or App to complete the Daily Symptom Tracker, each day you are Not Cleared To Return To Work.

Once you have been cleared to Return to Work by a WorkCare physician, you and your supervisor will receive an email that states you have been Cleared to Return to Work.

2.1.2 COVID-19 Health Screening Self-Assessment Questionnaire (Hardcopy)

The COVID-19 Health Screening Self-Assessment Questionnaire must be:

- Distributed to scheduled visitors, clients, and contractors before visiting Arcadis offices or sites.
- Post the self-assessment questionnaire and post Appendix A at entrances and/or field trailers.

Minimize visitors on site. All visitors (staff, subcontractors, clients, anticipated guests, unanticipated guests) to the site must be asked to review the applicable questionnaire from the following list.

Canada COVID-19 Health Screening Self-Assessment Questionnaire for Staff (English)

Canada COVID-19 Health Screening Self-Assessment Questionnaire for Staff (French)

Canada COVID-19 Health Screening Self-Assessment Questionnaire for Visitors (English)

Canada COVID-19 Health Screening Self-Assessment Questionnaire for Visitors (French)

U.S. COVID-19 Health Screening Self-Assessment Questionnaire for Staff, Contractors and Scheduled Visitors (English)

U.S. COVID-19 Health Screening Self-Assessment Questionnaire for Staff, Contractors and Scheduled Visitors (Spanish)

U.S. COVID-19 Health Screening Self-Assessment Questionnaire for Unscheduled Visitors/Guests (English)

U.S. COVID-19 Health Screening Self-Assessment Questionnaire for Unscheduled Visitors/Guests (Spanish)

If a client has a similar questionnaire that Arcadis staff are required to complete, the client questionnaire may be substituted for Arcadis questionnaire.

2.2 Client COVID-19 Health Screening Forms

Some clients are requiring our employees to complete their COVID-19 health screening forms.

- You are not required to share personal medical information with clients; therefore, Arcadis is not requiring you to complete any form requesting medical information. Your disclosure of personal medical information to clients is completely voluntary.
- Please understand, if you do not complete the form, you will not be allowed on the client's sites and facilities, per the client's directive.
- Also, if you complete the form, you have an ongoing duty to provide prompt notice of any changes to any of your responses. (Some clients may require periodically signing updated forms).
- If you are restricted from a client site as a result of your answers to the COVID-19 health screening form, or because you have chosen not to complete the form, Arcadis will attempt to find you alternative work that does not involve access to the client's site or facility; although, Arcadis cannot guarantee that other work will be available.

If your Project Manager is not already aware of the client COVID-19 health screening form, please alert them when you receive one from a client.

2.3 U.S. Vaccine Policy

Arcadis strongly encourages all employees to receive a COVID-19 vaccination. COVID-19 vaccines are effective at helping protect against severe disease and death from variants of the virus that causes COVID-19. In accordance with the Arcadis U.S. Vaccine Policy, all U.S. employees are encouraged to upload the vaccination details into WorkCare's WorkMatters portal.

Clients may require employees working at their sites be fully vaccinated or if unvaccinated, to complete surveillance testing. If the client requires Arcadis verification, Project Managers or Account Managers will reach out to HR Operations (HROperations.ANA@arcadis.com) with a list of names to be checked. If testing is required, contact Corporate Health & Safety.

2.4 Practice Good Hygiene

The best way to prevent illness is to avoid exposure to the virus. CDC and Health Canada recommend common flu and cold season preventative measures, including:

- Wash hands often with soap and water for at least 20 seconds. If soap and water are not readily available, use a hand sanitizer with at least 60% alcohol.
    - If hand sanitizer or soap & water are not available on site, bring your own source of water and hand soap to accommodate hand washing.
- Avoid touching your eyes, nose, and mouth.
- Cover your nose and mouth with a tissue when sneezing or coughing.
- Monitor your health daily by completing a self-assessment.
- Stay 6 feet (2 metres) away from others.

- Avoid crowds and poorly ventilated spaces.
- Do not share Personal Protective Equipment (PPE).
- Maintain and thoroughly clean PPE in accordance with manufacturer's instructions.
- Avoid sharing phones, offices, tools, and equipment. If sharing is necessary, clean and disinfect prior to use.
- Clean high touch surfaces daily.
- Get a vaccine (flu to reduce the risk of flu illness and COVID-19).

2.4.1 Hand Hygiene

Hand hygiene for infection prevention is an important part of the U.S. and Canada response to COVID-19. Washing hands with soap and water has been and will continue to be our primary method for good hand hygiene. Both CDC and HC recommend that you wash hands often with soap and water for at least 20 seconds especially after you have been in a public place, or after blowing your nose, coughing, or sneezing. Hand washing mechanically removes pathogens.

Alcohol based hand sanitizer is a flammable liquid and vapor. However, there is no evidence to suggest hand sanitizer poses a fire hazard when used according to package directions and warnings. To use hand sanitizer:

- Follow manufacturer instructions for use.
- Rub your hands together, covering all surfaces of both hands, including between your fingers and up around your fingertips and nails.
- Rub hands together for 30 seconds to allow your hands to completely absorb the product.
- Allow the hand sanitizer to completely dry.
- Do not touch food or anything until your hands are dry.
- Refer to the Safety Data Sheet (SDS) for hazards information.

If hand sanitizer is not available, Arcadis requires that project teams assess and address the need for hand washing (e.g., access to water and soap) while working on site. This can be achieved by having access to a functioning restroom, a portable hand washing station or as simple as having hand soap, bottled water and paper towels to clean hands as necessary. A handwashing sign that may be posted near handwashing stations is provided in Appendix D.

2.5 Clean Frequently Touched Surfaces

Arcadis recommends that project teams identify who is responsible for cleaning frequently touched surfaces in our workplaces (field trailers, client facilities, etc.). CDC and HC recommend that these surfaces are disinfected daily. This includes tables, doorknobs, light switches, countertops, handles, desks, phones, keyboards, toilets, faucets, and sinks. Before using a disinfectant product, understand the appropriate uses and limitations of the disinfectant, and refer to equipment/tool manufacturer care instructions to determine whether the disinfectant is compatible (e.g., using isopropyl alcohol to disinfect an iPhone).

> CDC cleaning and disinfecting facilities: https://www.cdc.gov/coronavirus/2019-ncov/prepare/disinfecting-building-facility.html
>
> Health Canada cleaning and disinfecting public spaces: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/cleaning-disinfecting-public-spaces.html

Health Canada hard surface disinfectants: https://www.canada.ca/en/health-canada/services/drugs-health-products/disinfectants/covid-19.html

If surfaces are dirty, clean them using detergent or soap and water prior to disinfection. To disinfect, most common EPA-registered or HC-approved household disinfectants will work. Use disinfectants appropriate for the surface.

If the sourcing of disinfectant products is limited, CDC and HC have outlined an option to use a diluted household bleach solution (at least 1,000 ppm sodium hypochlorite) as a disinfectant.

Standard household bleach is typically 5.25% sodium hypochlorite (52,500 ppm), whereas ultra-strength household bleach is typically 6% sodium hypochlorite (60,000 ppm). In accordance with Hazard Communication requirements, always refer to and have a copy of the Safety Data Sheet (SDS) available and on site with you. To **make a daily bleach solution** for use as a disinfectant:

- Mix 5 tablespoons (1/3rd cup) of standard bleach per gallon of water or for a smaller spray bottle size dilution, mix 4 teaspoons bleach per quart of water.
  OR
- 1 teaspoon (5 mL) per cup (250 mL) OR 4 teaspoons (20 mL) per litre (1000mL).
  Note: Solution must be mixed daily, because the solution will lose effectiveness as a disinfectant after 24-hours.

Follow manufacturer's instructions (e.g., Clorox) for application and proper ventilation, ensuring a contact time of at least 1 minute (for specific products and contact time information, refer to the CDC and HC links above). Check to ensure the product is not past its expiration date. Never mix household bleach with ammonia or any other cleanser. According to the HC, CDC and U.S. EPA, unexpired household bleach will be effective against coronaviruses when properly diluted.

A second alternative is to use an alcohol solution. The solution must have at least 70% isopropanol.

If supplies cannot be sourced locally, complete the PPE Request Form and submit to PPErequests@arcadis.com.

2.6 Practice Social (Physical) Distancing

The CDC definition of **social distancing, also called "physical distancing,"** means keeping a safe space (approximately 6 feet, 2 metres or about two arm lengths) between yourself and other people who are not from your household in both indoor and outdoor spaces. Situations where social/physical distancing should be practiced include but are not limited to tailgate and safety briefing meetings, breaks in field trailers, entering stores and workstations. Plan work activities to maximize social (physical) distancing and minimize close contact with others. Social (physical) distancing is mandatory for unvaccinated individuals and highly recommended for vaccinated individuals. If there are instances where social distancing is not being practiced where it should, Stop Work and remove yourself from the situation. Contact the Project Manager or your Supervisor and document in the H&S App as an "Close Call" or "Unsafe Behavior."

Additional information when working in teams is required is discussed in the "work specific situations" section below.

Note: The CDC defines **close contact** as: a person who was within 6 feet of an infected person for a cumulative total of 15 minutes or more over a 24-hour period starting from 2 days before illness onset (or, for asymptomatic patients, 2 days prior to test specimen collection) until the time the patient is isolated.[1]

2.7 Face Coverings

Health Canada and CDC recommends wearing face coverings in public settings, like on public and mass transportation, at events and anywhere you will be around other people. In the U.S., face coverings are required on planes, buses, trains, and other forms of public transportation traveling into, within, or out of the United States and in U.S. transportation hubs such as airports and stations. When visiting Arcadis offices and project sites, face coverings will be worn when moving about the space, in common areas and during meetings. If social/physical distancing can be maintained, face coverings may be removed when sitting at individual workstations or actively eating in cafés. Some jurisdictions require face coverings to be worn at all times indoors regardless of vaccination status.

In Canada, non-surgical face coverings are mandatory when flying and travelling through airports. The wearing of face coverings is either required or recommended in all other public settings across Canada (indoors and outdoors).

Studies show that face coverings reduce the spray of droplets when worn over the nose and mouth. Studies also show face coverings can reduce wearers' exposure to infectious droplets through filtration. How well the face covering protects the wearer depends on the fabrics used and how it is made (e.g., the type of fabric, the number of layers of fabric, how well the mask fits). Health Canada and CDC still recommends that you stay at least 6 feet away from other people (social distancing), frequent hand cleaning, avoid contact with people who are sick and other everyday preventive actions. Face coverings are not a substitute for social/physical distancing. Face coverings with exhalation valves or vents should NOT be worn to help prevent the person wearing the mask from spreading COVID-19 to others. Face shields and goggles are not a substitute for face coverings.

Face coverings offering various features appropriate for different work environments, including moisture wicking and FR, are now in stock at Airgas (U.S.). The Face Covering Guide outlines several options to facilitate selection of the face covering that is appropriate for your work.

Some jurisdictional entities and clients require the use of face coverings based on Health Canada and CDC guidance. CDC guidance on selection, use and care of face coverings is included in Appendix C.

2.8 Personal Protective Equipment

Be prudent with PPE use (PPE with a purpose). Continue to work with our vendors on your PPE ordering needs and consider alternatives (e.g., N95 dust masks may not be available, but half face elastomeric respirators with

[1] Individual exposures added together over a 24-hour period (e.g., three 5-minute exposures for a total of 15 minutes). Data are limited, making it difficult to precisely define "close contact;" however, 15 cumulative minutes of exposure at a distance of 6 feet or less can be used as an operational definition for contact investigation. Factors to consider when defining close contact include proximity (closer distance likely increases exposure risk), the duration of exposure (longer exposure time likely increases exposure risk), whether the infected individual has symptoms (the period around onset of symptoms is associated with the highest levels of viral shedding), if the infected person was likely to generate respiratory aerosols (e.g., was coughing, singing, shouting), and other environmental factors (crowding, adequacy of ventilation, whether exposure was indoors or outdoors). Because the general public has not received training on proper selection and use of respiratory PPE, such as an N95, the determination of close contact should generally be made irrespective of whether the contact was wearing respiratory PPE. At this time, differential determination of close contact for those using fabric face coverings is not recommended.

P100 cartridges are available in limited supplies). If PPE and supplies cannot be sourced locally, complete the PPE Request Form and submit to PPErequests@arcadis.com.

Select the appropriate glove for the task and include in the HASP, JSA and/or COVID-19 Preparedness, Response and Continuity Plan. Before using nitrile gloves as personal protective equipment (PPE), make sure to:

- Wash and dry your hands before and immediately after using gloves.
- Understand how to put nitrile gloves on and take them off (refer to The Orange Line article).
- Nitrile gloves offer protection against common consumer cleaning supplies, chlorinated solvents, and offer good dexterity and sensitivity.
- Change gloves between tasks or wash gloved hands with soap and water between tasks.
- Do not touch your face.
- Inspect gloves frequently for rips, tears, etc. and replace as necessary.
- Understand limitations of nitrile gloves.

2.9 Reporting a COVID-19 Exposure

Contact WorkCare (888-449-7787, press 9) to initiate the COVID-19 Screening and Return to Work Process flow chart if you have tested positive for COVID-19, have been asked to be tested for COVID-19 by a medical professional or have received a red “Stop” screen during the COVID-19 self-assessment instructing you to call WorkCare.

If you learn you have been in **close contact** with a worker, client or member of the public who is COVID-19 positive:

- Stop work.
- Notify your Supervisor and Project Manager.
- Self-quarantine in accordance with country-specific requirements (Canada and U.S.) and contact your personal physician for additional direction.
    - If working in the U.S., the following people are exempt from self-quarantine due to close contact and are asymptomatic
        - Fully vaccinated[2]
        - Had COVID-19 in the past 3 months

If you’ve been tested or asked to be tested for COVID-19 by a medical professional, please contact WorkCare (888-449-7787, press 9) to initiate the COVID-19 Screening and Return to Work Process flow chart.

2.9.1 WorkCare COVID-19 Screening & Return to Work Process

Contact WorkCare (888-449-7787, press 9) for access to doctors and nurses who will discuss your symptoms, complete a risk stratification process, and advise on return-to-work process. If you complete the Daily Screen Process through the WorkMatters App and receive a red screen, you will be prompted to complete the risk stratification process electronically and depending on the outcome, you may receive a call from a WorkCare nurse or physician. If prompted to complete the risk stratification process, you can expect to:

- Be placed into a low, moderate or high-risk category

[2] People are considered fully vaccinated two weeks after second dose in a two-dose series, such as Pfizer/Moderna vaccines, or two weeks after a single-does vaccine, such as Johnson & Johnson's Janssen vaccine.

    - Low Risk – you may be cleared to return to work at an office or project site
    - Moderate and High Risk – you will not be cleared to return to work at an office or project site and instructed to remain at home
    - An email will be sent to you, Corporate H&S, HR, and your Supervisor indicating whether you can proceed to an office or project site (cleared) or whether you must work remotely (not cleared). If you are not cleared, this will initiate Arcadis' internal contact tracing process.
- Moderate and High-Risk individuals will be required to complete the "Daily Symptom Tracker" during their self-isolation period.
- At the end of your self-isolation period, you will complete a Return-to-Work Survey in the WorkMatters Portal. The survey and daily symptom tracker will be reviewed by a WorkCare physician.
- You will receive a written notice from WorkCare indicating whether you are cleared or not cleared to return to work at an office or project site.

If you are not cleared, you will receive additional instruction, which may include continuing daily assessments and completing another return-to-work survey at a later date.

2.10 Interim Guidelines for Cardiopulmonary Resuscitation

The American Heart Association and Hearth & Stroke Foundation of Canada have issued interim Hands-only cardiopulmonary resuscitation (CPR) guidelines to reduce the risk when helping victims of cardiac arrest with suspected or confirmed COVID-19.

CPR and the use of automated external defibrillators (AED) significantly improve the chance of survival of patients experiencing cardiac arrest. During the COVID-19 pandemic, first aid trained folks and bystanders may feel uncomfortable performing lifesaving CPR and increasing their own risk of contracting the virus.

Hands-only CPR involves performing chest compressions only at a rate of 100 to 120 compressions per minute until an ambulance arrives.

When administering CPR, consider:

- Wearing a face covering
- Laying a cloth, towel, or clothing over the person's mouth and nose
- Perform hands-only CPR
- Use an AED, if available

2.11 Other Considerations

When planning field work, consider the following:

- Plan your journey to and from the site to manage social distancing and hand hygiene when you need to stop for gas or at a store for supplies
- Reevaluate the current field work situation as it relates to lone worker protocols
- A COVID-19 Preparation, Response and Continuity Plan template is required for all projects.

3 Travel Guidance

3.1 Traveling Between States, Provinces or Territories

Some states, provinces and territories have issued executive orders requiring self-quarantine, travel health screening questionnaires and/or COVID-19 testing for people traveling into or from certain locations. While some jurisdictions exempt essential workers, self-quarantine requirements may apply during off-work hours, confining the employee to their lodging location. Check local requirements before you travel to determine whether you can travel or if there is a need to self-quarantine at the destination. Prior to travel, it is important to have a destination plan in place and understand the steps you will take to remain safe and healthy throughout your trip. Whenever possible, use local project teams within a 4-hour drive radius.

3.2 Field Vehicles and Transportation

When using shared vehicles (fleet, rental, ride sharing services) follow the cleaning guidance above for frequently touched surfaces. Check with your rental agency before vehicle pick-up to understand their cleaning procedures, and supplement with your own cleaning, as necessary. Note: if using wipes, make sure the wipe is compatible with the surface being cleaned.

Canada: A limit of two vaccinated employees may share a vehicle. Unvaccinated individuals are not permitted to share vehicles.

U.S.: There is no limit to the number of vaccinated employees that may share a vehicle. Unvaccinated employees are limited to two people per vehicle and must wear face coverings.

When traveling by air for business-critical travel, check with the airline to obtain their latest COVID-19 requirements. A summary of current airline COVID-19 policies can be found here.

3.3 Lodging Considerations

Most hotel chains have implemented additional cleaning, disinfection and face covering in common area procedures. Check with your hotel before check-in to understand their procedures. Consider bringing a surface cleaner or disinfecting wipes to clean frequently touched surfaces such as doorknobs, tv remote, etc.

In instances where AirBnB has been authorized and approved in writing by the Project Manager and Supervisor, consider the following:

- The entire team should not stay at the same residential facility.
- Understand the AirBnB may need additional cleaning and disinfection of commonly touched surfaces upon arrival.

Lodging together is not permitted for unvaccinated employees. An exception is if the lodging configuration allows each individual to have a dedicated living space (e.g., own bedroom). Use of the common space will alternate among shared individuals allowing only one person in the space at a time. Wear face coverings in common spaces.

Always maintain good personal hygiene and avoid crowded places such as restaurants or bars. Consider using take out or outdoor seating. If self-quarantine is required by the jurisdiction during off-work hours, plan ahead and evaluate local food and/or grocery delivery options.

Canada: Dining together outdoors and indoors without face coverings is permitted if everyone is fully vaccinated. Outdoor dining is preferable. Indoor dining should be limited, and groups kept small. Dining together is not permitted if anyone is not vaccinated.

U.S.: Dining together outdoors without face coverings is permitted if everyone is fully vaccinated. Indoor dining is permitted if everyone is fully vaccinated and face coverings are worn in public spaces. Dining together is not permitted if anyone is not vaccinated.

3.4 Rental Equipment and Sample Cooler Handling

Clean the exterior of rental equipment and sample coolers upon arrival at the job site using a cleaning product that will not impact data quality. Wear gloves and safety glasses when handling sample coolers to prevent contact with acid preservation of the bottles in coolers. Where possible, order separate sets of equipment and "assign" equipment to individuals for use through the duration of the event.

4 Work-Specific Situations

4.1 Working with Little or No Contact with Others

Follow procedures listed in Section 2.0 and Section 3.0.

4.2 Working in Project Teams

When working in project teams (paired Arcadians, embedded staff, contractors, clients, etc.):

- If feasible, prior to visiting the site, have a H&S check in to confirm all attendees are complying with CDC or Health Canada guidelines, including:
    - Confirm understanding that workers or clients should not go to the job site if they have personally tested positive for COVID-19, have been in close contact to anyone else who has tested positive for COVID-19 or are exhibiting symptoms. If a worker discloses close contact with someone COVID-19 positive and the worker is asymptomatic, instruct the employee to complete the WorkCare Daily Screen and follow the instructions provided following the survey.
- Out of respect for all, ask everyone to self-disclose if they are not feeling well (exhibiting flu-like symptoms), and request that they should go home.
- Observe person(s) for symptoms, and use Stop Work, as necessary, and contact Project Manager.
- Set visual or physical barriers to keep the public away (caution tape and cones).
- Consider if "split shifts" can be used to limit contact, or if work can be scheduled during hours of low to no facility operations.
- Arcadis staff plan work activities, continuously use TRACK and re-plan work activities to maximize social distancing and minimize "close contact"
    - Practice good hygiene and clean commonly touched surfaces
        - Clean clipboard and pen prior to use

        - Bring your own pen
        - Disinfect shared equipment (water level meters, pumps, etc.)
        - Coordinate with sanitation vendor for portable hand wash station (soap & water or hand sanitizer)
    - Use work practices and tools to minimize close contact when feasible, such as:
        - Single person operating a winch instead of a two-person manual lift
        - Tools to maximize distance
    - Use PPE in accordance with the Job Safety Analysis (face shield, safety glasses, gloves, etc.)
    - Plan for breaks to allow for hydration, nutrition and rest/prevention of heat related illness
        - Select locations where social distancing can be maintained
        - Allow time for safe doffing/donning of personal safety items
        - Communicate individual needs for breaks before beginning work.
- If social distancing or other controls are not feasible discuss this with your supervisor and PM, discuss "Is the work necessary?" or "Can the work be rescheduled for a later date?"
    - Refer to Section 2.6 for the definition of close contact. CDC has indicated short periods of time in close contact may not increase risk of exposure.
- Wear face coverings in accordance with Section 2.7 and jurisdictional requirements.
- Subcontractors need to develop and implement their own procedures to protect their workers.

4.3 Embedded Employee Working at a Client Facility

Embedded employee at a client facility should:

- Inquire whether working remotely is an option.
- If not, and Arcadis must work at the client facility:
    - Ask if arrangements can be made to practice social distancing (e.g., split shift, separate workstation, etc.)
    - Practice good hygiene, and if you do not feel the situation is safe, you can execute your stop work authority by having discussions with your Supervisor and Project Manager.
- Wear face coverings when social/physical distancing cannot be maintained or in accordance with client or jurisdictional requirements.
- If client facility cleanliness is a concern discuss concerns with Project Manager. The Project Manager will discuss with the client. If the client will not increase cleaning, Arcadis employees will be provided with the supplies to clean and disinfect frequently touched surfaces as well as supplies to clean hands.
- Discuss and document Arcadis, client and jurisdictional protocol for reporting a COVID-19 case using the template in the Arcadis COVID-19 Preparedness, Response and Continuity Plan or similar form.

4.4 Working in Contact with the Public

When working in contact with the public (mall areas, parks, outdoor residential settings):

- Set visual or physical barriers (caution tape and cones) to keep the public away and maintain social distancing.
- Wear face coverings when working indoors or in enclosed spaces.
- Consider posting signs reminding the public of social distancing guidance (example in Appendix B).

4.5 Working at Indoor Residential Settings

When working at indoor residential settings, consider the following guidelines:

- Call ahead to ask if the resident(s) is experiencing flu-like symptoms or if anyone in the house is in mandatory or precautionary self-quarantine. Reschedule the work if the resident is experiencing symptoms or under quarantine. Also share Arcadis work procedures and explain that Arcadis will be practicing social distancing during the work.
- Upon arrival, assess the residents for signs of flu-like symptoms. If observed, use Stop Work, exercise social distancing and contact the Project Manager.
- Where feasible, wear gloves, wipe down surfaces prior to touching them and thoroughly wash hands after completing the work (do not touch face).
- Ask if arrangements can be made to practice social distancing (meaning stay 6 feet [2 metres] away).
- Schedule your work when resident is not home, if your work area allows for access (e.g., a basement crawl space the doesn't require entry to the main living area of the home).
- Wear face coverings when working at indoor residential settings.

4.6 Projects Involving Drinking Water Systems, Recreational Water and/or Wastewater

According to the CDC, at this time, the risk of transmission of the virus that causes COVID-19 through sewerage systems is thought to be low. Although transmission of the virus that causes COVID-19 through sewage may be possible, there is no evidence to date that this has occurred.

Wastewater and sewage workers should use standard practices, practice basic hygiene precautions, and wear personal protective equipment (PPE) as prescribed for current work tasks.

When working on projects involving drinking water systems, recreational water and/or wastewater:

- The COVID-19 virus has not been detected in drinking water.
- Conventional water treatment methods that use filtration and disinfection, such as those in most municipal drinking water systems, should remove or inactivate the virus that causes COVID-19.
- Standard practices associated with wastewater treatment plant operations should be sufficient to protect wastewater workers from the virus that causes COVID-19.
- Review the project Health & Safety Plan and task-specific Job Safety Analysis for required personal protective equipment and other controls.
- Wear face coverings when working indoors.

4.7 Construction Management/Construction

4.7.1 Field Trailers

Field trailers may present unique challenges for social distancing. Consider the following:

- Restrict access by posting site signage (Appendix D) requesting all visitors, including site workers. All who enter the field trailer should knock and don a face covering before entering.
    - The project team will determine the maximum occupancy based on the ability to maintain social distancing.

- Local jurisdictions may require face coverings in all indoor spaces regardless of vaccination status. In areas without jurisdictional mandates, all workers will wear face coverings in common spaces and when social/physical distancing cannot be maintained.
- Maintain a log of visitors entering the trailer use the “Arcadis Contact Tracing Log” in Appendix E. Assign a person responsible for signing visitors in and out.
- Clean surfaces regularly. In the absence of professional cleaning services, occupants will develop a schedule for site personnel to complete cleaning of commonly touched surfaces.
    - When using common surfaces, each individual is responsible for wiping down the shared surface before and after use.
- Assess and address the need for the availability of hand washing (e.g., access to water and soap) while working on site. This can be achieved by:
    - Having access to a functioning restroom
    - Portable hand washing station
    - Hand soap and bottled water to clean hands as necessary.
- Plan seating arrangement so that personnel inside the trailer maintain social distancing, at least 6-feet (2 m) of separation.
- Meetings in the trailer will not exceed the maximum occupancy as determined based on the ability to maintain social distancing. Unvaccinated individuals must wear face coverings and maintain 6 feet (2 m) of physical distance.
- Consider the use of physical barriers to separate the field trailer from the public and/or site activities.

4.7.2 Other Construction Guidance

Additional guidance related to construction and construction management activities include:

- Consider use of technology (e.g., digital sign in using QR codes, virtual tailgate, or construction meetings, video camera systems to minimize the number of people on site).
- For tailgate or other meetings that are not virtual:
    - Unvaccinated individuals must wear face coverings at all times, when meeting indoors.
    - Maintain 6 feet (2 m) of physical distance at all times between attendees (both seated and standing).
    - Have the person leading the meeting sign everyone in.
    - If signature is required, everyone should have their own pen.
    - Hold meetings in outdoor spaces whenever feasible.
- For work outdoors:
    - Masks are optional when working outside more than 6 feet (2 m) apart (socially distanced).
    - Determine comfort level and vaccination status of field team when deciding whether to wear face covering for work tasks that need to be completed within 6 feet (2 m) and physical distancing cannot be maintained. Unvaccinated staff must wear face coverings when physical distancing cannot be maintained.
- Simultaneous operations coordination to separate contractors:
    - Coordinate movements around the site
    - Set up work zones with visual barriers for specific activities with transition areas in common spaces
    - Post social distancing signage (refer to Section 4.4)

- Maintain social distancing with at least 6-feet (2 m) of separation whenever feasible
- Consider the following administrative controls:
  - Activity rotation - schedule work when the fewest number of people are present
  - “Split shifts” can be used to limit contact, or if work can be scheduled during hours of low to no facility operations.

- Work in teams/pairs:
  - Plan work activities, continuously use TRACK and re-plan work activities to maximize social distancing and minimize “close contact”
  - Use equipment or tools to increase distance between personnel to greater than 6-feet (2m) or eliminate the need for a second person.
- Coordinate with contractors to make sure they are following the same social distancing, hand hygiene and cleaning guidance to reduce the risk to other project personnel.

5 Post Shift Considerations

At the end of the work shift, clean the vehicle, if used throughout the day. Wash hands prior to leaving the site and after the commute.

Upon arriving home or at lodging, shower and launder clothing.

Appendix A

Site Signage – Self-Assessment Required

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Arcadis Employees

Have you done your “Daily Screen “ today?

Before each day, you must complete the online **“Daily Screen”.**

QR Code for daily self-assessment.

SAFE Return

Appendix B

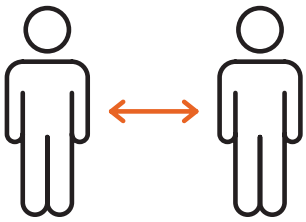
Site Signage – Social Distancing

ARCADIS

Project Sites

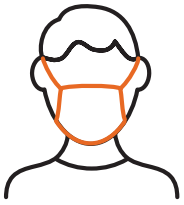
Keep Yourself and Others Working Safely

100% compliance is required by you and our subcontractors.



Maintain physical (social) distance of six feet, about two arms' length.

Need to talk? Shut equipment down if noise is interfering, use hand signals, radios, or move to another area of the site where distance can be maintained.



Face coverings must be worn when six feet of physical distance cannot be maintained.

***Stop Work** if procedures are not followed. It's mandatory!*

SAFE Return

Appendix C

Guidance for the Use of Face Coverings

Guidance for the Use of Face Coverings

Health Canada and CDC recommends wearing face coverings in public settings, like on public and mass transportation, at events and anywhere you will be around other people. In the U.S., face coverings are required on planes, buses, trains, and other forms of public transportation traveling into, within, or out of the United States and in U.S. transportation hubs such as airports and stations. Travelers are not required to wear a mask in outdoor areas of a conveyance (like on a ferry or the top deck of a bus). Health Canada and CDC still recommend that you stay at least 6 feet, 2 meters or about two arm lengths away from other people (social/physical distancing), frequent hand cleaning, avoid contact with people who are sick and other everyday preventive actions.

Considerations for face coverings:

- Some jurisdictional entities and clients require the use of face coverings.
- When visiting Arcadis offices and project sites, face coverings are to be worn inside while moving about the space, in common areas and during meetings.
    - Unless otherwise specified by the local jurisdiction, face coverings may be removed when sitting at individual workspaces where social/physical distancing is maintained.
- If not fully vaccinated, wear a mask in indoor public places.
- If fully vaccinated, you should wear a mask in indoor public places of areas with substantial or high transmission.
- If fully vaccinated and have a condition or are taking medications that weaken the immune system, additional protections may be required, like wearing a mask. Individuals should discuss with their healthcare provider.
- The face coverings are not surgical masks or N95 respirators.
- These do not replace other evidence-based measures such as social/physical distancing, frequent hand washing practices, avoid crowds and avoid poorly ventilated spaces. Face coverings are not a substitute for social/physical distancing.
- Face coverings can become contaminated on the outside or when touched by unwashed hands.
- Avoid touching the face covering. Handle only by the ear loops, cords or head strap.
- Have an extra face covering to replace one that becomes wet.
- Face coverings should not be shared with others.
- Face coverings with exhalation valves or vents should NOT be worn to help prevent the person wearing the mask from spreading COVID-19 to others (source control).
- Face coverings should sit snugly against the face and not have any gaps. To improve fit consider:
    - Selecting a style with a nose wire
    - Using a mask fitter or brace
    - Knot the ear loops of a 3-ply face mask where they join the edge of the mask, then fold and tuck the unneeded material under the edges.
    - Place a second mask on top of the first
        - Do not “double mask” a KN95 and do not use two surgical-style masks on top of one another.
- Additional information on improving face covering fit and filtration is available here.

What is a Face Covering?

A face covering is a material that covers the nose and mouth. It can be secured to the head with ties or straps or simply wrapped around the lower face. A face covering may be disposable; factory-made; or homemade or hand-sewn. The most effective fabrics for face coverings are tightly woven fabrics, such as cotton and cotton blends; breathable; and two or three layers. When selecting a cloth face covering, look for:

- Multiple layers of tightly woven, breathable fabric.
- Nose wire.
- Mask should block light when held up to a bright light source.

Scarves, ski masks or balaclava are usually made of loose knit fabrics and are not suitable as a face covering. Wear these items over your face coverings.

Face coverings should have two or more layers of breathable fabric, completely cover your nose & mouth, and fit snugly against the sides of your face and not have gaps. When wearing a gaiter ensure it has two layers or fold it to make two layers. If you wear glasses, find a mask that fits closely over your nose or one that has a nose wire to limit fogging.

Face Covering Use & Care

Wash hands prior to touching your face covering (i.e. putting it on, adjusting, removing). The face covering should cover the nose, mouth and secure under the chin. It should fit snugly against the sides of the face. When removing the mask, avoid touching the front of the mask and your face with your hands. Upon removing a face covering, you also need to wash your hands.

Disposable face coverings will be discarded after each use.

Reusable face coverings must be washed daily after use. Place face coverings in a sealed bag or bin until it can be laundered. Wash face coverings as soon as possible to prevent them from becoming moldy.

Cleaning face coverings using a washing machine:

- Face coverings can be washed with regular laundry
- Use regular laundry detergent and the appropriate setting according to the fabric label.

Washing face coverings by hand:

- Wash face coverings with tap water and laundry detergent or soap.
- Rinse thoroughly with clean water to remove detergent or soap.

Dry face coverings by:

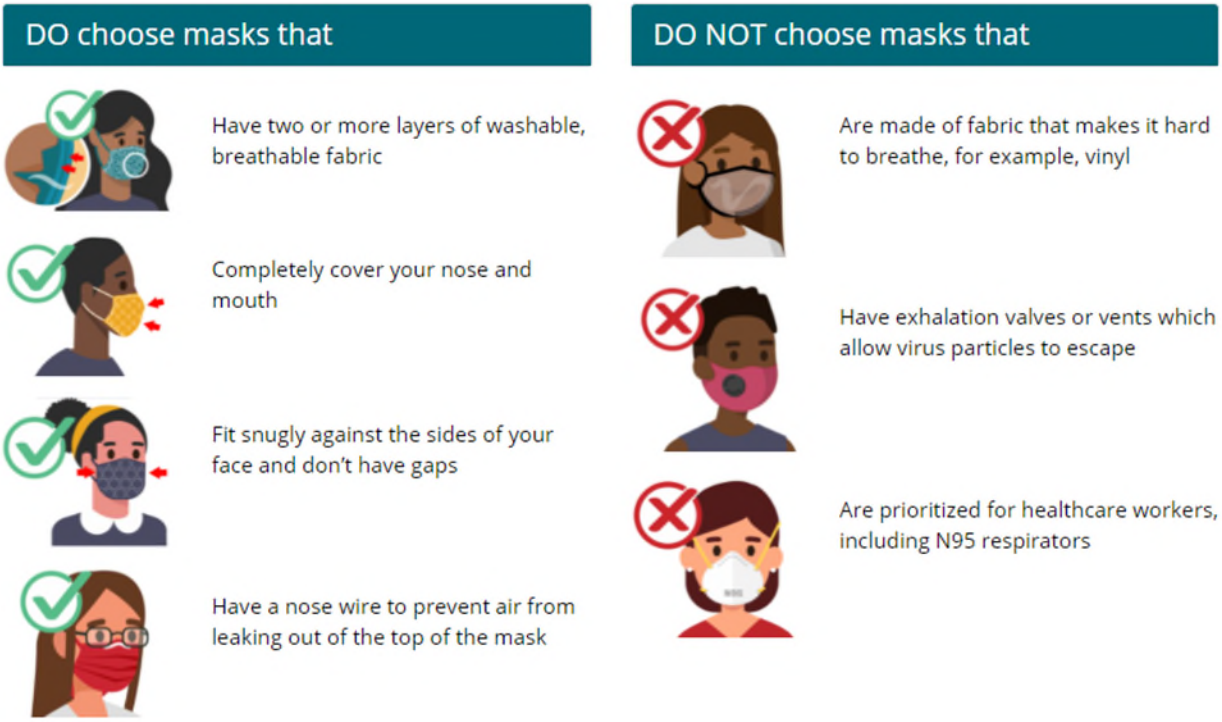
- Machine until completely dry using the warm or hot.
- Air dry by hanging or lying flat and allow to completely dry. If possible, hang it in direct sunlight.

Discard face coverings that:

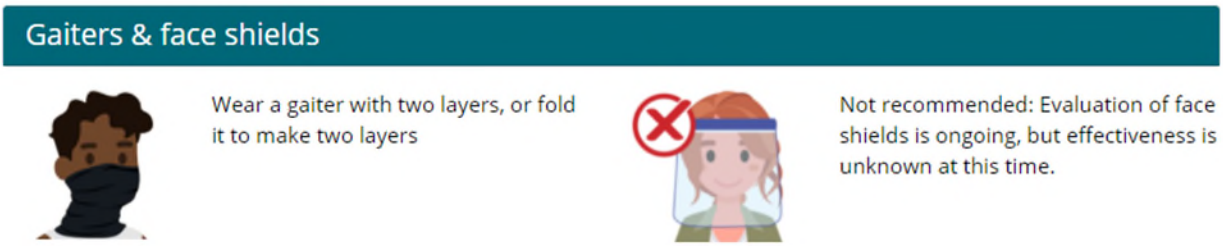
- No longer cover the nose and mouth.

- Have stretched out or damaged ties or straps.
- Will not stay on the face or requires continual adjustment.
- Have holes or tears in the fabric.

The following graphics are from the U.S. CDC:



Special Considerations



Note: Some jurisdictions may not consider gaiters or bandanas acceptable face coverings.

Cold weather gear

Wear your scarf, ski mask or balaclava over your mask

Scarves, ski masks and balaclavas are not substitutes for masks

How to Wear

Wear a mask **correctly** and **consistently** for the best protection.

- Be sure to wash your hands or use hand sanitizer before putting on a mask.
- Do **NOT** touch the mask when wearing it. If you have to often touch/adjust your mask, it doesn't fit you properly, and you may need to find a different mask or make adjustments.

For more information, visit our How to Wear Masks web page.

Do wear a mask that

- Covers your nose and mouth and secure it under your chin.
- Fits snugly against the sides of your face.

Choose a mask with a nose wire

- A nose wire is a metal strip along the top of the mask
- Nose wires prevent air from leaking out of the top of the mask.
- Bend the nose wire over your nose to fit close to your face.

Use a mask fitter or brace

- Use a mask fitter or brace over a disposable mask or a cloth mask to prevent air from leaking around the edges of the mask.

Check that it fits snugly over your nose, mouth, and chin

- Check for gaps by cupping your hands around the outside edges of the mask.
- Make sure no air is flowing from the area near your eyes or from the sides of the mask.
- If the mask has a good fit, you will feel warm air come through the front of the mask and may be able to see the mask material move in and out with each breath.

Add layers of material

2 ways to layer

- Use a cloth mask that has multiple layers of fabric.
- Wear a disposable mask underneath a cloth mask.
  - The cloth mask should push the edges of the disposable mask against your face.

Make sure you can see and breathe easily

Knot and tuck ear loops of a 3-ply mask

- Knot the ear loops of a 3-ply face mask where they join the edge of the mask
- Fold and tuck the unneeded material under the edges
- For instructions, see the following https://youtu.be/GzTAZDsNBe0 .

Other things to consider

Certain types of facial hair, like beards, can make mask fitting difficult. People with beards can do one or more of the following:

- Shave their beards.
- Trim their beards close to the face.
- Use a mask fitter or brace.
- Wear one disposable mask underneath a cloth mask that has multiple layers of fabric. The second mask should push the edges of the inner mask snugly against the face and beard.

Masks designed for people with beards are being evaluated, and information will be provided when it becomes available.

How NOT to wear a mask

Around your neck

On Your forehead

Under your nose

Only on your nose

On your chin

Dangling from one ear

On your arm

How to Take off a Mask

1

Carefully, untie the strings behind your head or stretch the ear loops

2

Handle only by the earloops or ties

3

Fold the outside corners together

4

Be careful not to touch your eyes, nose, and mouth when removing and wash hands immediately after removing

Appendix D

Additional Signage

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Best Practices

Wash your hands.

Wash in hot water for 40 seconds: 20 seconds with soap, 20 seconds to rinse.

Wipe surfaces with disinfectant wipes after you are finished.

Maintain proper social distancing.

Stand back 6 feet from others who may be washing their hands, or waiting in line to wash.

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Best Practices

You touch it, you clean it.

Remember to clean any surface you touch with the provided disinfectant spray.

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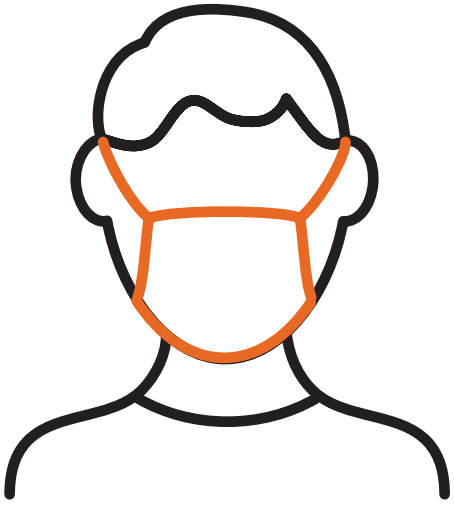
Arcadis Staff, Visitors & Deliveries

Wear face cover.



Face covering must be worn at
all times.

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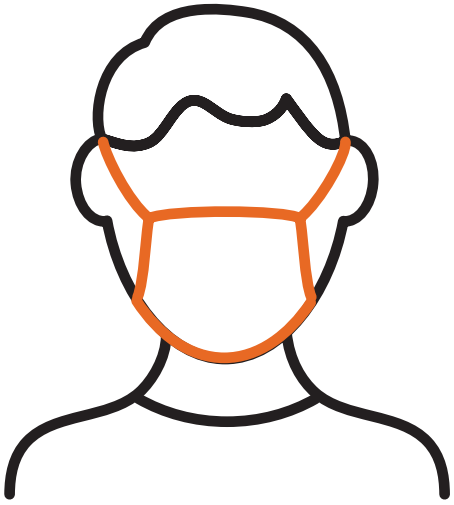
ARCADIS

Arcadis Staff, Visitors & Deliveries

Wear face cover.



Please wear face covering when moving about the space. Face coverings can be removed while seated at workstation.

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ARCADIS

Visitors & Deliveries

All staff, visitors or deliveries must use the main entrance.

Located: Main lobby front door

Firstname Lastname: 123 555 1212
Firstname Lastname: 123 555 1212

SAFE Return

ARCADIS

Restricted

Authorized Staff Only

In order to maintain proper social distancing, this area is restricted to authorized staff.

Need something?

Contact: Firstname Lastname 123 555 1218

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ARCADIS

Restricted

Maximum Occupancy

2

In order to maintain proper social distancing, the number of people allowed in this area is limited.

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Closure

Room Closed

In order to maintain proper social distancing guidelines, this room is temporarily closed.

SAFE Return

Off limits

CUT

Do not use

CUT

Restricted

Appendix E

Arcadis Contact Tracing Log

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Arcadis Contact Tracing Log

Printed Name	Company	Cell phone or email	Date/Time On Site	Date/Time Off Site

Arcadis U.S., Inc.
1 Executive Drive, Suite 303
Chelmsford
Massachusetts 01824
Phone: 978 937 9999
Fax:
www.arcadis.com

Appendix D

Excavation and Material Handling Plan (EMHP)

RACER Trust

Excavation and Materials Handling Plan

Former GM Delco Plant 5, Kokomo, Indiana

October 2021

Excavation and Materials Handling Plan

Former GM Delco Plant 5, Kokomo, Indiana

USEPA ID IND000806844

October 25, 2021

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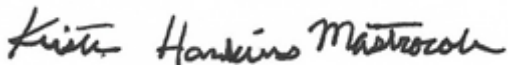

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Acronyms and Abbreviations

CMI	Corrective Measures Implementation
COC	chain-of-custody
CY	cubic yards
ft	feet
GM	General Motors
HAZWOPER	Hazardous Waste Operations and Emergency Response
ISS	In-Situ Stabilization and Solidification
lb/acre	pounds per acre
mg/kg	milligrams per kilogram
PC	Portland cement
RACER	Revitalizing Auto Communities Environmental Response Trust
TCE	Trichloroethylene
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
ZVI	zero-valent iron

1 Introduction

Arcadis U.S., Inc (Arcadis) has prepared this Excavation and Materials Handling Plan (EMHP) as a component to the Resource Conservation and Recovery Act (RCRA) Corrective Measures Implementation (CMI) Work Plan on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust for the former General Motors (GM) Delco Plant 5 facility located at 1723 North Washington Street, Kokomo, Indiana (the Site).

As part of the RCRA Correction Action process, United States Environmental Protection Agency (USEPA) issued a Final Decision and Response to Comments (Final Decision, USEPA 2021) outlining the final corrective measures for the Site: In-Situ Solidification and Stabilization (ISS) with Monitored Natural Attenuation (MNA) for Groundwater and Soil, Institutional Controls, and Long-Term Care/Stewardship.

Corrective measures at the Site will involve site preparation, material handling and waste management and site restoration. Material handling and waste management will involve the movement of thousands of cubic yards of soils at the Site; therefore, this EMHP is designed to assure that remediation work conducted at the Site is conducted in a manner that is protective of human health and the environment, with a particular emphasis on the health of site workers and residents.

2 Generating Activities

Materials to be managed at the Site, include but are not limited to: (1) overburden; (2) construction debris and general refuse; (3) dewatering and decontamination fluids; (4) reagents for ISS, and (5) topsoil.

Prior to handling and management of these materials, all personnel will be required to be familiar with the Site-specific health and safety plan. Additionally, all Site personnel (Remedial Contractor and Engineer) will be required to have the appropriate Occupational Safety and Health Administration 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training, annual 8-hour HAZWOPER refresher, and all other required training mandated by federal, state, and local regulations.

2.1 Overburden Materials

Overburden materials will be excavated and staged for reuse. These materials are being excavated to provide access to the underlying soils within the remediation footprint to be treated by ISS. During staging, the overburden will be characterized for determination of on-site reuse or off-site disposal. If approved for reuse, the overburden materials will be placed and compacted atop a geotextile demarcation fabric, following the implementation of ISS.

2.2 Construction Debris and General Refuse

Construction debris from former facility operations and abandoned monitoring wells may be encountered during excavation of the overburden. Construction debris and abandoned monitoring wells will be segregated and staged separately for characterization as necessary prior to off-site disposal.

Additionally, general refuse will be generated during daily activities, and may include plastic, wood, construction fencing, etc. General refuse is expected to be non-impacted waste and shall be disposed of off-site.

2.3 Dewatering and Decontamination Fluids

Dewatering of the excavation is not anticipated. Only collection of stormwater runoff from within the ISS treatment zone, temporary stockpile area and batch plant and reagent storage area is anticipated. All stormwater captured will be collected and containerized on-site.

2.4 ISS Reagents

The Contractor will perform the ISS work in accordance with the Contract Drawings (Appendix A of the CMI Work Plan). The ISS work will be performed in a 2-step process: Step 1 – Zero Valent Iron (ZVI) Mixing and Step 2 – Portland Cement (PC) Mixing.

2.4.1 ZVI Reagent

ZVI will consist of commercially processed cast iron aggregate that has been ground and placed in moisture tight bags to prevent surface oxidation. ZVI shall be iron product CC-1200, provided by Connelly GPM, Inc. located in Chicago, Illinois and will be delivered to the site in 3,000-pound super sacks.

ZVI will be mixed in-situ via slurry. The slurry will consist of non-potable water sourced by the Remedial Contractor, ZVI and bentonite. All imported ZVI and bentonite will be used during Step 1 – ZVI Mixing. Excess bentonite will be exported at completion of the project by the remedial contractor. The empty super sack bags associated with the ZVI and bentonite are considered general refuse.

2.4.2 PC

PC will be Type I/II. PC will be delivered and stored in a silo or other appropriate bulk storage container. It is anticipated that the PC will be added to the ISS treatment zone in the dry. Any excess PC will be exported at completion of the project by the remedial contractor.

2.5 Topsoil and Vegetation

A 4-inch-thick topsoil layer is anticipated to be placed at the Site to promote vegetative growth. Prior to import, topsoil will be sampled and analyzed to confirm that it meets regulatory, geotechnical, and agricultural requirements for use onsite. Following placement, the topsoil will be seeded and mulched in accordance with the Contract Drawings (Appendix A of the CMI Work Plan).

3 Material Handling and Characterization

A temporary stockpile area and batch plant/reagent storage area shall be located north of the abandoned Spraker Street in the parking lot area. The parking lot received a Corrective Action Complete designation from EPA in 2017; therefore, the safe management of materials on this property is a priority. The stockpile and storage areas will be constructed in accordance with the Contract Drawings (Appendix A of CMI Work Plan), which includes a geotextile and plastic liner.

Stockpiles will be handled in a manner to prevent and/or minimize potential dust generation. A water spray will be used for dust suppression, and foam or surfactant will be used for stabilization of stockpiles in accordance with the Ambient Air Monitoring Plan (Appendix B of the CMI Work Plan) , if necessary. The temporary stockpile area and batch plant/reagent storage area will be maintained for the duration of the project to prevent runoff and fugitive dust emissions. Stormwater that enters these locations will be collected and containerized for disposal.

3.1 Material Staging

Only construction debris and general refuse is currently planned for off-site disposal. Soils with trichloroethylene (TCE) concentration exceeding 100 milligrams per kilogram (mg/kg) shall be mixed via ISS as part of the corrective measure. This section further outlines details associated with characterizing of material for on-site reuse or off-site disposal.

3.1.1 Overburden Materials

It is anticipated that approximately 8,500 cubic yards (CY) of material will be excavated as overburden and staged in the temporary stockpile area intended for use as backfill. Stockpiles shall be no greater than 10 feet in height; therefore, the anticipated dimensions of the temporary stockpile area shall have a minimum area of 2,500 square feet to adequately accommodate the overburden volume.

3.1.2 Construction Debris

In addition to the overburden stockpile, construction debris from former GM Delco Plant 5 demolition and abandoned monitoring wells may be uncovered during excavation. Construction debris and abandoned monitoring wells will need to be stockpiled separately within the temporary stockpile area for off-site disposal and cannot be returned to the excavation footprint as fill.

3.1.3 Dewatering and Decontamination Fluids

Liquids produced on-site will be collected in containers to be staged on secondary containment. Water collected is anticipated to be used as a portion of the non-potable water source component associated with Step 1 – ZVI Mixing. Prior to use of the collected water, the collected water will be pretreated using no larger than 100-micron filters to remove suspended particles. Any excess water and all decontamination water not used as the project progresses will be characterized and disposed off-site at an appropriate disposal facility.

3.2 Characterization of Materials

Only construction debris and general refuse is currently planned for off-site disposal. This section further outlines details associated with characterizing of material for on-site reuse or off-site disposal.

3.2.1 Overburden Sampling Procedures

Stockpiled overburden materials will be sampled to verify that the materials meet the requirements of the Site prior to using them for backfill and shall meet a TCE concentration of less than 100 mg/kg to be used as backfill. A minimum of one sample will be collected for every 500 cubic yards of overburden material. Each sample will be submitted to Pace Analytical in Indianapolis, Indiana, and analyzed for TCE. Soils with TCE concentrations higher than 100 mg/kg will be returned to the active mixing areas to be treated during the Step 1 - ZVI Mixing; however, if the Step 1 – ZVI Mixing has been completed, the soils will be characterized for off-site disposal. Soils with TCE concentrations lower than 100 mg/kg will be reused on-site as described in **Section 5**.

3.2.2 Waste Characterization

Waste requiring off-site disposal will be evaluated with respect to the contaminants expected to be present in the Site materials. Sampling will be conducted as outlined in **Section 3.2.1** for Overburden Sampling Procedures; however, different sampling parameters will be analyzed. The sampling parameters for off-site disposal will include toxicity characteristic leaching procedure volatile organic compound (VOCs) for soils and total VOCs for water. Other parameters may be required by the disposal facility. Samples will be collected for these parameters after a sufficient volume has been generated for off-site disposal. Upon receipt of analytical data associated with the waste characterization, waste profiles will be prepared to facilitate load out and off-site disposal in accordance with **Section 4**.

3.2.3 Sample Management

The following nomenclature will be used to identify all analytical samples collected: Stockpile Number-Date (Pile##-MMDDYY). Information regarding each stockpile sample will be appropriately documented. At a minimum, the following will be recorded in the Site field notebook:

- Name of sample collected following the nomenclature described above;
- Parameters sampled;
- A sketch indicating the time and location of sample collected; and
- Screening results/visual observations, if applicable.

Samples for laboratory analysis will be placed in laboratory provided containers. The containers will be clearly labeled with the sample identification nomenclature, date of collection, and analysis to be performed. Samples will be submitted to Pace Analytical laboratory in Indianapolis, Indiana for analysis. Standard chain-of-custody (COC) procedures will be followed, and all COCs shall be scanned, sent to the Arcadis project team, and filed prior to the next workday.

4 Off-Site Disposal and Documentation

Waste characterized for off-site disposal will be stockpiled separately from the material for reuse. Trucks will be loaded from the temporary stockpile area. Once loaded, the trucks rails and tires will be dry decontaminated and a tarp/cover will be secured across the bed. Prior to leaving the Site, the truck will be inspected to verify it meets all federal, state, and local codes for transportation. All waste removed from the Site will be properly documented. Non-hazardous wastes will be transported from the Site under non-hazardous waste manifests or bills of lading.

4.1 Records, Inspections and Reporting

The Remedial Contractor controlling the temporary stockpile area will maintain records of which stockpiled material is for off-site disposal. Records will include what is currently staged for off-site disposal, what has left the Site, and truck inspection logs. Tracking logs associated with exported materials shall document the following:

- Date
- Stockpile Number/Excavation Area
- Load Number
- Bill of Lading Number
- Facility; and,
- Volume.

Bills of lading will be signed by Arcadis on behalf of RACER Trust, for each off-Site shipment of waste generated. Copies of the bills of lading will be maintained at the site and scanned into an electronic file.

4.2 General Refuse Disposal

General refuse (including packaging from ISS reagents and personnel protective equipment) will be collected and disposed of into metal trash dumpsters in a designated location. Dumpsters will have a secure watertight lid, be placed away from storm water conveyances and drains, and meet all federal, state, and municipal regulations. No general refuse will be buried onsite.

5 Import, Reuse and Documentation

It is anticipated that approximately 8,500 cy of material will be excavated as overburden and staged in the temporary stockpile area intended for use as backfill, following the ISS of approximately 8,000 cy. Additionally, approximately 2,500 cy of topsoil will be imported to re-establish the Site.

ISS Reagents and topsoil shall be shipped to the Site in accordance with all federal, state, and local codes for transportation. Materials shall be protected from moisture and contamination while in transit and during staging. All materials imported to the Site will be properly documented.

5.1 ISS Reagents

ZVI will be delivered to the site in 3,000-pound super sacks. Super sacks will be stored off the ground within the batch plant and reagent storage area, in either a weatherproof enclosure or covered by weatherproof tarpaulins, until use. PC shall be imported to the Site and stored in a silo or other appropriate bulk storage container. ZVI and PC shall be staged within the batch plant and reagent storage area.

5.2 Overburden

Overburden material will be placed and compacted in lifts, not to exceed 10 inches, using a vibratory roller. Standard proctor compaction test and in place density testing shall be performed on each lift to ensure proper placement of the fill material and shall be within 92 to 95% of the modified proctor. In-place density testing shall be performed at a frequency of one for every 2,500 square feet (ft) of lift placed.

After the overburden backfill is in place and compacted, soil samples of the upper 0.5 ft will be collected on a 100 ft by 100 ft grid pattern (approximately 20 samples). These soil samples will be submitted to Pace Analytical for VOC analysis. The data will be used to calculate an exposure point concentration for the Site and supplement the Environmental Restrictive Covenant.

5.3 Topsoil

The anticipated volume of topsoil required for a 4-inch-thick layer is approximately 2,500 CY. Topsoil shall be a locally available, fertile, friable soil of loamy character, obtained from well-drained arable land and reasonably free from subsoil, refuse, roots, heavy or stiff clay, rocks larger than 2 inches, coarse sand, sticks, brush, litter, and other deleterious substances. Topsoil shall be capable of supporting normal vegetation as demonstrated by the growth of health vegetation on it and should not be taken from a source known to contain any of the noxious weeds defined as such in the Indiana State Seed Law, IC 15-16-7-2.

5.3.1 Physical and Fertility Testing

Maximum particle size, 2 inches, with maximum 3 percent retained on 1/4-inch screen. The pH shall be tested in accordance with American Association of State Highway and Transportation Officials T289, or equivalent. Topsoil shall conform to the following limits:

- Silt 30% to 80%
- Clay 5% to 30%
- Sand 5% to 50%
- Organic Material 5% to 10%

- pH 6.2 to 7.4

At least two representative samples shall be sent to an approved laboratory for physical soil fertility testing. The results of the soil fertility testing shall provide recommendations for lime and fertilizer application rates.

5.3.2 Analytical Testing

Grab samples will be collected and analyzed for:

- VOCs (by USEPA SW-846 Method 8260)
- Semi-volatile Organic Compounds including Polyaromatic Hydrocarbons (by USEPA Methods 8270)
- Polychlorinated Biphenyls (by USEPA Methods 8082)
- Resource Conservation and Recovery Act Metals (by USEPA Method 6020, and USEPA Method 7471)
- Per- and Polyfluoroalkyl Substances (by USEPA Method 8327)

At least two representative samples shall be sent to an approved laboratory for analytical, and soil fertility testing. Soil contamination levels shall not exceed the Indiana Department of Environmental Management Remediation Closure Guide for Residential Direct Contact Soil Exposure Limits.

5.4 Site Restoration

Topsoil will be placed following placement and grading associated with the overburden. Topsoil will be placed in a 4-inch, single loose lift and graded. After placement, the area will be seeded with a 100 pounds per acre (lb/ac) 4-way blend of turf type tall fescue, 50 lb/ac creeping red fescue, 45 lb/ac perennial ryegrass and 1.55 lb/ac white dutch clover. This seed mixture shall be applied at the rate of 196.5 lb/ac. Mulch shall be procured and applied in accordance with Section 621 – Seeding and Sodding of the Indiana Department of Transportation Standard Specifications 2020.

5.5 Records, Inspection, and Reporting

The Remedial Contractor will maintain records of all reused and imported materials. Records will include what has been imported to date, what is currently staged, and what has been used in association with the ISS mixing. Tracking logs of imported materials shall document:

- Date
- Load Number
- Ticket Number
- Originating Facility; and,
- Volume.

Additionally, the remedial contractor will maintain inspection logs of materials stockpiled for reuse. Inspections will be conducted daily to ensure the effectiveness of relevant erosion and sediment control measures and verify environmental impacts are being minimized. Each inspection will include a review of the material being stockpiled, the location, conditions of the surrounding environment, and any specific issues associated with the stockpile or surrounding area. Any issues that are observed will be managed via a corrective action. The corrective action will be documented as follows:

- Details of the stockpile;
- Issues observed; and

- Corrective action taken

Inspection reports and corrective action reports will be maintained on-site for the duration of the work.

6 References

Arcadis. Ambient Air Monitoring Plan, Former GM Delco Plant 5, Kokomo, Indiana, October 2021.

Arcadis. Corrective Measures Implementation Work Plan, Former GM Delco Plant 5, Kokomo, Indiana, October 2021.

USEPA. 2021. Final Decision and Response to Comments for RACER Trust Former GM Delco Plant 5, 1723 North Washington Street, Kokomo, Indiana, EPA ID: IND 000 806 844. June 16.

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Appendix E

Construction Quality Assurance Plan (CQAP)

RACER Trust

Construction Quality Assurance Plan

Former GM Delco Plant 5, Kokomo, Indiana

October 25, 2021

Construction Quality Assurance Plan

Former GM Delco Plan 5, Kokomo, Indiana

October 25, 2021

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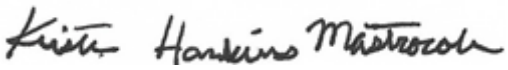

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Acronyms and Abbreviations

CMI	Corrective Measures Implementation
CQAP	Construction Quality Assurance Plan
DFCR	Daily Field Construction Report
EMHP	Excavation and Materials Handling Plan
ESCs	Erosion and Sediment Controls
GM	General Motors Corporation
HASP	Health and Safety Plan
ISS	in situ solidification and stabilization
mg/kg	milligrams per kilogram
RCRA	Resource Conservation and Recovery Act
QA	Quality Assurance
QC	Quality Control
TCE	trichloroethylene
UCS	Unconfined Compressive Strength
USEPA	United States Environmental Protection Agency
ZVI	Zero valent iron

1 Introduction

Arcadis U.S., Inc (Arcadis) has prepared this Construction Quality Assurance Plan (CQAP) as a component to the Resource Conservation and Recovery Act (RCRA) Corrective Measures Implementation (CMI) Work Plan on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust for the former General Motors (GM) Delco Plant 5 facility located at 1723 North Washington Street, Kokomo, Indiana (the Site; **Figure 1**).

As part of the RCRA Correction Action process, United States Environmental Protection Agency (USEPA) issued a Final Decision and Response to Comments (USEPA 2021) outlining the final corrective measures for the site: In-Situ Solidification and Stabilization (ISS) with Monitored Natural Attenuation for Groundwater and Soil, Institutional Controls, and Long-Term Care/Stewardship. As part of the ISS scope of work, this CQAP has been prepared to maintain an effective quality control system for the Site.

Corrective measures at the site will involve mobilization and site preparation, material handling and waste management, and site restoration. The purpose of this document is to present the Construction Quality Assurance (QA) and Quality Control (QC) requirements to be implemented during execution of the corrective measure as presented in the CMI Work Plan and further detailed in the Contract Drawings (Appendix A of the CMI Work Plan). This CQAP defines the various management and inspection personnel directly responsible for the QA/QC activities. In addition, this CQAP addresses specific QA/QC testing requirements for each of the various components of the Work.

2 Roles, Responsibilities, and Required Experience

Arcadis will act as the Engineer and will have ultimate responsibility for the oversight of construction to ensure that construction activities are executed in conformance with the Contract Drawings (Appendix A of the CMI Work Plan) and Quality Assurance requirements (Construction Quality Assurance Plan and Quality Assurance Project Plan: Appendix E and Appendix G of the CMI Work Plan, respectively).

The Engineer's CQA team will be comprised of qualified engineers or professionals meeting the requirements specified in **Section 2.1 and 2.2**. The remedial contractor will be responsible for the quality of construction and for compliance with the Contract Drawings (Appendix A of the CMI Work Plan). The QC team members will be employed or contracted by the remedial contractor meeting the requirements specified in **Section 2.4 through 2.6**.

2.1 Construction Manager

The Engineer's Construction Manager is responsible for acting as RACER's On-Site representative and ensuring that the remedial construction activities are implemented in accordance with the Contract Drawings (Appendix A of the CMI Work Plan), and the CQAP. The duties and responsibilities of the Construction Manager will include the following:

- Reviewing Daily Field Construction Reports (DFCR);
- Provide support to the QA Staff (i.e., field samplers, data validators, and air monitoring specialist) in interpreting the meaning and intent of the Contract Drawings (Appendix A of the CMI Work Plan) and in the performance and supervision of the QA testing program;
- Observing construction materials delivered to the Site to determine general conformance with the Contract Drawings (Appendix A of the CMI Work Plan);
- Conducting and recording observations regarding the proper storage and handling of equipment and materials;
- Provide consultation and technical support to the remedial contractor;
- Identify, as appropriate and in coordination with the QA Staff, discrepancies or deficiencies in project work.
- Communicate with other members of the QA team to ensure proper implementation of the remedial construction; and,
- Assistance in preparation of the remedial action report.

2.2 QA Staff

QA Staff will provide on- and off- Site support as needed and will report directly to the Construction Manager. The primary duties of the QA Staff are to verify that all QA/QC tests are performed in accordance with the Contract Drawings (Appendix A of the CMI Work Plan), ensure that all installed equipment and materials have passed the required tests, and ensure that a complete and properly constructed product is provided by the Contractor in accordance with the Contract Drawings (Appendix A of the CMI Work Plan).

Upon completion of material and equipment tests, the field staff will provide reports to the Construction Manager outlining testing results, failures, and the corrective actions employed to obtain acceptable test results. All relevant

and required test data, reporting data, and remedial contractor submissions. Additional duties and responsibilities of the QA Staff include the following:

- Review and approve of shop drawings and submittals;
- Performance of QA testing activities
- Visually inspecting materials imported to the Site for conformance with the specifications and Contractor-provided submittals;
- Coordinate QA activities with the Site Superintendent and the On-Site Construction Manager;
- Review field and laboratory QA testing results for conformance with the Contract Drawings (Appendix A of the CMI Work Plan);
- Identifying areas that require re-work and/or repair;
- Attend project meetings;
- Review reports prepared by the QC Observer/Inspector(s);
- Assist Superintendent in review of shop drawings, product data, and other Contractor submittals;
- Document that field and laboratory QA testing have been conducted at the frequencies established in the Contract Drawings (Appendix A of the CMI Work Plan);
- Coordinate the delivery of samples to the QA Laboratory; and,
- Assist in the preparation of the remedial action report.

2.3 QA Laboratory

The QA Laboratory is an entity independent of the remedial contractor, located off-Site, that will be responsible for conducting tests on soil and other construction materials to ensure conformance with the Contract Drawings (Appendix A of the CMI Work Plan). The QA Laboratory will report directly to the QA Staff and shall be accredited and licensed to perform the required testing. The QA Laboratory will have experience in testing soil and other construction materials and will be familiar with construction materials testing standards including ASTM International and Association of American Safety and Highway Transportation Officials (AASHTO) standards.

2.4 Site Superintendent

The Site Superintendent will have overall responsibility for directing the remedial contractor's workforce to implement the construction in accordance the Contract Drawings (Appendix A of the CMI Work Plan), including implementing the QC program and coordinating with QC Manager to ensure QC testing is performed in accordance with the Contract Drawings (Appendix A of the CMI Work Plan). Additional duties of the Site Superintendent include the following:

- Communicating changed Site conditions to the Construction Manager;
- Preparing and transmitting submittals and shop drawings to the Construction Manager; and
- Preparation and transmittal of weekly progress reports, including an updated project schedule.

2.5 QC Manager

The QC Manager will be responsible for overseeing all quality control testing performed by the remedial contractor and providing contractor certification reports to the QA Staff. Other related duties include assisting the Site Superintendent in preparing and transmitting shop drawings and other submittals, providing required samples, and coordinating testing activities with the QA staff. The QC Manager will provide daily QC reports

which document all testing performed at the Site for that day; these reports shall be submitted to the QA Staff for review and approval. The QC Manager will report directly to the Site Superintendent.

2.6 QC Staff

The QC Staff will report directly to the QC Manager. The QC Observer will have experience and training in both the testing and inspection of earthwork, granular materials, erosion and sediment controls, and other components of the remedial construction scope. The duties and responsibilities of this position include the following:

- Inspecting materials imported to the Site for conformance with the Contract Drawings (Appendix A of the CMI Work Plan) and for variations from material that was tested after being delivered to the Site;
- Performing tests on construction materials to ensure that chemical and physical characteristics are in conformance with the specifications;
- Obtaining samples for QC testing;
- Conducting and recording observations regarding the proper storage and handling of equipment and materials;
- Preparing daily reports documenting results of QC testing; and
- Assisting with the preparation of “as-built” drawings.

2.6.1 Contractor’s Surveyor

A surveyor licensed in the State of Indiana will be under the direction of the remedial contractor. The surveyor will establish all lines, elevations, reference marks, control points, etc., needed by the remedial contractor or Engineer during the progress of the Work, and from time to time to verify such marks by instrument or other appropriate means.

Surveyor shall provide survey control for each stage of construction and provide and certify survey “As-Built” documentation for various components of construction for inclusion into the remedial action report. The surveyor will report directly to the QC Manager. Even though the surveyor shall work directly for the remedial contractor, he/she/they will be required to supply all data requested by the QA Staff as soon as possible.

2.6.2 2.2.5 CQC Laboratory

The QC Laboratory will be an independent, qualified soils and materials testing laboratory retained by the remedial contractor. The laboratory will conduct tests on representative soils at the source of the material, in the field, and/or at the laboratory to determine compliance with the construction Contract Documents.

3 Quality Control/Quality Assurance Documentation and Meetings

The documentation of construction activities will support the determination that the CMI has been implemented in accordance with the CMI Work Plan and associated Contract Drawings (Appendix A of the CMI Work Plan). The documentation process includes recognition of construction tasks that will be observed and documented; assignment of responsibilities for the observation, testing and documentation of these tasks; and the completion of the required reports, data sheets, forms, and checklists to provide an accurate record of the work performed during the corrective measure.

3.1 Daily Field Construction Reports

The Construction Manager will complete a DFCR of each day's construction activities. The DFCR report will contain, at a minimum, the following information:

- Date, project name, location, and the number of on-Site workers.
- Time that work starts and ends, in addition to the time of work stoppages related to inclement weather, or insufficient equipment or personnel or other reasons.
- Data on weather conditions, including temperature, cloud cover and precipitation.
- Overview of work zone and perimeter air monitoring activities being performed.
- Contractor's current on-Site equipment and materials;
- Chronological description of work in progress;
- A description of any health and safety issues.
- Results of QA/QC field sampling and testing performed by on-Site personnel.
- Documentation of problem/deficiencies noted during construction (e.g. when construction materials or activities are observed or tested that do not meet the requirements of the Contract Drawings (Appendix A of the CMI Work Plan)), and corrective actions taken to address or resolve the problems/deficiencies. The documentation of problems/deficiencies and corrective actions may include the following information:
    - A description of the problem or deficiency, including reference to supplemental data or observations leading to the identification of the problem or deficiency.
    - Location of the problem or deficiency, including site plans and photos depicting the location and nature of the problem/deficiency and a written description of how and when the problem or deficiency was discovered.
    - Identification of corrective actions taken by the Contractor to address or resolve the problem/deficiency.
- A record of pertinent communications with other on-Site parties, subcontractors, vendors, or regulatory agencies regarding the day's construction activities.

3.2 Weekly Progress Reports

Weekly Progress Reports shall be prepared by the Site Superintendent to summarize construction progress, document unresolved issues related to the project scope, and forecast the work schedule moving forward. The Weekly Progress Reports shall contain a detailed projection of Site activities for the following two (2) weeks and an updated overall project schedule presented as a Gantt chart. Photos depicting activities completed the previous week or clarifying unresolved project issues shall be included within the Weekly Progress Reports.

Weekly Progress Reports shall be submitted to the Construction Manager in advance of the regularly scheduled weekly progress meeting for review and distribution.

3.3 Inspection and Testing Forms

The QC Manager will be responsible for completing and submitting all QC inspection and testing forms required. The forms shall be submitted to the Site Superintendent and subsequently the Construction Manager for review and approval. The Construction Manager may solicit the assistance of the QA Staff to complete the review and provide written response of acceptance or denial to Site Superintendent. The remedial contractor shall be responsible for keeping all records, archived samples, and inspection forms and results for all QC procedures required to meet the requirements of the Contract Drawings (Appendix A of the CMI Work Plan). QA Staff will be responsible for reviewing all the QC data and if necessary collect QA samples that can be used to validate the QC data.

3.4 Submittals

The remedial contractor will be responsible for adhering to all submittal procedures and corresponding timelines listed in the Contract Drawings (Appendix A of the CMI Work Plan). The Site Superintendent, with support from the QC Manager and Staff, shall prepare and submit, to the Construction Manager, all submittals required in the Contract Drawings. Information contained in the remedial contractor's submittals that is not applicable to the Specification furnished should be clearly lined out or deleted. The remedial contractor's submittals must be legible, clean, and clearly reproduced.

All required submittals shall be reviewed by the Construction Manager, with support from the QA Staff, for conformance with the requirements presented in the Contract Drawings (Appendix A of the CMI Work Plan). The remedial contractor will not be permitted to perform any activity that directly or indirectly involves the item or items covered by a submittal until a "reviewed and takes no exception" stamp is provided by the Engineer.

3.5 Record Drawings

The surveyor licensed in the State of Indiana shall be responsible for surveying and documenting the completed components of construction, including, but not limited to:

- Existing Conditions;
- Extent of Overburden Excavation;
- Extent of ISS Step 1 – Zero Valent Iron (ZVI) Mixing;
- Extent of ISS Step 2 – Portland Cement (PC) Mixing;
- Extent of ISS Regrading (including Bulking);
- Extent of Overburden Placement; and,
- Final Restoration.

The Contractor's Surveyor shall submit the survey data in accordance with the requirements of the Contract Drawings (Appendix A of the CMI Work Plan). Additionally, the Site Superintendent shall maintain a set of Contract Drawings that is clearly labeled "Record Drawings" at the Site. The Site Superintendent shall be responsible for marking-up the details, profiles, and plan sheets within "Record Drawings" to reflect as-built conditions that deviate from the design.

At the conclusion of construction, the Site Superintendent shall submit the “Record Drawings” to the Construction Manager for review and approval. The Construction Manager and any member of the QA Staff shall be allowed to review the “Record Drawings” at any time during progression of construction activities.

3.6 Corrective Measures Closure Report

A corrective measures closure report will be prepared by the Engineer following completion of corrective measure. The report will meet the requirements of RACER Trust, and at a minimum, contain the following information:

- A summary of all imported material including reagents and water utilized for ISS and the associated material documentation.
- Air monitoring data results.
- Weekly progress reports.
- A photograph log documenting the corrective measure conducted during implementation.
- As-Builts consisting of plans and details to depict the as constructed conditions for the corrective measure completed by a licensed surveyor in the State of Indiana.
- Correspondence with RACER Trust, as deemed relevant to the corrective measure.
- A summary of field observations (i.e., deviations from the Contract Drawings (Appendix A of the CMI Work Plan), quantities of soil relocated and mixed in-situ) and QA/QC test results.
- A summary of problems and deficiencies encountered during construction, including recurring problems and/or deficiencies discovered, and resolutions for such problems/deficiencies.
- Documentation indicating that acceptance criteria were met, including a comparison of documented procedure data with the Contract Drawings (Appendix A of the CMI Work Plan).
- A summary and documentation of all waste streams generated as part of the project, including final treatment/disposal destination and volume.

3.7 Quality Control/Quality Assurance Meetings

Meetings will be held on a regular basis during the project. They include a pre-construction meeting, daily safety/tailgate meetings, and weekly progress meetings. A brief description of each project meeting is provided below.

3.7.1 Pre-Construction Meetings

A pre-construction meeting will be held at the Site to: 1) introduce project team members representing the Engineer, the remedial contractor, RACER Trust, and the USEPA; 2) review Contract requirements; 3) establish a detailed schedule of operations; and 4) resolve issues (if any) raised by the attending parties.

Following the pre-construction meeting, the Engineer will prepare the meeting minutes to document the proceedings and decisions made by those in attendance. Meeting minutes will be circulated to all attendees and other parties affected by the decisions made at the meeting.

3.7.2 Safety/Tailgate Meetings

Safety/tailgate meetings will be held in the morning and after lunch at the Site to discuss operations, daily tasks, health and safety issues, and coordination issues. Safety/tailgate meetings will be attended by the Site Superintendent, Construction Manager, QC Manager, QA and QC Staff, and other parties who are present on Site.

3.7.3 Progress Meetings

Progress meetings will be held on Site for the duration of the project (generally on a weekly basis). In advance of each weekly progress meeting, the Site Superintendent shall prepare and submit the Weekly Progress Report to the Construction Manager for review and circulation to all meeting participants. Participants at these meetings will include the Site Superintendent, Construction Manager, QC Manager and other relevant QA and QC Staff as needed.

Other attendees may also include members of the Engineer's team, Contractor's team, and USEPA personnel. Progress meetings will be held to discuss issues including (but not limited to) project status, schedule, scope of work, and overall project implementation. Following each meeting, the Engineer will prepare meeting minutes to document the proceedings and decisions made by those in attendance. Meeting minutes will be circulated to all attendees and other parties affected by the decisions made at the meeting.

4 Quality Assurance and Quality Control Testing

The corrective measure to be performed at the Site will be completed in three phases: 1) Mobilization and Site Preparation; 2) Material Handling and Waste Management; and 3) Site Restoration. Additional information regarding each of these phases is provided below.

4.1 Mobilization and Site Preparation

This subsection identifies the initial activities to be performed at the Site. In general, those activities include: 1) mobilization of equipment, materials, and supplies; 2) utility investigation; 3) management of traffic; and 4) installation of soil erosion and sediment controls. Additional information regarding each of these activities is provided below.

4.1.1 Mobilization of Equipment, Materials and Supplies

The Remedial Contractor will mobilize the necessary equipment, materials, supplies and personnel to the Site. Upon completion of the corrective measure, the Remedial Contractor will demobilize equipment, excess materials and personnel from the Site leaving only the required controls and infrastructure in place required to complete stabilization of the Site.

4.1.2 Utility Investigation

Prior to initiation of land disturbance, the Site Superintendent or QC Manager will coordinate to have utility locations identified within and near the Limits of Disturbance. Site Superintendent or QC Manager shall utilize Indiana 811 in addition to utility as-built information provided by RACER Trust, to locate and mark utilities. In some cases, locating these utilities may require coordination with RACER Trust and local utility providers. During utility locate procedures, QC personnel will document the following information items:

- Time and date that Indiana 811 is contacted by the Remedial Contractor and assurance that utility clearance is completed prior to the initiation of any intrusive activities.
- Time and date that utility locations/alignments are marked-out on the ground.
- Once exposed, assurance that utility locations, alignments, depths, sizes, and materials of construction are surveyed and documented by the Remedial Contractor.
- Once exposed, assurance that utilities identified for protection on the Contract Drawings (Appendix A of the CMI Work Plan) are protected in accordance with the utility owner's requirements.

QA Staff will oversee the utility investigation for verification of known utilities and identification of unknown utilities that may affect the implementation of the corrective measure.

4.1.3 Management of Traffic

Site security measures will be implemented by the remedial contractor to preserve the safety of motorists, workers, pedestrians, and the integrity of the work during the corrective measure. The remedial contractor shall be responsible for procuring and maintaining site security features (e.g., chain-link fence and gate locks) throughout the life of the project. The QC Manager will visually inspect that security measures as they are installed and ensure that they are inspected daily and maintained. In addition, the remedial contractor will facilitate 24-hour surveillance of the site to further prevent access to the site and open excavation zones.

During daily operations, construction traffic will enter and exit the Site via West Spraker Street while personnel will access the Site via West Butler Street. Construction traffic entering the Site will be directed by Site personnel based on current Site activities and the purpose of the delivery or shipment.

4.1.4 Survey Control and Documentation

An initial survey shall be performed by the Surveyor to document existing site conditions. During these activities, the Surveyor shall establish survey control points for documenting construction and testing locations for subsequent work activities. The Surveyor shall provide survey data in accordance with **Section 3.5** and the Contract Drawings (Appendix A of the CMI Work Plan).

4.1.5 Soil Erosion and Sediment Controls

All erosion and sediment controls (ESCs) shall be installed by the remedial contractor in accordance with the Contract Drawings (Appendix A of the CMI Work Plan) and the Stormwater Pollution Prevention Plan (SWPPP) prior to any land disturbance. ESCs shall be installed and removed in accordance with the Contract Drawings, unless otherwise approved in advance by the Engineer. The QC Manager will document, through visual observation, that ESCs are installed, inspected, and maintained in accordance with the Contract Drawings.

Daily updates on the working status of ESCs shall be noted in the DFCR by the Construction Manager. In addition, weekly inspections will be conducted and filed by the QC Manager and observed by the QA Staff. In the event changes in field conditions require modifications to existing ESCs, the Site Superintendent or QA Manager shall notify the Construction Manager in a timely manner.

4.2 Material Handling and Waste Management

This subsection identifies remedial construction activities to be performed at the Site. The Contractor will complete the following activities: 1) monitoring well abandonment; 2) removal of overburden soils; and 3) in-situ solidification and stabilization (ISS).

4.2.1 Monitoring Well Abandonment

Prior to mobilization, QA Staff will contract with a driller licensed in the State of Indiana to abandon existing groundwater monitoring wells within the ISS treatment zone in accordance with applicable regulations. Any groundwater monitoring wells not scheduled for abandonment in the ISS treatment zone shall be protected. Any damage to the wells to be protected will be the responsibility of the remedial contractor to correct/repair immediately to the satisfaction of the Engineer.

4.2.2 Removal of Overburden Soils

Removal activities refer to the relocation of overburden soil to a temporary stockpile area for characterization prior to reuse, in accordance with the CMI Work Plan and Contract Drawings (Appendix A of the CMI Work Plan). Removal activities will be performed by the remedial contractor to the limits and in the manner depicted in the Contract Drawings. Prior to initiation, the Surveyor under the instruction of the Site Superintendent will be responsible for surveying and marking all limits of remediation.

The Site Superintendent or QC Manager shall be responsible for ensuring that removal activities are extended to the limits depicted in the Contract Drawings (Appendix A of the CMI Work Plan). Designated QC Staff shall ensure that all necessary QC testing associated with excavation is conducted. During removal activities, the designated QA Staff and Construction Manager shall inspect the soil to ensure that it is suitable for reuse as

backfill as specified in the Excavation and Materials Handling Plan (EMHP) and the Contract Drawings. Construction debris and material not suitable for reuse will be segregated from the overburden excavated material and stockpiled separately for characterization and off-site disposal.

Upon completion of removal activities and approval by the designated QA personnel and the Construction Manager, the Surveyor under the instruction of the QC Manager, shall conduct a final survey to document as-built conditions associated with overburden removal.

4.2.2.1 Temporary Stockpile Area

The Contractor will construct overburden stockpiles in accordance with the EMHP as needed during regrading activities within the designated Temporary Stockpile Area, as detailed in the Contract Drawings (Appendix A of the CMI Work Plan). The designated QC Manager will document, through visual observation, that ESCs have been adequately installed around stockpiles and this documentation will be reviewed by the QA personnel.

The remedial contractor shall maintain adequate space and capacity for maneuvering vehicles, that material is protected from erosion, and free of debris. At the end of the workday, exposed faces from regrading shall be protected in accordance with the Ambient Air Monitoring Plan, using ESCs to control erosion and dust generation.

4.2.2.2 Dewatering and Water Management

Dewatering is not anticipated for completion of the work. Any water that comes in contact with the open excavation, treated ISS footprint, stockpiled materials, or used for decontamination will be containerized. The remedial contractor will construct secondary containment around containers in accordance with the EMHP and Contract Drawings (Appendix A of the CMI Work Plan). The QC Manager will document, through visual observation, that secondary containment have been adequately installed around containers. The remedial contractor shall maintain adequate space and capacity for maneuvering vehicles and that the secondary containment is free of debris.

Prior to completion of the ISS, the containerized water will be used in preparation of the ZVI bentonite slurry mixture. The QC Manager will document, through manual measurements or metering the volume of containerized water used for preparation of the slurry mixture. The QC Manager shall provide the documentation to the Site Superintendent and subsequently the Construction Manager. The Construction Manager may delegate review of this information to the QA Staff.

Following completion of ISS, any captured water from decontamination activities will be sampled to determine method of off-site disposal.

4.3 In-Situ Solidification and Stabilization

The remedial contractor will perform the ISS in accordance with the Contract Drawings (Appendix A of the CMI Work Plan). The ISS work will be performed in a 2-step process.

- **Step 1 – ZVI Mixing** will include soil mixing equipment (augers, excavator mixing head, or excavator bucket) that will mix and shear soils in place, and a slurry will be added to the soil during mixing. The slurry mixture will consist of bentonite clay, water and 1% by dry weight ZVI. After the Step 1 – ZVI Mixing, the amended soils will be allowed to react for a minimum of 28 days.
- **Step 2- PC Mixing** will include the same mixing equipment utilized in Step 1 – ZVI Mixing. The ZVI treated soils will be solidified through the addition of PC at 5% by dry weight.

4.3.1 Step 1 – ZVI Mixing

The ZVI will consist of commercially processed cast iron aggregate that has been ground and placed in moisture tight bags to prevent surface oxidation. ZVI shall be iron product CC-1200, provided by Connelly GPM, Inc. located in Chicago, Illinois and will be delivered to the site in 3,000-pound super sacks. Storage of ZVI at the site will be off the ground, in either a weatherproof enclosure or covered by weatherproof tarpaulins, until use. It is anticipated that approximately 1% ZVI by weight will be mixed by dry weight to achieve treatment of contaminants in Site soils.

To confirm that the Step 1 – ZVI Mixing meets the design criteria for mass percentage of ZVI, QC sampling will be conducted. For each slurry mixture, the following batch information will be recorded: the minimum of ZVI (in pounds), the mass of clay (in pounds), and the volume of water (in gallons). This information will be tracked by the QC Manager and provided to the Superintendent and subsequently the Construction Manager. The Construction Manager may delegate review of this information to the QA Staff.

Additional quality control measures to be implemented during soil mixing activity include accurately recording the number of mixing passes, the depth at refusal, time mixing, pounds of ZVI added and pounds of bentonite clay added, for each individual mixing column/cell.

4.3.2 Step 2 – PC Mixing

PC will be Type I/II. Step 2 – PC Mixing will include the same mixing equipment utilized in Step 1 - ZVI Mixing but will commence after the 28-day ZVI treatment timeframe. It is anticipated that approximately 5% Portland cement by weight will be mixed by dry weight to achieve an average unconfined compressive strength (UCS) of 50 pounds per square inch measured at 28 days or sooner.

The contractor shall collect verification samples, using an in-situ wet sampler, at a frequency of one set for every 500 cubic yards or daily from the ISS area and test the samples for compressive strength (ASTM International D1633). Each set of samples shall consist of four (4) 3-inch by 6-inch sample specimens (cylinders) of homogenized solidified soils obtained from the ISS treatment zone either the surface, mid-point, or bottom depth. Samples shall be prepared and cured in accordance with ASTM International C31. Prior to filling the cylinders, the sample material will be passed through a 3/8 inch-opening sieve.

ISS samples will be collected, handled, packaged, and tested by the QC Staff as indicated below and in accordance with ASTM-1362.

- Samples will be placed in properly labeled boxes (including sample location, depth, and column).
- Samples will be wrapped in clear plastic wrap to prevent moisture loss.
- Samples will be stored in a cool, dry locations and allowed to cure and solidify for a minimum of 48 hours, but not more than 72 hours, before transport to a testing laboratory.
- Samples will not be allowed to freeze.
- One cylinder will be tested after 7 days, 14, and 28 days (total of 5 cylinders) of cure for unconfined compressive strength (UCS) of cylindrical concrete specimens (ASTM D1633). Two samples will be available in case there is suspected damage to a sample to be run as needed.
- The remaining one cylinder will be stored at the laboratory for subsequent testing should the test criteria not be met in the first two sample cylinders.
- Sample results will be reported no later than 3 days after testing has been performed.

ISS materials that do not pass the required performance criteria shall be addressed by the remedial contractor. ISS materials that are re-mixed shall be sampled and tested in accordance with the procedure referenced above. Remedial contractor may elect to alter the mix design for re-mixing of these areas as necessary to meet the project performance criteria.

4.4 Site Restoration

This subsection identifies site restoration activities to be performed at the Site. The Contractor will complete the following activities: 1) placement of stockpiled overburden soils; and 3) placement of topsoil and vegetation.

4.4.1 Placement of Overburden Soils

Backfilling of the ISS area will not be permitted for a minimum period of 7 days following the completion of Step 2-PC Mixing and receipt of approved performance results from field QA/QC testing program indicating ISS has achieved the required design strength. Prior to placement of the overburden, a geotextile demarcation fabric will be placed to delineate between the ISS treatment zone and overburden soils.

The Contractor will replace the stockpiled overburden soils in accordance with the Contract Drawings (Appendix A of the CMI Work Plan). Prior to soil replacement, the QA Staff will document through visual observation and analytical testing that the overburden is suitable for reuse. Stockpiled overburden soils will be delineated into 500 cubic yard segments. From each 500 cubic yard segment, a grab sample will be collected and analyzed for trichloroethylene (TCE) concentration. Any segment of the stockpile where TCE is greater 100 milligrams per kilogram (mg/kg) of TCE will be further characterized and disposed of off-site. Stockpile segments where overburden is less than 100 mg/kg will be used as backfill.

Overburden shall be placed in 10-inch loose lifts and compacted with a vibratory roller or equivalent to 92-95% of the Modified proctor at a frequency of one in-situ density test for every 2,500 square feet per lift. After the overburden backfill is in place and compacted, soil samples of the upper 0.5 feet will be collected on a 100-foot by 100-foot grid pattern (approximately 20 samples). These soil samples will be submitted for VOC analysis. The data will be used to calculate an exposure point concentration for the site and supplement the Environmental Restrictive Covenant planned for the site. Further details regarding waste characterization and reuse of overburden are presented in the EMHP.

4.4.2 Placement of Topsoil and Vegetation

Following placement and grading of the overburden soils, the Site will be restored with topsoil. Topsoil will be spread loosely in a single 4-inch lift. Topsoil shall conform to the specifications outlined in the EMHP and the Contract Drawings (Appendix A of the CMI Work Plan).

The topsoil will be fertilized and seeded with a 100 pound per acre (lb/ac) of a 4-way blend of turf type tall fescue, 50 pound per acre (lb/ac) creeping red fescue, 45 lb/ac perennial ryegrass, and 1.6 lb/ac white dutch clover at a rate of 196.5 lb/ac creeping as specified in the Contract Drawings (Appendix A of the CMI Work Plan). Mulch will be procured and applied in accordance with Section 621 – Seeding and Sodding of the Indiana Department of Transportation Standard Specifications 2020.

Remedial contractor will be responsible for maintaining, including watering of the seed until vegetation is uniformly established across the Site (greater than 80% grass per square foot), at which time temporary erosion controls may be removed.

4.5 Decontamination

The remedial contractor will decontaminate (as necessary) all vehicles, equipment, and personnel that come into contact with potentially impacted materials. The decontamination of equipment and personnel will be performed within dedicated decontamination area(s) to be field located.

The remedial contractor will identify decontamination areas and decontamination procedures for vehicles, equipment, and personnel in the Health and Safety Plan (HASP). These procedures will be reviewed by the Engineer prior to initiation of construction activities.

- Personnel decontamination areas will be located within the contamination reduction zone and include those facilities necessary to decontaminate personnel upon exiting the work area (exclusion zone), in accordance with the Contractor's HASP, and in accordance with local, state, and federal laws and regulations.
- Vehicles and equipment will be positioned in a decontamination area and visually inspected by the Contractor prior to handling non-impacted materials or leaving the site. Any visible soils or other debris will be promptly removed and disposed of off-site in accordance with the EMHP. Precautions will be taken to limit contact between the vehicle/equipment, personnel performing the decontamination activities, and any decontamination liquids that may accumulate in the decontamination area.

The Construction Manager will observe the remedial contractor's decontamination procedures and document that the following activities are completed in accordance with this CQAP and the remedial contractor's HASP (as appropriate):

- Project equipment that come in contact with potentially impacted materials are decontaminated prior to handling non-impacted material or leaving the Site.
- Vehicle and equipment surfaces (including tires) are free of visible soils, debris, or stains.
- Equipment, such as pumps, are flushed using clean water and appropriate cleaning agents, as necessary.
- Wash water, solids and other materials generated during decontamination activities are collected and placed into appropriate waste containers for characterization and off-site disposal in accordance with the EMHP.

5 References

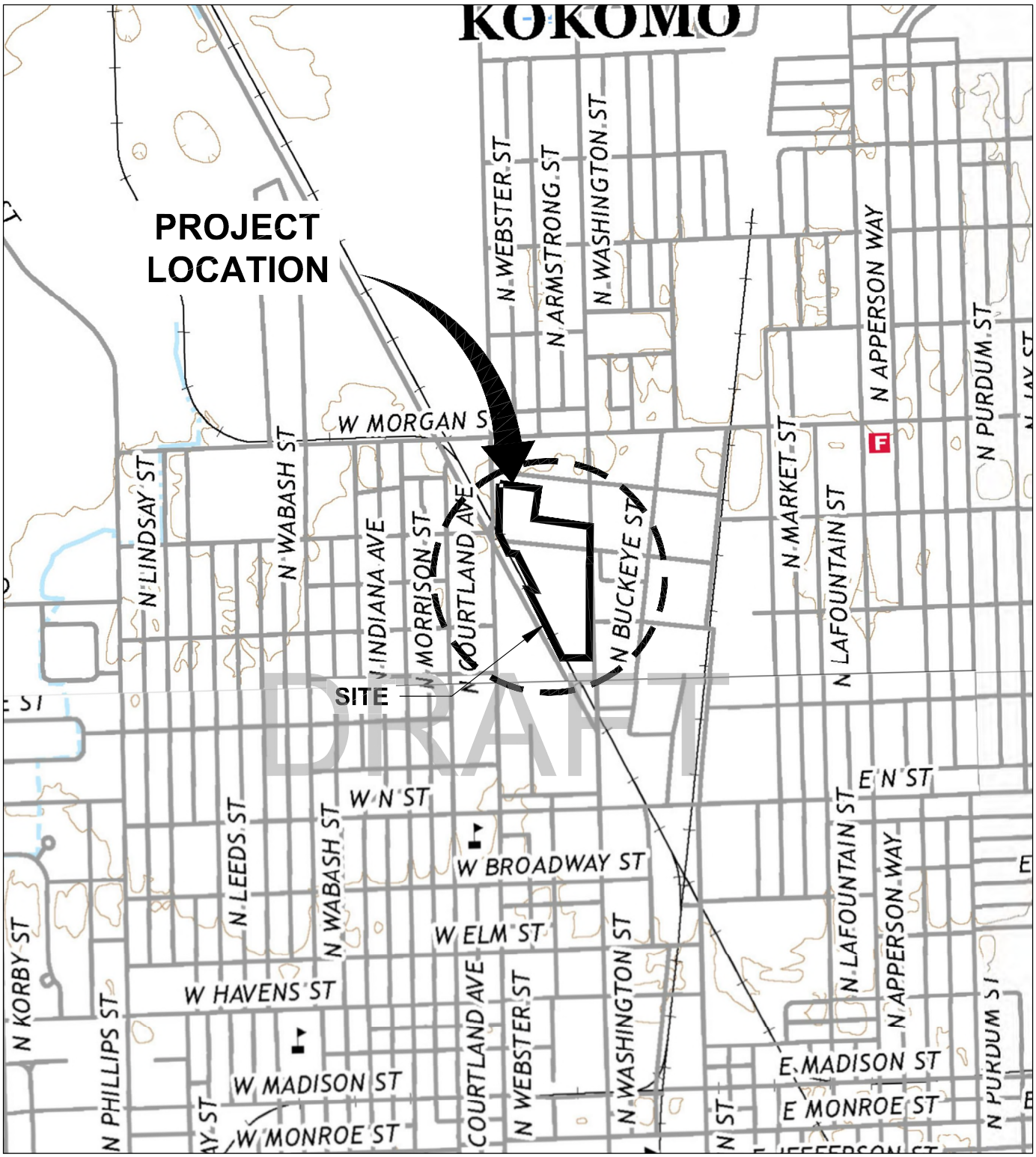
Arcadis. Ambient Air Monitoring Plan, Former GM Delco Plant 5, Kokomo, Indiana, October 2021.

Arcadis. Excavation and Materials Handling Plan, Former GM Delco Plant 5, Kokomo, Indiana, October 2021.

Arcadis. Corrective Measures Implementation Work Plan, Former GM Delco Plant 5, Kokomo, Indiana, October 2021.

Arcadis. Site Specific Health and Safety Plan, Former GM Delco Plant 5, Kokomo, Indiana, October 2021.

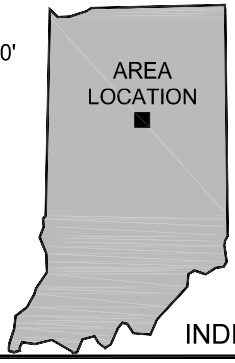
Figures



REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD GALVESTON, IND. 2016, MIAMI, IND. 2016, KOKOMO EAST, IND. 2016, AND KOKOMO WEST, IND. 2016.

0 1000' 2000'

Approximate Scale: 1 in. = 1000 ft.



RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

SITE MAP

ARCADIS

FIGURE
1

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RESTAURANT PARKING

ASPHALT

FORMER WATER TANK

FORMER PUMP HOUSE

SPRAKER STREET

ASPHALT

VACATED ROBINSON STREET

GRASS

SPRAKER S

N

LEGEND

PROPERTY BOUNDARY

EXCAVATION/TREATMENT AREA

DRAFT

GRASS

FORMER EAST MANUFACTURING BUILDING

FORMER OIL HOUSE

WASHINGTON STREET

FORMER HAZARDOUS WASTE STORAGE

CONC.

LORDEMAN STREET

BUCKEYE STREET

X

0 50' 100'

GRAPHIC SCALE

RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

SITE LAYOUT

ARCADIS

FIGURE 2

CITY:Syracuse DIV/GROUP:Env-141 DB:A.Schilling LD:A.Schilling PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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Appendix F

Groundwater Contingency Plan (GCP)

RACER Trust

Groundwater Contingency Plan

Former Delco Plant 5, Kokomo, Indiana

October 25, 2021

Groundwater Contingency Plan

Former Delco Plant 5, Kokomo, Indiana

October 25, 2021

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A Product Information and Safety Data Sheets

1 Introduction

Arcadis U.S., Inc. (Arcadis) has prepared this Groundwater Contingency Plan as a component to the Resource Conservation and Recovery Act (RCRA) Corrective Measures Implementation (CMI) Work Plan (CMI Work Plan) on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust for the former General Motors (GM) Delco Plant 5 facility located at 1723 North Washington Street, Kokomo, Indiana (the site; **Figure 1**).

As part of the RCRA Correction Action process, the United States Environmental Protection Agency (USEPA) issued a Final Decision and Response to Comments (Final Decision; USEPA 2021) outlining the final corrective measures for the site: In-Situ Solidification and Stabilization (ISS) with Monitored Natural Attenuation (MNA) for Groundwater and Soil, Institutional Controls, and Long-Term Care/Stewardship. As part of the ISS scope of work, USEPA has requested that RACER Trust prepare a groundwater remediation contingency plan:

- "During remediation, the source zone would be disturbed, which may result in a temporary spike in groundwater concentrations. Groundwater monitoring will occur simultaneously with the remedial activities. Contingency triggers and measures will be incorporated into the final remedial design to address the potential risk associated with a temporary increase in [volatile organic compound] VOC concentrations in groundwater caused by the in-situ mixing. The purpose of this contingency plan will be to assure the short-term efficacy of the remediation by preventing the expansion of the groundwater plume. Metrics designed to trigger the contingency plan will include, but may not be limited to, [chlorinated volatile organic compound] CVOC concentrations within an approved monitoring network." (USEPA 2021)

There will be two areas of focus for ISS treatment: the North Area and the South Area. The general process for the treatment will be removing the upper overburden soils, mixing zero-valent iron (ZVI) and water with the soils to create a slurry, allowing the ZVI-soil mixture to react for approximately 28 days (as identified in the ISS treatability study [Arcadis 2019]), then solidifying the mixture with Portland cement to create a geotechnically stable monolith. Details regarding the phasing of the implementation are provided in the CMI Work Plan.

Some portions of the excavation will encounter the saturated sand and gravel unit, historically identified as the S1 Unit. During this process, there is potential to mobilize volatile organic compounds (VOCs) into the groundwater. This contingency plan details the groundwater monitoring, data evaluation, and contingency measures that may be implemented if a significant increase in VOC concentrations is observed.

2 Groundwater Monitoring

Arcadis has completed several investigations at the site since 2005 including several phases of a RCRA Facility Investigation (RFI), a pre-design investigation, a pilot test for in-situ chemical oxidant treatment, a vertical aquifer profiling (VAP) investigation, a natural attenuation assessment, and an isotope evaluation. These investigations have provided various pieces of data (summarized below) that are used to evaluate the groundwater conditions at the site.

2.1 Groundwater Characteristics (S1 Unit)

The groundwater flow direction in the S1 Unit is to the east-southeast. The gradient in the S1 Unit across the site is relatively flat; however, it increases in magnitude to the southeast with a range of 0.00035 to 0.0016 foot per foot (ft/ft). Hydraulic conductivity in the S1 Unit ranges from 13.9 feet per day (ft/day) to 133 ft/day, with an average hydraulic conductivity of 84.1 ft/day. The calculated groundwater velocity ranges from 0.024 ft/day to 1.1 ft/day, with an average groundwater velocity of 0.7 ft/day. (Table 3.4.1 of the RFI Report; Arcadis 2010).

In 2016, Arcadis completed a VAP investigation that evaluated a transect of soil borings along the eastern and southern property boundaries to identify the primary contaminant mass flux zones and to evaluate potential off-site migration of groundwater impacts (Arcadis 2017). The relative mass flux distinguishes the mass that moves in transport zones from the mass stored in the slow advection and storage zones within an aquifer. The largest component of mass flux occurs in the middle area of the transect and is predominantly trichloroethene (TCE). In the southwestern transect area, there is a relatively small area where chlorinated VOCs (CVOCs) are migrating; however, concentrations of cis-1,2-dichlorethylene (cis-1,2-DCE) and vinyl chloride indicate biodegradation of TCE from the South Area via reductive dechlorination. Figures 5a through 5d of the VAP Investigation Report present the mass flux results from this investigation (Arcadis 2017).

2.2 Groundwater Monitoring Program

To appropriately monitor groundwater migrating from the ISS treatment areas, new groundwater monitoring wells will be installed downgradient of the excavation footprint. It should be noted that the CMI Work Plan identifies the ISS treatment areas; however, additional construction details, such as sloping/benching or sheeting/shoring, as well as stockpile and equipment staging, and other project components, will not be specifically identified until the remedial contractor documents are received and a remedial contractor is selected. The selected remedial contractor will provide the most cost-effective and efficient process for excavating overburden and treating soils to the design specifications presented in the CMI WP: Therefore, the layout of monitoring locations (new and existing wells) identified in this contingency plan are subject to change.

The intent of the plan will remain regardless of the remedial contractor's approach. Conceptually, Arcadis will monitor two transects of monitoring wells located approximately 80 ft (Transect 1) and 160 ft (Transect 2) in the downgradient direction (southeast) of the North Area (**Figure 2**). Because the South Area is closer to the eastern property boundary, the two transects are approximately 60 ft (Transect 1) and 120 ft (Transect 2) in the downgradient direction. It should be noted that the "downgradient direction" was

identified using a combination of the groundwater flow direction, distribution of groundwater TCE concentrations, and relative mass flux position along the property boundaries.

2.3 Sampling Frequency and Method

Groundwater samples will be collected from Transect 1 and Transect 2 prior to the overburden excavation to establish a baseline for evaluation. During excavation and implementation of ISS, groundwater samples will be collected from Transect 1 monthly to determine if a significant increase in concentrations is observed immediately downgradient from the treatment area. If such increase is identified, the corresponding monitoring wells in Transect 2 will be sampled at the same frequency.

Groundwater samples will be collected from the new or existing monitoring wells using a disposable bailer after purging three well volumes from the well. Because the data are being used as an indicator of groundwater conditions during remediation, collecting groundwater samples using passive diffusion samplers (PDBs; the method used for semi-annual monitoring at the site) is not required. Groundwater samples will be submitted to Pace Analytical in Indianapolis, Indiana for VOC analysis (SW-846 Method 8260) on a one-week turnaround time.

VOC results will be compared to the baseline concentrations (collected prior to excavation) to evaluate if a significant increase in the groundwater concentrations is observed immediately downgradient from the ISS treatment area. For the purposes of this Groundwater Contingency Plan, a significant increase will be considered as an order of magnitude more than baseline. If the groundwater concentration from a monitoring well exhibits a significant increase in VOC concentrations, confirmation groundwater samples will be collected from the identified well(s) and submitted to Pace Analytical on a 2-day turnaround time. If a significant increase in VOC concentrations is confirmed, Arcadis will notify USEPA, and sampling of corresponding monitoring wells in Transect 2 will commence on the same frequency as that for Transect 1. If groundwater samples from monitoring wells in Transect 2 exhibit a significant increase in VOC concentrations, Arcadis will discuss the results with USEPA and determine whether the contingency measures identified in Section 3 should be implemented. Groundwater monitoring will continue on the planned schedule for monitoring wells that do not exhibit a significant increase in VOC concentrations.

Following completion of ISS treatment, if contingency measures have not been required, Arcadis will collect two additional samples: one at approximately 30 days post-solidification and one at approximately 90 days post-solidification. At that time, Arcadis will conclude that no significant increase in groundwater impacts occurred, will resume routine groundwater monitoring, and will prepare the Long-Term Stewardship Plan for USEPA review.

3 Groundwater Contingency Measure

The groundwater contingency measures are intended to partially mitigate the short-term increases associated with any mobilized contaminants such that a significant increase in off-site groundwater concentrations or a change to the plume footprint off site is not observed. Note that the contingency measures are not intended to treat groundwater migrating off site to the maximum contaminant levels (MCLs). The remedial objective for groundwater contingency is to reduce groundwater VOC concentrations leaving the site to within an order of magnitude of baseline conditions.

The contingency measures will be installed downgradient of the ISS treatment areas with confirmed significant increases in groundwater VOC concentrations, as identified above. These measures will focus upgradient from the high mass flux zones identified in the VAP investigation, as these areas are believed to have the greatest influence on off-site groundwater concentrations. Based on the results of the VAP investigation, the following areas exhibit the highest mass flux and can be individually targeted using the proposed contingency measures.

- SB-1617 to SB-1602 (25 ft distance) – Approximately 16 ft thick;
- SB-1602 to SB-1619 (75 ft distance) – Approximately 12 ft thick;
- SB-1616 to SB-1606 (75 ft distance) – Approximately 20 ft thick;
- SB-1610 to SB-1611 (50 ft distance) – Approximately 8 ft thick.

3.1 In-Situ Groundwater Treatment

Impacted groundwater downgradient from the ISS treatment areas will be treated in situ through injections of a ZVI-carbon-based amendment such as PeroxyChem's EHC®, GeoForm™, or similar products (hereafter referred to as "Reagent"). EHC® is a mixture of food-grade organic carbon, nutrients, and ZVI. GeoForm™ is a mixture of food-grade organic carbon and a sulfated form of ZVI. Product information and a safety data sheets are included as **Appendix A**.

Injection of a Reagent into the subsurface creates strongly reducing conditions and causes both abiotic and biotic reductive dechlorination of CVOCs. ZVI facilitates direct abiotic degradation processes and provides secondary benefits for biological treatment: dissolved hydrogen generation, oxygen scavenging, and alkalinity/pH increases. The organic carbon stimulates microbially mediated enhanced anaerobic biodegradation processes. The addition of sulfur increase reactivity and sorption of VOCs onto the iron particles and provides a source for iron sulfide to precipitate, which can also provide abiotic treatment. An advantage of this combined abiotic/biotic approach is that the chemical reduction pathway does not generate vinyl chloride, and the ZVI can treat daughter products (such as cis-1,2-DCE and vinyl chloride) that may accumulate as a result of microbially mediated reductive dechlorination. Additionally, based on past experience, Reagent injections are expected to sustain treatment for approximately 1 to 3 years.

The Reagent is injected as a slurry, typically at solids concentrations between 25 and 35 percent. The ZVI material, composed of micron-size particles, is larger than the pore throat diameter of the soil matrix. As such, subsurface distribution of the ZVI material is limited by physical straining effects of the soil matrix. To achieve a sufficient distribution, the Reagent slurry will be injected into the subsurface at pressures of 100 to 200 pounds per square inch (PSI).

Reagent will be injected at multiple direct-push injection locations downgradient from the monitoring locations showing the significant increase in VOC concentrations and in areas exhibiting the highest mass flux. Depending on the specific monitoring locations, the injections may be completed at depths ranging from 10 to 30 ft bgs.

If contingency measures are warranted, Arcadis will submit a simplified scope of work identifying the Reagent selection, injection locations, intervals, and volumes based on field observations during ISS implementation. The following subsections summarize key aspects of the remedial design for the site.

3.1.1 Substrate Selection

There are several commercially available mixtures of ZVI and organic carbon. These substrates are available in a variety of ZVI particle sizes (e.g., nanometer to micrometer size) as well different organic carbon formulations. The Reagents identified above are cost-effective and widely used amendments. EHC has been on the market for more than 15 years while GeoForm is a newer product. Micro-scale ZVI is proposed because nano-scale ZVI particles tend to clump during injection. Micro-scale ZVI is commonly injected as a slurry under pressure to distribute the amendment through fractures created around the injection borehole. Because ZVI has been shown to be effective at reducing the concentrations of CVOCs in the soil matrix, the combined ZVI/organic carbon substrate should be effective at reducing the concentrations of CVOCs in the dissolved groundwater.

As noted in **Appendix A**, Reagent slurry is typically injected at concentrations of 25 to 35 percent solids for in situ treatment applications. The simplified scope of work will provide more details regarding the selected reagent and target concentration.

3.1.2 Direct-Push Injection Locations and Depths

The Reagent will be injected along a north-south transect east of the treatment zones based on where the significant increases in groundwater concentrations are observed. However, for the South Area, the injections may be along a northeast-southwest transect based on the VAP investigation results. If contingency measures are warranted, Arcadis will submit a simplified scope of work identifying the injection locations, intervals, and volumes.

Injections will focus on the saturated soils with the highest mass flux; therefore, each injection location may target a different interval based on the VAP investigation. Reagent injections are typically completed at 2-foot intervals. Given the depth of the planned injections (approximately 10 to 30 ft bgs) and the clay and till overlaying the S1 Unit, daylighting of substrate is not anticipated.

The Reagent will be procured according to the injection volumes and loading that will be calculated and presented in the simplified scope of work; however, it is possible that excess Reagent will be left over after the planned injections are completed. If present, excess Reagent material will be injected into the identified target injection locations, or additional nearby injection locations may be established.

3.1.3 Direct-push Injection Methodology

Direct-push methods rely on the hydraulic advancement of small-diameter (typically 1.25- to 3.25-inch-diameter) hollow steel rods into the target injection zone. During steel rod advancement, subsurface soil is displaced, not removed from the borehole. Because the Reagent is injected using tooling with pressure-activated orifices, the

amendment will be injected at multiple depths within the same direct-push boring from the top down across the target injection zone.

The Reagent will be delivered to the site as a dry powder in 50-pound bags. Before injection, the Reagent will be mixed with water on site to create a slurry. The mixed Reagent slurry will be injected into the target zones through the direct-push tooling and injection ports. The system will be equipped with a flow control valve, flow totalizer, and pressure gauge to monitor and control the flow rate and pressure to the direct-push borehole. As noted above, injections will be conducted at multiple depths to cover the target injection interval for each treatment area. As needed to avoid clogging of the tooling, the system may be flushed with approximately 10 gallons of water at the completion of each injection location.

Dilution and flushing water will be obtained from the public fire hydrant or delivered potable water, depending on the optimum process flow. During the injection event, a sample will be collected from the dilution/flushing water and will be analyzed for VOCs.

Investigation-derived wastes, including decontamination liquids and disposable materials (e.g., protective equipment), will be managed in accordance with the CMI Work Plan.

3.2 Post-Injection Monitoring

Groundwater samples will be collected from monitoring wells downgradient from the injection area approximately 1 month after injections. Groundwater samples will be analyzed for VOCs (USEPA SW-846 Method 8260) total organic carbon (TOC; USEPA SW-846 9060A), dissolved iron (USEPA SW-846 6010), dissolved gasses (acetylene, methane, ethane, and ethene; RSK 175), sulfate (USEPA 300.0), and field water quality parameters. Groundwater samples will be collected using low-flow methods because PDBs are not ideal for all constituents being monitored for this treatment technology. Following the 1-month post-injection sampling, additional samples will be collected for VOC analysis as part of ongoing semi-annual groundwater monitoring. A sampling summary is included as **Table 1**.

4 References

Arcadis. 2010. RCRA Corrective Action RCRA Facility Investigation Report, Former GM Delco Plant 5, Kokomo, IN, USEPA ID IND000806844. May 21.

Arcadis. 2017. Vertical Aquifer Profiling Investigation Report, Former GM Delco Plant 5, Kokomo, IN, USEPA ID IND000806844. May 9.

Arcadis. 2019. RCRA Corrective Action Corrective Measures Proposal, Former GM Delco Plant 5, Kokomo, IN. September 5.

USEPA. 2021. Final Decision and Response to Comments for RACER Trust Former GM Delco Plant 5, 1723 North Washington Street, Kokomo, Indiana, EPA ID: IND 000 806 844. June 16.

Table

Table 1.
Sampling and Analysis Plan
RACER Trust
Former GM Delco Plant 5
Kokomo, Indiana

Sampling Location	Location	Frequency	VOCs	Biogeochemical Parameters			Field Parameters[B]
				TOC	Dissolved Iron (field-filtered)	Dissolved Gasses[A]	
			USEPA 8260B	USEPA 9060A	USEPA 6010	RSK 175	Field measurement
Baseline Sampling (pre-ISS Field Work)							
Northern Source Area							
Planned New Wells	Downgradient	One-time	x	-	-	-	-
MW-1501-S1	Source Area	One-time	x	-	-	-	-
MW-0621-S1	Downgradient	One-time	x	-	-	-	-
MW-0102-S1U	Property Boundary	One-time	x	-	-	-	-
MW-0704-S1	Off-site	One-time	x	-	-	-	-
MW-0705-S1	Off-site	One-time	x	-	-	-	-
Southern Source Area							
MW-0517-S1	Downgradient	One-time	x	-	-	-	-
MW-0604-S1	Downgradient	One-time	x	-	-	-	-
MW-0504-S1	Property Boundary	One-time	x	-	-	-	-
During ISS Field Work							
Dilution Water		One-time	x	-	-	-	x (pH only)
Northern Source Area							
Planned New Wells	Downgradient	Monthly	x	-	-	-	-
MW-1501-S1	Source Area	Monthly	x	-	-	-	-
MW-1502-S1	Downgradient	Monthly	x	-	-	-	-
MW-0102-S1U	Property Boundary	Monthly	x	-	-	-	-
MW-0704-S1	Off-site	Monthly	x	-	-	-	-
MW-0705-S1	Off-site	Monthly	x	-	-	-	-
Southern Source Area							
MW-0517-S1	Downgradient	Monthly	x	-	-	-	-
MW-0604-S1	Downgradient	Monthly	x	-	-	-	-
MW-0504-S1	Property Boundary	Monthly	x	-	-	-	-
Post-ISS Field Work							
Northern Source Area							
Planned New Wells	Downgradient	30/90	x	-	-	-	-
MW-1501-S1	Source Area	30/90	x	-	-	-	-
MW-1502-S1	Downgradient	30/90	x	-	-	-	-
MW-0102-S1U	Property Boundary	30/90	x	-	-	-	-
MW-0704-S1	Off-site	30/90	x	-	-	-	-
MW-0705-S1	Off-site	30/90	x	-	-	-	-
Southern Source Area							
MW-0517-S1	Downgradient	30/90	x	-	-	-	-
MW-0604-S1	Downgradient	30/90	x	-	-	-	-
MW-0504-S1	Property Boundary	30/90	x	-	-	-	-

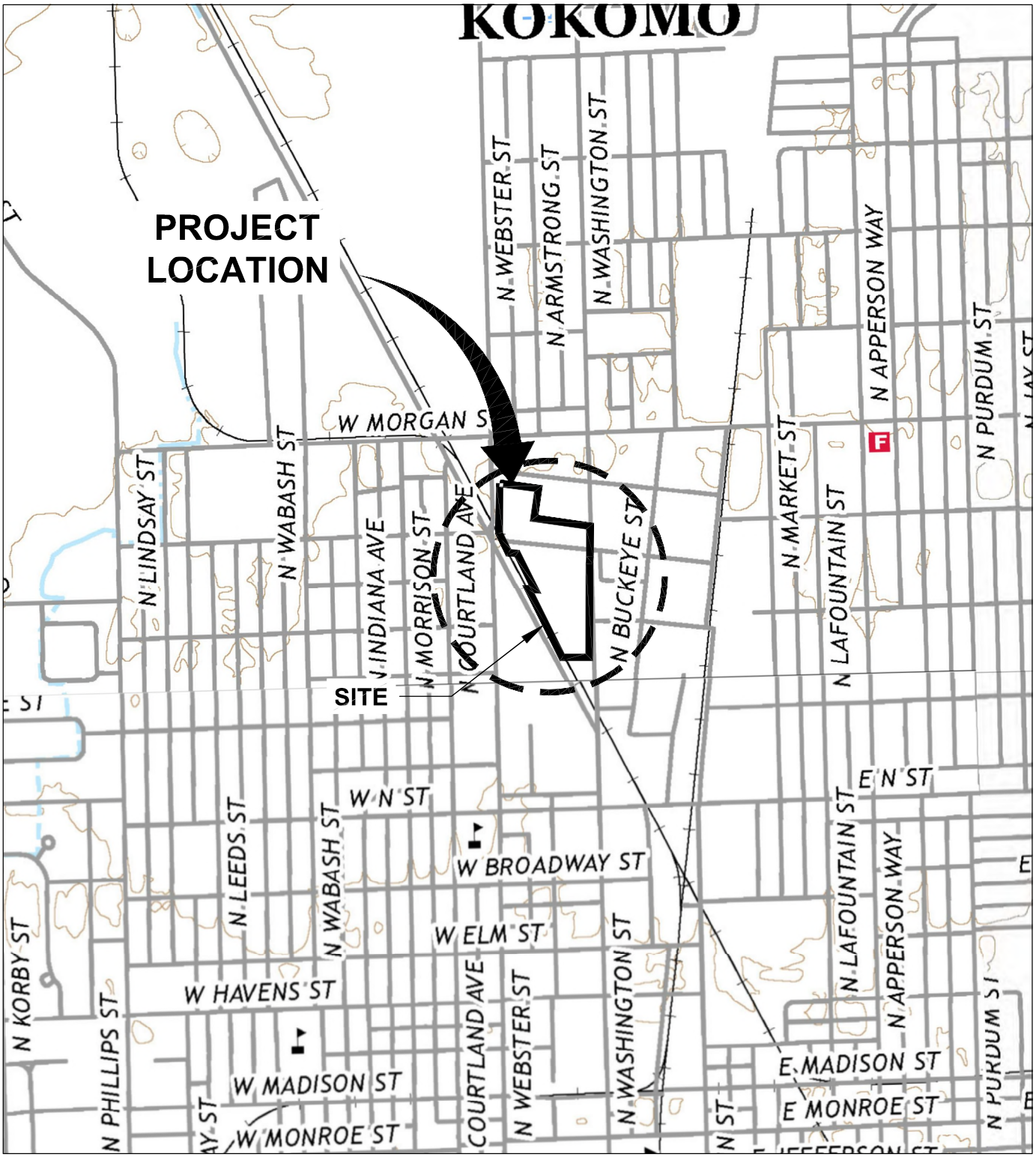
Table 1.
Sampling and Analysis Plan
RACER Trust
Former GM Delco Plant 5
Kokomo, Indiana

Sampling Location	Location	Frequency	VOCs	Biogeochemical Parameters			Field Parameters[B]
				TOC	Dissolved Iron (field-filtered)	Dissolved Gasses[A]	
			USEPA 8260B	USEPA 9060A	USEPA 6010	RSK 175	Field measurement
Post-Reagent Injection Monitoring							
Northern Source Area							
Planned New Wells	Downgradient	30-GW	x	x	x	x	x
MW-0102-S1U	Property Boundary	30-GW	x	x	x	x	x
MW-0704-S1	Off-site	30-GW	x	x	x	x	x
MW-0705-S1	Off-site	30-GW	x	x	x	x	x
Southern Source Area							
MW-0517-S1	Downgradient	30-GW	x	x	x	x	x
MW-0604-S1	Downgradient	30-GW	x	x	x	x	x
MW-0504-S1	Property Boundary	30-GW	x	x	x	x	x

Notes:
ISS - in-situ solidification and stabilization
RACER - Revitalizing Auto Communities and Environmental Response
TOC - Total organic carbon
USEPA - United States Environmental Protection Agency SW-846
VOC - Volatile organic compound
[A] Dissolved gasses include: acetylene, methane, ethane, and ethene.
[B] Field parameters include: dissolved oxygen, oxidation-reduction potential, pH, temperature, conductivity, and turbidity unless stated otherwise.

30/90 - Groundwater samples collected 30 days and 90 days after ISS treatment is complete in areas where no groundwater contingency measures were completed.
30-GW - Groundwater samples collected 30 days after Reagent injections are complete. Samples will only be collected from monitoring wells downgradient from injection areas

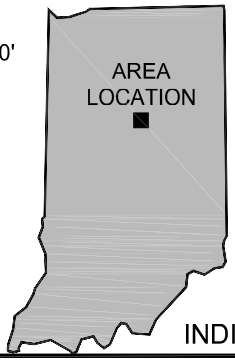
Figures



REFERENCE: BASE MAP USGS 7.5. MIN. TOPO. QUAD GALVESTON, IND. 2016, MIAMI, IND. 2016, KOKOMO EAST, IND. 2016, AND KOKOMO WEST, IND. 2016.

0 1000' 2000'

Approximate Scale: 1 in. = 1000 ft.



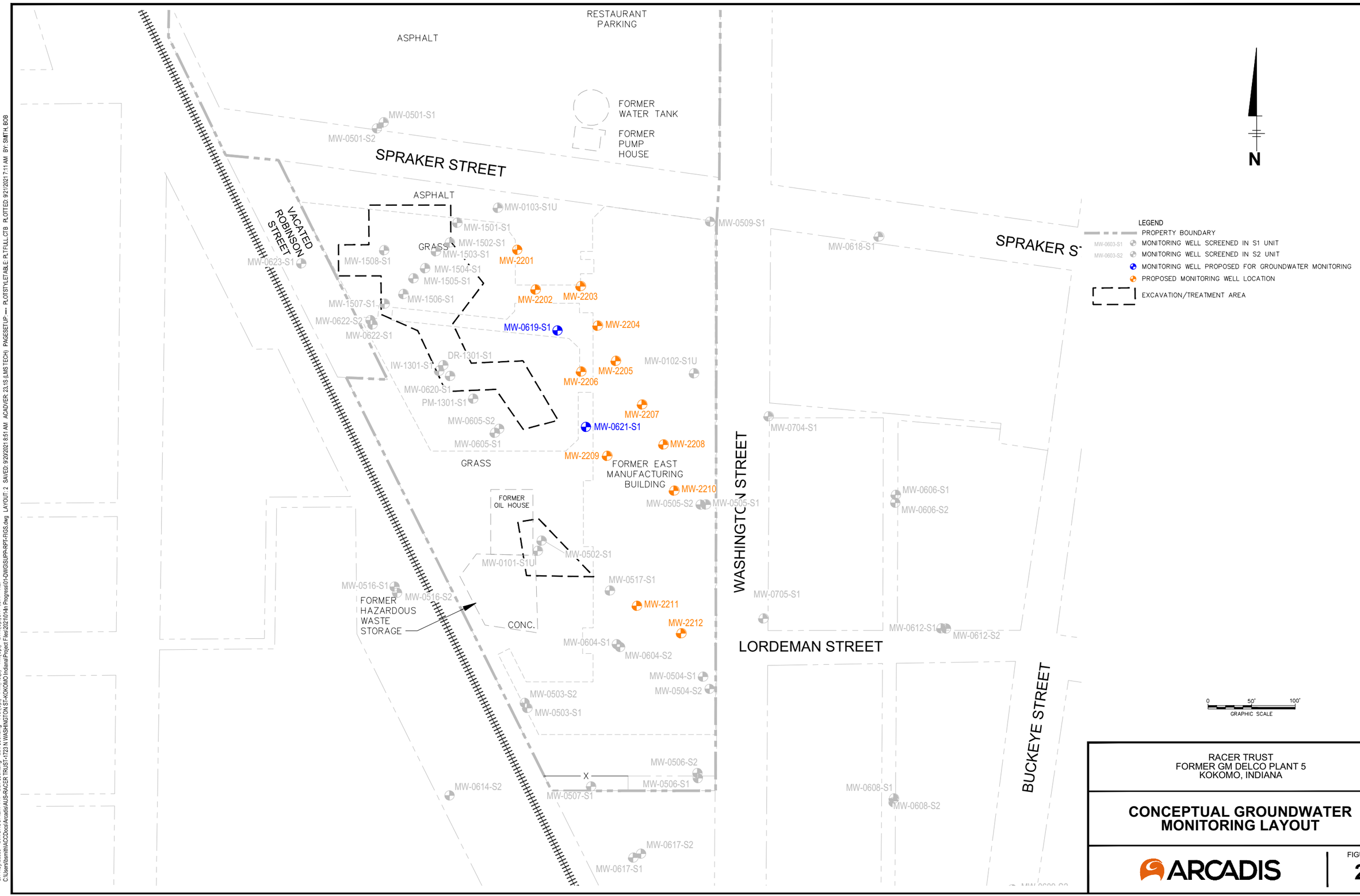
RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

SITE MAP

ARCADIS

FIGURE
1

CITY: SYRACUSE DIV/GROUP: ENV DB: G.STOWELL PM:(Reqd) LYR:ON=*;OFF=*REF
C:\Users\aschilling\OneDrive - ARCADIS\BIM 360 Docs\RACER TRUST\FORMER GM DELCO PLANT 5 - KOKO\2018\IN000884.2017\01-DWG\CMP-Fig1-Site Loc.dwg LAYOUT: 1 SAVED: 10/25/2018 1:22 PM ACADVER: 21.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 10/25/2018 1:24 PM BY: SCHILLING, ADAM
XREFS: IMAGES:
CMP-X-PA-T



RACER TRUST
FORMER GM DELCO PLANT 5
KOKOMO, INDIANA

CONCEPTUAL GROUNDWATER MONITORING LAYOUT

ARCADIS

FIGURE
2

CITY:Syracuse DIV/GROUP:Env-141 DB:A.Schilling LD:A.Schilling PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
C:\Users\bsmith\ACCDocs\Arcadis\AUS-RACER TRUST-1723 N WASHINGTON ST-KOKOMO Indiana\Project Files\20210104h Progress\01-DWG\SUPP-RPT-FIGS.dwg LAYOUT: 2 SAVED: 9/29/2021 8:51 AM ACADVER: 23.1S (LMS TECH) PAGESETUP: --- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 9/21/2021 7:11 AM BY: SMITH, BOB

Appendix A

EHC Product Information and Safety Data Sheet

EHC® Reagent Slurry Preparation and Application Guidelines

EHC® *In Situ* Chemical Reduction (ISCR) Reagent is composed of food grade organic carbon and zero-valent iron for reduction of persistent organic and/or inorganic contaminants from the subsurface environment. EHC reagent has been applied for source area treatment, plume treatment, and plume management using methods such as:

- Application into an open excavation via
  - Direct placement in to the base of an excavation following source area removal
  - A trench style permeable reactive barrier (PRB)
  - Soil mixing
- Injection applications

The choice of installation method will depend on your site-specific conditions, including treatment depth and geology.

APPLICATION INTO AN OPEN EXCAVATION

Excavation base:

The most common application for direct placement of EHC reagent is the addition of EHC to saturated soil and/or standing groundwater at the base of an excavation following a source area removal (See Figure 1). EHC can either be mixed into the backfill material prior to placement or applied in lifts and then mixed in place. It is advisable to mix the EHC with sufficient backfill to cover the thickness of the excavation that is expected to encounter groundwater, taking into account seasonal variability in the groundwater table.

Figure 1. Backfill with 5% EHC by weight at an open excavation following source area removal

The EHC powder could also be physically mixed into saturated soil at the base of an excavation using a backhoe. Depending on the remaining impacts and the treatment goals, an application rate of 0.5 - 5% of EHC by soil mass is generally recommended for backfill applications.

Trench/PRB:

EHC reagent could also be added to a trench excavation to form a PRB for plume management (Figure 2). The trench is installed across the plume and backfilled with a mixture of EHC and sand up to the groundwater table to form a reactive zone. The groundwater is treated as it passes though the reactive barrier. In general, a higher

application rate of 5 - 10% of EHC by soil mass is recommended to sustain continuous removal over time. The remainder of the trench is backfilled with clean fill material (e.g. pea gravel or sand).

Figure 2. Placement of a mixture of EHC and sand into a trench excavation to form a PRB for plume control

Mixing of EHC with Backfill Material:

If wind is low, the dry powder can be mixed with the backfill at ground surface using construction equipment. Alternatively, the powder can be mixed into the backfill in the excavation using construction equipment and safe construction methods. If winds are high, it may be necessary to prepare a slurry of EHC containing a high percentage of solids and mix the slurry into the backfill or it may help to spray with water during application. See Figure 3.

Figure 3. Dry mixing of EHC (provided in sacks) and sand

Direct Soil Mixing:

The EHC reagent may also be placed directly on the bottom of an excavation either in dry powder form if winds are low, or in slurry form if winds are high. In such a case, it may be advisable to mix the powder or slurry into the native soil at the bottom of the excavation using construction equipment and safe construction methods. This will be particularly useful if contaminants are expected to be present in the remaining soil. For deeper impacts, deep soil mixing equipment such as a Lang Tool could be used. See Figure 4.

Figure 4. Deep soil mixing using a Lang Tool

APPLICATION VIA INJECTION

The most common application method for EHC is direct injection using direct push technology. The EHC is mixed with water to form a slurry and is injected directly through the direct push probe rods in to the saturated zone. The preferred approach for injections is often in the top-down direction using an injection tip that directs the slurry horizontally, for example pressure activated direct push tips have been successfully utilized. For each injection point, the rods are initially advanced to the top of the targeted depth interval and a specified volume of slurry is injected before proceeding down to the next depth. The injections are to be evenly distributed over the targeted depth interval, using a vertical injection spacing of approximately 2-4 ft.

Figure 5. Injection tip with horizontal direction low pressure demonstration with water

Water Flushing during Injection:

It is not recommended to apply larger amounts of chase water for the purpose of distributing EHC, but it is recommended to inject a smaller volume of water upon completion of a point to clean the rods. Flushing with water between injection intervals can be required to avoid clogging of the injection tip, but normally, if the injection flow rate is kept >3 gpm and the time inbetween injections are kept to a minimum, water flushing between intervals is not required. In general, it is recommended to keep water flushing at a minimum to limit the risk of daylighting and only inject just enough water to clean out the injection tip.

Injection Spacing:

The recommended spacing between injection points are based on two factors: radius of influence distribution (ROI) and soil acceptance. Both of these factors may vary greatly depending on injection technique and lithology. It is recommended to be as flexible as possible during a field installation and/or to evaluate these parameters during a pilot-scale test injection. However, based on experience from a range of sites, a ROI of at least 5 ft is observed with direct injection; due to this an injection spacing of 10 to 15 ft (staggered rows) is generally recommended. Soil acceptance may also vary greatly depending on the lithology and injection depth. As a general guideline, we recommend no more than 100 lbs EHC per vertical foot for more permeable formations. For clayey formations, soil acceptance has in some instances been limited to 20 lbs per vertical foot. Therefore, a closer spacing may have to be applied in a scenario with a higher dosing requirement combined with a low permeability formation to limit the injection volume per point. Note that significantly greater ROIs has been observed with fracturing techniques with up to 8,000 lbs EHC injected per fracture and ROIs of more than 30 ft. Information on how to monitor the ROI and observations from a range of sites is available upon request.

Pump Requirements:

Using an injection pump that is capable of generating at least 500 psi of pressure at a flow rate of 5 gpm is recommended. The pump needs to be able to handle solids. For example piston pumps, grout pumps and progressing cavity pumps have worked well in the past, with a preference towards the piston and grout pumps. EHC would typically be injected at pressures of 100 to 200 psi. However, higher pressures are sometimes required to initiate the injection. It would be ideal to have a higher pressure pump available on site that can generate over 500 psi and as high a flow rate as possible. Deeper installations may require higher injection pressures.

Other injection considerations:

Sufficient rod length and injection tips are recommended to allow 3 to 5 injection points to be capped overnight to prevent backflow if need be (more for shallow depths and less for deep installations).

PREPARATION OF EHC SLURRY

EHC reagent may need to be mixed into a slurry to avoid loss of product or for direct push injections. The solids content of the slurry may be varied depending on the desired injection volume and slurry properties. When applied via direct injection, normally a concentration of between 25 and 35% solids is targeted as calculated as the mass of EHC divided by the mass of water plus EHC. This results in a final wet density of the slurry of approximately 1.09 to 1.13 g/cm^3. More dilute slurry may promote permeation (as opposed to fracturing) in more granular formations if the flow rate and pressure is kept low. More viscous slurry with up to 35% solids has been found to limit problems with daylighting during injection, particularly for shallow applications into low-permeability formations.

EHC is delivered as a dry powder in 50-lb bags or 2,000 lb supersacks. Table 1 indicates the volume of water required to attain a given percent solids level for a 50-lb bag of EHC.

	25% slurry	30% slurry	35% slurry
Mass EHC per bag (lbs)	50	50	50
Volume water per bag (USG)	18.0	14.0	11.1
Estimated specific gravity of slurry	1.09	1.11	1.13
Volume slurry per bag (USG)	22.0	18.0	15.2

Table 1. Volume of water required to attain different slurry solids contents per 50-lb bag of EHC.

Figure 6. EHC slurries

Preparing the EHC slurries on site in a mixing tank with a paddle-mixer at the bottom (grout mixers) is recommended (figure 7). The slurry is then transferred to a feed tank connected to a pump allowing for easy transfer of the slurry; the slurry could then be pumped straight into the application – either the excavation or injection pump. In general, we recommend continuous mixing in smaller batches (<100 USG / 400 L) to avoid settling of solids at the bottom.

The EHC slurry has also been prepared in a variety of other ways; everything from in-line automated mixing systems and recirculation of slurry using high-flow trash pumps to manual mixing using a hand-held drill with a mixing attachment. However, particularly for larger projects, a mechanical mixing system on site is recommended.

Figure 7. Grout / paddle mixing unit with feed-tank and injection pump.

Figure 8. Mixing of EHC slurry using recirculation

HEALTH AND SAFETY

Prior to working with EHC consult the Safety Data Sheet (SDS) to understand proper safety, handling, storage and disposal procedures. Any vessel that contains wet EHC or EHC and water must be vented due to potential pressure build up from fermentation gasses. When working with EHC, it is recommended to use standard personal protective equipment, including: safety glasses, steel toe boots, nitrile gloves, hearing protection (when direct push equipment is used), and hard hat. Dust mask may be required when in close contact with EHC under certain conditions.

The information contained herein is presented to the best of our knowledge, PeroxyChem makes no representations or warranties regarding the accuracy, quality, or reliability of this information and shall under no circumstances be liable with respect to such information. EHC IS a Trademark of PeroxyChem. © 2017 PeroxyChem. All rights reserved. Document 08-02-ESD-17

SAFETY DATA SHEET
EHC® Reagent

SDS # : EHC-C
Revision date: 2021-02-08
Format: NA
Version 2.03

1. PRODUCT AND COMPANY IDENTIFICATION

Product Identifier

Product Name EHC® Reagent

Alternate Commercial Name EHC® Fine, EHC ®-F, EHC® Granular, EHC® 50%

Recommended use of the chemical and restrictions on use

Recommended Use: For the remediation of contaminated groundwater

Restrictions on Use No uses to be advised against were identified.

Manufacturer Address
Manufacturer/Supplier

PeroxyChem LLC
2005 Market Street
Suite 3200
Philadelphia, PA 19103
267/422-2400 (General Information)
sdsinfo-pxc@evonik.com (E-Mail General Information)

Emergency telephone numbers

For leak, fire, spill or accident emergencies, call:
1 800 / 424 9300 (CHEMTREC - U.S.A.)
1 703 / 527 3887 (CHEMTREC - Collect - All Other Countries)
+1 303/ 389-1409 (Medical - U.S. - Call Collect)

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status
This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200)

Combustible dust

GHS Label elements, including precautionary statements

EMERGENCY OVERVIEW

Warning

Hazard Statements
May form combustible dust concentrations in air

Precautionary Statements - Prevention
Dry or powdered ingredients are combustible. Dispersal of finely divided dust from products into air may form mixtures that are ignitable or explosive. Minimize airborne dust generation and eliminate sources of ignition.

Hazards not otherwise classified (HNOC)
No hazards not otherwise classified were identified.

Other Information
CONTAINMENT HAZARD: Any vessel that contains wet EHC must be vented due to potential pressure build up from fermentation gases

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical name	CAS-No	Weight %
Iron	7439-89-6	25 - 50
Organic amendment	Proprietary	50 - 75
Soybean oil	8001-22-7	2
Viscosity modifier	Proprietary	0 - 4

4. FIRST AID MEASURES

Eye Contact In case of contact, immediately flush eyes with plenty of water. If irritation persists, call a physician.

Skin Contact Wash skin with soap and water.

Inhalation Remove person to fresh air. If breathing is difficult or if discomfort occurs and persists, obtain medical attention.

Ingestion Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water and afterwards drink plenty of water or milk. Call a poison control center or doctor immediately for treatment advice.

Most important symptoms and effects, both acute and delayed	Asthma-like and/ or skin allergy-like symptoms.
Indication of immediate medical attention and special treatment needed, if necessary	Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media	Dry chemical, CO2, sand, earth, water spray or regular foam.
Unsuitable extinguishing media	Do not use a solid water stream as it may scatter and spread fire.
Specific Hazards Arising from the Chemical	Avoid generating dust; fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.
Flammable properties	Combustible material

Explosion data

Sensitivity to Mechanical Impact	Not sensitive.
Sensitivity to Static Discharge	Not sensitive.
Protective equipment and precautions for firefighters	As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions	Avoid dust formation. Avoid dispersal of dust in the air (i.e., cleaning dust surfaces with compressed air.). For personal protection see Section 8.
Other	Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Use only non-sparking tools.
Environmental Precautions	Recover the product in solid form, if possible. Do not flush into surface water or sanitary sewer system.
Methods for Containment	Cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.
Methods for cleaning up	Sweep or vacuum up spillage and return to container. The waste may be recovered and recycled.

7. HANDLING AND STORAGE

Handling	Minimize dust generation and accumulation. Use only non-sparking tools. Remove all sources of ignition. Refer to Section 8.
Storage	Keep in a dry, cool and well-ventilated place. Keep away from open flames, hot surfaces and sources of ignition. Any vessel that contains wet EHC® must be vented due to potential pressure build up from fermentation gases.
Incompatible products	Strong acids. Oxidizing agents

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines	This product, as supplied, does not contain any hazardous materials with occupational exposure limits established by the region specific regulatory bodies. Local nuisance dust standards apply.

Appropriate engineering controls

Engineering measures It is recommended that all dust control equipment such as local exhaust ventilation and material transport systems involved in the handling of this product contain explosion relief vents or an explosion suppression or an oxygen-deficient environment. Ensure that dust-handling systems (such as exhaust ducts, dust collectors, vessels, and processing equipment) are designed in a manner to prevent the escape of dust into the work area (i.e., there is no leakage from the equipment). Use only appropriately classified electrical equipment and powered industrial trucks.

Individual protection measures, such as personal protective equipment

Eye/Face Protection Safety glasses with side-shields.

Skin and Body Protection Wear suitable protective clothing. Protective shoes or boots.

Hand Protection Use gloves if extended exposure is anticipated Neoprene gloves

Respiratory Protection Whenever dust in the worker's breathing zone cannot be controlled with ventilation or other engineering means, workers should wear respirators or dust masks approved by NIOSH/MSHA, EU CEN or comparable organization to protect against airborne dust.

Hygiene measures Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	Flakes
Physical State	Solid
Color	Brown, Tan
Odor	odorless
Odor threshold	Not applicable
pH	5.6 (as aqueous solution)
Melting point/freezing point	Decomposes
Boiling Point/Range	Not applicable
Flash point	Not applicable
Evaporation Rate	No information available
Flammability (solid, gas)	Combustible material
Flammability Limit in Air	
Upper flammability limit:	No information available
Lower flammability limit:	No information available
Vapor pressure	No information available
Vapor density	No information available
Density	No information available
Specific gravity	No information available
Water solubility	practically insoluble
Solubility in other solvents	No information available
Partition coefficient	No information available
Autoignition temperature	No information available
Decomposition temperature	No information available
Viscosity, kinematic	No information available (Solid)
Viscosity, dynamic	No information available
Explosive properties	Low level dust explosion hazard
K_{st}	19 bar-m/sec: St1 Class dust
Oxidizing properties	No information available

Other Information

Molecular weight	No information available

Bulk density 0.50 - 0.80 mg/l 31.2 - 49.9 lb/cu ft

10. STABILITY AND REACTIVITY

Reactivity None under normal use conditions.

Chemical Stability Stable.

Possibility of Hazardous Reactions May react with water to release flammable hydrogen gas.

Hazardous polymerization Hazardous polymerization does not occur.

Conditions to avoid Heat, flames and sparks.

Incompatible materials Strong acids. Oxidizing agents.

Hazardous Decomposition Products Burning produces obnoxious and toxic fumes.

11. TOXICOLOGICAL INFORMATION

Product Information

LD50 Oral Iron: 98.6 g/kg (rat)
LD50 Dermal No information available
LC50 Inhalation Iron: > 100 mg/m^3 6 hr (rat)

Serious eye damage/eye irritation May cause slight irritation.
Skin corrosion/irritation May cause slight irritation.

Sensitization May cause sensitization by inhalation.

Chemical name	LD50 Oral	LD50 Dermal	LC50 Inhalation	NOAEL Oral Value
Iron (7439-89-6)	98600 mg/kg (Rat)			
Viscosity modifier ()	6770 mg/kg (Rat)			

Information on toxicological effects

Symptoms Inhalation of dust may cause shortness of breath, tightness of the chest, a sore throat and cough.

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation May cause irritation.
Chronic toxicity No known chronic effects of components present at greater than 1%.

Carcinogenicity Contains no ingredient listed as a carcinogen.

Mutagenicity No known mutagenic or teratogenic effects.

Neurological effects Not neurotoxic

Reproductive toxicity This product does not contain any known or suspected reproductive hazards.
Developmental toxicity Not a reproductive hazard.

STOT - single exposure No information available.
STOT - repeated exposure No information available.

Aspiration hazard No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Ecotoxicity effects Contains no substances known to be hazardous to the environment or that are not degradable in waste water treatment plants

Chemical name	Toxicity to algae	Toxicity to fish	Toxicity to Microorganisms	Toxicity to daphnia and other aquatic invertebrates
Iron		96 h LC50: = 13.6 mg/L (Morone saxatilis) static		48 h Daphnia magna EC50 = 8934.78 mg/l

Persistence and degradability No data is available on the product itself. The organic components are biodegradable and can be expected to contribute to BOD.

Bioaccumulation Does not bioaccumulate.

Mobility Is not likely mobile in the environment due its low water solubility.

Other Adverse Effects None known.

13. DISPOSAL CONSIDERATIONS

Waste disposal methods Recovery/recycling recommended. Dispose of in accordance with local regulations.

Contaminated Packaging Empty remaining contents. Dispose of in accordance with local regulations.

14. TRANSPORT INFORMATION

DOT NOT REGULATED

15. REGULATORY INFORMATION

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories
This product has the following hazards that are reportable under The Emergency Planning and Community Right-to-Know rule (EPCRA Tier II):

• Combustible dust

Clean Water Act
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA/EPCRA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

CWC (Chemical Weapons Convention) - Annex on Chemicals Not applicable

US State Regulations

U.S. State Right-to-Know Regulations
This product contains the following substances regulated under state Right-to-Know laws:

Chemical name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Soybean oil			X		

California Proposition 65
This product does not contain any Proposition 65 chemicals

CANADA

Environmental Emergencies
This product contains no substances listed under Canada's Environmental Emergency regulations.

Canadian National Pollutant Release Inventory
This product contains no substances reportable under Canada's National Pollutant Release Inventory regulations.

International Inventories

Chemical name	TSCA (United States)	DSL (Canada)	EINECS/ELINCS (Europe)	ENCS (Japan)	China (IECSC)	KECL (Korea)	PICCS (Philippines)	AICS (Australia)	NZIoC (New Zealand)
Iron 7439-89-6	X	X	231-096-4	X	X	X	X	X	X
Organic amendment		X	281-689-7		X		X	X	X
Viscosity modifier	X	X	232-536-8	X	X	X	X	X	X

All ingredients are directly listed on the active TSCA Inventory

Mexico

Mexico - Grade Slight risk, Grade 1

16. OTHER INFORMATION

NFPA	**Health Hazards** 1	**Flammability** 1	**Stability** 0	**Special Hazards** -
HMIS	**Health Hazards** 1	**Flammability** 1	**Physical hazard** 0	**Personal Protection** -

NFPA/HMIS Ratings Legend Severe = 4; Serious = 3; Moderate = 2; Slight = 1; Minimal = 0

References	Refer to NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* , for safe handling.
Revision date:	2021-02-08
Revision note	SDS sections updated: 1.
Issuing Date:	2018-02-02

Disclaimer

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Prepared By:

PeroxyChem

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End of Safety Data Sheet

Environmental Solutions

GeoForm™ BIOGEOCHEMICAL REAGENTS

Product Sheet

GeoForm™ Biogeochemical Reagents are engineered to deliver the building blocks needed to promote *in situ* biogeochemical reactions. GeoForm™ provides a source of sulfate, ferrous iron, electron donors, pH buffer, and nutrients to promote mechanisms for dehalogenation via enhanced anaerobic bioremediation, abiotic degradation, and the formation of reactive minerals. The component ratios have been optimized to maximize the formation of reactive iron sulfide minerals that provide an expanded surface area for abiotic degradation pathways. In addition, the amount of electron donor can be adjusted based on site specific geochemistry. GeoForm™ can be used for the treatment of groundwater and saturated soil impacted by persistent halogenated compounds and will also immobilize many heavy metals.

Key Benefits

- Multiple mechanisms for contaminant degradation
- Promotes higher reaction rates
- Treats mixed plumes with CVOCs and heavy metals
- Improved distribution properties / reactive surface area
- Minimal generation of daughter products
- Improved longevity
- pH balanced

GeoForm™ Formulations and Applications

GeoForm is available in two formulations – a fully soluble formulation for ease of injection and a solid formulation for extended release.

GeoForm™ Soluble:

- Formulated to deliver as a fully soluble dry powder in two parts:
  - GeoForm™ Soluble Mix – a proprietary blend of sulfate and ferrous iron
  - ELS® Dry Concentrate – a powdered concentrate version of our ELS® Microemulsion organic carbon substrate
- Remains fully in solution during mixing and injection
- Ideal for plume and hot-spot treatment
- Longevity of 2-3 years
- Application via injection wells, infiltration networks or direct push

GeoForm™ Extended Release:

- Formulated with a long-lasting source of hydrogen donor and zero valent iron (ZVI) for continued rejuvenation of iron sulfide minerals
- Ideal for Permeable Reactive Barrier (PRB) and source area treatment
- Longevity of 5-10 years
- Application via direct push, hydraulic or pneumatic fracturing or soil mixing

Environmental Solutions

GeoForm™ BIOGEOCHEMICAL REAGENTS

Product Sheet

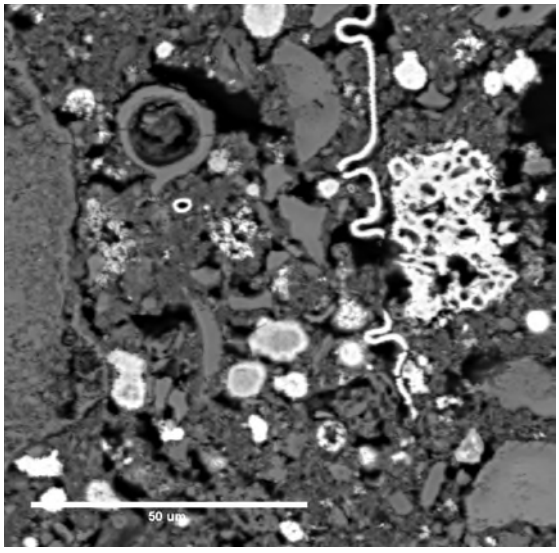
GeoForm™ Treatment Mechanisms

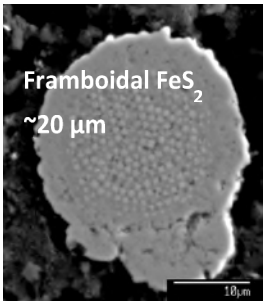
GeoForm™ rapidly creates reducing conditions by promoting both biotic and abiotic reduction mechanisms. The organic carbon serves as an electron donor for dechlorinating bacteria; stimulating biological reductive dechlorination. Under sulfate reducing conditions, the creation of reactive iron sulfide minerals will provide an expanded area for abiotic dehalogenation reactions. GeoForm™ Extended Release also promotes direct chemical reduction in contact with ZVI.

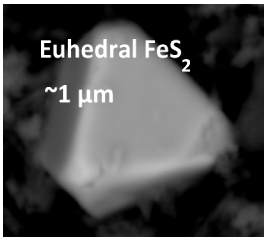
	Composition	Treatment Mechanisms		
		Biotic Reduction	Abiotic Reduction	
			Reductive Minerals	ZVI
GeoForm™ Soluble	Soluble Sulfate and Ferrous Iron Mix added to an Emulsified Organic Carbon Substrate	●	●	
GeoForm™ Extended Release	Extended Release Organic Carbon, Sulfate, Ferrous Iron, Micro-Scale ZVI	●	●	●

An Expanded Abiotic Treatment Zone

A key attribute of GeoForm™ is the creation of an expanded treatment zone for abiotic dehalogenation. While abiotic degradation in contact with ZVI is going to be limited to the ZVI particle surface interface, the reductive mineral zone created by GeoForm™ may extend a significant distance downgradient from the placement zone. GeoForm™ releases dissolved iron and sulfate which will diffuse in to the surrounding soil matrix and transport with groundwater flow. Once reducing conditions have been established, sulfate reducing bacteria will reduce the sulfate to sulfide which will co-precipitate with ferrous iron and coat the soil with reactive iron sulfide minerals. This increases the surface area for abiotic degradation beyond the area of application and solves an important limitation of traditional ISCR reagents. Furthermore, the iron sulfide zone may be continuously replenished from low levels of organic carbon or hydrogen, thereby acting as an electron shuttle for continued abiotic reduction. The main reaction pathway is via beta-elimination, limiting the generation of daughter products.







	Particle Size (µm)	Surface Area (m^2/kg)
Micro-Scale ZVI	50-250	~5-30
Framboidal Pyrite	20	~10
FeS Coatings	3	~80
Euhedral Pyrite	1	>200

Electron microprobe analyses performed on iron sulfide precipitation products estimated that 4.1 ft^2 of very reactive surface area was generated per liter of groundwater with 3,000 mg/L sulfate reduced to an estimated 3 µm thick FeS precipitate (Leigh et al).

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SAFETY DATA SHEET
GeoForm™ Soluble Mix

SDS # : BGCBS2
Revision date: 2021-02-19
Format: NA
Version 1.02

1. PRODUCT AND COMPANY IDENTIFICATION

Product Identifier

Product Name GeoForm™ Soluble Mix

Recommended use of the chemical and restrictions on use

Recommended Use: Remediation of contaminated soil and groundwater

Restrictions on Use Not for direct treatment of potable drinking water.

Manufacturer/Supplier

PeroxyChem LLC
2005 Market Street
Suite 3200
Philadelphia, PA 19103
Phone: +1 267/ 422-2400 (General Information)
E-Mail: sdsinfo-pxc@evonik.com

Emergency telephone numbers

For leak, fire, spill or accident emergencies, call:
1 800 / 424 9300 (CHEMTREC - U.S.A.)
1 703 / 527 3887 (CHEMTREC - Collect - All Other Countries)
+1 303/ 389-1409 (Medical - U.S. - Call Collect)

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status

This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Acute toxicity - Oral	Category 4
Skin corrosion/irritation	Category 2
Serious eye damage/eye irritation	Category 2
Combustible dust	

GHS Label elements, including precautionary statements

EMERGENCY OVERVIEW

Warning

Hazard Statements
H302 - Harmful if swallowed
H315 - Causes skin irritation
H319 - Causes serious eye irritation
May form combustible dust concentrations in air

Precautionary Statements - Prevention
P280 - Wear protective gloves and eye/face protection
P264 - Wash hands thoroughly after handling
P270 - Do not eat, drink or smoke when using this product
Dry or powdered ingredients are combustible. Dispersal of finely divided dust from products into air may form mixtures that are ignitable or explosive. Minimize airborne dust generation and eliminate sources of ignition.

P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/ attention
P302 + P352 - IF ON SKIN: Wash with plenty of water and soap
P332 + P313 - If skin irritation occurs: Get medical advice/ attention
P362 - Take off contaminated clothing and wash before reuse
P301 + P312 - IF SWALLOWED: Call a POISON CENTER or doctor if you feel unwell
P330 - Rinse mouth

Precautionary Statements - Disposal
P501 - Dispose of contents/ container to an approved waste disposal plant

Hazards not otherwise classified (HNOC)

No hazards not otherwise classified were identified.

Other Information

CONTAINMENT HAZARD: Any vessel that contains wet product must be vented due to potential pressure build up from gases.

Unknown acute toxicity
0% of the mixture consists of ingredient(s) of unknown toxicity

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical name	CAS-No	Weight %
Ferrous Sulfate Monohydrate	17375-41-6	30 - 35
Trade secret	Proprietary	5 - 10
Organic salt	Proprietary	50 - 55
Inorganic salt	Proprietary	5 - 10

4. FIRST AID MEASURES

Eye Contact
Hold eyes open and rinse slowly and gently with water for 15 to 20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for further treatment advice.

Skin Contact
Take off contaminated clothing. Wash off immediately with soap and plenty of water for at least 15 minutes. Get medical attention if irritation develops and persists. Wash contaminated clothing before reuse.

Inhalation
Move victim to fresh air. If breathing difficulty or discomfort occurs and persists, obtain medical attention.

Ingestion
Rinse mouth with water and afterwards drink plenty of water or milk. Get medical attention if symptoms occur.

Most important symptoms and effects, both acute and delayed
Causes serious eye irritation. May cause skin irritation. Inhalation of dust in high concentration may cause irritation of respiratory system.

Indication of immediate medical attention and special treatment needed, if necessary
Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media
Carbon dioxide (CO_2). Dry chemical. Water spray. Foam.

Specific Hazards Arising from the Chemical
Fine dust dispersed in air, in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Flammable properties
Combustible material

Hazardous Combustion Products
Oxides of sulfur. Carbon monoxide.

Explosion data
Sensitivity to Mechanical Impact
Not sensitive.
Sensitivity to Static Discharge
Fine dust dispersed in air, in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Protective equipment and precautions for firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions Avoid dust formation. Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Avoid contact with eyes. Use personal protective equipment. For personal protection see Section 8.

Other For further clean-up instructions, call PeroxyChem Emergency Hotline number listed in Section 1 "Product and Company Identification" above.

Environmental Precautions Local authorities should be advised if significant spillages cannot be contained.

Methods for Containment Maintain good housekeeping practices to avoid accumulation of settled dust, especially on overhead surfaces. Cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.

Methods for cleaning up Pick up and transfer to properly labeled containers. Take precautionary measures against static discharges. Avoid wetting dust and clean up as a dry powder with appropriate PPE for handling dry dusty materials; store in containers that keep material dry, segregated but allow to vent. The waste may be recovered and recycled.

7. HANDLING AND STORAGE

Handling Avoid contact with eyes. Avoid breathing dust. Wash thoroughly after handling. Wear personal protective equipment. Refer to Section 8. Minimize dust generation and accumulation. Keep away from open flames, hot surfaces and sources of ignition. Dry powdered material can build static electricity when subjected to the friction of transfer and mixing operations. Provide adequate precautions, such as electrical grounding and bonding, or inert atmosphere.

Storage Store in a well-ventilated place. Keep cool. Keep away from open flames, hot surfaces and sources of ignition. Any vessel that contains wet product must be vented due to potential pressure build up from gases.

Incompatible products Oxidizing agents. Strong acids. Strong bases.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines .

Chemical name	ACGIH TLV	OSHA PEL	NIOSH	Mexico
Ferrous Sulfate Monohydrate 17375-41-6	TWA: 1 mg/m³	-	-	-
Chemical name	**British Columbia**	**Quebec**	**Ontario TWAEV**	**Alberta**
Ferrous Sulfate Monohydrate 17375-41-6	TWA: 1 mg/m³	TWA: 1.0 mg/m³	TWA: 1 mg/m³	TWA: 1 mg/m³

Appropriate engineering controls

Engineering measures Provide appropriate exhaust ventilation at places where dust is formed. Use grounding and bonding of dry handling equipment for pneumatics or free falling powder during processing in enclosed systems. Use only appropriately classified electrical equipment and powered industrial trucks. and.

Individual protection measures, such as personal protective equipment

Eye/Face Protection Whenever airborn dust concentrations are high, appropriate protective eyewear, such as

mono-goggles, should be worn to prevent eye contact. Chemical goggles consistent with EN 166 or equivalent.

Skin and Body Protection Wear suitable protective clothing. Protective shoes or boots.

Hand Protection Protective gloves EN374: Rubber gloves, Nitrile rubber, PVC.

Respiratory Protection Whenever dust in the worker's breathing zone cannot be controlled with ventilation or other engineering means, workers should wear respirators or dust masks approved by NIOSH/MSHA, EU CEN or comparable organization to protect against airborne dust.

Hygiene measures Must have clean water available for washing in case of eye or skin contamination. Wash skin before eating, drinking, chewing gum, or using snuff. Shower after work. Remove contaminated clothing and wash before reuse. Wash all work clothing separately; do not mix with household laundry.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	Light-tan powder
Physical State	Solid
Color	Light tan
Odor	odorless
Odor threshold	Not applicable
pH	6.84 (1% solution)
Melting point/freezing point	No information available
Boiling Point/Range	No information available
Flash point	No information available
Evaporation Rate	No information available
Flammability (solid, gas)	Combustible material
Flammability Limit in Air	
Upper flammability limit:	No information available
Lower flammability limit:	No information available
Vapor pressure	No information available
Vapor density	No information available
Density	No information available
Specific gravity	No information available
Water solubility	Soluble in water
Solubility in other solvents	No information available
Partition coefficient	No information available
Autoignition temperature	No information available
Decomposition temperature	No information available
Viscosity, kinematic	Not applicable (Solid)
Viscosity, dynamic	No information available
Explosive properties	Low level dust explosion hazard
K_{st}	St1 Class dust
Oxidizing properties	No information available

Other Information

Molecular weight	No information available
Bulk density	= 0.99 g/cm³ (loose) / 1.15 g/cm³ (tapped)

10. STABILITY AND REACTIVITY

Reactivity None under normal use conditions.

Chemical Stability Stable under recommended storage conditions.

Possibility of Hazardous Reactions Avoid generating dust; fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard. Product may form by-products during processing which can be toxic or potentially explosive such as hydrogen, hydrogen sulfide and carbon monoxide.

Hazardous polymerization Hazardous polymerization does not occur.

Conditions to avoid Heat, flames and sparks.

Incompatible materials Oxidizing agents. Strong acids. Strong bases.

Hazardous Decomposition Products Thermal decomposition can lead to release of irritating and toxic gases and vapors: Sulfur oxides, Hydrogen sulfide, Hydrogen gas, Carbon oxides (COx), Calcium oxides, Potassium oxides.

11. TOXICOLOGICAL INFORMATION

Product Information

No acute toxicity information is available for this product. Data is for major component in product. May be harmful if swallowed. Irritating to eyes and skin.

Unknown acute toxicity 0% of the mixture consists of ingredient(s) of unknown toxicity

LD50 Oral > 670 319 (mouse, 4-hr) (iron sulfate monohydrate)
LD50 Dermal No information available
LC50 Inhalation No information available

Serious eye damage/eye irritation Irritating to eyes.
Skin corrosion/irritation Irritating to skin.

Sensitization Not expected to be sensitizing based on the components.

Component Information

Chemical name	LD50 Oral	LD50 Dermal	LC50 Inhalation	NOAEL Oral Value
Trade secret ()	= 5680 mg/kg (Rat)		> 22 mg/L (Rat) 1 h	

Information on toxicological effects

Symptoms Dust is irritating eyes, nose, throat, and lungs.

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Chronic toxicity Chronic exposure to dust at concentrations exceeding occupational exposure limits may cause pneumoconosis (lung disease).

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Chemical name	ACGIH	IARC	NTP	OSHA
Trade secret		Group 3		

IARC (International Agency for Research on Cancer) — *Group 3 - Not classifiable as to its carcinogenicity to humans*

Mutagenicity This product is not recognized as mutagenic by Research Agencies

Reproductive toxicity This product is not recognized as reprotox by Research Agencies.

STOT - single exposure None known.
STOT - repeated exposure None known.

Target organ effects Eyes, Skin, Respiratory System.

Aspiration hazard Not applicable.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Ecotoxicity effects Ecotoxicity effects of component substances

Chemical name	Toxicity to algae	Toxicity to fish	Toxicity to Microorganisms	Toxicity to daphnia and other aquatic invertebrates
Trade secret		96 h LC50: 220 - 460 mg/L (Leuciscus idus) static		24 h LC50: = 330 mg/L (Psammechinus miliaris)

Persistence and degradability The organic components are biodegradable and can be expected to contribute to BOD. Biodegradability does not pertain to inorganic substances.

Bioaccumulation Bioaccumulation is unlikely.

Mobility No information available.

Other Adverse Effects None known.

13. DISPOSAL CONSIDERATIONS

Waste disposal methods This material, as supplied, is not a hazardous waste according to Federal regulations (40 CFR 261). This material could become a hazardous waste if it is mixed with or otherwise comes in contact with a hazardous waste, if chemical additions are made to this material, or if the material is processed or otherwise altered. Consult 40 CFR 261 to determine whether the altered material is a hazardous waste. Consult the appropriate state, regional, or local regulations for additional requirements. Recovery/recycling recommended.

Contaminated Packaging Dispose of in accordance with local regulations.

14. TRANSPORT INFORMATION

DOT NOT REGULATED

TDG NOT REGULATED

15. REGULATORY INFORMATION

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories
This product has the following hazards that are reportable under The Emergency Planning and Community Right-to-Know rule (EPCRA Tier II):

- Acute toxicity
- Serious eye damage/eye irritation
- Skin corrosion/irritation
- Combustible dust

Clean Water Act
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA/EPCRA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

CWC (Chemical Weapons Convention) - Annex on Chemicals Not applicable

US State Regulations

U.S. State Right-to-Know Regulations
This product does not contain any substances regulated under applicable state right-to-know regulations

California Proposition 65
This product does not contain any Proposition 65 chemicals

CANADA

Environmental Emergencies
This product contains no substances listed under Canada's Environmental Emergency regulations.

Canadian National Pollutant Release Inventory
This product contains no substances reportable under Canada's National Pollutant Release Inventory regulations.

International Inventories

Chemical name	TSCA (United	DSL (Canada)	EINECS/ELINCS	ENCS (Japan)	China (IECSC)	KECL (Korea)	PICCS (Philippines)	AICS (Australia)	NZIoC (New

	States)		(Europe)						Zealand)
Ferrous Sulfate Monohydrate 17375-41-6		H	H	X	H	H	H	X	X
Trade secret	X	X	231-821-4	X	X	X	X	X	X
Organic salt		H	H	X	X	H	X	X	X
Inorganic salt	X	X	205-633-8	X	X	X	X	X	X

All ingredients are directly listed on the active TSCA Inventory

Mexico

Mexico - Grade Slight risk, Grade 1

16. OTHER INFORMATION

NFPA	**Health Hazards** 1	**Flammability** 1	**Stability** 0	**Special Hazards** -
HMIS	**Health Hazards** 1	**Flammability** 1	**Physical hazard** 0	**Personal Protection** -

NFPA/HMIS Ratings Legend Severe = 4; Serious = 3; Moderate = 2; Slight = 1; Minimal = 0

References Refer to NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids* , for safe handling.

Revision date: 2021-02-19
Revision note SDS sections updated: 1.

Issuing Date: 2021-02-19

Disclaimer

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Prepared By:

PeroxyChem
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End of Safety Data Sheet

SAFETY DATA SHEET
GeoForm™ Extended Release

SDS # : GEOS
Revision date: 2021-02-18
Format: NA
Version 1.01

1. PRODUCT AND COMPANY IDENTIFICATION

Product Identifier

Product Name GeoForm™ Extended Release

Recommended use of the chemical and restrictions on use

Recommended Use: Remediation of contaminated soil and groundwater

Restrictions on Use Use as recommended by the label.

Manufacturer/Supplier

PeroxyChem LLC
2005 Market Street
Suite 3200
Philadelphia, PA 19103
267/422-2400 (General Information)
sdsinfo-pxc@evonik.com (E-Mail General Information)

Emergency telephone numbers

For leak, fire, spill or accident emergencies, call:
1 800 / 424 9300 (CHEMTREC - U.S.A.)
1 703 / 527 3887 (CHEMTREC - Collect - All Other Countries)
+1 303/ 389-1409 (Medical - U.S. - Call Collect)

2. HAZARDS IDENTIFICATION

Classification

OSHA Regulatory Status
This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200) and the 2015 Workplace Hazardous Materials Information System (WHMIS)

Skin corrosion/irritation	Category 2
Serious eye damage/eye irritation	Category 2
Combustible dust	

GHS Label elements, including precautionary statements

EMERGENCY OVERVIEW

Warning

Hazard Statements
May form combustible dust concentrations in air
H315 - Causes skin irritation
H319 - Causes serious eye irritation

Precautionary Statements - Prevention
P264 - Wash hands thoroughly after handling
P280 - Wear protective gloves and eye/face protection
Keep away from all ignition sources including heat,sparks and flame.
Keep container closed and grounded.
Prevent dust accumulations to minimize explosion hazard.

P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/ attention
P302 + P352 - IF ON SKIN: Wash with plenty of water.
P332 + P313 - If skin irritation occurs: Get medical advice/ attention

Hazards not otherwise classified (HNOC)

No hazards not otherwise classified were identified.

Other Information

CONTAINMENT HAZARD: Any vessel that contains wet product must be vented due to potential pressure build up from gases.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical name	CAS-No	Weight %
Ferrous Sulfate Monohydrate	17375-41-6	10 - 15
Iron	7439-89-6	40 - 50
Organic amendment	Proprietary	20 - 30%
Starch	Proprietary	< 10

4. FIRST AID MEASURES

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. If irritation persists, call a physician.

Skin Contact Wash off with warm water and soap. In the case of skin irritation or allergic reactions see a physician.

Inhalation Remove person to fresh air. If breathing is difficult or if discomfort occurs and persists, obtain medical attention.

Ingestion Clean mouth with water and afterwards drink plenty of water. Get medical attention if symptoms occur.

Most important symptoms and effects, both acute and delayed May cause skin and eye irritation.

Indication of immediate medical attention and special treatment needed, if necessary Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media Carbon dioxide (CO_2). Dry chemical. Water spray. Foam.

Specific Hazards Arising from the Chemical Fine dust dispersed in air, in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Flammable properties Not combustible

Hazardous Combustion Products Oxides of sulfur. Carbon monoxide.

Explosion data
Sensitivity to Mechanical Impact Not sensitive.
Sensitivity to Static Discharge Fine dust dispersed in air, in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.

Protective equipment and precautions for firefighters As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautions Avoid contact with eyes. Use personal protective equipment. For personal protection see Section 8. Avoid dust formation. Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area).

Other For further clean-up instructions, call PeroxyChem Emergency Hotline number listed in Section 1 "Product and Company Identification" above.

Environmental Precautions Prevent entry into waterways, sewers, basements or confined areas.

Methods for Containment Maintain good housekeeping practices to avoid accumulation of settled dust, especially on overhead surfaces. Cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.

Methods for cleaning up Pick up and transfer to properly labeled containers. Take precautionary measures against static discharges. Avoid wetting dust and clean up as a dry powder with appropriate PPE for handling dry dusty materials; store in containers that keep material dry, segregated but allow to vent. The waste may be recovered and recycled.

7. HANDLING AND STORAGE

Handling Avoid contact with eyes. Avoid breathing dust. Wear personal protective equipment. Refer to Section 8. Minimize dust generation and accumulation. Keep away from open flames, hot surfaces and sources of ignition. Dry powdered material can build static electricity when subjected to the friction of transfer and mixing operations. Provide adequate precautions, such as electrical grounding and bonding, or inert atmosphere.

Storage Store in a well-ventilated place. Keep cool. Keep away from open flames, hot surfaces and sources of ignition. Any vessel that contains wet product must be vented due to potential pressure build up from gases.

Incompatible products Oxidizing agents. Strong acids. Strong bases.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Control parameters

Exposure Guidelines .

Chemical name	ACGIH TLV	OSHA PEL	NIOSH	Mexico
Ferrous Sulfate Monohydrate 17375-41-6	TWA: 1 mg/m³	-	-	-
salt	TWA: 10 mg/m³	-	-	Mexico: TWA 10 mg/m³

Chemical name	British Columbia	Quebec	Ontario TWAEV	Alberta
Ferrous Sulfate Monohydrate 17375-41-6	TWA: 1 mg/m³	TWA: 1.0 mg/m³	TWA: 1 mg/m³	TWA: 1 mg/m³
salt	TWA: 10 mg/m³	-	TWA: 10 mg/m³ inhalable	-

Appropriate engineering controls

Engineering measures Adequate engineering controls and/or personal protective equipment must be used to prevent contact with skin and eyes. Provide emergency on-site eyewash. Provide appropriate exhaust ventilation at places where dust is formed. Use grounding and bonding of dry handling equipment for pneumatics or free falling powder during processing in

enclosed systems. Use only appropriately classified electrical equipment and powered industrial trucks.

Individual protection measures, such as personal protective equipment

Eye/Face Protection Whenever airborn dust concentrations are high, appropriate protective eyewear, such as mono-goggles, should be worn to prevent eye contact.

Skin and Body Protection Wear suitable protective clothing. Protective shoes or boots.

Hand Protection Wear suitable gloves (tested to EN374): Nitrile rubber, Rubber/latex/neoprene or other suitable chemical resistant gloves.

Respiratory Protection Whenever dust in the worker's breathing zone cannot be controlled with ventilation or other engineering means, workers should wear respirators or dust masks approved by NIOSH/MSHA, EU CEN or comparable organization to protect against airborne dust.

Hygiene measures Do not eat, drink or smoke when using this product. Must have clean water available for washing in case of eye or skin contamination. Wash skin before eating, drinking, chewing gum, or using snuff. Shower after work. Remove contaminated clothing and wash before reuse. Wash all work clothing separately; do not mix with household laundry.

9. PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

Appearance	Brown Powder
Physical State	Solid
Color	Brown
Odor	Nearly odorless
Odor threshold	Not applicable
pH	6 - 8
Melting point/freezing point	No information available
Boiling Point/Range	No information available
Flash point	No information available
Evaporation Rate	No information available
Flammability (solid, gas)	Combustible material
Flammability Limit in Air	
Upper flammability limit:	No information available
Lower flammability limit:	No information available
Vapor pressure	No information available
Vapor density	No information available
Density	No information available
Specific gravity	No information available
Water solubility	Insoluble in water
Solubility in other solvents	No information available
Partition coefficient	No information available
Autoignition temperature	No information available
Decomposition temperature	No information available
Viscosity, kinematic	Not applicable (Solid)
Viscosity, dynamic	Not applicable
Explosive properties	Low level dust explosion hazard
Oxidizing properties	Not applicable

Other Information

Molecular weight No information available

0.92 g/cm³ (loose) / 1.13 g/cm³ (tapped)

10. STABILITY AND REACTIVITY

Reactivity None under normal use conditions.

Chemical Stability Stable under recommended storage conditions.

Possibility of Hazardous Reactions Avoid generating dust; fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard. Product may form by-products during processing which can be toxic or potentially explosive such as hydrogen, hydrogen sulfide and carbon monoxide.

Hazardous polymerization Hazardous polymerization does not occur.

Conditions to avoid Heat, flames and sparks.

Incompatible materials Oxidizing agents. Strong acids. Strong bases.

Hazardous Decomposition Products Thermal decomposition can lead to release of irritating and toxic gases and vapors: Hydrogen sulfide, Hydrogen gas, Sulfur oxides, Carbon oxides (COx),

11. TOXICOLOGICAL INFORMATION

Product Information

Product does not present an acute toxicity hazard based on known information.

LD50 Oral Iron Salt: > 670 mg/kg (mouse, 4-hr)
LD50 Dermal No information available
LC50 Inhalation No information available

Serious eye damage/eye irritation Irritating to eyes.
Skin corrosion/irritation Irritating to skin.

Sensitization Not expected to be sensitizing based on the components.

Chemical name	LD50 Oral	LD50 Dermal	LC50 Inhalation	NOAEL Oral Value
Iron (7439-89-6)	98600 mg/kg (Rat)			
Trade secret ()	= 8500 mg/kg (Rat)			
Viscosity modifier ()	6770 mg/kg (Rat)			

Information on toxicological effects

Symptoms No information available.

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Carcinogenicity Contains no ingredients above reportable quantities listed as a carcinogen.

Mutagenicity No known mutagenic or teratogenic effects.

Reproductive toxicity This product does not contain any known or suspected reproductive hazards.

STOT - single exposure No information available.
STOT - repeated exposure No information available.

Aspiration hazard No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity

Ecotoxicity effects Not expected to have significant environmental effects

Chemical name	Toxicity to algae	Toxicity to fish	Toxicity to Microorganisms	Toxicity to daphnia and other aquatic invertebrates
Iron		96 h LC50: = 13.6 mg/L (Morone saxatilis) static		48 h Daphnia magna EC50 = 8934.78 mg/l
Trade secret		96 h LC50: 220 - 460 mg/L (Leuciscus idus) static		24 h LC50: = 330 mg/L (Psammechinus miliaris)
Magnesium Hydroxide		96 h LC50: = 511.31 mg/L (Pimephales promelas) static		

Persistence and degradability The organic components are biodegradable and can be expected to contribute to BOD. Biodegradability does not pertain to inorganic substances.

Bioaccumulation Bioaccumulation is unlikely.

Mobility No information available.

Other Adverse Effects None known.

13. DISPOSAL CONSIDERATIONS

Waste disposal methods This material, as supplied, is not a hazardous waste according to Federal regulations (40 CFR 261). This material could become a hazardous waste if it is mixed with or otherwise comes in contact with a hazardous waste, if chemical additions are made to this material, or if the material is processed or otherwise altered. Consult 40 CFR 261 to determine whether the altered material is a hazardous waste. Consult the appropriate state, regional, or local regulations for additional requirements. Recovery/recycling recommended.

Contaminated Packaging Dispose of in accordance with local regulations.

14. TRANSPORT INFORMATION

DOT NOT REGULATED

TDG NOT REGULATED

15. REGULATORY INFORMATION

U.S. Federal Regulations

SARA 313
Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372

SARA 311/312 Hazard Categories
This product is not subject to reporting under the Emergency Planning and Community Right-to-Know rule.

Clean Water Act
This product does not contain any substances regulated as pollutants pursuant to the Clean Water Act (40 CFR 122.21 and 40 CFR 122.42)

CERCLA/EPCRA
This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material

CWC (Chemical Weapons Convention) - Annex on Chemicals Not applicable

US State Regulations

U.S. State Right-to-Know Regulations
This product contains the following substances regulated under state Right-to-Know laws:

Chemical name	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
salt					X
Trade secret			X		

California Proposition 65
This product does not contain any Proposition 65 chemicals

CANADA

Environmental Emergencies
This product contains no substances listed under Canada's Environmental Emergency regulations.

Canadian National Pollutant Release Inventory
This product contains no substances reportable under Canada's National Pollutant Release Inventory regulations.

International Inventories

Chemical name	TSCA (United States)	DSL (Canada)	EINECS/ELINCS (Europe)	ENCS (Japan)	China (IECSC)	KECL (Korea)	PICCS (Philippines)	AICS (Australia)	NZIoC (New Zealand)
Ferrous Sulfate Monohydrate 17375-41-6		H	H	X	H	H	H	X	X
Iron 7439-89-6	X	X	231-096-4	X	X	X	X	X	X
Organic amendment		X	281-689-7		X		X	X	X
salt					X		X	X	X

Starch	X	X	232-940-4	X	X	X	X	X	X

All ingredients are directly listed on the active TSCA Inventory

Mexico

Mexico - Grade Minimum risk, Grade 0

16. OTHER INFORMATION

NFPA	**Health Hazards** 1	**Flammability** 1	**Stability** 0	**Special Hazards** -
HMIS	**Health Hazards** 1	**Flammability** 1	**Physical hazard** 0	**Special precautions** -

Revision date: 2021-02-18
Revision note SDS sections updated, 1.

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End of Safety Data Sheet

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Appendix G

Quality Assurance Project Plan (QAPP)

RACER Trust

Quality Assurance Project Plan

Former GM Delco Plant 5, Kokomo, Indiana

January 14, 2022

Quality Assurance Project Plan

Former GM Delco Plant 5, Kokomo, Indiana

January 14, 2022

Prepared By:
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Attachments

Attachment 1. Organizational Chart
Attachment 2. Field Sampling Standard Operating Procedures
Attachment 3. Laboratory Standard Operating Procedures

Acronyms and Abbreviations

%R	percent recovery
CLP	Contract Laboratory Program
CMI	Corrective Measure Implementation
CMP	Corrective Measure Plan
COC	chain of custody
DQI	data quality indicator
DQO	data quality objective
EDD	electronic data deliverable
GC/MS	gas chromatography/mass spectrometry
HazMat	hazardous material
IDW	investigation-derived waste
ISS	In-Situ Solidification and Stabilization
LCS	laboratory control sample
MCL	Maximum Contaminant Level
MDL	method detection limit
MNA	monitored natural attenuation
MS	matrix spike
MSD	matrix spike duplicate
Order	Administrative Order on Consent
OSHA	Occupational Safety and Health Administration
PID	photoionization detector
PM	Project Manager
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RACER	Revitalizing Auto Communities Environmental Response
RFI	RCRA Facility Investigation
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group

SOP	Standard Operating Procedure
SVOCs	semi-volatile organic compounds
TCLP	toxicity characteristic leaching procedure
TGI	Technical Guidance Instruction
TM	Task Manager
TOC	total organic carbon
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds

Introduction

Arcadis, U.S., Inc. (Arcadis) has prepared this Quality Assurance Project Plan (QAPP) on behalf of Revitalizing Auto Communities Environmental Response (RACER) Trust for the former GM Delco Plant 4 facility located at 1723 North Washington Street, Kokomo, Indiana (the site). The United States Environmental Protection Agency (USEPA) and RACER Trust signed an Administrative Order on Consent (Order, RCRA-05-2011-0017) with an effective date of September 29, 2011. Pursuant to the Order, RACER Trust has worked in cooperation with USEPA to investigate historical releases of hazardous wastes or hazardous constituents at or from the site located in Kokomo, Indiana (USEPA ID IND000806844). The QAPP presents the analytical methods and procedures that will be used for data collection and analysis pertaining to the samples collected during the selected final corrective measures for the site, identified as In-Situ Solidification and Stabilization (ISS) with monitored natural attenuation (MNA) for soil and groundwater.

This QAPP was prepared in a manner consistent with the following reference and guidance documents:

- USEPA Requirements for Quality Assurance Project Plans, EPA-QA/R-5 (USEPA, 2001) (https://www.epa.gov/quality/agency-wide-quality-system-documents);
- USEPA Guidance for Quality Assurance Project Plans, EPA-QA/G-5 (USEPA, 2002) (https://www.epa.gov/quality/agency-wide-quality-system-documents); and
- USEPA Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA-QA/G-4 (USEPA, 2006) (https://www.epa.gov/quality/agency-wide-quality-system-documents).

Information contained in this QAPP has been organized into the following sections:

Section	Content
1. Project Management	
1.1	Distribution List
1.2	Project/Task Organization
1.3	Project Definition/Background
1.4	Project/Task Description
1.5	Quality Objectives and Criteria for Measurement Data
1.6	Special Training Needs/Certification
1.7	Documents and Records
2. Data Generation and Acquisition	
2.1	Sampling Process Design
2.2	Sampling Methods
2.3	Sample Handling and Custody
2.4	Analytical Methods
2.5	Quality Control

Section	Content
2.6	Instrument/Equipment Testing, Inspection, and Maintenance
2.7	Instrument/Equipment Calibration and Frequency
2.8	Inspection/Acceptance of Supplies and Consumables
2.9	Non-Direct Measurements
2.10	Data Management
3. Assessment and Oversight	
3.1	Assessments and Response Actions
3.2	Reports to Management
4. Data Validation and Usability	
4.1	Data Review, Verification, and Validation
4.2	Verification and Validation Methods
4.3	Reconciliation with User Requirements

Details on each of the subjects listed above are provided in the subsequent sections.

1 Project Management

1.1 Distribution List

Copies of the QAPP and any subsequent revisions and/or addenda will be distributed to the individuals listed in the following table.

RACER Trust	Cleanup Manager	Robert Hare	419-277-0815	rhare@racertrust.org
USEPA	Project Manager	Michelle Kaysen	312-886-4253	Kaysen.Michelle@epa.gov
Arcadis	Project Manager	Sarah Fisher	317-236-2813	Sarah.Fisher@arcadis.com
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Pace Analytical (Minneapolis, Minnesota)	Project Manager	Carolynne Trout	612 607 1700	carolynne.trout@pacelabs.com

1.2 Project/Task Organization

The activities to be completed under the Order will require integration of personnel from the organizations identified below, collectively referred to as the project team. An organizational chart is provided as Attachment 1.

The responsibilities of the various team members are summarized below. Arcadis, on behalf of RACER Trust, has overall technical responsibility for site activities. Project direction will be provided by RACER Trust. Arcadis personnel will perform related sampling activities, evaluate data, and prepare the deliverables.

1.2.1 RACER Trust

- Overseeing Arcadis work products
- Providing approval of Arcadis major project deliverables
- Reviewing Arcadis work products

1.2.2 Arcadis

Project Manager (PM)

- Management and coordination of all aspects of the project with an emphasis on adhering to the objectives of the site activities

- Review documents prepared by Arcadis
- Verifying that corrective actions are taken for deficiencies cited during audits of site activities
- Manage relevant day-to-day activities
- Manage project schedule and budget
- Verify that corrective actions are taken for deficiencies cited during audits of relevant site activities
- Coordinate client requests and meetings with project team

Task Manager (TM)

- Managing task specific activities
- Developing, establishing, and maintaining files on relevant site activities
- Reviewing data reductions from relevant site activities
- Performing overall quality assurance (QA)/quality control (QC) of relevant portions of the site activities
- Reviewing relevant field records and logs
- Instructing personnel working on relevant site activities
- Coordinating field and laboratory schedules pertaining to relevant site activities
- Requesting sample bottles from the laboratory
- Reviewing field instrumentation maintenance and calibration to meet quality objectives
- Preparing reports pertaining to relevant site activities
- Maintaining field project files of notebooks/logs, data reductions, and calculations

Field Personnel

- Performing field procedures associated with the investigations
- Performing field analyses and collect QA/QC samples
- Calibrating, operating, and maintaining field equipment
- Reducing field data
- Maintaining sample custody
- Preparing field records and logs

Project Chemist

- Reviewing laboratory data packages
- Overseeing and interfacing with the analytical laboratory
- Reviewing audit reports
- Preparing data validation reports

1.2.3 Analytical Laboratory

Pace Analytical of Indianapolis, Indiana and Minneapolis, Minnesota, will serve as the analytical laboratory for the project. General responsibilities and duties include:

- Performing sample analyses and associated laboratory QA/QC procedures

- Supplying sample bottles and coolers
- Maintaining laboratory custody of samples
- Strictly adhering to all protocols in the QAPP

Laboratory Project Manager

- Primary communication link between Arcadis and laboratory technical staff
- Monitoring workloads and maintaining availability of resources
- Overseeing preparation of analytical reports
- Supervising in-house chain of custody

Quality Assurance Manager

- Supervising laboratory technical staff and inspecting all project-related laboratory activities
- Conducting audits of all laboratory activities

Sample Custodian

- Receiving and inspecting the incoming sample containers
- Recording the condition of the incoming sample containers
- Verifying chain of custody
- Notifying laboratory project manager of sample receipt and inspection discrepancies
- Assigned a unique identification number
- Initiating transfer of samples to lab sections
- Controlling and monitoring access/storage of samples and extracts

Laboratory Technical Personnel

- Sample analysis and execution of the laboratory procedures developed to determine the data quality
- Proper preparation and analysis of project samples in accordance with the laboratory Quality Assurance Manual and Standard Operating Procedures

1.3 Problem Definition/Background

The site is a 10.5 acres property located in Kokomo, Indiana, the county seat of Howard County. The site is bounded by Butler Street to the north, beyond which are residential and industrial properties; by an abandoned industrial property to the south (former Midwest Plating Corporation); a railroad to the west, beyond which are residential and commercial properties; and North Washington Street to the east, beyond which are residential properties.

The property was developed for Apperson Brothers Automobile Company, which manufactured Haynes Automobiles from 1915 to 1926. Wolfe Manufacturing made radio cabinets at the property from 1926 to the late 1930s. Reliance Manufacturing made women's clothing and parachutes during World War II, occupying the property from the later 1930s to 1953. GM Delco manufactured circuit board assemblies from 1953 to 1991.

Demolition of the plant was completed in 1993. The majority of the site is a vacant grass field, with a parking lot and dead-end road in the northern portion of the property and a small concrete pad in the southern portion of the grass field.

RACER Trust and its predecessors have performed investigative work to identify the nature and extent of hazardous waste and/or hazardous constituents at or from the site, results of which are summarized in the RCRA Facility Investigation (RFI) Report (Arcadis 2010). The risk assessment completed during the RFI concluded that there were no potentially significant risks under the current land use and groundwater use, and the only potential future risk was from potential vapor intrusion from a future building over five soil boring locations (SB-0746, SB-0749, SB-0756, SB-0757, and SB-0775). An updated Corrective Measure Plan (CMP) was submitted to USEPA in 2019 (Arcadis 2019) to address the potential risk to receptors and to address groundwater restoration.

In the Final Decision and Response to Comments issued on June 16, 2021 (USEPA, 2021), the USEPA identified their selected final corrective measures for the site as ISS with MNA for groundwater and soil, institutional controls, and long-term care/stewardship.

The primary constituents of concern at the site have been identified as volatile organic compounds (VOCs), primarily trichloroethene.

1.4 Project Task/Description

This QAPP is Appendix G of the set of planning documents prepared for the Corrective Measures Implementation (CMI) Work Plan, the purpose of which is to implement remedial action to address VOC impacted soil and groundwater via ISS with MNA. Additional details of the remedial action are included in the CMI Work Plan.

Use of MNA will reduce groundwater concentrations of VOCs migrating offsite. MNA will contribute to long-term aquifer restoration and eventually lead to groundwater impacts migrating offsite at concentrations below USEPA drinking water quality Maximum Contaminant Levels (MCLs). In order to reduce the timeframe for groundwater restoration through MNA alone, ISS using sorbing agents (e.g., zero valent iron) is the selected remedy to address source area soils. This will reduce migration of soil impacts to groundwater, thereby increasing the speed at which MNA reduces groundwater impacts migrating offsite.

Implementation of a groundwater monitoring program will generate data to evaluate the groundwater plume and efficacy of MNA.

1.5 Quality Objectives and Criteria for Measurement Data

1.5.1 Data Quality Objectives

The data quality objective (DQO) process, as described in EPA-QA/G-4 (USEPA, 2006), is used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. The following sections address each of the seven sequential steps in the USEPA DQO process.

Step 1: State the Problem

VOCs were released during the operations conducted at the site, which resulted in impacts to the soil and groundwater. Remedial actions to be undertaken include MNA, supplemented with ISS to address source area soils and subsequently reduce soil impacts leaching to groundwater migrating offsite. The scope of this QAPP refers to these activities.

Step 2: Identify the Goal of the Study

The overall objective for the remedial program is long-term aquifer restoration to concentrations below the USEPA MCLs. This objective will be accomplished by obtaining necessary data of known and acceptable quality to evaluate the efficacy of MNA to reduce soil and groundwater concentrations of VOCs. Specifically, data will be obtained to evaluate trends in the groundwater plume over time; determine the appropriate disposal requirements for construction water, drill cuttings, debris, and miscellaneous construction material; and verify that construction activities are not impacting the air quality of the surrounding community.

Step 3: Identify Information Inputs

Groundwater, air, soil, and waste characterization samples will be collected and analyzed for the constituents presented in Tables 1a through 1d. Laboratory analysis will be performed with sufficient sensitivity to confidently detect target parameters. The data will be evaluated for completeness, general conformance with the requirements of this QAPP, and consistency among data sets.

Step 4: Define the Boundaries of the Study

The site is the former GM Delco Plant 5 facility, located at 1723 North Washington Street, Kokomo, Indiana.

Step 5: Developing the Analytical Approach

Groundwater samples will be collected and analyzed by Pace Analytical for VOCs, metals (total and dissolved iron and manganese), nitrate, sulfate, chloride, total organic carbon (TOC), and dissolved gases (methane, ethane, ethene, and acetylene). Field analysis of groundwater will include pH, specific conductivity, oxidation reduction potential, dissolved oxygen, turbidity, and temperature as well stabilization parameters and sulfide using a HACH test kit.

Perimeter air samples will be collected and analyzed by Pace Analytical for VOCs.

While not anticipated, soil samples may be collected and analyzed by Pace Analytical for VOCs.

Waste characterization samples will be collected and analyzed by Pace Analytical for toxicity characteristic leaching procedure (TCLP) VOCs, semivolatile organic compounds (SVOCs), and metals.

Step 6: Specify Performance of Acceptance Criteria

All analytical results will be compared to the criteria documented in Tables 1a through 1d as appropriate. The data will be used to monitor the constituents of concern in groundwater, evaluate the effectiveness of the selected remedy, evaluate maintenance of air quality during construction activities, and ensure waste management is appropriately conducted.

Any limitations on the use of the data will be established following data validation. The amount of error associated with laboratory data will be assessed. Laboratory generated quality control limits are listed in Table 4.

Step 7: Develop the Plan for Obtaining Data

Sampling of the respective media is scheduled as follows:

- Long-term groundwater sampling is scheduled to occur semiannually.
- Groundwater sampling and perimeter air monitoring sampling are scheduled to occur during ISS treatment implementation. If required, soil samples may also be collected during ISS treatment implementation.
- Waste characterization sampling will occur as needed.

1.5.2 Data Categories

Three data categories have been defined to address various analytical data uses and the associated QA/QC effort and methods required to achieve the desired levels of quality. These categories are:

Screening Data: Screening data affords a quick assessment of site characteristics or conditions. These data collection activities involve rapid, non-rigorous methods of analysis and quality assurance. Screening data quality objectives are generally applied to physical and/or chemical properties of samples, preliminary ecological and/or human health and safety indicators, and visual or other qualitative observations used to make rapid assessment decisions for deployment or additional assessment.

Screening Data with Definitive Confirmation: Screening data provide rapid identification and quantitation however, because screening generally involves the use of less precise methods of analysis with less rigorous sample preparation, the quantitation may be relatively imprecise. Generally, at least 10% of the data are confirmed using analytical methods and QA/QC procedures and criteria associated with definitive data. This objective can also be used to verify less rigorous laboratory-based methods. This objective of data quality is available for data collection activities that require qualitative and/or quantitative verification of a select portion of sample findings.

Definitive Data: Definitive data are generated using rigorous analytical methods, such as approved USEPA reference methods. Data are analyte-specific, with confirmation of analyte identity and concentration. Methods produce tangible raw data (e.g., chromatograms, spectra, digital values). Data may be generated at the site or at an off-site location, as long as the QA/QC requirements are satisfied. For data to be definitive, either analytical or total measurement error must be determined. Definitive data are used for formal site characterization, environmental monitoring, confirmation of field data, to support decision-making, and for risk assessments.

It is anticipated that both screening and definitive data categories will be used during the investigation. Screening techniques will include measurement of water quality parameters during the collection of groundwater samples and monitoring of air quality (i.e., VOC concentration and particulate matter) during sampling and ISS treatment implementation. All samples submitted to the project laboratory for analysis will be determined using definitive techniques.

For this project, three levels of data reporting have been defined. They are as follows

Level 1 – Minimal Reporting: Minimal or “results only” reporting is used for analyses that, due either to their nature (i.e., field monitoring) or the intended data use (i.e., preliminary screening), do not generate or require extensive supporting documentation.

Level 2 – Modified Reporting: Modified reporting is used for analyses performed following standard USEPA-approved methods and QA/QC protocols and that, based on the intended data use, require some supporting documentation but not full Contract Laboratory Program-type (CLP-type) reporting. Examples of this type of reporting are waste characterization samples, borehole water samples, and samples that are collected for remedial operation and maintenance (i.e., groundwater contingency monitoring). Elements required for a Level 2 Laboratory data report include documentation of the following:

- Chain of custody
- Case narrative
- Final parameter concentration for all samples
- Preparation or extraction and analysis dates/times
- Method blanks
- Surrogate recoveries

- Matrix Spike (MS) and Matrix Spike Duplicate (MSD) recoveries and relative percent difference (RPD)
- Laboratory duplicate RPD
- Laboratory control sample (LCS) recoveries.

Level 4 - Full Reporting: Full "CLP-type" reporting is used for those analyses that, based on the intended data use, require full documentation. Examples of this type of reporting are air, soil, and groundwater samples that will be relied on for risk evaluation and confirmation. This reporting level would include documentation of the elements for Level 2 listed above and the following:

- Instrument initial and continuing calibrations
- Instrument blanks
- Gas chromatograph/mass spectrometer (GC/MS) instrument tuning
- Internal standard areas
- Serial dilution
- Raw data output for all field samples and associated QA/QC samples.

The analytical methods to be used during the investigation are derived from the Test Methods for Evaluating Solid and Water, Physical/Chemical Methods (SW-846), USEPA Methods and Guidance for Analysis of Water, Standard Methods for the Examination of Water and Wastewater, and USEPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air analytical methods. A summary of the testing methods is provided in Tables 1a through 1d.

Analytical results will be reported by the laboratory in both electronic data deliverable (EDD) and digital (i.e., PDF) format. PDF reports will be provided as Level 4 reports.

1.5.3 Data Quality Indicators

The primary QA objective is to ensure that the data are of known and acceptable quality, and that the analysis is performed with sufficient sensitivity to confidently detect target parameters. To support the overall project DQOs and to gauge measurement performance, six data quality indicators (DQI) have been defined: representativeness, comparability, completeness, precision, accuracy, and sensitivity. Each DQI is defined below.

Representativeness. Representativeness is the extent to which measurements represent the site conditions. It is dependent on sampling and analytical variability, and the variability (or homogeneity) of the site itself. The sampling activities have been designed to assess the presence of the constituents at the time of sampling. This QAPP presents field sampling methodologies and laboratory analytical methodologies. The use of the prescribed field and laboratory analytical methods with associated holding times and preservation requirements are intended to provide representative data.

Comparability. Comparability is defined as the extent to which data from one data set can be compared directly to similar or related data sets and/or decision-making standards. Comparability between this investigation and to the extent possible, with existing data will be maintained through consistent use of the sampling and analytical methodologies set forth in this QAPP, the analytical methods, stringent applicable of established QA/QC procedures, and utilization of appropriately trained personnel.

Completeness. Completeness is defined as a measure of the amount of usable data collected compared to the total amount of data that was expected to be obtained. This will be determined upon final assessment of the analytical results. Three measures of completeness are defined: (1) sampling completeness, defined as the number of valid samples collected relative to the number of samples planned for collection, (2) analytical completeness, defined as the number of valid sample measurements relative to the number of valid samples

collected, and (3) overall completeness, defined as the number of valid sample measurements relative to the number of samples planned for collection.

Precision. Precision is a measure of agreement among repeated measurements. The goal is to maintain a level of analytical precision consistent with the project objectives. To maximize precision, sampling and analytical procedures will be followed and work will adhere to established protocols presented in this QAPP. Analytical precision will be determined through the use of the same analytical methods to perform repeated analyses on the same sample, including the analysis of matrix spike duplicate samples laboratory duplicates, and field duplicates. Collection of field duplicate samples allows for evaluating the precision of sample collection, sample handling, preservation, and storage.

Precision for laboratory and field measurements will be expressed as the RPD between two duplicate determinations. Acceptance criteria for laboratory precision are presented in Table 3.

Accuracy/Bias. Accuracy is the degree of agreement of a measured value with its true value. Accuracy can be expressed as a percent recovery or percent deviation of the measurement with respect to its known or true value. Accuracy will be determined through evaluation of spike recoveries (e.g., surrogate recoveries, LCS recoveries, MS recoveries, reference material recoveries, etc.) and instrument calibration. Acceptance for spike recoveries are presented in Table 3.

Bias is defined as the constant or systematic distortion of a measurement process as a persistent positive or negative deviation from the known or true value. This may be due to improper sample collection, sample matrix, poorly calibrated analytical or sampling equipment, or limitations or errors in analytical methods and techniques. Blank samples (laboratory or field) are also used to assess contamination of samples that may bias results high.

Sensitivity. Sensitivity refers to the ability of an analytical procedure to quantify an analyte at a given concentration. The sensitivity requirements should be established such that the laboratory reporting limits (RLs) are at or below the relevant and applicable regulatory limits for each contaminant of concern for the project. Method detection limit (MDL) is defined as the minimum concentration of a substance that can be identified, measured, and reported with a 99 percent confidence that the analyte concentration is greater than zero and is determined from repeated analysis of a sample in a given matrix containing the analyte. MDLs have been determined as required in Title 40 of the Code of Federal Regulation Part 136B. The RL is greater than or equal to the lowest standard used to establish the calibration curve. Results greater than the MDL and less than the RL will be qualified estimated (J) by the laboratory. Non-detected results will be reported at the RL. The MDLs and RLs for the constituents of concern are provided in Tables 1a through 1d.

1.6 Special Training Needs/Certification

In compliance with the Occupational Safety and Health Administration (OSHA) final rule, “Hazardous Waste: Operations and Emergency Response [29 Code of Federal Regulations 1910.120(e)]”, all personnel performing sampling activities at the site will have completed the requirements for OSHA 40-Hour Hazardous Waste Operations and Emergency Response training. Persons in field supervisory positions will have also completed the additional OSHA 8 Hour Supervisory Training.

Field personnel involved with the shipping of samples to the subcontracted laboratory will have completed the United States Department of Transportation (USDOT) Hazardous Materials (HazMat) #1 – USDOT/International Air Transportation Association HazMat Shipping and Transportation.

Arcadis’ Human Resources Department maintains records to document management and technical training accomplished by each staff member. Training documentation records are stored in the Arcadis Training Center database.

1.7 Documents and Records

Detailed descriptions of the documentation and reporting requirements are presented below.

1.7.1 Sample Designation System

Samples will be identified with a unique designation system that will facilitate sample tracking. The sample designation system to be employed during the sampling activities will be consistent, yet flexible enough to accommodate unforeseen sampling events and conditions. An alpha-numeric system is considered appropriate and will be used by field personnel to assign each sample with a unique sample identification number.

The sample type codes are as follows:

- Groundwater monitoring samples: MW-XXXX-SX (mmddyy)
- Waste characterization samples: WC-XX (mmddyy)
- Perimeter ambient air samples: AA-XX (mmddyy)
- Soil samples: SS-XX-depth (mmddyy) or SB-XX-depth (mmddyy)

Field duplicate samples will be submitted blind to the laboratory with no indication of the parent sample location. Duplicate samples will be identified as Dup-XX (mmddyy).

Blanks will be identified as follows:

- Equipment blank: EB-XX (mmddyy)-Sampler Initials
- Trip blank: TB-XX (mmddyy)-Sampler Initials

Detailed descriptions of the sample identifications will be recorded in the field log.

1.7.2 Field Documentation

Field personnel will provide comprehensive documentation covering various aspects of field sampling, field analysis, and sample chain of custody. This documentation creates a record that allows reconstruction of field events to aid in the data review and interpretation process. Documents, records, and information relating to the performance of the field work will be retained in the project file.

The various forms of documentation to be maintained throughout the investigation include:

- Field Notebooks/Forms – All pertinent information regarding the site and sampling procedures will be documented. A field notebook consisting on a waterproof, bound notebook that will contain a record of all activities performed at the site. Detailed notes will be made as to the exact sampling location, physical observations, and weather conditions (as appropriate). To ensure that data collected in the field is consistent, accurate, and complete, forms may be used during repetitive data collection (e.g., depth to groundwater in monitoring wells during groundwater sampling).
- Sample Labels – Sample labels reduce the possibility of confusing sample containers and provide information necessary to complete chain of custody (COC) forms. To the extent practical, sample containers will be pre-labeled before sample collection (with all required information except the date and time of sample collection) and the labels protected with a clear tape covering.
- Sample Chain of Custody – COC forms provide a legal record of possession of the samples, from sample collection through submittal to the laboratory. Chain of custody forms will be filled out at each sampling site, at

a group of sampling sites, or at the end of each day of sampling by field personnel designated to be responsible for sample custody. In the event that samples are relinquished by the designated sampling person to other sampling or field personnel, the chain of custody form will be signed and dated by the appropriate personnel to document the sample transfer. The original chain of custody form will accompany the samples to the laboratory, and copies will be forwarded to the project files. When the form is complete, it will indicate that there were no lapses in sample accountability. A sample chain of custody form is included in Standard Operating Procedure (SOP) Sample Chain of Custody, Revision 2, April 2020 (copy included in Attachment 2).

- Persons will have custody of samples when the samples are in their physical possession, in their view after being in their possession, or in their physical possession and secured so they cannot be tampered with. In addition, when samples are secured in a restricted area accessible only to authorized personnel, they will be deemed to be in the custody of such authorized personnel. A custody seal will be placed on each sample cooler during secure storage and prior of release of custody of the samples to the shipping company for delivery to the laboratory. The purpose of the custody seal is to maintain sample integrity; sample tampering or contamination may be indicated if the seal is broken during storage or transportation.
- Field Equipment, Calibration, and Maintenance Logs – To document the calibration and maintenance of field instrumentation, calibration and maintenance logs will be maintained for each piece of field equipment that is not factory calibrated.

1.7.3 Laboratory Documentation Files

- Laboratory Project Files. The laboratory will establish a file for pertinent data. The file will include all correspondence (including emails), faxed information, phone logs, and chain of custody forms. The laboratory will retain project files and data packages for a period of not less than five years.
- Laboratory Logbooks. Workbooks, bench sheets, instrument logbooks, and instrument printouts will be used to trace the history of samples through the analytical process and to document important aspects of the work, including the associated QC checks. As such, all logbooks, bench sheets, instrument logs, and instrument printouts will be part of the permanent record of the laboratory.

  Each page or entry will be dated and initialed by the analyst at the time of entry. Errors in entry will be crossed out in indelible ink with a single stroke, corrected without the use of white-out or by obliterating or writing directly over the erroneous entry, and initialed and dated by the individual making the correction. Pages of logbooks that are not used will be completed by lining out unused portions.

  Information regarding the sample, analytical procedures performed, and the results of the testing will be recorded on laboratory forms or personal notebook pages by the analyst. These notes will be dated and will also identify the analyst, the instrument used, and the instrument conditions.

  Laboratory notebooks will be periodically reviewed by the laboratory group leaders for accuracy, completeness, and compliance with the laboratory standard operating procedures and quality assurance manual. All entries and calculations will be verified by the laboratory group leader. If all entries on the pages are correct, then the laboratory group leader will initial and date the pages. Corrective action will be taken for incorrect entries before the laboratory group leader signs.

- Computer and Hard Copy Storage. All electronic files and deliverables will be retained by the laboratory for not less than five years; hard copy data packages (or electronic copies) will also be retained for not less than five years.

1.7.4 Data Reporting Requirements

- Field Data Reporting. Information collected in the field through visual observation, manual measurement, and/or field instrumentation will be recorded in field notebooks or data sheets and/or on forms. Such data will be reviewed for adherence to the applicable field standard operating procedures and for consistency. Concerns identified as a result of this review will be discussed with the field personnel, corrected if possible, and, as necessary, incorporated into the data evaluation process (as necessary).

  Where applicable, field data forms and calculations will be processed and included in appendices to the appropriate project reports (when generated). The original field logs, documents, and data reductions will be kept in the main project file.

- Laboratory Data Reporting. The laboratory is responsible for preparing Level 4 data packages (as defined previously) for all samples. Analytical results will be provided by the laboratory in a digital format (i.e., PDF) as well as an EDD. The project database is maintained in EQuIS and hence requires that the EDD be provided in the EQuIS EFWEDD four-file format (Sample, Test, Result, Batch).

  Upon receipt, the data packages will be examined to ensure that the correct analyses requested on the chain of custody were performed for each sample submitted. If discrepancies were noted, the Project Chemist will be notified and will promptly follow up with the laboratory to resolve any issues.

  The data packages will be validated in accordance with the procedures presented in this QAPP. Data that do not meet the specified standards will be flagged pending resolution of the issue. The flag will not be removed from the data until the issue associated with the sample results is resolved. Although flags may remain for certain data, the use of that data may not necessarily be restricted.

  Data reports for all parameters will include, at a minimum, the following items:

  - Narrative: The narrative includes a summary of activities that took place during sample analysis, including the following information:
    - Laboratory name and address
    - Date of sample receipt
    - Cross-reference of laboratory identification number to sample identification
    - Analytical methods used
    - Deviations from specified protocol
    - Corrective actions taken.

  The narrative will also contain any sample handling documents, including field and internal COC forms, air bills, and shipping tags.

  - Analytical Results: Analytical results will include the following information, as applicable:
    - Sample ID
    - Laboratory ID
    - Date of collection
    - Date of receipt
    - Date of extraction
    - Date of analysis

- Dilution factor
- Detection limits.

Sample results on the report forms will be corrected for dilutions. Soil samples will be reported on a dry weight basis. All results will be reported uncorrected for blank contamination.

The analytical reports will be expanded to include all supporting documentation necessary to provide a full data package. This additional documentation will include, at a minimum, all raw data required to recalculate any result, including printouts, chromatograms, and quantitation reports; standards used in calibration and calculation of analytical results; sample extraction, digestion, and other preparation logs; standard preparation logs; and instrument run logs.

2 Data Generation and Acquisition

2.1 Sampling Process Design

Previous investigations have identified impacted soil and groundwater across the site.

- Groundwater sampling will include ISS implementation and long-term monitoring sampling of monitoring wells for one or more of the following: VOCs, metals (total and dissolved iron and manganese), nitrate, sulfate, chloride, TOC, and dissolved gases (methane, ethane, ethene, acetylene).
- Air sampling will include perimeter monitoring for VOCs.
- Soil sampling may include VOCs.
- Waste characterization sampling will include TCLP VOCs, TCLP SVOCs, and TCLP metals as needed throughout the remedial action implementation.

2.2 Sampling Methods

Arcadis will collect all required samples. Appropriate standard operating procedures should be reviewed prior to sample collection to ensure that samples are collected in accordance with the project requirements.

Field activities will be performed in accordance with Arcadis SOPs, Technical Guidance Instructions (TGIs), and Quality Procedures (copies included in Attachment 2). General procedures include:

- Sample Chain of Custody, Arcadis SOP, Revision 2, April 2020
- Calibration, Arcadis TGI, Version 1.0, July 2020
- Groundwater and Soil Sampling Equipment Decontamination, Arcadis TGI, Revision 1, May 8, 2020
- Multiple Gas Air Monitoring and Field Screening When Sampling Groundwater Monitoring Wells, Arcadis TGI, Revision 1, May 8, 2020
- Field Activities Documentation, Arcadis ENV Quality Procedure QP# 3.06, November 2016
- Field Sampling, Measurement, and Observations, Arcadis ENV Quality Procedure QP# 3.08, October 2017

Groundwater will be sampled in accordance with established Arcadis TGIs (copies included in Attachment 2). Applicable procedures include:

- In-Situ and Ex-Situ Water Quality Parameters, Arcadis TGI, Revision 0, October 16, 2018
- Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells, Arcadis TGI, Revision 1, May 8, 2020
- Manual Water-Level and Non-Aqueous Phase Liquid Monitoring, Arcadis TGI, Revision 1, May 8, 2020
- Monitoring Well Development, Arcadis TGI, Revision 0, April 24, 2017
- Monitoring Well Installation, Arcadis TGI, Revision 0, April 24, 2017
- Monitoring Well Integrity Survey, Arcadis TGI, Revision 0, April 19, 2017
- Passive Diffusion Bag (PDB) Sampling, Arcadis TGI, Revision 0, October 12, 2018
- Standard Groundwater Sampling for Monitoring Wells, Arcadis TGI, Revision 0, October 8, 2018

Air will be sampled in accordance with established Arcadis TGIs (copy included in Attachment 2). Applicable procedures include:

- Indoor or Ambient Air Sampling and Analysis via USEPA Method TO-15, Revision 1, August 19, 2016

Soil will be sampled in accordance with established Arcadis TGIs (copy included in Attachment 2). Applicable procedures include:

- Soil Drilling and Sample Collection, Arcadis TGI, Revision 1, May 12, 2020

Investigation-derived wastes (IDW) include purge water, decontamination water, drill cuttings, sampling supplies, and personal protective equipment generated during sampling activities. The intent of managing IDW is to ensure that impacted materials and media are not allowed to contaminate non-impacted materials and media. Where necessary to promote the safe, efficient, and environmentally protective performance of work, investigation-derived materials and wastes will be managed consistent with the Arcadis TGI Investigation-Derived Waste Handling and Storage, Revision 1, May 15, 2020 and sampled in accordance with Arcadis TGI Resource Conservation and Recovery Act Waste Characterization Sampling, May 20, 2021 (copies included in Attachment 2). Disposable equipment (including used personal protective equipment) will be containerized, appropriately labeled during the sampling events, and disposed of accordingly. Equipment will be decontaminated as appropriate.

2.3 Sample Handling and Custody

2.3.1 Sample Containers and Preservation

Appropriate sample containers, preservation methods, and laboratory holding times for the samples are shown in Table 4.

The analytical laboratory will supply appropriate sample containers and preservatives, as necessary. The bottles will be purchased pre-cleaned to USEPA Office of Solid Waste and Emergency Response Directive 9240.05A requirements. Certificates of analysis for each lot of sample containers will be maintained by the laboratory and will be available upon request. The field personnel will be responsible for properly labeling containers and preserving samples (as appropriate).

2.3.2 Field Custody Procedures

The sampling team will maintain overall responsibility for the care and custody of the samples until they are transferred or properly dispatched to the laboratory. The objective of field sample custody is to ensure that samples are not tampered or modified from the time of collection through transport and transfer to the analytical laboratory. Persons will have “custody of samples” when the samples are in their physical possession, in their view after being in their possession, or in their physical possession and secured so they cannot be tampered with. In addition, when samples are secured in a restricted area accessible only to authorized personnel, they will be deemed to be in the custody of such authorized personnel.

- Field Logbooks. Field logbooks will provide the means of recording data collecting activities performed. As such, entries will be described in as much detail as possible so that persons going to the site could reconstruct a particular situation without reliance on memory. Field logbooks will be bound field survey books or notebooks, and have numbered, water-resistant pages. Entries will be made in ink, with no erasures. If an incorrect entry is made, the information will be crossed out with a single strike mark and initialed by the person making the correction.

Recorded information typically includes, but may not be limited to the following:

- Name and location of site
- Date and time of arrival and departure
- Name and signature of person keeping log
- Names of all persons onsite
- Purpose of visit
- Level of personal protection equipment used
- Field instrument identification and calibration information
- Location of sampling points
- Results of field measurements made
- Number of samples taken, volume of samples taken
- Preservation
- Method of sample collection and any factors that may affect its quality
- Name of sample collector
- All sample identification numbers (assigned prior to sample collection)
- Description of samples, including as applicable depth at which the sample was collected
- Weather conditions on the day of sampling and any field observations
- Number and description of photographs taken, if any

- Sample Labelling. Sample labels are an important part of proper documentation as their use reduces the possibility of confusing sample containers and provides the information necessary during handling to complete COC forms. The following information is required on each sample label:
  - Site name or location
  - Date and time collected
  - Sample identification number
  - Sampler's initials
  - Parameter sampled
  - Preservative

  When possible, preprinted sample labels (i.e., preprinted with items noted above except of date and time collected) will be affixed to sample bottles prior to delivery at the sampling site and the labels themselves protected from the sample matrix with a clear-tape covering.

- Field Chain of Custody Forms. The COC form is intended as a legal record of possession of the sample. Completed chain of custody forms will be required for all samples to be analyzed. Chain of custody forms will be initiated by the sampling crew in the field. The chain of custody forms will contain the sample's unique identification number, sample date and time, sample description, sample type, preservation (if any), and analyses required. The original chain of custody form will accompany the samples to the laboratory. Copies of the chain of custody will be made prior to shipment (or multiple copy forms used) and placed in the project files. The chain of custody forms will remain with the samples at all times. The samples and signed chain of custody forms will remain in the possession of the sampling crew until the samples are delivered to the

express carrier (e.g., Federal Express), hand delivered to the laboratory, picked up by a laboratory courier, or placed in secure storage.

- Sample Custody Seals. Custody seals are narrow strips of adhesive paper or glass fiber used to demonstrate that no tampering of the shipping container has occurred. The custody seals will be signed and dated by the sampling crew and placed across the opening of the lid and body of the shipping containers and at least on one side and the front of the container. The custody seals will be covered with clear, wide tape. These custody seals shall be plainly visible.

2.3.3 Packing, Handling, and Shipping Requirements

All shipping or sample transfer information will be recorded at the end of each day or collection period on COC forms. Sample packaging and shipment procedures are designed so that the samples will arrive at the laboratory with the chain of custody, intact.

It is imperative that all samples are submitted to the laboratory with ample time for the analysis to be completed within the method-specified holding time. It should be noted that the laboratory needs to be aware that missing a holding time is unacceptable and may result in unusable data if the holding time is missed.

General sample packaging and shipping requirements are as follows:

- Securely affix the sample label to the container with clear packing tape.
- Check the cap on the sample container to confirm that it is properly sealed.
- Complete the chain of custody form with the required sampling information and confirm that the recorded information matches the sample labels. NOTE: If the designated sampler relinquishes the samples to other sampling or field personnel for packing or other purposes, the sampler will complete the chain of custody prior to this transfer. The appropriate personnel will sign and date the chain of custody form to document the sample custody transfer.
- Using duct tape, secure the outside drain plug at the bottom of the cooler.
- Wrap glass sample containers in bubble wrap or other cushioning material.
- Place 1 to 2 inches of cushioning material at the bottom of the cooler.
- Place the sealed sample containers into the cooler.
- Place ice in plastic bags, seal the bags, and place the bags loosely in the cooler.
- Fill the remaining space in the cooler with cushioning material.
- Place chain of custody forms in a plastic bag and seal. Tape the forms to the inside of the cooler lid.
- Close the lid of the cooler and secure with duct tape.
- Wrap strapping tape (or equivalent) around both ends of the cooler at least twice.
- Mark the cooler on the outside with the shipping address and return address, affix “Fragile” labels, and draw (or affix) arrows indicating “this side up.” Cover the labels with clear plastic tape. Place a signed custody seal over the cooler lid. NOTE: If the samples are being delivered directly to the laboratory or will be picked up by the lab’s courier service, this step is eliminated.

Samples will be packaged by field personnel and transported as low-concentration environmental samples. The samples will be hand-delivered or delivered by an express carrier within 48 hours of the time of collection. In some cases, the analytical method may require analysis within a shorter holding time, and arrangements will need

to be made to accommodate the laboratory requirements. Shipments will be accompanied by the chain of custody form identifying the contents. The original form will accompany the shipment; copies will be retained by the sampler for the sampling office records. If the samples are sent by common carrier, a bill of lading will be used. Receipts or bills of lading will be retained as part of the permanent project documentation. Commercial carriers are not required to sign off on the chain of custody form as long as the forms are sealed inside the sample cooler, and the custody seals remain intact.

Custody seals and cooler packing materials will be provided by the analytical laboratory. The filled, labeled, and sealed containers will be placed in a cooler on ice and carefully packed to eliminate the possibility of container breakage. Trip blanks of analyte-free water will be provided by the laboratory and included in each cooler containing samples to be analyzed for VOCs.

2.3.4 Laboratory Custody Procedures

Upon sample receipt, laboratory personnel will be responsible for sample custody. The original field chain of custody form will accompany all samples requiring laboratory analysis. Samples will be kept secured in the laboratory until all stages of analysis are complete. All laboratory personnel having samples in their custody will be responsible for documenting and maintaining sample integrity.

- Sample Receipt and Storage. Upon sample receipt, the laboratory sample custodian will verify the package seal, open the package, verify the sample integrity, and compare the contents against the field chain of custody. If a sample container is broken, the sample is in an inappropriate container, has not been preserved by appropriate means, of if there is a discrepancy between the chain of custody and the sample shipment, Arcadis will be notified. The laboratory sample custodian will then log the samples in, assign a unique laboratory identification number to each, and label the sample bottle with the laboratory identification number. The project name, field sample code, date sampled, date received, analysis required, storage location and date, and action for final disposition will be recorded in the laboratory tracking system.
- Sample Analysis. Analysis of an acceptable sample will be initiated by a work sheet that will contain pertinent information for analysis. The analyst will sign and date the laboratory chain of custody form when removing the samples from storage. Samples will be organized into sample delivery groups (SDGs) by the laboratory.
- Sample Storage Following Analysis. The remaining sample volume and extracts/digestates (if any) will be maintained by the laboratory for one month after the final report is delivered to Arcadis. After this period, the samples will be disposed of in accordance with applicable rules and regulations.

2.4 Analytical Methods

2.4.1 Field Analytical Procedures

Field analytical procedures may include the monitoring of VOCs using a photoionization detector (PID), and the measurement of water quality parameters during groundwater sampling tasks. Water quality parameters will include pH, specific conductance, oxidation reduction potential, dissolved oxygen, temperature, and turbidity. Samples will be analyzed using a multi-parameter water quality instrument equipped with a flow-through cell. Groundwater samples will be analyzed for sulfide using a HACH test kit.

2.4.2 Laboratory Parameters and Methods

Laboratory analytical requirements presented in the sub-sections below include a general summary of requirements, specifics related to each sample medium to be analyzed, and details of the methods to be used for this project. Current approved methods will be used for all applicable parameters and sample media.

The following tables (attached at the end of this QAPP) summarize general analytical requirements:

- Table 1a: Parameters, Methods, and Target Quantitation Limits (Groundwater)
- Table 1b: Parameters, Methods, and Target Quantitation Limits (Air)
- Table 1c: Parameters, Methods, and Target Quantitation Limits (Soil)
- Table 1d: Parameters, Methods, and Target Quantitation Limits (Waste Characterization)
- Table 2: Sample Quantities and Quality Control Frequencies
- Table 3: Laboratory Quality Control Limits
- Table 4: Sample Containers, Preservation, and Holding Times

Laboratory analytical SOPs are provided in Attachment 3 of this document. The SOPs are based on the methodology requirements promulgated in:

- USEPA Test Methods for Evaluation Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, Third Edition, Final Update V and updates.
- USEPA Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100.
- Standard Methods for the Examination of Water and Wastewater.
- Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air.

2.5 Quality Control

2.5.1 Field Quality Control Checks

- Field Measurements. To verify the quality of data using field instrumentation, duplicate measurements will be obtained and reported for all field measurements. A duplicate measurement will involve obtaining measurements a second time at the same sampling location.
- Sample Containers. New, certified, clean sample containers will be supplied by the laboratory.

- Field Duplicates. Field duplicates will be collected to evaluate precision, sample homogeneity, and to verify the reproducibility of the sampling methods. Field duplicates are two separate samples collected from the sample location in the field and submitted to the laboratory as two distinct samples. In general, field duplicates will be collected at a 10% frequency (i.e., one field duplicate for every 10 samples collected) and submitted blind to the laboratory. Table 3 provides an estimated number of field duplicates to be prepared for each applicable parameter and matrix.
- Equipment Rinse Blanks. Equipment rinse blanks are used to monitor the cleanliness of the sampling equipment and the effectiveness of the cleaning procedures. Rinse blanks will be prepared and submitted for analysis at a frequency of 1 per day or once for every 20 samples collected, whichever is more frequent, when reusable sample equipment cleaning occurs. When dedicated sampling devices are used or sample containers are used to collect the samples, rinse blanks will not be necessary. Rinse blanks will be prepared by filling sample containers with analyte-free water (supplied by the laboratory), which has been poured over or routed through decontaminated field sampling equipment before the collection of environmental samples. Table 3 provides an estimated number of rinse blanks collected during the investigation activities.
- Trip Blanks. Trip blanks will be used to assess whether site samples have been exposed to non-site-related VOCs during field handling procedures and shipping. Trip blanks will be analyzed at a frequency of once per day, per cooler containing samples to be analyzed for VOCs. A trip blank will consist of a VOC vial filled with analyte-free water (supplied by the laboratory), taken to the sampling site, and transported back to the laboratory without having been exposed to sampling procedures. Table 2 provide an estimated number of trip blanks collected for each matrix and parameter during the investigation activities.

2.5.2 Analytical Laboratory Quality Control Checks

Internal laboratory QC checks will be used to monitor data integrity and to document the validity of the generated data. The checks reveal information about sampling technique, analyst technique, instrument capability, possible sources of contamination, precision of the results, and difficulties with the matrix. These checks will include method blanks, LCS, MS/MSD, laboratory duplicates, internal standards, and surrogate samples. Advisory quality control limits are identified in Table 3.

- Calibration Verification. Initial calibration of instruments will be performed as required in the method and when any ongoing calibration does not meet control criteria. The number of points used in the initial calibration if defined in each analytical method. Ongoing calibration verification will be performed as specified in the analytical methods to monitor instrument performance. In the event that an ongoing calibration does not meet control limits, analysis of samples will be suspended until the source of the control failure if either eliminated or reduced to within control specifications. Any samples analyzed while the instrument was out of control will be reanalyzed.
- Method Blanks. Sources of contamination in the analytical process, whether specific analyses or interferences, must be identified, isolated, and corrected. A method blank is an “analyte-free” matrix that is treated exactly as the sample including exposure to all glassware, equipment solvents, reagents, labeled compounds, internal standards, and surrogates that are used with sampled. The method blank is useful in identifying possible sources of contamination within the analytical process (i.e., laboratory environment, reagents, or apparatus). For this reason, it is necessary that the method blank is initiated at the beginning of the analytical process and encompasses all aspects of the analytical work. One method blank will be analyzed with each analytical series associated with no more than 20 samples. Blank corrections will not be applied by the laboratory to the original data.

- Matrix Spike/Matrix Spike Duplicates. A matrix spike is an aliquot of an environmental sample to which known quantities of target analytes are added in the laboratory. A matrix spike duplicate is a second aliquot of the sample which is also spiked with identical concentrations of target analytes. The MS and MSD are analyzed in an identical manner as the sample. The purpose of a MS is to determine the accuracy of the overall analytical procedure for determining the analytes of concern in the sample. The MSD analysis is used to document both the precision and accuracy of the method in a given sample matrix.

  To get the true benefit from MS and MSD analyses, it is necessary that the sample come from the project site so that it is possible to ascertain if the matrix itself is contributing to analytical difficulties or outliers. MS/MSD pairs will be analyzed at a 5% frequency (i.e., additional sample volume for MS and MSD analysis will be collected for every 20 field samples collected per matrix). When MS recoveries are outside quality control limits, associated LCS and surrogate spike recoveries will be evaluated (as applicable) to attempt to verify the reason for the deviation and determine the effect on the reported sample results. Table 3 presents an estimated number of MS and MSD analyses for each applicable parameter.

- Laboratory Duplicates. Laboratory duplicates assess laboratory precision. Laboratory duplicates are defined as a separate aliquot of an individual sample that is analyzed as a separate sample. Table 3 presents an estimated number of laboratory duplicates for each applicable parameter.
- Laboratory Control Samples. An LCS is a blank matrix, free from the analytes of interest, spiked with verified known amounts of analytes created from a source other than that used to make up calibration standards. The LCS is carries through the analysis along with the samples. The intent of LCS analysis is to provide insight into the intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. This includes the preparation of calibration standards, validity of calibration, sample preparation, instrument set-up, and the premises inherent in quantitation. One LCS will be analyzed with each analytical series associated with not more than 20 samples.
- Surrogate Spikes. A surrogate spike is an organic non-target analyte that is unlikely to occur under natural conditions but that have similar chemical properties to the analytes of interest. The surrogate standard is added to the sample in a known amount, prior to purging or extraction, and is used to evaluate the response of the analyte to the preparation and analysis procedures. The surrogate concentration is measured using the same procedures used to measure other analytes in the sample. The surrogate spike is utilized to provide broader insight into the proficiency and efficiency of an analytical method on a sample-specific basis. This control reflects analytical conditions that may not be attributable to sample matrix.

  If surrogate spike recoveries exceed specified QC limits, the analytical results must be evaluated thoroughly in conjunction with other control measures. In the absence of other control measures, the integrity of the data may not be verifiable, and reanalysis of the samples with additional control may be necessary.

  Surrogate spike compounds will be selected utilizing the guidance provided in the analytical methods and will be added to all field samples and laboratory quality control samples.

- Internal Standards. Internal standard areas and retention times will be monitored for organic analyses performed by GC/MS methods. Method-specified internal standard compounds will be spiked into all field samples, calibration standards, and quality control samples after preparation and prior to analysis. If internal standard areas in one or more samples exceed the specified tolerances, the cause will be investigated, the instrument will be recalibrated if necessary, and all affected samples may be re-analyzed.

  The acceptability of internal standard performance will be determined using the guidance provided within the analytical methods

2.5.3 Data Precision Assessment Procedures

Field precision is difficult to measure because of temporal variations in field parameters. However, precision will be controlled through the use of experienced field personnel, properly calibrated meters, and duplicate field measurements. Field duplicates will be used to assess precision for the entire measurement system, including sampling, handling, shipping, storage, preparation, and analysis.

Analytical precision for will be evaluated by calculating the RPD for field duplicates, laboratory duplicates, and MS/MSD samples, as follows:

$$RPD = \frac{abs(D1 - D2)}{\frac{(D1 + D2)}{2}} \; x \; 100$$

Where: abs = absolute value

RPD = relative percent difference

D1 = sample value

D2 = duplicate sample value

Acceptance criteria for laboratory and field precision are specified in Table 3.

If RPDs are outside of the limits for laboratory QC samples, the associated sample results will be qualified as specified in the applicable data validation guidance (see Section 4.2). In general, sample results will be qualified as estimated (“UJ” or “J” qualifiers) when RPDs are outside of the acceptance criteria. The qualifiers will be added to the project database.

In the event that field duplicate RPDs or differences are outside of the specified limits, the associated sample results (parent, field duplicate, and remaining samples associated with the duplicate) will be qualified as estimated (“UJ” or “J” qualifiers). The qualifiers will be added to the project database. Note that field duplicate RPD is only calculated for results greater than five-times the RL in both the parent and field duplicate samples. For results less than five-times the RL, the acceptance criteria for water samples is that the results should differ by no more than two-times the RL and for soil and air samples is that the results should differ by no more than three-times the RL.

2.5.4 Data Accuracy Assessment Procedures

The accuracy of field measurements will be controlled by employing experienced field personnel, using properly calibrated field meters, and adhering to established protocols. The accuracy of field meters will be assessed by review of calibration and maintenance logs.

Laboratory accuracy will be assessed by evaluating the results of spiked samples (i.e., MS/MSD, surrogate spikes, and LCS) for percent recovery (%R). %R will be calculated as follows:

$$REC = \frac{A - X}{B} \; x \; 100$$

Where: A = value measured in spiked sample or standard

X = value measured in original sample

B = amount added to sample or true value of the standard

Acceptance criteria for MS/MSD, surrogate spikes, and LCS are specified in Table 3. Note that the limits provided are the high and low range for each analysis provided by the laboratory at the time this QAPP was written. Acceptance limits are updated periodically by the laboratory, and the QC sample result will be compared to the current laboratory limits provided in the analytical data report on an analyte-by-analyte basis. If MS/MSD, surrogate spikes, and/or LCS recoveries are outside of the specified limits, the associated sample results will be qualified as specified in the applicable data validation guidance (see Section 4.2). In general, sample results associated with high recoveries are qualified as estimated with a potential for high bias ("J+" qualifiers) and sample results associated with low recoveries are qualified as estimated with a potential for low bias ("UJ" or "J-" qualifiers). If the recoveries exhibit a gross exceedance (i.e., less than 10% recovery for organic analyses and less than 30% recovery for inorganic analyses), the associated sample results will be qualified as rejected ("R" qualified) and the result in unusable.

2.5.5 Data Representativeness Assessment Procedures

Representativeness will be assessed by examining sample preservation, results of the precision and accuracy evaluation, and adherence to method holding time. Failure of the field or laboratory personnel to properly handle samples may result in qualification of the data as estimated or unusable. The use of laboratory data from a sample with a failed holding time could render the data unusable, in particular, for VOC analysis there is a potential for loss of compounds and the concentration may be biased low. The representativeness review will qualitatively consider whether precision and/or accuracy are sufficient to characterize the representativeness of the samples.

2.5.6 Blank Sample Assessment Procedures

Blank samples will be used to determine the existence and magnitude of contamination resulting from laboratory or field activities. The method blank is used as a check on laboratory procedures as well as possible contamination from laboratory equipment (i.e., reagents, glassware, etc.). Equipment blanks are collected in the field from the sampling equipment to check for possible residual contamination and assess potential cross-contamination during sampling tasks. Trip blanks determine the integrity of the sample container for loss or addition of analytes due to handling and transport. Detections in any blank samples will be used to qualify similar detections in associated field samples.

2.5.7 Data Completeness Assessment Procedures

Completeness of a field or laboratory data set will be calculated by comparing the number of usable measurements (i.e., all measurements except rejected data) actually obtained to the total number of usable measurements that were planned.

$$Completeness = \frac{usable\ data\ points\ obtained}{total\ data\ points\ obtained}\ x\ 100$$

As a general guideline, overall project completeness is expected to be at least 90 percent. The assessment of completeness will require professional judgment to determine data usability for the intended purposes.

2.5.8 Data Comparability Assessment Procedures

Comparability will be assessed by evaluating whether samples were collected in a manner similar to previous sampling events and analytes using similar analytical methodology as previous events.

2.5.9 Sensitivity Assessment Procedures

Sensitivity is related to the reporting limit. In general, RLs should be less than the applicable standard. Analytical results for samples that are reported as non-detected for a particular analyte that have RLs greater than the applicable standard cannot be used to demonstrate compliance with the applicable standard. Samples that are contaminated with sufficient quantity of material, such that dilutions are performed, are a leading cause of RLs exceeding applicable criteria. However, there may be instances where such exceedances are insignificant relative to the site specific DQOs. The sensitivity review will qualitatively consider whether the RLs are sufficiently low to compare analytical results to the applicable standards, which considering the project DQOs.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

Preventive maintenance schedules have been developed for both field and laboratory instruments. A summary of the maintenance activities to be performed is presented below.

2.6.1 Field Instruments and Equipment

Prior to any field sampling, each piece of field equipment will be inspected to confirm that it is operational. If the equipment is not operational, it must be serviced prior to use. All meters that require charging or batteries will be fully charged or have fresh batteries. If instrument servicing is required, it is the responsibility of the Field Sampling Manager to follow the maintenance schedule and arrange for prompt service.

Logbooks will be kept for each field instrument. Logbooks will contain records of operation, maintenance, calibration and any problems and repairs. Logbooks for each piece of equipment will be maintained in project records.

Field equipment returned from a site will be inspected to confirm it is in working order. This inspection will be recorded in the logbook or field notebooks, as appropriate. It will also be the obligation of the last user to record any equipment problems in the logbook.

Non-operational field equipment will either be repaired or replaced. Appropriate spare parts for field equipment/meters will be available from the rental companies or manufacturers. Arcadis-/subcontractor-owned or leased equipment will be maintained in accordance with the manufacturer’s instructions.

2.6.2 Laboratory Instruments and Equipment

Laboratory instrument and equipment documentation procedures include details of any observed problems, corrective measure(s), routine maintenance and instrument repair (including information regarding the repair and the individual who performed the repair).

Preventive maintenance of laboratory equipment generally will follow the guidelines recommended by the manufacturer. A malfunctioning instrument will be repaired immediately by in-house staff or through a service call from the manufacturer.

Maintenance schedules for laboratory equipment adhere to each manufacturer's recommendations. Records reflect the complete history of each instrument and specify the time frame for future maintenance. Major repairs or maintenance procedures are performed through service contracts with the manufacturer or qualified contractors. Paperwork associated with service calls and preventive maintenance calls will be kept on file by the laboratory.

Laboratory Systems Managers are responsible for the routine maintenance of instruments used in the laboratory. Any routine preventive maintenance carried out is logged into the appropriate logbooks. The frequency of routine maintenance is dictated by the nature of samples being analyzed, the requirements of the method used and/or the judgment of the Laboratory Systems Manager.

All major instruments are backed up by comparable (if not equivalent) instrument systems in the event of unscheduled downtime. An inventory of spare parts is also available to minimize equipment/instrument downtime.

On a daily basis, the operation of balances, incubators, ovens, refrigerators, and water purification systems will be checked and documented. Any discrepancies will be immediately reported to the appropriate laboratory personnel for resolution.

2.7 Instrument/Equipment Calibration and Frequency

2.7.1 Field Equipment Calibration Procedures and Frequency

Calibration checks of field equipment will be performed daily when used. Field equipment operation, calibration, and maintenance procedures are provided in the equipment operation manuals.

2.7.2 Laboratory Equipment Calibration Procedures and Frequency

Instrument calibration will follow the specifications provided by the instrument manufacturer or specific analytical method used. The analytical methods for chemical constituents are identified in Tables 1a though 1c.

When analyses are conducted according to USEPA methods, the calibration procedures and frequencies specified in the applicable method will be followed. Records of calibrations will be filed and maintained by the laboratory. These records will be subject to QA audit. For all instruments, the laboratory will maintain trained repair staff with in-house spare parts or will maintain service contracts with vendors.

All standards used to calibrate equipment are traceable, directly or indirectly, to the National Institute of Standards and Technology. All standards received will be logged into standard receipt logs maintained by the individual analytical groups. Each group will maintain a standards log that tracks the preparation of standards used for calibration and QC purposes.

2.8 Inspection/Acceptance of Supplies and Consumables

All supplies to be used in the field and laboratory will be available when needed. They will be free of target chemicals and interferences. All reagents will be tested prior to use in the laboratory. All standards will be verified against a second source standard. The laboratory will follow a “first in/first out” procedure for the storage and use of all consumables to minimize the risk of contamination and degradation.

2.9 Non-direct Measurements

Non-direct measurements will not be used on this project.

2.10 Data Management

The purpose of the data management is to provide for the accuracy and ready accessibility of all of the necessary data to meet the analytical and reporting objectives of the project. The data management program established for the project includes field documentation and sample QA/QC procedures, methods for tracking and managing the data, and a system for filing all site-related information. More specifically, data management procedures will be employed to efficiently process the information collected such that the data are readily accessible and accurate. These procedures are described in detail in the following section.

The data management plan has four elements: (1) sample designation system, (2) field activities, (3) sample tracking and management, and (4) data management system.

2.10.1 Sample Designation System

A concise and easily understandable sample designation system is an important part of the project sampling activities. It provides a unique sample number that will facilitate both sample tracking and easy resampling of select locations to evaluate data gaps, if necessary. The sample designation system to be employed during the sampling activities will be consistent, yet flexible enough to accommodate unforeseen sampling events or conditions. A combination of letters and numbers will be used to yield a unique sample number for each field sampled collected. The sample designation system is described in more detail in Section 1.7.1.

2.10.2 Field Activities

Field activities designed to gather the information necessary to make decisions require consistent documentation and accurate record keeping. During site activities, standardized procedures will be used for documenting field activities, data security, and QA. These procedures are described in further detail in the following subsections.

- Field Documentation. Complete and accurate record keeping is a critical component of the field activities. When interpreting analytical results and identifying data trends, investigators realize that field notes are an important part of the review and validation process. To confirm that all aspects of the field investigation are thoroughly documented, several different information records, each with its own specific reporting requirements, will be maintained, including field logs, instrument calibration records, and COC forms. A description of each of these types of field document is provided in other sections of this QAPP.
- Data Security. Measures will be taken during the field investigation to prevent samples and records from being lost, damaged, or altered. When not in use, all field notebooks will be in the possession of project personnel. Access to these files will be limited to the field personnel who utilize them.
- Sample Tracking and Management. A record of all field documentation will be maintained to provide verification of the validity of data used in the site analysis. To effectively execute such documentation, carefully constructed sample tracking and data management procedures will be used throughout the sampling program.

  Sample tracking will begin with the completion of chain of custody forms. Copies of all completed chain of custody forms will be maintained in the field office. The laboratory will verify receipt of the samples electronically (via email) on the following day.

  When analytical data are received from the laboratory, the incoming analytical data packages will be reviewed against the information on the chain of custody to confirm that the correct analyses were performed for each sample and that results for all samples submitted for analysis were received. Any discrepancies noted will be promptly followed up with the laboratory.

2.10.3 Data Management System

In addition to the sample tracking system, a data management system will be implemented. The central focus of the data management system will be the development of a personal computer-based project database. The project database will combine pertinent geographical, field, and analytical data. Information that will be used to populate the database will be derived from surveying of sampling locations, field observations, and analytical results. Each of these sources is discussed in the following sections.

- Field Observations. An important part of the information that will ultimately reside in the data management system for use during the project will originate with observations that are recorded in the field logbook.

  The field logbook will include the locations sampled, the sampling methodologies used, QA/QC procedures, sample identification numbers, equipment decontamination procedures, personnel involved in the activity, and any other noteworthy events that occurred.

  Field logbooks are valuable tools to keep project personnel informed on the details of the field activities and are also invaluable during the development of the required reports. Each field logbook will be reviewed for accuracy and completeness by the respective sampling activity manager. As appropriate, information included in the field logbook will be used to transfer field observations into the data management system.

- Analytical Results. Analytical results will be provided by the laboratory in digital format. The data packages will be examined to confirm that the correct analyses were performed for each sample submitted and that all of the analyses requested on the chain of custody form were performed. If discrepancies are noted, the laboratory will be contacted to resolve any issues.

  Each data package will be validated. Any data that do not meet the specified standards will be flagged pending resolution of the issue. The flag will not be removed from the data until the issue associated with the sample results is resolved. Although flags may remain for certain data, the use of those data may not necessarily be restricted.

  The individual EDDs, supplied by the laboratory in EQuIS four-file format, will be loaded into the appropriate database. Any analytical data that cannot be provided by the laboratory in electronic format will be entered manually. After entry into the database, the EDD data will be compared to the field information previously entered into the database to confirm that all requested analytical data have been received.

- Data Analysis and Reporting. A valuable function of the data management system will be the manual generation of tables of analytical results during report preparation. Tables of analytical data will be produced as part of data interpretation and reporting tasks and will include a comparison of the analytical results to the applicable investigation standards.

3 Assessment and Oversight

3.1 Assessment and Response Actions

Performance and systems audits will be completed in the field and the laboratory during the sampling, as described below.

3.1.1 Field Audits

The Arcadis TM will monitor field performance. Field performance audit summaries will contain an evaluation of field activities to verify that the activities are performed according to established protocols. Field performance audits may be performed by the Arcadis, USEPA, or RACER Trust. The auditor(s) will review field reports and communicate concerns, as appropriate. The observations made during field performance audits and any recommended changes/deviations to the field procedures will be recorded and documented.

In addition, systems audits comparing scheduled QA/QC activities from this QAPP with actual QA/QC activities completed will be performed. The PM and Project Chemist may periodically confirm that work is being performed consistent with this QAPP.

3.1.2 Laboratory Audits

Internal audits are conducted by the laboratory consistent with their Quality Systems Manual. As part of the audit, the overall performance of the laboratory staff is evaluated and compared to the performance criteria outlined in the laboratory Quality Systems Manual and SOPs. The results of the audits are summarized and issues to each department supervisor, the laboratory manager, and the laboratory director. A systems audit of each laboratory may be performed by the Arcadis Project Chemist to determine whether the procedures implemented by each laboratory are in compliance with the Quality Systems Manual and SOPs.

As a participant in state and federal certification programs, the laboratory is audited by representatives of the regulatory agency issuing certification. Audits are usually conducted on an annual basis and focus on laboratory conformance to the specific program protocols for which the laboratory is seeking certification. The auditor reviews sample handling and tracking documentation, analytical methodologies, analytical supportive documentation, and final reports. The audit findings are formally documented and submitted to the laboratory for corrective action, if necessary.

3.1.3 Corrective Action

Corrective actions are required when field or analytical data are not within the objectives specified in this QAPP. Corrective actions include procedures to promptly investigate, document, evaluate, and correct data collection and/or analytical procedures. Field and laboratory corrective action procedures for the assessment are described below.

3.1.4 Field Procedures

- Field Procedures. If, during field work, a condition is noted by the field crew that would have an adverse effect on data quality, corrective action will be taken so as not to repeat this condition. Condition identification, cause, and corrective action implemented will be documented on a Corrective Action Form. The PM or his designee will be responsible for follow-up and acceptance of corrective actions. Project personnel will

continuously monitor ongoing work performance in the normal course of daily responsibilities. Examples of situations that would require corrective actions are provided below:

- Protocols as defined by the QAPP have not been followed
- Equipment is not in proper working order or properly calibrated
- QC requirements have not been met
- Issues resulting from performance or systems audits

- Laboratory Procedures. In the laboratory, when a condition is noted to have an adverse effect on data quality, corrective action will be taken so as not to repeat this condition. Condition identification, cause, and corrective action to be taken will be documented, and reported to Arcadis. Corrective action may be initiated, at a minimum, under the following conditions:
  - Protocols as defined by this QAPP have not been followed
  - Predetermined data acceptance standards are not obtained
  - Equipment is not in proper working order or calibrated
  - Sample and test results are not completely traceable
  - QC requirements have not been met
  - Issues resulting from performance or systems audits

  Laboratory personnel will continuously monitor ongoing work performance in the normal course of daily responsibilities. Corrective action will be initiated upon identification of the problem. At whatever level this occurs (analyst, supervisor, data review, or QC), it will be brought to the attention of the Laboratory QA Manager and, ultimately, the Laboratory Director. Final approval of any action deemed necessary is subject to the approval of the Laboratory Director.

  Corrective action deemed necessary based on system or performance audits, the analytical results of split samples, or the results of data review will be implemented. The corrective action may include sample re-extraction, re-preparation, reanalysis, cleanup, dilution, matrix modification, or other activities deemed necessary to assure usable analytical data.

3.2 Reports to Management

3.2.1 Internal Reporting

The analytical laboratory will submit analytical reports to Arcadis for data validation. Supporting data (i.e., historic data, related field or laboratory data) will also be reviewed to evaluate data quality, as appropriate. Internal reporting will include the following:

- Assessment of data accuracy, precision, and completeness for both field and laboratory data.
- Results of the performance and systems audits.
- Significant QA/QC problems, solutions, corrections, and potential consequences.
- Analytical data validation report.

3.2.2 Reporting

Upon receipt of the data package from the laboratory, Arcadis will determine if the data package has met the required DQOs. The analytical data package will be incorporated into one or more of the following reports.

- Semi-annual Progress and Data Reports, as identified in Paragraph 26.b of the Administrative Order on Consent, with a reduction in frequency to semi-annual approved on December 22, 2016. To be submitted by January 15 and July 15 of each year.
- Long Term Stewardship Plan, as identified in Section V of the Final Decision and Response to Comments and Section 6.1 of the CMI Work Plan. Anticipated schedule for submittal by the completion of the Corrective Measures construction activities.
- Final Remedy Construction Completion Report/Corrective Measures Completion Report, as identified in Paragraph 26.d of the Administrative Order on Consent and Section 6.1 of the CMI Work Plan. Anticipated schedule for submittal within 45-days after Final Inspection for Corrective Measures construction activities.

As identified in Paragraph 31 of the Administrative Order on Consent, RACER will retain for at least 6 years after the Administrative Order on Consent is terminated, all data and all final documents related to the Administrative Order on Consent. RACER will notify EPA in writing 90-days before destroying any such records and give EPA the opportunity to take possession of any non-privileged documents.

4 Data Validation and Usability

After field and laboratory data are obtained, the data will be subject to the following:

- Review
- Data validation
- Reduction, or manipulation mathematically or otherwise into meaningful and useful forms.
- Organization, interpretation, and reporting.

4.1 Data Review, Verification, and Validation

4.1.1 Field Data Reduction

Information collected in the field through visual observation, manual measurement, and/or field instrumentation will be recorded in field notebooks, log sheets, and/or on forms. Such data will be reviewed for adherence to this QAPP and for consistency. Any concerns identified as a result of this review will be discussed with the field personnel, corrected if possible, and, as necessary, incorporated into the data evaluation process.

4.1.2 Field Data Review

Field data calculations, transfers, and interpretations will be conducted by the field personnel and reviewed for accuracy. Logs and documents will be checked for:

- General completeness.
- Readability.
- Usage of appropriate procedures.
- Appropriate instrument calibration and maintenance.
- Reasonableness in comparison to present and past data collected.
- Correct sample locations.
- Correct calculations and interpretations.

4.1.3 Field Data Reporting

Where appropriate, field data forms and calculations will be processed and included in appendices to the reports. The original field logs, documents, and data reductions will be kept in the project file.

4.1.4 Laboratory Data Reduction

The calculations used for data reduction will be in accordance with the analytical methods. Whenever possible, analytical data will be transferred directly from the instrument to a computerized data system. Raw data will be entered into permanently bound laboratory notebooks. The data entered must be sufficient to document all factors used to arrive at the reported value.

Concentration calculations for chromatographic analyses will be based on response factors. Quantitation will be performed using internal standards for GC/MS methodology. Concentration calculations for metals and wet chemistry, if appropriate, will be based on linear regression.

Unless otherwise specified, all values will be reported uncorrected for blank contamination

4.1.5 Laboratory Data Review

Data will be subject to multi-level review by the laboratory. The group leader will review all data reports prior to release for final data report generation. The QA Manager will review the final data reports, and the Laboratory Director will review a cross section of the final data reports prior to release.

If discrepancies or deficiencies are present in the analytical results, corrective action will be taken. Deficiencies discovered as a result of internal data review, as well as the corrective actions to be used to rectify the situation, will be documented on a Corrective Action Form.

4.2 Verification and Validation Methods

Data validation is a standardized review process for judging the analytical quality and usefulness of a discrete set of chemical data and is necessary to ensure that data of known and documented quality are used in making environmental decisions that meet the DQOs of the site. Data validation is a systematic process that compares a body of data to the requirements in a set of documented acceptance criteria to ascertain its completeness, correctness, and consistency. Data validation will be performed by the Arcadis Project Chemist (or his designee). The data validation personnel will work independently from all other project teams within the organization of Arcadis. Data validators are not associated with the field staff involved in the collection of samples or end users (project team) preparing data reports for the client. Furthermore, the project chemistry group has previous work experience in a laboratory environment and are familiar with the analytical methods and data validation guidance.

Data will be validated using the USEPA National Functional Guidelines for Organic Superfund Methods Data Review, EPA 540-R-20-005, November 2020 (with reference to the historical USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, OSWER 9240.1-05A-P, October 1999, as appropriate) and USEPA National Functional Guidelines for Inorganic Superfund Methods Data Review, EPA 540-R-20-006, November 2020 (with reference to the historical USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, OSWER 9240.1-45, October 2004, as appropriate); and professional judgment, where appropriate. These procedures and criteria may be modified, as necessary, to address project-specific and method-specific criteria, control limits and procedures. Data validation will consist of data screening, checking, reviewing, editing and interpretation to document analytical data quality and to determine whether the quality is sufficient to meet the DQOs.

The data validator will verify that reduction of laboratory measurements and laboratory reporting of analytical parameters is in accordance with the procedures specified for each analytical method and/or as specified in this QAPP. Any deviations from the analytical method or any special reporting requirement apart from those specified in this QAPP will be detailed on COC forms.

Upon receipt of laboratory data, the following items will be evaluated by the data validator:

- Evaluate completeness of data package.
- Verify that field COC forms were completed and that samples were handled properly.

- Requested analytical method performed and sample preparation and analysis dates present. Evaluate that sample holding times have been met. Holding time exceedances, should they occur, will be documented. Data for all samples exceeding holding time requirements will be flagged as either estimated or rejected. The decision as to which qualifier is more appropriate will be made on a case-by-case basis.
- Requested target analytes are reported with the requested reporting limits and in the correct result units.
- Laboratory data qualifiers are defined.
- Sampling dates, date and time of laboratory receipt of samples, and sample conditions upon receipt (i.e., sample preservation, cooler temperature) are identified.
- Sample- and instrument-related QC data and QC acceptance criteria are provided (e.g., method blanks, field blanks, surrogate recoveries, internal standard recoveries, field duplicates, LCS recoveries, MS/MSD recoveries).
- Sample results are evaluated by comparing sample-related QC data to the requirements presented in the QAPP and data validation guidelines.
- Investigate anomalies identified during review. When anomalies are identified, they will be discussed with the Project Manager and/or Laboratory Manager, as appropriate.
- If data appear suspect, investigate the specific data of concern. Calculations will be traced back to raw data. If calculations do not agree, the cause will be determined and corrected.

It should be noted that qualified results for not necessarily invalidate data. The goal to produce the best possible data does not necessarily mean that data must be produced without QC qualifiers. Qualified data can provide useful information.

During the review process, laboratory qualified and unqualified data are verified against the supporting documentation. Based on this evaluation, qualifier codes may be added, deleted, or modified by the data reviewer. Results will be qualified with the following codes in accordance with the National Functional Guidelines:

Qualifier	Definition
Concentration Qualifiers (Laboratory Assigned)	
U	The analyte/compound was analyzed for but not detected. The associated value is the compound reporting limit.
B	The analyte/compound has been found in the sample as well as its associated blank, its presence in the sample may be suspect.
J	The analyte/compound was positively identified, however, the associated numerical value is an estimated concentration only.
Quantitation Qualifiers (Laboratory Assigned)	
E	The compound was quantitated above the calibration range.
D	Concentration is based on a diluted sample analysis.
Validation Qualifiers	
UJ	The analyte/compound was not detected above the reported sample quantitation limit, however, the reported limit is approximate and may or may not represent the actual reporting limit.
UB	The analyte/compound is considered non-detect at the listed value due to associated blank contamination (i.e., concentration in the sample is less than five-times the concentration detected in

Qualifier	Definition
	the associated blank).
J	The analyte/compound was positively identified, however, the associated numerical value is an estimated concentration.
J+	The result is an estimated quantity, but the result may be biased high.
J-	The result is an estimated quantity, but the result may be biased low.
R	The sample results are rejected and the data are unusable.

Two facts will be noted to all data users:

- The “R” qualifier means that the associated value is unusable. In other words, due to significant QC problems, the analysis is invalid and provides no information as to whether the compound is present or not. “R” values should not appear on data tables because they cannot be relied upon, even as a last resort.
- No compound concentration, even if it has passed all QC tests, is guaranteed to be accurate. Strict QC serves to increase confidence in data but any value potentially contains error.

Resolution of any issues regarding laboratory performance or deliverables will be handled between the laboratory and the data validator. Suggestions for reanalysis may be made by the Project Chemist at this point.

4.3 Reconciliation with User Requirements

The data results will be examined to determine the performance that was achieved for each DQI. The performance will then be compared with the project objective and DQOs. Of particular note will be samples at or near action levels. All deviations from objectives will be noted. Additional action may be warranted when performance does not meet performance objectives for critical data. Options for corrective action relating to incomplete information, questionable results, or inconsistent data may include the following:

- Retrieval of missing information;
- Request for additional explanation or clarification;
- Reanalysis of sample from extract (when appropriate); and
- Recalculation or reinterpretation of results by the laboratory.

These actions may improve the data quality, reduce uncertainty, and eliminate the need to qualify or reject data.

If these actions do not improve the data quality to an acceptable level, the following additional actions may be taken:

- Extrapolation of missing data from existing data points
- Use of historical data
- Evaluation of the critical/non-critical nature of the sample

If the data gap cannot be resolved by these actions, an evaluation of the data bias and potential for false negatives and positives can be performed. If the resultant uncertainty level is unacceptable, additional sample collection and analysis may be required.

5 References

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Tables

Table 1-A
Parameters, Methods, and Target Quantitation Limits (Groundwater)
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Analyte	CAS Number	Site-Specific Groundwater Vapor Intrusion Screening Level - Residential (µg/L)[1]	Site-Specific Groundwater Vapor Intrusion Screening Level - Commercial (µg/L)[1]	USEPA Maximum Contaminant Level (µg/L)[2]	Laboratory MDL (µg/L)[3,4]	Laboratory RL (µg/L)[3,4]
VOCs (SW-846 8260C)						
Acetone	67-64-1	--	--	--	50	100
Benzene	71-43-2	--	--	5	1.0	5.0
Bromodichloromethane	75-27-4	--	--	80	2.5	5.0
Bromoform	75-25-2	--	--	80	2.5	5.0
Bromomethane	74-83-9	--	--	--	3.9	5.0
2-Butanone	78-93-3	--	--	--	12	25
Carbon disulfide	75-15-0	--	--	--	5.0	10
Carbon tetrachloride	56-23-5	--	--	5	2.5	5.0
Chlorobenzene	108-90-7	--	--	100	2.5	5.0
Chloroethane	75-00-3	--	--	--	2.5	5.0
Chloroform	67-66-3	--	--	80	2.5	5.0
Chloromethane	74-87-3	--	--	--	2.5	5.0
Cyclohexane	110-82-7	--	--	--	50	100
1,2-Dibromo-3-chloropropane	96-12-8	--	--	0.2	5.0	10
Dibromochloromethane	124-48-1	--	--	80	2.5	5.0
1,2-Dibromoethane	106-93-4	--	--	0.05	2.5	5.0
1,2-Dichlorobenzene	95-50-1	--	--	600	2.5	5.0
1,3-Dichlorobenzene	541-73-1	--	--	--	2.5	5.0
1,4-Dichlorobenzene	106-46-7	--	--	75	2.5	5.0
Dichlorodifluoromethane	75-71-8	--	--	--	5.0	5.0
1,1-Dichloroethane	75-34-3	--	--	--	0.6	5.0
1,2-Dichloroethane	107-06-2	--	--	5	0.6	5.0
1,1-Dichloroethene	75-35-4	55,120	77,160	7	2.5	5.0
cis-1,2-Dichloroethene	156-59-2	41,260	57,760	70	0.65	5.0
trans-1,2-Dichloroethene	156-60-5	44,270	61,980	100	0.86	5.0
1,2-Dichloropropane	78-87-5	--	--	5	2.5	5.0
cis-1,3-Dichloropropene	10061-01-5	--	--	--	2.5	5.0
trans-1,3-Dichloropropene	10061-02-6	--	--	--	2.5	5.0
Ethylbenzene	100-41-4	--	--	700	1.0	5.0
2-Hexanone	591-78-6	--	--	--	12	25
Isopropylbenzene	98-82-8	--	--	--	2.5	5.0
Methyl acetate	79-20-9	--	--	--	25	50
Methylcyclohexane	108-87-2	--	--	--	25	50
Methylene chloride	75-09-2	--	--	5	5.0	5.0
4-Methyl-2-pentanone	108-10-1	--	--	--	12	25
Methyl tert-butyl ether	1634-04-4	--	--	--	2.1	4.0
Styrene	100-42-5	--	--	100	2.5	5.0
1,1,2,2-Tetrachloroethane	79-34-5	--	--	--	2.5	5.0
Tetrachloroethene	127-18-4	23,430	32,800	5	0.93	5.0
Toluene	108-88-3	--	--	1,000	1.0	5.0
1,2,4-Trichlorobenzene	120-82-1	--	--	70	2.5	5.0
1,1,1-Trichloroethane	71-55-6	--	--	200	0.89	5.0
1,1,2-Trichloroethane	79-00-5	--	--	5	2.5	5.0
Trichloroethene	79-01-6	1,540	2,150	5	0.80	5.0
Trichlorofluoromethane	75-69-4	--	--	--	2.5	5.0
1,1,2-Trichlorotrifluoroethane	76-13-1	--	--	--	2.5	5.0
Vinyl chloride	75-01-4	540	1,810	2	0.97	2.0
Xylenes, Total	1330-20-7	--	--	10,000	5.0	10

Table 1-A
Parameters, Methods, and Target Quantitation Limits (Groundwater)
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Analyte	CAS Number	Site-Specific Groundwater Vapor Intrusion Screening Level - Residential (µg/L)[1]	Site-Specific Groundwater Vapor Intrusion Screening Level - Commercial (µg/L)[1]	USEPA Maximum Contaminant Level (µg/L)[2]	Laboratory MDL (µg/L)[3,4]	Laboratory RL (µg/L)[3,4]
Dissolved Gases (AM20GAX)						
Acetylene	74-86-2	--	--	--	0.128	0.5
Ethane	74-84-0	--	--	--	0.1715	1
Ethene	74-85-1	--	--	--	0.2413	1
Methane	74-82-8	--	--	--	1.9764	5
Metals (SW-846 6010B)						
Iron	7439-89-6	--	--	300	32.4	100
Manganese	7439-96-5	--	--	50	1.12	10
General Chemistry						
Nitrate Nitrogen (EPA 300.0)	14797-55-8	--	--	10,000	14	50
Sulfate (SW-846 9038)	14808-79-8	--	--	250,000	5,100	10,000
Chloride (SM 4500-Cl-E)	16887-00-6	--	--	250,000	612	1,000
Total Organic Carbon (SM 5310C	7440-44-0	--	--	--	204	1,000

Notes:
1. The data are screened against site-specific Groundwater Vapor Intrusion Screening Criteria for residential and commercial/industrial values
2. USEPA National Primary Drinking Water Regulations, May 2009.
3. Concentrations detected less than the reporting limit but greater than the method detection limit must be reported with the appropriate qualifier.
4. The laboratory limits provided are current as of the writing of the QAPP. The samples will be reported using the current limits at the time of the

Abbreviations and Acronyms
MDL = Method Detection Limit
µg/L = micrograms per liter
RL = Reporting Limit
VOCs = Volatile Organic Compounds

Table 1-B
Parameters, Methods, and Target Quantitation Limits (Air)
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Analyte	Vapor Screening Level	CAS Number	Laboratory MDL ($\mu g/m^3$)[1,2]	Laboratory RL ($\mu g/m^3$)[1,2]
VOCs (TO-15)				
Trichloroethene	2.24 $\mu g/m^3$ off-site (9.42 $\mu g/m^3$ worker)	79-01-6	0.196	0.546

Notes:

1. Concentrations detected less than the reporting limit but greater than the method detection limit must be reported with the appropriate qualifier.

2. The laboratory limits provided are current as of the writing of the QAPP. The samples will be reported using the current limits at the time of the analysis.

Abbreviations and Acronyms

MDL = Method Detection Limit

$\mu g/m^3$ = Micrograms per cubic meter

RL = Reporting Limit

VOCs = Volatile Organic Compounds

Table 1-C
Parameters, Methods, and Target Quantitation Limits (Soil)
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Analyte	IDEM 2021 Commercial/Industrial Soil Exposure Screening Level (mg/kg)	CAS Number	Laboratory MDL (mg/Kg)[1,2,3]	Laboratory RL (mg/Kg)[1,2,3]
VOCs (SW-846 8260C)				
Acetone	100000	67-64-1	0.05	0.1
Benzene	51	71-43-2	0.001	0.005
Bromodichloromethane	13	75-27-4	0.0025	0.005
Bromoform	860	75-25-2	0.0032	0.005
Bromomethane	30	74-83-9	0.004	0.005
2-Butanone	28000	78-93-3	0.012	0.025
Carbon disulfide	740	75-15-0	0.005	0.010
Carbon tetrachloride	29	56-23-5	0.0025	0.005
Chlorobenzene	760	108-90-7	0.0025	0.005
Chloroethane	2100	75-00-3	0.0025	0.005
Chloroform	14	67-66-3	0.0025	0.005
Chloromethane	460	74-87-3	0.0025	0.005
Cyclohexane	280	110-82-7	0.05	0.10
1,2-Dibromo-3-chloropropane	0.64	96-12-8	0.0025	0.005
Dibromochloromethane	390	124-48-1	0.0025	0.005
1,2-Dibromoethane	1.6	106-93-4	0.0025	0.005
1,2-Dichlorobenzene	380	95-50-1	0.0025	0.005
1,3-Dichlorobenzene	-	541-73-1	0.0025	0.005
1,4-Dichlorobenzene	110	106-46-7	0.0025	0.005
Dichlorodifluoromethane	370	75-71-8	0.005	0.005
1,1-Dichloroethane	160	75-34-3	0.0025	0.005
1,2-Dichloroethane	20	107-06-2	0.0025	0.005
1,1-Dichloroethene	1000	75-35-4	0.0025	0.005
cis-1,2-Dichloroethene	2300	156-59-2	0.0025	0.005
trans-1,2-Dichloroethene	300	156-60-5	0.0025	0.005
1,2-Dichloropropane	66	78-87-5	0.0025	0.005
cis-1,3-Dichloropropene	-	10061-01-5	0.0025	0.005
trans-1,3-Dichloropropene	-	10061-02-6	0.0025	0.005
Ethylbenzene	250	100-41-4	0.0025	0.005
2-Hexanone	1300	591-78-6	0.05	0.1
Isopropylbenzene	270	98-82-8	0.0025	0.005
Methyl acetate	29000	79-20-9	0.0025	0.005
Methylcyclohexane	-	108-87-2	0.0025	0.005
Methylene chloride	3200	75-09-2	0.01	0.02
4-Methyl-2-pentanone	3400	108-10-1	0.012	0.025
Methyl tert-butyl ether	2100	1634-04-4	0.0025	0.005
Styrene	870	100-42-5	0.0025	0.005
1,1,2,2-Tetrachloroethane	27	79-34-5	0.0025	0.005
Tetrachloroethene	170	127-18-4	0.0014	0.005
Toluene	820	108-88-3	0.0025	0.005
1,2,4-Trichlorobenzene	260	120-82-1	0.0025	0.005
1,1,1-Trichloroethane	640	71-55-6	0.0025	0.005
1,1,2-Trichloroethane	6.3	79-00-5	0.0025	0.005
Trichloroethene	19	79-01-6	0.001	0.005
Trichlorofluoromethane	1200	75-69-4	0.0025	0.005
1,1,2-Trichlorotrifluoroethane	910	76-13-1	0.0025	0.005
Vinyl chloride	17	75-01-4	0.0025	0.005
Xylenes, Total	260	1330-20-7	0.005	0.010

Table 1-C
Parameters, Methods, and Target Quantitation Limits (Soil)
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Analyte	IDEM 2021 Commercial/Industrial Soil Exposure Screening Level (mg/kg)	CAS Number	Laboratory MDL (mg/Kg)[1,2,3]	Laboratory RL (mg/Kg)[1,2,3]

Notes:

1. Concentrations detected less than the reporting limit but greater than the method detection limit must be reported with the appropriate qualifier.

2. The laboratory limits provided are current as of the writing of the QAPP. The samples will be reported using the current limits at the time of the analysis.

3. Soil results will be reported on a dry-weight basis.

Abbreviations and Acronyms

MDL = Method Detection Limit

mg/Kg = milligrams per kilogram

RL = Reporting Limit

VOCs = Volatile Organic Compounds

Table 1-D
Parameters, Methods, and Target Quantitation Limits (Waste Characterization)
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Analyte	CAS Number	Action Limit (mg/L)[1]	Laboratory MDL (mg/L) [2,3]	Laboratory RL (mg/L) [2,3]
TCLP VOCs (SW-846 1311/8260C)				
Benzene	71-43-2	0.5	0.01	0.05
2-Butanone	78-93-3	200	0.5	1
Carbon tetrachloride	56-23-5	0.5	0.025	0.05
Chlorobenzene	108-90-7	100	0.025	0.05
Chloroform	67-66-3	6.0	0.025	0.05
1,2-Dichloroethane	107-06-2	0.5	0.025	0.05
1,1-Dichloroethene	75-35-4	0.7	0.025	0.05
Tetrachloroethene	127-18-4	0.7	0.025	0.05
Trichloroethene	79-01-6	0.5	0.025	0.05
Vinyl chloride	75-01-4	0.2	0.01	0.02
TCLP SVOCs (SW-846 1311/8270D)				
1,4-Dichlorobenzene	106-46-7	7.5	0.05	0.1
2,4-Dinitrotoluene	121-14-2	0.13	0.05	0.1
Hexachlorobenzene	118-74-1	0.13	0.05	0.1
Hexachlorobutadiene	87-68-3	0.5	0.05	0.1
Hexachloroethane	67-72-1	3	0.05	0.1
2-Methylphenol	95-48-7	200	0.05	0.1
3&4-Methylphenol	108-39-4 / 106-44-5	200	0.1	0.2
Nitrobenzene	98-95-3	2	0.05	0.1
Pentachlorophenol	87-86-5	100	0.25	0.5
Pyridine	110-86-1	5	0.05	0.1
2,4,5-Trichlorophenol	95-95-4	400	0.25	0.5
2,4,6-Trichlorophenol	88-06-2	2	0.05	0.1
TCLP Metals (SW-846 1311/6010C/7470A)				
Arsenic	7440-38-2	5.0	0.05	0.1
Barium	7440-39-3	100	2.5	5
Cadmium	7440-43-9	1.0	0.025	0.05
Chromium	7440-47-3	5.0	0.05	0.1
Lead	7439-92-1	5.0	0.05	0.1
Mercury	7439-97-6	0.2	0.001	0.002
Selenium	7782-49-2	1.0	0.05	0.1
Silver	7440-22-4	5.0	0.05	0.1

Notes:

1. Waste characterization screening criteria reflect 40 CFR 261, Appendix II, 1993 ed., as amended by 58 FR 46040,

2. Concentrations detected less than the reporting limit but greater than the method detection limit must be reported with the appropriate qualifier.

3. The laboratory limits provided are current as of the writing of the QAPP. The samples will be reported using the current limits at the time of the analysis.

4. The target reporting limits are based on wet weight. The actual reporting limits will vary based on sample weight and moisture content.

Abbreviations and Acronyms

MDL - Method Detection Limit

mg/L = Milligrams per Liter

RL = Reporting Limit

SVOCs = Semivolatile Organic Compounds

TCLP = Toxicity Characteristic Leaching Procedure

VOCs = Volatile Organic Compounds

Table 2
Sample Quantities and Quality Control Frequencies
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Parameter	Estimated Environmental Sample Quantity	Field QC Analyses						Laboratory QC Sample						Total
		Trip Blank		Rinse Blank		Field Duplicate		MS		MSD		Lab Duplicate		
		Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	
Groundwater														
VOCs (SW-846 8260C)	162	1/cooler	TBD	1/20	8	1/10	16	1/20	8	1/20	8	NA	--	202
Metals (SW-846 6010B)	7	NA	--	1/20	1	1/10	1	1/20	1	1/20	1	NA	--	11
Nitrate Nitrogen (EPA 300.0)	7	NA	--	1/20	1	1/10	1	1/20	1	1/20	1	NA	--	11
Sulfate (SW-846 9038)	7	NA	--	1/20	1	1/10	1	1/20	1	1/20	1	NA	--	11
Chloride (SM 4500-Cl-E)	7	NA	--	1/20	1	1/10	1	1/20	1	1/20	1	NA	--	11
Total Organic Carbon (SM 5310C)	7	NA	--	1/20	1	1/10	1	1/20	1	1/20	1	NA	--	11
Dissolved Gases (AM20GAX)	7	NA	--	1/20	1	1/10	1	1/20	1	1/20	1	NA	--	11
Air														
VOCs (TO-15)	120	NA	--	NA	--	1/10	6	NA	--	NA	--	1/20	6	126
Soil														
VOCs (SW-846 8260C)	50	1/cooler	TBD	1/20	2	1/10	3	1/20	2	1/20	2	NA	--	59
Waste Characterization														
TCLP VOCs (SW-846 1311/8260C)	10	NA	--	NA	--	NA	--	NA	--	NA	--	NA	--	10
TCLP SVOCs (SW-846 1311/8270D)	10	NA	--	NA	--	NA	--	NA	--	NA	--	NA	--	10
TCLP Metals (SW-846 1311/6010C)	10	NA	--	NA	--	NA	--	NA	--	NA	--	NA	--	10
TCLP Mercury (SW-846 1311/7470A)	10	NA	--	NA	--	NA	--	NA	--	NA	--	NA	--	10

Abbreviations and Acronyms
Freq = Frequency
MS = Matrix Spike
MSD = Matrix Spike Duplicate
NA = Not Applicable
No. = Number
QC = Quality Control
SVOCs = Semivolatile Organic Compounds
TBD = To Be Determined
TCLP = Toxicity Characteristic Leaching Procedure
VOCs = Volatile Organic Compounds

Table 3
Laboratory Quality Control Limits
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Parameter	Accuracy - Percent Recovery			Precision - Relative Percent Difference		
	Surrogate	MS/MSD	LCS	MS/MSD	Lab Duplicate	Field Duplicate
Groundwater						
VOCs (SW-846 8260C)	77% - 120%	11% - 161%	51% - 140%	20	--	35
Metals (SW-846 6010B)	--	75% - 125%	80% - 120%	20	--	35
Nitrate Nitrogen (EPA 300.0)	--	80% - 120%	80% - 120%	15	--	35
Sulfate (SW-846 9038)	--	90% - 110%	90% - 110%	20	--	35
Chloride (SM 4500-Cl-E)	--	90% - 110%	90% - 110%	20	--	35
Total Organic Carbon (SM 5310C)	--	80% - 120%	90% - 110%	20	--	35
Dissolved Gases (AM20GAX)	--	70% - 130%	70% - 130%	20	--	35
Air						
VOCs (TO-15)	70% - 130%	--	70% - 130%	--	25	50
Soil						
VOCs (SW-846 8260C)	40% - 149%	10% - 179%	42% - 148%	20	--	50
Waste Characterization						
TCLP VOCs (SW-846 1311/8260C)	77% - 120%	26% - 173%	51% - 164%	20	--	--
TCLP SVOCs (SW-846 1311/8270C)	15% - 156%	12% - 151%	17% - 126%	20	--	--
TCLP Metals (SW-846 6010B)	--	75% - 125%	80%- 120%	20	--	--
TCLP Mercury (SW-846 7470A)	--	75% - 125%	80%- 120%	20	--	--

Notes:

1. The listed QC limits are based on the laboratory-provided limits at the time of this document. The limits are updated periodically by the laboratory, and the current limits at the time of analysis will be reported.

Abbreviations and Acronyms

LCS = Laboratory Control Sample
MS = Matrix Spike
MSD = Matrix Spike Duplicate
SVOCs = Semivolatile Organic Compounds
TCLP = Toxicity Characteristic Leaching Procedure
TPH = Total Petroleum Hydrocarbons
VOCs = Volatile Organic Compounds

Table 4
Sample Containers, Preservation, and Holding Times
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Parameter	Method	Bottle Type[1]	Preservation	Holding Time[2]
Groundwater				
VOCs	SW-846 8260C	2-40ml glass vials with Teflon®-lined lid	HCl to pH<2; Cool to <6°C	14 days to analysis
Metals	SW-846 6010B	1 L plastic bottle	HNO_3 to pH<2; Cool to <6°C	180 days to analysis
Nitrate Nitrogen	EPA 300.0	1 250 mL plastic bottle	Cool to <6°C	48 hours to analysis
Sulfate	SW-846 9038	1 250 mL plastic bottle	Cool to <6°C	28 days to analysis
Chloride	SM 4500-Cl-E	1 250 mL plastic bottle	Cool to <6°C	28 days to analysis
Total Organic Carbon	SM 5210C	2-40ml glass vials with Teflon®-lined lid	H_2SO_4 to pH<2; Cool to <6°C	28 days to analysis
Dissolved Gases	AM20GAX	2-40ml glass vials with Teflon®-lined lid	HCl to pH<2; Cool to <6°C	14 days to extraction
Air				
VOCs	TO-15	Summa canister	None	30 days to analysis
Soil				
VOCs	SW-846 8260C	igh Level: 2-40ml glass vials with Teflon®-lined l	MeOH; Cool to <6°C	14 days to analysis
		ow Level: 2-40ml glass vials with Teflon®-lined li	Freeze within 48 hours of collection	14 days to analysis
Waste Characterization				
TCLP VOCs	SW-846 1311/8260C	1-4oz glass jar with Teflon®-lined lid	Cool to <6°C	14 days to TCLP extraction
				14 days to analysis
TCLP SVOCs	SW-846 1311/8270D	1-8oz glass jar with Teflon®-lined lid	Cool to <6°C	14 days to TCLP extraction
				7 days to extract prep
				40 days to analysis
TCLP Metals	SW-846 1311/6010B	1-4oz wide mouth glass jar	Cool to <6°C	180 days to TCLP extraction
				180 days to analysis
TCLP Mercury	SW-846 1311/7470A			28 days to TCLP extraction
				28 days to analysis

Table 4
Sample Containers, Preservation, and Holding Times
Quality Assuarance Project Plan
RACER Trust, Former GM Delco Plant 5
Kokomo, Indiana

Parameter	Method	Bottle Type[1]	Preservation	Holding Time[2]

Notes:

1. The laboratory should be consulted prior to sample collection, as it may be possible to combine sample volume for multiple analyses in one sample container.
2. All holding times are measured from date of collection. It is imperative that all samples are submitted to the laboratory with ample time for the analysis to be completed within the holding time. Missing a holding time is unacceptable and may result in unusable data if the holding time is missed.

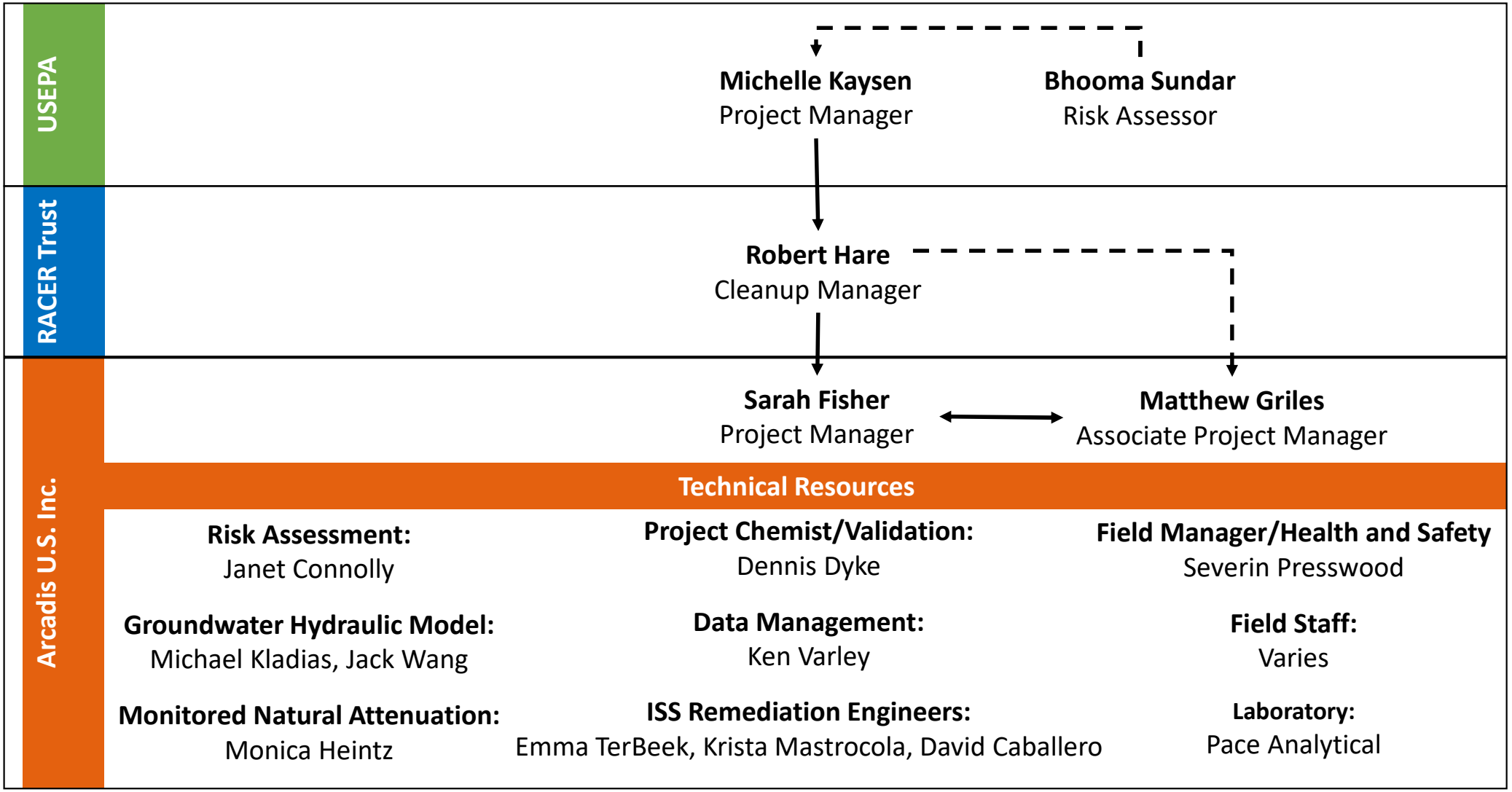
Abbreviations and Acronyms

HCl = Hydrochloric Acid
HNO_3 = Nitric Acid
H_2SO_4 = Sulfuric Acid
L = Liter
MeOH = methanol
ml = milliliter
oz = Ounce
SVOCs = Semivolatile Organic Compounds
TCLP = Toxicity Characteristic Leaching Procedure
VOCs = Volatile Organic Compounds

Attachment 1

Organizational Chart

Attachment 1: Organizational Chart



Attachment 2

Field Sampling Standard Operating Procedures

Arcadis ENV Quality Procedure	
TOPIC: **FIELD ACTIVITIES DOCUMENTATION**	
Revision Date: November 2016 **Revision Letter: C**	**QP#: 3.06**
Quality Reviewer:	
Quality Reviewer Signature:	

STATEMENT OF POLICY:

It is Arcadis Environment Business Line (ENV) policy that field activities must be documented to facilitate the interpretation of data; show compliance with project plans, work plans, and contract terms; and to serve as evidentiary records. Documentation reflecting activities performed must be legible, organized, and complete. Applicable regulatory and client requirements should be considered when documenting field activities. Project-specific requirements for documentation typically should be described in the Work Plan, Field Sampling Plan (FSP), and/or in the Quality Assurance Project Plan (QAPP).

1. Purpose

The purpose of this Quality Procedure (QP) is to provide a standard procedure for the documentation of fieldwork activities. This documentation pertains to site-related projects, but is not limited to the collection of samples, subsurface information, and oversight of construction activities. Field documentation must include, at a minimum, project title and number, date and times of activities, the identification of the employee performing the work, and the specifics of the work being performed.

2. Responsibilities

Certified Project Manager (CPM) – is responsible for the project-related administration of this QP.

Quality Consultant – is responsible for providing quality assurance and quality control guidance to the CPM in implementing this procedure. Note that for federal projects, there are specific requirements and qualifications for the QA Officer assigned to the project.

Project Team Members – who are assigned to document field activities, are responsible for compliance with this procedure.

3. Terms and Definitions

Field Sampling Plan (FSP) – A document that describes the procedures and protocols necessary to complete field sampling and data collection activities.

Work Plan – A document that describes proposed project activities.

Arcadis ENV Quality Procedure	
TOPIC: **FIELD ACTIVITIES DOCUMENTATION**	
Revision Date: November 2016 **Revision Letter: C**	**QP#: 3.06**
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Quality Reviewer Signature:	

Quality Assurance Project Plan (QAPP) – A document that prescribes the quality assurance/quality control (QA/QC) procedures to be followed. Uniform Federal Policy (UFP) QAPPs are now frequently required for environmental projects by most federal regulatory agencies. A UFP QAPP includes Worksheets used to document the entire project plan developed following the systematic planning process. For more details on the UFP QAPP see http://www.epa.gov/fedfac/documents/qualityassurance.htm. Note that if the project QAPP is written following the UFP format, it will also contain a description of the sampling rationale and sampling locations as well as QA/QC requirements. The UFP QAPP format is designed to capture the entire systematic planning process. If a UFP QAPP is written for a project, a separate FSP is generally not required unless specified by the particular client or contract.

Technical Guidance Instruction (TGI) – Document describes the procedure and/or protocol necessary to conduct a specific activity.

4. Related Forms

Forms used for documenting field activities may be included as attachments to the FSP or the QAPP and may include the following examples:

- Chain-of-custody (COC) form
- Sample data log
- Field modification form
- Sample receipt form
- Corrective action form
- Field activity log
- Calibration log
- Analysis request and chain-of-custody record
- Daily quality control reports
- Purge log
- Soil boring log.

Examples of TGIs with field forms and check-lists can be found in the QMS Document Library.

Arcadis ENV Quality Procedure	
TOPIC: **FIELD ACTIVITIES DOCUMENTATION**	
Revision Date: November 2016 **Revision Letter: C**	**QP#: 3.06**
Quality Reviewer:	
Quality Reviewer Signature:	

DESCRIPTION OF PROCEDURE:

1. General Requirements

1.1 Documentation Format

Documentation of field activities provides an accurate and comprehensive record of the work performed sufficient for a technical peer to reconstruct the day's activities and confirm that necessary client, regulatory, contract, and work plan requirements were met. General requirements include:

- Use of field books (preferably bound) as the primary source for information collection and recording. Field books should be dedicated to the project and appropriately labeled.
- Use of personal digital assistant (PDA) to document select field sampling and data collection activities using Arcadis' electronic data gathering system (EDGE); examples include subsurface data, well/piezometer installation, groundwater sampling, and water-level measurements. Use of PDAs with EDGE is optional but encouraged.
- Use of a Field Activity Log is suggested to formally document activities and events as a supplement to bound field books. The Field Activity Log can be a standard or project-specific form or a bound field book. Preprinted standard forms are available for many activities and should be used whenever possible. These forms will provide prompts and request additional information that may be useful and/or needed. Project-specific field forms may be generated or existing forms may be modified to meet specific project needs. Client-supplied forms may be substituted, as required.
- Appropriate header information is documented on the first page of notes for each day of fieldwork, including project title, project number, date, time, author, and relevant setting information such as weather conditions, topography, surface water conditions, observed site activities/uses, and other persons in field team. In addition, include on every page of notes the page number and date. Project-specific information depends on the nature of work being performed and should be discussed by the project team prior to commencing fieldwork. As appropriate, dedicated field logs/journals or forms should be used. When Field Activity Log Forms are used, information fields that are not applicable should be noted as such with the symbol "N/A" or other appropriate notation.
- Field documentation entries shall be made using indelible ink.
- Data entries shall be legible. A single line should be drawn through incorrect entries and the corrected entry written next to the original strikeout. Strikeouts are to be initialed and dated by the originator.

- Units of measurement shall be specified. The level of accuracy shall be indicated (e.g., observed estimate, quantified census from direct count, and electronic data collection).
- Field records are to be maintained in project files unless otherwise specified by a client or stipulated by a contract.
- Unless addressed specifically by a client or stipulated by a contract, site photographs should be taken to document the general setting and landscape as well as site-specific issues/resources of interest. Photo locations and the compass direction of view should be recorded in the notes with the photo number.

1.2 Documentation Entries

A chronology of field events should be recorded. General entry requirements include:

- Visitors to the site, including owner and regulatory agency representatives
- Summary of pertinent project communications with the client, regulators, or other site visitors during the fieldwork
- Other contractors or entities working on site
- A description of the day's field activities, generally in chronological sequence or in order of significance, using military time notation (e.g., 9:00 a.m. as 0900, and 5:00 p.m. as 1700)
- If applicable, calibration of measuring and test equipment and identification of the calibration standard(s) (use a Calibration Log, if available, with cross-reference entered into the field book)
- Field equipment identification, including information such as the type, manufacturer, model number, or other specific information
- If applicable sampling activities are being performed, weather information such as temperature, wind speed and direction, precipitation, time of measurement, and units
- Documentation of safety meeting (e.g., tailgates and tailboards) topics and attendees
- Verification of subsurface utility clearance in accordance with ENV ivision policy
- Safety and/or monitoring equipment readings, including time of measurements and units
- If applicable, specific forms used for collection of data are referenced in the field notebook
- Subcontractor progress and/or problems encountered
- Changes in the scope of work
- Other unusual events.

Arcadis ENV Quality Procedure	
TOPIC: **FIELD ACTIVITIES DOCUMENTATION**	
Revision Date: November 2016 **Revision Letter: C**	**QP#: 3.06**
Quality Reviewer:	
Quality Reviewer Signature:	

2. Specific Requirements

2.1 Sample Collection

Sample collection data are documented in a bound field book, PDA, and/or on a Field Activity Log. Where both are being used, information contained in one is cross-referenced to the other. Entries such as the following examples should be consistent with the requirements in the project-specific Work Plan, FSP, and QAPP:

- Sample identification number, location taken, depth interval, sample media, sample preservative, collection time, and date
- Sample collection method and protocol
- Physical description of the sample (using a standard classification system for soil)
- If a composite sample, include the number, location(s), and depth(s) of grab samples incorporated in the composite
- Quality-related samples (e.g., field duplicates, trip blanks, equipment rinse, blanks matrix spikes, and matrix spike duplicates)
- Container description and sample volume
- Pertinent technical data, such as pH, conductivity, temperature, and head-space readings
- Pertinent technical comments
- Identification of personnel collecting the sample.

2.2 Sample Labeling

Sample labels must be prepared and attached to sample containers. Labels are either provided by the laboratory performing the analyses or are generated internally. Labels should be indelible and securely attached to the container. The information to be provided may include:

- Sample identification number
- Sample date, initials or name of who collected the sample, and collection time
- Physical description of the sample (e.g., water, solid, gas, or other physical medium)
- Analytical parameters and method(s)
- Preservatives, if present
- Sample location and depth, if applicable
- Client.

Although this information is typically written out, it can also be recorded in an electronic tracking system if a bar code is used.

2.3 Analysis Request and Chain-of-Custody Record

A critical component of data collection is the documentation that the samples were obtained from specific locations and received by the laboratory or archive without alteration. Evidence of collection, shipment, laboratory receipt, and laboratory custody until disposal or archive must be properly documented. Documentation will be accomplished through a COC record that documents each sample and identifies the individuals responsible for sample collection, shipment, and receipt. A sample is considered in custody if at least one of the following criteria is met:

- The sample is in a person's actual possession
- The sample is in unobstructed view, after being in the person's actual possession
- The sample is locked and only accessible by the custodian after having been in the person's actual possession
- The sample is in a secured area, restricted to authorized personnel (e.g., laboratory).

An example COC form to be used by ENV personnel in collecting and shipping samples can be found on the corporate Intranet. A laboratory typically will not accept samples for analysis without a correctly prepared COC form. The COC must be signed by each individual who has the sample in his/her custody. Each sample shipped to a laboratory for analyses must be documented on the COC. Information on this form correlates with other supporting documentation, including the field log book, sample labels, and sample collection logs.

The COC documents the elapsed time and the custodians of the sample from the time of its collection. The individuals who have physically handled the sample(s) or witnessed initial sample collection and packaging (sample team member) must be identified on the form. A sample team member relinquishes the sample by signing the COC. Individuals who either relinquish or receive samples must include their complete names, company affiliation, and the date and time the sample(s) were relinquished. The times that the samples are relinquished and received by the next custodian should coincide, with the exception of transfer by commercial carriers. These carriers will not be required to sign the COC.

If a sample is to be stored for a period of time (e.g., overnight), measures are taken to secure the sample container in a manner that only provides access to the custodian of record. If samples are relinquished to a

commercial carrier (i.e., UPS or Federal Express), the carrier waybill number is recorded, and a copy of the waybill is attached to the COC. These documents are maintained with other field documentation. The original COC is sealed inside a zip-top plastic bag and placed inside the shipping container with the samples.

If corrections are made to the COC, the corrections should be made (single line through the error, initial, and date) by the originator of the change, and, if necessary, an explanation of the change should be provided. The documentation should be of a level of detail that clearly documents the change to a third-party reviewer.

Guidance for choosing a laboratory and completing analyses requests and COC can be found in QP 2.09-Subcontracting Laboratory Services and on the corporate Intranet for the Arcadis Laboratory Program (ALP) and should also be described in the project-specific planning documents (i.e., Work Plan, FSP. or QAPP).

2.4 Subsurface Logs

Test pits, soil borings, monitoring wells or rock coreholes wells, and piezometer installations are to be recorded in bound field books or PDA and may be supplemented with prepared forms. Personnel completing the log are to supply the following information:

- Administrative and technical information included in the header.
- Types of equipment used (e.g., drill rig type, drilling tools used [including diameter and length], or backhoe model).
- Subcontractor/driller used.
- Descriptions of subsurface materials encountered and the number and type of samples collected, if any.
- Subsurface exploration depth and units of measure.
- For drilling, length of recovery.
- Sample type and sample number for geotechnical or analytical samples collected. These data are to be also entered on the sample collection log (if used) and the sample label.
- Classification standard protocol used, if any (e.g., ASTM International Standard Penetration Test).
- Narrative description of the soil, sediment, or bedrock (using standard classification system) and other pertinent information.
- Additional data, such as background and sample vapor/gas readings, observation of sheens, non-aqueous-phase liquid, depth to water (if encountered), presence of (but generally not description of) odors, changes in drilling conditions, and other pertinent information.
- Description of the materials used to seal the boring, unless it is completed as a well or piezometer.

2.5 Monitoring Well/Piezometer Installation

In addition to requirements in Section 2.4, subsequent well or piezometer development activities may involve transcription of field data from the field book onto a computer-based boring log. The field notebook or PDA is to be used to identify the chronology and major events of the installation activity, and the computer-based boring log is to be used to correlate the geologic strata to the major elements of the monitoring well construction. Information to be collected and recorded must meet the regulatory and client requirements and may include the following:

- Location identity
- Screen and riser type, length, diameter, and location
- Diameter
- Total depth
- Sump location and depth and diameter
- Materials of construction (e.g., stainless steel, polyvinyl chloride, or other material)
- Seal type(s) and or depth(s)
- Sand or gravel pack type, including materials (e.g., silica) and gradation
- Depth to water before and after installation.

2.6 Air Sampling Logs

At a minimum, air sampling documentation should include:

- Start and finish time of sampling
- Sampling location
- Sampling method/media
- Volume sampled.

2.7 Construction, Demolition, Abandonment, and Related Activities

Monitoring and documentation of construction and comparable activities shall be documented in bound field books and/or on appropriate company forms and should include similar information as specified above, including information such as:

- Project name and number
- Owner or client name
- Contractor or subcontractors performing the work
- Contractor or subcontractor superintendent(s) and personnel (as available) on site
- Chronological sequence and description of work activities performed, including workday start and completion times
- Reference to contract sections, work plans, or specifications describing work being performed
- Reference to relevant permit conditions and regulatory requirements and/or reference to regulatory guidance documents controlling work approach
- Listing of all trades performing work by contractor and subcontractor
- Hours worked per trade
- Work hours per day per shift, if applicable
- Equipment on site (e.g., description, model number, size, and type) and hours of use
- Listing of equipment on site being left idle
- Description and quantity of materials used or incorporated, with reference to contract or specification item number, if feasible; include simple sketch of excavation with approximate dimension, if applicable
- Calculations with dimensions for quantities of material used or incorporated
- Delineation of the work area and access routes (e.g., fencing, flagging, or staking), confirmation that activities occurred within the work area or description of work occurring outside the delineated work area and justification (as needed), and characterization of impacts outside the designated work area
- Documentation of compliance with speed limits, dust control, erosion control best management practices, and other basic elements of construction activities as dictated by project work plans and applicable permits and regulatory criteria.

2.8 Daily Safety Meeting

A Daily Safety Meeting is to be conducted and documented each workday prior to the initiation of field activities, with on-site ENV personnel, contractors, subcontractors, and visitors if possible. Safety topics discussed are entered on the Daily Safety Meeting Form (available on the corporate Intranet). Topics discussed should include site-specific conditions, procedures to be followed that day, and protective equipment. A printed listing of the attendees at the meeting and their signatures should be included. Other required data are:

- Identification of the individual conducting the meeting and his/her signature
- Identification of the project supervisor and project manager.

2.9 Calibration

Documentation of the calibration and calibration results shall be made for field equipment requiring calibration measuring and test equipment calibration data are recorded in the field book or on the Field Activity Log. Calibration data include the following:

- Unique identification of instrument being calibrated, including type, model, and serial number
- Date and time of calibration
- Standards used in the calibration, including standard identity, concentration, lot number, and manufacturer of the standard
- Instrument reading with respect to each calibration standard
- Comments, as necessary, regarding instrument performance.

2.10 Photographs and Videos

When the client allows, photographs and videos may be used to help document pre-, active, and post-field activities. In sensitive areas (e.g., secured or confidential), the client must be contacted to evaluate security procedures concerning use of photographs or videos. Photographic and video documentation should include project title, project number, date, time, and description of conditions. The time should also be documented if time is important to a sequence of photographs.

Photographs are documented by numbering digital photographs and identifying the number and subject on the Field Activity Log. Individual prints may be marked with a stamp or preprinted self-adhesive labels, or by writing the project number and sequential number of each photograph and referencing the numbers in the field book, the Field Activity Log, or a dedicated photo log. Videos used for field documentation are to be identified by project title, project number, and description.

2.11 Subcontractor Preparedness Checklist

Prior to starting work, a review is to be made and documented of a subcontractor's preparedness to perform specified activities. This review may be documented on the Field Activities Log or on checklists that may be

developed according to requirements for subcontracted work activities. Particular emphasis should be on site-specific issues that may require special consideration such as health and safety, access, and unique settings. These should be discussed in advance with the CPM and the client in developing and implementing the Scope of Work.

— END OF PROCEDURE —

STATEMENT OF POLICY:

It is Arcadis Environment Business Line (ENV) policy that field sampling, measurements, and observations must be conducted and documented to facilitate later data interpretation, provide an evidentiary record and to demonstrate that field activities have been performed consistently and in accordance with approved site-specific project planning documents. Site-specific documents describing field sampling activities may include, but are not limited to, work plans, the Project Quality Plan (PQP), Quality Assurance Project Plan (QAPP), Field Sampling Plan (FSP), applicable Standard Operating Procedures (SOPs) and Technical Guidance Instructions (TGIs), Quality Procedures (QPs), Health and Safety Plan (HASP), and/or other appropriate project documents associated with the sampling program.

1. Purpose

The objective of this Quality Procedure (QP) is to provide a consistent process for the execution of activities associated with field sampling, measurements, and observations. This QP, while focused on field sampling activities, should be performed in conjunction with QP 3.06 Field Activities Documentation.

2. Responsibilities

Certified Project Manager (CPM) – is responsible for implementation of this QP, including verification that site-specific project planning documents are followed (including approved deviation decisions, if necessary). Although a Field Supervisor may lead the sampling activities, the CPM is ultimately responsible for staff's adherence to this QP.

Quality Consultant – responsible for providing quality assurance and quality control (QA/QC) guidance to the CPM in implementing this procedure. Note that for Federal projects there are specific requirements for the QA officer assigned to a project.

Project Team Members – project participants who are involved in sampling activities are responsible for compliance with this procedure. Individuals involved in the sampling program will read and adhere to the site-specific project planning documents that direct their field activities.

3. Terms and Definitions

Work Plan – a document that describes proposed project activities.

Quality Assurance Project Plan (QAPP) – a document that prescribes the quality assurance/quality control procedures to be followed. Uniform Federal Policy (UFP)-QAPPs are now frequently required for environmental projects by most federal regulatory agencies. UFP-QAPP includes Worksheets used to document the entire project plan developed following the systematic planning process. For more details on the UFP-QAPP see: http://www.epa.gov/fedfac/documents/qualityassurance.htm. Note that if the project QAPP is written following the

Printed copies of this procedure are uncontrolled.

Uniform Federal Policy (UFP) that it will also contain a description of the sampling rationale and sampling locations as well as quality assurance/quality control requirements. The UFP-QAPP format is designed to capture the entire systematic planning process. If a UFP-QAPP is written for a project, a separate FSP may not be required unless specified by the particular regulatory agency, client or contract.

Field Sampling Plan (FSP) – a document that describes the procedures and protocols necessary to complete field sampling and data collection activities.

Health and Safety Plan (HASP) – a document that describes the hazards of planned activities and the controls to be implemented to protect site personnel.

Data Quality Objective (DQO) – a statement that specifies the quality of data required to support the purposes and intent of the sampling and analysis activity. DQOs are based on the intended use of the data; as such, different data uses and needs may require different levels of data quality.

Standard Operating Procedures (SOP) and Technical Guidance Instruction (TGI) – Documents that describe a procedure and/or protocol necessary to conduct a specific field activity. SOPs/TGIs may also be created or revised on a program or project specific basis. An SOP/TGI library is available on The Source.

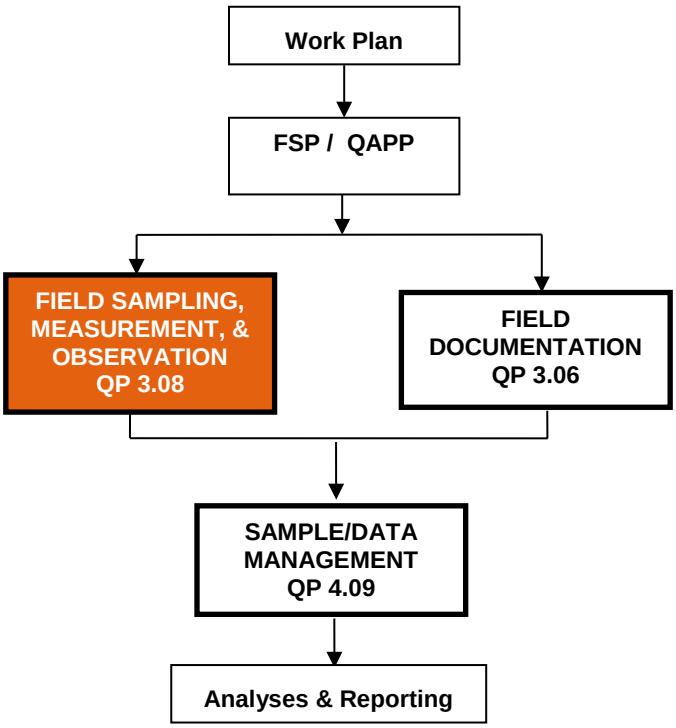
4. Related Forms

Forms such as purge logs, soil boring logs appropriate for the field sampling activity and observations.

DESCRIPTION OF PROCEDURE:

Sampling and data quality directly affect overall project success because sampling and other field activities are a critical and fundamental component of projects. Errors, mistakes, missed communications, or out-of-scope or out-of-compliance actions may have an adverse effect on a project. Because field conditions cannot be anticipated absolutely, procedures for a particular sampling program must include a formal process for making decisions and obtaining appropriate approvals for deviations necessitated by conditions. Within this context, the basic procedures and requirements for sampling and other field measurements and observations are outlined in the project documents (FSP, QAAP or Work Plan) and the associated procedures. Sample collection, data collection, and drilling locations should be documented (i.e., tape measurements with respect to site features, GPS measurements, and or survey by a licensed land surveyor). It is also recommended taking to the field site maps showing pre-existing and proposed sampling, drilling, data collection, and well locations. It is also recommended the field staff be aware of previous data measurements so field staff can note and communicate any significant changes.

The following flow chart provides the major components of a typical field characterization program and highlights where field sampling activities fit in.



1. Field Sampling, Measurement, and Observation Activities

Field operations are conducted to provide reliable information, data, and/or samples that meet the project and data quality objectives. It is essential that field sampling, measurement, and observation activities begin with the field team having a detailed familiarity with appropriate site-specific project planning documents, most notably the FSP. Time should be scheduled and budgeted for the field team members to review the plan(s) and ask questions. With a good understanding of what samples or data are to be collected, as well as where and why they are to be collected, field personnel will perform the following activities during the implementation of field characterization activities.

1.1 Briefing and Preparation

Before field activity begins, a kick-off meeting should be held to ensure that the project team understands the project objectives and the procedures that will be followed. The CPM and appropriate project office and field personnel (e.g., Field Supervisor, Crew Leader, or entire crew) should engage in a briefing via telephone discussion or in person to review (in summary fashion) the following:

- Project objectives and project plans
- DQOs
- Sampling locations
- SOPs/TGIs

- Chain of command
- HASP
- Provisions for addressing deviations
- Other special circumstances or information critical to the success of the sampling event and integrity of the data and documentation.

When possible, the CPM and/or Field Supervisor should perform a reconnaissance site visit prior to initiation of the sampling or other field activities to review sample locations and consider health and safety or other logistical challenges the site may present. The CPM must also ensure that any utility clearance requirements have been met. Finally, the CPM and/or Field Supervisor must verify that the necessary subcontracts, notifications, and approvals are in place, including coordination with client personnel, agency oversight personnel, access to private or public property (i.e., legal), and coordination with utility companies/agencies regarding the potential of buried, overhead, or other sensitive infrastructure that may affect project implementation and/or health and safety.

1.2 Standard Operating Procedures and Technical Guidance Instructions

Applicable SOPs and TGIs must be followed to ensure consistency and quality in method and resulting data. An SOP/TGI library is available on The Source. SOPs and TGIs may also be created or revised on a program or project specific basis. Deviation from established procedure(s) during a data collection activity must be documented. Where plans and SOPs allow discretion (do A or B) or choice (exact sampling location) these decisions should be documented in the field notebook. In cases where the integrity of the data being collected may be jeopardized, field personnel must consider stopping associated work activities until the CPM or other project authority can be consulted as to what corrective action is warranted before work can recommence. Follow the hierarchy of regulatory, client, ENV in selecting and modifying methods and procedures.

1.3 Equipment and Instrumentation

The site-specific project planning documents will be reviewed to identify the types of equipment, instrumentation, and supplies that are needed for the sampling, measurement, observation, or other data collection activities. The selected equipment and instrumentation will meet the requirements of the specifications, methods, and procedures provided in the FSP, QAPP, HASP, or other planning document(s). Further, the Field Supervisor/Crew Leader is responsible for verifying that the equipment and instrumentation are in good working order, clean and, if necessary, properly calibrated and maintained before, during, and after use in the field. (See QP 3.07 Calibration and Control of Measuring and Test Equipment).

1.4 Physical Sample Management

It is extremely important that proper procedures be followed in the sample identification system employed for collected samples, the chain-of-custody procedures, and the manner in which the samples are tracked from collection point, through handling and shipment, and to receipt by the laboratory (including sampling techniques, sample volumes, holding times, preservation, packaging, and shipping procedures). Field personnel are

responsible for obtaining the proper number and type of quality control samples, including but not necessarily limited to trip blanks, duplicates, matrix spikes, matrix spike duplicates, and equipment rinse blanks (these requirements should be specified in the site-specific project planning documents and reviewed prior to commencing the field program). These procedures are specified in the Work Plans, FSP, QAPP, and or HASP, or other project planning documents and shall be reviewed by field personnel prior to initiation of field activities. Deviation from established procedures could impact the integrity of the sample or activity; and must be justified, approved by the CPM, and be appropriately documented.

1.5 Qualitative Data Management

Based on requirements specified in site-specific project planning documents, field activities should adhere to applicable SOPs and WTGIs and be carried out in a consistent manner that is well documented in accordance with QP 3.06 Field Activities Documentation. This includes care in making and recording accurate and precise measurements and observations in a timely manner.

1.6 Decontamination

Field personnel will review and be familiar with required decontamination procedures, including those for cleaning field equipment, proper storage of cleaned field equipment, and for properly disposing of waste generated from decontamination procedures. If decontamination is conducted on site, the activities will be performed in a designated, controlled location that will not impact collected samples. Decontamination activities will be appropriately documented in the field notes, following the protocols specified in the FSP/QAPP or SOP/TGI and QP 3.06 Field Activities Documentation. Wastes generated in the field will be collected, stored, and properly disposed in accordance with FSP/QAPP protocols.

It is important to note that decontamination includes personal protective equipment as well as vehicles and equipment. It is critical that equipment used in one area not serve as a source of contamination of another. This may include weeds or affected soil/water (e.g., carried-in tires or equipment) that could be transported outside the designated work area. In particular, work in surface waters potentially supporting amphibians and other ecological resources may require specific decontamination procedures between sampling events even if no pollutants are anticipated in the waters.

1.7 Corrective Action

The CPM and field personnel will be familiar with site-specific project planning procedures designed to address deficiencies or deviations quickly and efficiently, so as not to unnecessarily hold up progress or compromise the integrity of the field effort. Based on the procedures established in the site-specific project planning documents, specific steps are taken as soon as a potential problem is identified. At a minimum, deficiencies or deviations must be reported to the CPM (through pre-established chain of command) and then fully documented to include the nature of the problem, the corrective action taken, and the person(s) responsible for correcting or otherwise

addressing the problem. Site-specific project planning documents should contain site-specific corrective action procedures.

— END OF PROCEDURE —

ARCADIS Design & Consultancy for natural and built assets

TECHNICAL GUIDANCE INSTRUCTION: CALIBRATION

TGI-CAN-SER-30

Version 1.0

Rev Date: July 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
1	8 July 2020	all	Original TGI	T.Austrins

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APPROVAL SIGNATURES

Prepared by: Date: July 8, 2020

Ryan Fletcher

Reviewed by: Date: July 8, 2020

Troy Austrins (Technical Expert)

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1 INTRODUCTION

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2 SCOPE AND APPLICATION

This document outlines the basic calibration protocols to ensure consistency. The procedures listed here within apply to all Arcadis employees and contractors who conduct environmental and/or remedial monitoring.

To ensure consistent and accurate measurements, monitoring equipment must be properly maintained and calibrated. Records of the maintenance and calibration must also be kept for auditing purposes.

This TGI is in no way intended to replace the specific equipment manufacturers calibration instructions. ALWAYS follow the instructions provided with your equipment regarding calibration procedures.

3 PERSONNEL QUALIFICATIONS

A qualified individual is responsible for overseeing proper calibration procedures. A qualified person is a person who holds a post-secondary education in a relevant field and has undergone internal Arcadis mentorship/training with an intermediate or senior field personnel.

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4 EQUIPMENT LIST

The following is a general equipment list required to compete drilling activities.

- Equipment to be Calibrated
  - Combustible Gas Detector (CGI), such as RKI, PID, etc
  - Water Quality Meter, such as Horiba, YSI, etc.
- Calibration Gas (gas detector)
- Calibration Solutions (water quality meter)
- Tedlar Bag (gas detector)
- Calibration logs
- PPE (gloves, safety glasses).

5 CAUTIONS

Gasses and chemical reagents are utilized during equipment calibration procedures.

- Chemical reagents used in calibrations (hazards are outlined in associated MSDS)
- Combustible and/or toxic gasses used for calibration of CGI's and PID's

6 HEALTH AND SAFETY CONSIDERATIONS

Follow all Arcadis standard health and safety protocols at all times.

Additional hazards specific to calibration may include:

- Compressed gas.
- Explosion hazards.
- Splashing from chemical reagents
- Dermal contact with chemical reagents

7 PROCEDURE

Maintenance of Field Equipment

- Field equipment must be maintained in good operating condition, free of soiling and stored in the supplied equipment cases.
- Broken parts must be replaced or repaired prior to use.
- Equipment is decontaminated prior to storage.

Water Quality Meters

- Water quality meters are calibrated in accordance with the manufacturer's instructions using fresh chemical calibration solutions (supplied or purchased).
- Most equipment is supplied pre-calibrated and ready for use by Arcadis' equipment supplier. Notwithstanding pre-calibration by suppliers, equipment must be calibration checked prior to use, ideally the same day as it is used.

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- Equipment is calibration checked daily prior to use and recalibrated when results fail to provide stable readings within 10% of standard solution values.
- Dissolved oxygen meters are sensitive to changes in air pressure and must be recalibrated when used at a location with a significant change in elevation above sea level. Salinity also affects the operation of the probe, consult the manufacturers instruction when compensating for salinity.
- Record calibration results are recorded in field notes.

Water Level Tapes and Interface probes

Equipment Check

- Inspect the probe and tape for damage.
- Turn Sensitivity Dial fully clockwise.
- Depress the Battery Test button to test the battery and circuitry (excluding the probe when not in use).
- Submerse the probe in a container of tap water. This completes the circuit and activates the buzzer and light.

Routine Care

- After the depth to water has been recorded, the cable should be carefully rewound onto the reel, the probe wiped dry and placed into the probe holder.
- The probe, cable and reel can be cleaned with a phosphate free (non-abrasive) detergent and warm water.
- Use of a Water Level Meter Carrying Bag adds to the service life of the meter.
- Use of the Tape Guide adds to the life of the cable.

Battery Replacement

- battery type - alkaline, 9 volt.
- The battery is housed in a convenient battery drawer located in the faceplate of the Water Level Meter.
- To replace the battery, simply press the drawer in, lift then pull.
- The battery drawer should slide out of the faceplate enough to pull it out.
- Note the polarity and place another new battery in the drawer and slide it back into the faceplate.

Replacement Parts. The following parts may become lost or damaged and probes should be sent out to a certified equipment supplier for repairs:

- Probes

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- Reels
- Replacement cable with probe (Complete)
- Lights, switches, etc.
- Splice kits

Combustible Gas Detectors and PID's

- Combustible gas detectors must be calibrated prior to use and calibration checked daily.
- Use calibration methods specified by the manufacturer using an appropriate calibration gas.
- Calibrate meters in non-hazardous locations in fresh air conditions.
- Allow meters to warm-up prior to commencing calibration procedures.
- Use 400 ppm hexane for standard field screening purposes.
- Use higher concentration calibration gasses in the LEL range for hygiene applications.

8 WASTE MANAGEMENT

Ensure that spent gas canisters are disposed of in accordance to local legislation and through a certified company equipped to deal with these types of waste.

9 DATA RECORDING AND MANAGEMENT

Keep detailed records of calibration of Arcadis owned equipment inside of the equipment carrying case at all times.

Record calibration details in your project field notes.

10 QUALITY ASSURANCE

Record daily calibration details in your project field notes.

11 REFERENCES

None

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TGI – GROUNDWATER AND SOIL SAMPLING EQUIPMENT DECONTAMINATION

Rev: 1

Rev Date: May 8, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Cassandra McCloud / Pete Frederick
1	May 8, 2020	4-5	Added note regarding use of Liquinox and 1,4-Dioxane	Marc Killingstad

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APPROVAL SIGNATURES

Prepared by: Date: 02/23/2017

Derrick Maurer

Technical Expert Reviewed by: Date: May 8, 2020

Marc Killingstad (Technical Expert)

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2 SCOPE AND APPLICATION

Decontamination is performed on sampling equipment prior to sample collection to ensure that the sampling equipment that contacts a sample, or monitoring equipment that is brought into contact with environmental media to be sampled, is free from analytes of interest and/or constituents that could interfere with laboratory analysis for analytes of interest. Sampling equipment must be appropriately cleaned prior to use for sampling or coming into contact with environmental media to be sampled, and following completion of the sampling event prior to shipment or storage. The effectiveness of the decontamination procedure should be verified by collecting and analyzing equipment blank samples.

The sampling equipment cleaning procedures described herein includes pre-field, in the field, and post-field cleaning of sampling equipment which may be conducted at an established equipment decontamination area (EDA) on site, as appropriate and necessary. Sampling equipment that may require decontamination at a given site includes: soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; down-hole instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned before collecting each sample, between each

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sample collected, and prior to placing sampling equipment in protective cases, or containers for transport. Cleaning procedures for sampling equipment should be monitored by collecting equipment blank samples as required in project work plans, field sampling plans, quality assurance project plans (QAPP), or other pertinent project documents. Dedicated and/or single-use (i.e., not to be re-used) sampling equipment will not require decontamination.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The equipment required for equipment decontamination is presented below:

- Health and safety equipment, including appropriate PPE, as required in the site Health and Safety Plan (HASP)
- Deionized water that meets that analytical criteria for deionized water with no detectable constituents above the reporting limits for the methods to be used and analytes being analyzed for. Deionized water is used for inorganics, and organic-free water for VOCs, SVOCs, pesticides, etc.
- Non-phosphate detergent such as Alconox or, if sampling for phosphorus or phosphorus-containing compounds, Liquinox (or equivalent). NOTE: *Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).*
- Tap water
- Rinsate collection plastic containers
- DOT-approved waste shipping container(s), as specified in the work plan, field sampling plan, or regulatory requirements if decontamination waste is to be shipped for disposal
- Brushes
- Large heavy-duty garbage bags
- Spray bottles

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- (Optional) – Isopropyl alcohol (free of ketones) or methanol. These can be wipes or diluted with water (usually 1part isopropyl/methanol to 10 parts water) if a spray is needed.
- Airtight, sealable plastic baggies, such as Ziploc-type
- Plastic sheeting

5 CAUTIONS

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium. If manual drying of equipment is required, use clean lint-free material to wipe the equipment dry. Ensure all rinsate materials do not adversely affect sample collection efficiency or analytical results.

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts. Properly containerize equipment to ensure cross-contamination doesn't happen from other uncontaminated surfaces or equipment.

If equipment is damaged to the extent that decontamination is uncertain due to cracks, gouges, crevices, or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination regarding hazardous materials will be performed by a DOT-trained individual for cleaning materials shipped by Arcadis.

Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock.

6 HEALTH AND SAFETY CONSIDERATIONS

Review the safety data sheets (SDS) for the cleaning agents and materials used in decontamination. If solvent is used during decontamination, use appropriate PPE and work in a well-ventilated area and stand upwind while applying solvent to equipment. Apply solvent in a manner that minimizes potential for exposure to workers and bystanders. Follow health and safety procedures outlined in the HASP.

7 PROCEDURE

A designated area will be established to clean sampling equipment in the field prior to and following sample collection. Equipment cleaning areas will be set up within or adjacent to the specific work area, but not at a location that expose equipment to contamination (i.e. exposed to combustion engine exhaust). Detergent solutions will be prepared in clean containers for use in equipment decontamination. Decontaminated equipment should be handled by workers wearing clean gloves, properly changed to prevent cross-contamination.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.

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2. Wash with detergent solution (Alconox, Liquinox or equivalent) to remove all visible particulate matter and any residual oils or grease. NOTE: *Liquinox has shown to provide false positives for 1,4-Dioxane and should not be used at sites where that may be a constituent of concern (COC).*
3. If equipment is very dirty, precleaning gross debris with a brush and tap water may be necessary.
4. If non-aqueous phase liquids are present, the use of isopropyl alcohol (free of ketones) or methanol is recommended. Cloth wipes or diluted solution can be used to remove the non-aqueous phase liquids that are hard to remove with detergent solution in step 2. Consult with project manager if non-aqueous phase liquids are present onsite and design an appropriate decontamination procedure that includes step 4.
5. Rinse with deionized water.

Decontaminating Submersible Pumps

Submersible pumps may be used during well development, groundwater sampling, or other investigative activities. The pumps must be cleaned and flushed before and between uses. This cleaning process will consist of an external detergent solution wash and tap water rinse, a flush of detergent solution through the pump, followed by a flush of potable water through the pump. Flushing will be accomplished by using an appropriate container filled with detergent solution and another container filled with potable water. The pump should be flushed with deionized water as the last step prior to use. The pump will run long enough to effectively flush the pump housing and hose (unless new, disposable hose is used). Disconnect the pump from the power source before handling. The pump and hose should be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

8 WASTE MANAGEMENT

Equipment decontamination rinsate will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the work plan or Waste Management Plan (WMP).

9 DATA RECORDING AND MANAGEMENT

Equipment cleaning and decontamination will be noted in the field notebook for project documentation. Information will include the type of equipment cleaned, the decontamination location, specific procedures utilized, solvents and/or cleaning agents used, source of water, and deviations or omissions from this TGI.

Unusual field conditions should be noted if there is potential to impact the efficacy of the decontamination or subsequent sample collection.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the project documentation. Records will be maintained for solvents used in decontamination, including lot number and expiration date.

Containers with decontamination fluids will be labeled.

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10 QUALITY ASSURANCE

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross contamination. The equipment blank is prepared by pouring deionized water (or organic-free water, for organic analyses) over the clean and dry tools and collecting the water into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters that are performed on the field samples collected with the equipment that was cleaned as specified in the sampling and analysis plan. Equipment blanks are collected per equipment set, which represents all of the tools needed to collect a specific sample.

11 REFERENCES

USEPA Region 9 - Field Sampling Guidance #1230, Sampling Equipment Decontamination.

USEPA Region 1 - Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

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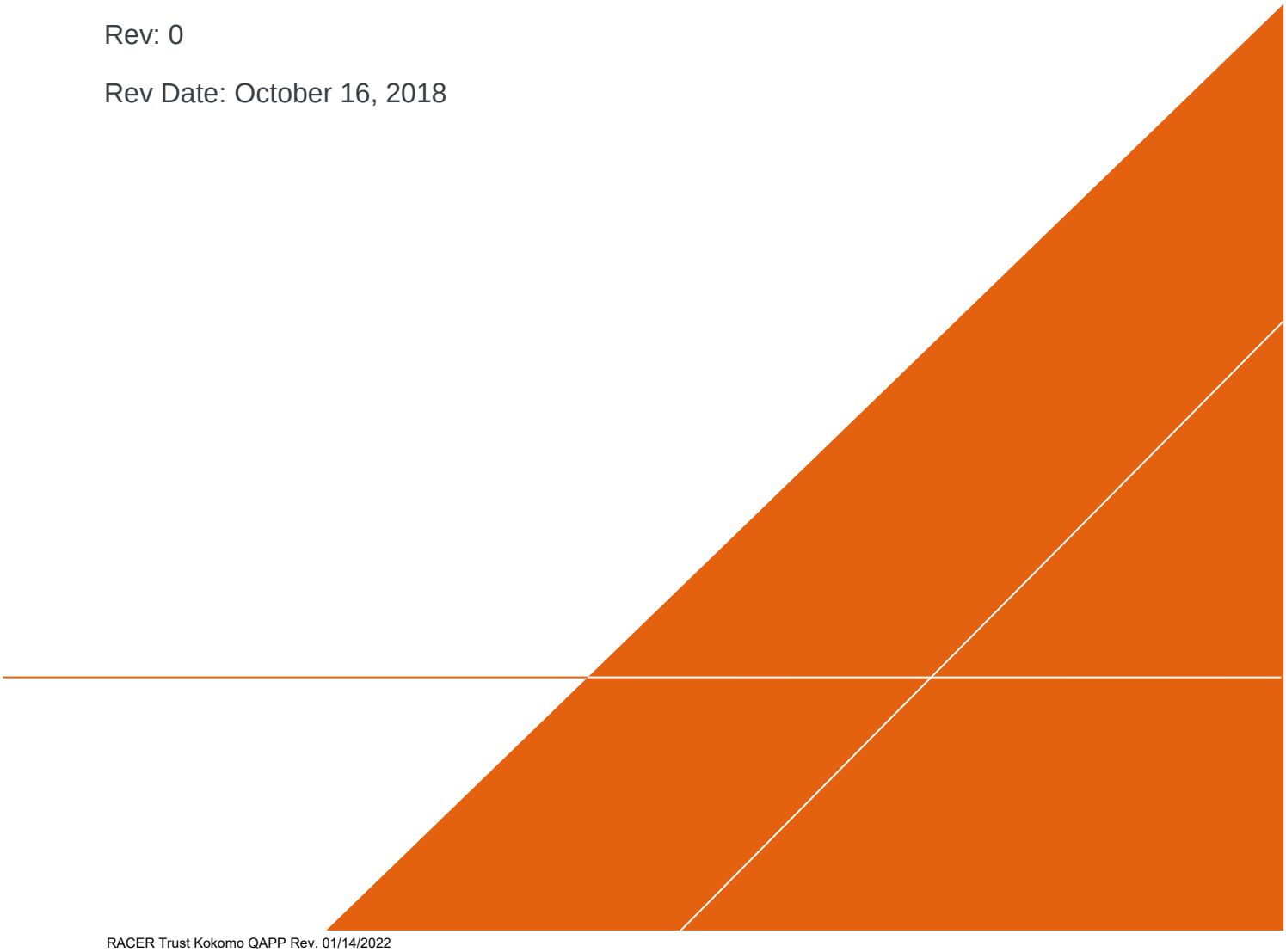
TGI - IN-SITU AND EX-SITU WATER QUALITY PARAMETERS

Rev: 0

Rev Date: October 16, 2018



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 16, 2018	All	Updated and re-written as TGI (in-situ and ex-situ adaptation)	Marc Killingstad

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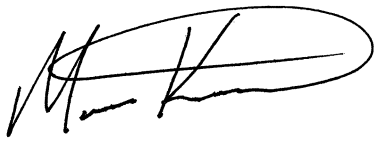
APPROVAL SIGNATURES

Prepared by:		10/16/2018
	Chris Shepherd	Date:
Technical Expert Reviewed by:		10/16/2018
	Marc Killingstad (Technical Expert)	Date:

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2 SCOPE AND APPLICATION

Water quality parameters (e.g., turbidity, specific conductivity, pH, and temperature) of natural waters are usually measured in the field. The temperature, pH, specific conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP) and turbidity of surface water will be measured in-situ or ex-situ with a multiparameter water quality meter (i.e., multimeter).

Conductivity is the ability of a solution to pass an electric current. This current is carried by inorganic dissolved solids. The measurement is useful to quantify the chemical purity of the water relative to the amount of dissolved solids in a solution. Generally, temperature-compensated conductivity, termed specific conductivity, is measured by a water quality meter. Specific conductivity can also be used to estimate total dissolved solids (TDS) in solution (grams per liter or g/L) by multiplying the specific conductivity (measured in millisiemens per centimeter or mS/cm) by 0.65, which assumes that sodium chloride is a reasonable surrogate for the dissolved solids in solution.

Measuring the concentration of DO in water is an important component in evaluating the quality of natural as well as contaminated waters. The effects of wastes on rivers/streams, the suitability of water for fish

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and other organisms, as well as the effects of remediation efforts, can often be ascertained from the DO content. Dissolved oxygen levels generally range from 5 to 9 milligrams per liter (mg/L) when measured in water that is in equilibrium with air, depending on the temperature and barometric pressure; however, levels may be lower in a 'reducing' environment where anoxic conditions exist in water (e.g., gasoline plume undergoing bioremediation).

The measurement from an ORP sensor represents the net status of all the oxidation and reduction reactions in the sample being measured. Positive results indicate an oxidizing environment while negative results indicate a reducing environment. ORP is determined by measuring the potential of a chemically-inert electrode which is immersed in the solution. The sensing electrode potential is read relative to the reference electrode of the pH probe and the value is presented in millivolts (mV).

ORP meter results can indicate possible contamination and can be particularly useful if it is known that one component of the sample is primarily responsible for the observed value. For example, excess chlorine in a sample will result in a large positive ORP value while the presence of hydrogen sulfide will result in a large negative ORP value. Together with pH, temperature, and knowledge of the dominant species in a sample, ORP results help predict the oxidation state of ions in solution and whether certain reactions may take place.

Temperature readings will be taken at each water sampling location to assist understanding the water quality as well as compensating measurements. A thermometer is typically part of the multimeter. If not, a temperature probe or thermometer will be used.

The measurement of turbidity is useful in that it expresses the relative amount of suspended particles in the water column. Turbidity cannot be measured in-situ.

Refer to the following documents for procedures of groundwater sample collection:

TGI – Standard Groundwater Sampling for Monitoring Wells (describes the methods to be used to collect groundwater samples using traditional purging and sampling techniques)

TGI - Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells (describes low-flow purging and sampling techniques)

TGI – Passive Diffusion Bag Sampling, TGI – Groundwater Sampling with HydraSleeves™, and *TGI - Bailer-Grab Groundwater Sampling* (describes no-purge/passive sampling techniques)

3 PERSONNEL QUALIFICATIONS

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Prior to mobilizing to the field, the sampling team will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan

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(FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the field sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

The following materials, as required, will be available during field measurement of water quality parameters:

- Site-specific HASP and health and safety documents identified in the HASP (e.g., job safety assessments [JSAs])
- Field Implementation Plan (FIP) that includes site map with sampling locations, well construction records (table or logs), sampling plan, and prior groundwater sampling records (if available)
- Field notebook, pen(s) (indelible ink) and/or smart device (smart phone or tablet)
- Field laptop / data manager
- Water Quality Measurement Log (**Attachment 1**)
- Water Quality Meter Calibration Log (**Attachment 2**)
- Appropriate personal protective equipment (PPE) (e.g., latex or nitrile gloves, safety glasses, etc.) as specified in the HASP
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)
- Well key(s)
- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP
- Dedicated plastic sheeting (e.g., Weatherall Visqueen) or other clean surface to prevent sampling equipment from coming in contact with the ground
- Electronic water-level indicator (e.g., Solinist Model 101) or oil/water interface probe with 0.01-foot accuracy (oil/water as appropriate, note that sampling will not be performed when sheen or light non-aqueous phase liquid [LNAPL] is present)
- Multiparameter (temperature/pH/specific conductivity/ORP/turbidity/DO) water quality meter or sonde with flow-through cell (as appropriate) plus reader and protective housing; for example:
    - YSI Professional Plus Multiparameter Instrument
    - YSI EX01 or EX02 Multiparameter Sonde

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  - Horiba W-22 XD Multiparameter Instrument
  - Hydrolab DS5 Multiprobe and Display
- Operation manual(s) for multiparameter meter
- Water quality meter extension cable (as needed for in-situ readings of deepest well)
- Standard solutions for calibration
- Multimeter maintenance kit and extra DO membranes if using amperometric DO probe
- Extra batteries for the various instruments
- Tape measure and/or masking tape for in-situ readings
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels)

5 CAUTIONS

NOTE: *Proper operation and maintenance are very important for a functioning meter and accurate readings. Carefully follow manufacturer's instructions for operation (including down-hole use), maintenance, and calibration as each manufacturer's instructions will vary.*

Verify the meter is intended for in-situ measurements and that all necessary parts are available prior to field mobilization.

Check and record the expiration dates of calibration fluids. Verify that calibration readings are reasonable and correspond to previous calibration readings when available. Expired calibration fluids may result in erroneous results. If accurate measurements of TDS are required, site-specific calibration will be necessary in accordance with the manufacturer's specifications.

Turbidity meters will be stored and used in dry locations.

When taking measurements in the field, verify that readings make sense and compare to historical readings when possible.

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP. Also, at a minimum, wear latex gloves and safety glasses when working with calibration solutions.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well

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head), and potentially the use of sharp cutting tools (scissors, knife)—open well caps slowly and keep face and body away to allow to vent any built-up pressure; only use non-toxic peppermint oil spray for stinging insect nests; review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives, and use appropriate hand protection.

If working at a site with hazardous levels of volatile organic compounds, headspace and/or breathing zone readings will be measured prior to working at/in the well, in accordance with the HASP.

7 PROCEDURE

The procedure is organized into the following sections:

A. Standard Procedures – calibration, operation, and maintenance procedures that apply to all methods and meters

B. Calibration – general calibration procedures for:
    a. Multimeter
    b. Turbidity meter

C. Operation – general measurement operations for:
    a. Ex-situ measurements
        i. Multimeter
        ii. Turbidity meter
    b. In-situ measurements (downhole multimeter only)

D. Maintenance
    a. Multimeter
    b. Turbidity meter

7.1 Standard Procedures

Calibration

- The meter will be calibrated following the manufacturer's instructions as calibration steps vary by manufacturer.
- Calibration information will be recorded in the calibration log (Attachment 2) and the field notebook.
- Check batteries/power levels during calibration.
- More frequent calibration may be necessary in harsh conditions or per project plans.

Operation

- The meter will be operated following the manufacturer's instructions.

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- Mutimeters can be operated in-situ (down-hole, in water, etc.) or ex-situ (water is transferred to container for measurement).
- Two readings will be made after stabilization (minimum 2 minutes) and the average will be recorded in the field notebook or both measurements will be recorded in the water quality measurement log and/or logger.
- Additional details for pH, conductivity, temperature, dissolved oxygen, and turbidity operation are presented in section **7.3 Operation** below.

Maintenance

- The meter will be maintained according to the manufacturer's instructions.
- Maintenance information will be recorded in the field notebook or instrument log.
- Manufacturer recalibration or replacement probes may be required on a routine basis.
- A replacement meter and probes will be available onsite or ready for overnight shipment, as necessary.
- Additional details for pH, conductivity, temperature, dissolved oxygen, and turbidity maintenance are presented in section **7.4 Maintenance** below.
- More frequent maintenance (probe replacement, sensor reconditioning, etc.) may be necessary in harsh conditions or per project plans.

7.2 Calibration

Multimeter Calibration

1) Connect cables from meter to reader
2) Check probes and ensure they are clean
3) Switch on instrument and allow to warm-up
4) Check battery life and replace, if needed
5) Adjust date/time, if needed
6) Soak all probes in distilled or de-ionized water for at least 5 minutes (some probes may require longer soak times, see below and manufacturer instructions) and then shake off excess liquid.
    i. NOTE: *If the probes are recently reconditioned or have slight build-up, allow for longer soaking period.*
7) Navigate to calibration display/mode
8) **pH Calibration** – when in use, the pH meter will be calibrated daily, at a minimum.
    i. Connect electrode (if applicable) or remove protective cap from electrode
    ii. Rinse end of electrode in distilled/deionized water and shake off excess water

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iii. Measure and record temperature of buffer solutions

iv. Immerse pH electrode in pH buffer 7.00, set the temperature to that of the buffer 7.00, and allow sufficient time for the electrode to stabilize

v. Adjust the calibration for the correct readout and temperature

vi. Confirm/press the calibration button

vii. Remove electrode from buffer and rinse with distilled/deionized water

viii. Immerse pH electrode in buffer 4.00, set the temperature control to that of the buffer 4.00, and allow sufficient time for the electrode to stabilize

ix. Adjust the calibration for the correct readout and temperature

x. Confirm/press the calibration button

xi. Rinse electrode with distilled/deionized water

xii. A pH 10 calibration will also be performed if high pH is anticipated, following manufacturers procedures

xiii. The pH meter is calibrated

9) **Conductivity Calibration** – when in use, the conductivity meter will be calibrated daily, at a minimum.

i. Conductivity is generally measured in specific conductivity (temperature compensated), verify with the FIP/work plan

ii. Soak the probe in distilled/deionized water for at least 30 minutes

iii. Remove the probe from the water and fling out drops clinging inside

iv. Immerse the probe to or beyond the vent holes in a beaker containing 1.413 mS/cm standard solution and gently agitate vertically to remove entrapped air

v. Repeat Steps 3 and 4 at least once more

vi. Press calibration button

10) **Temperature calibration** – temperature will be verified according to FIP/work plan, if applicable.

11) **Dissolved Oxygen (DO) calibration** – when in use, the DO meter will be calibrated daily using the air calibration method or less frequently if using an optical sensor (see below).

i. Preparation

1. Polarographic sensor – periodically recondition sensor, replace fluids, and Teflon® membrane, per manufacturer, and air bubbles should not be present

2. Galvanic sensor – Periodically recondition sensor, replace fluids, and membrane, per manufacturer, and air bubbles should not be present

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3. Optical sensor – Per manufacturer, most will only require field checks and maintenance, however, weekly checks are recommended to verify the accuracy, at a minimum

ii. Obtain a barometric pressure reading from a daily weather report or from the instrument, as required by instrument

iii. Keep instrument upright and vent cap/cover while retaining a small amount of clean water (do not cover probes) for non-optical sensors only

iv. Allow 5 to 15 minutes for optimum probe stabilization and polarization, for non-optical sensors (reading will range between 5 to 9 mg/L depending on temperature and barometric pressure)

v. Press calibration button, if reading is more than 2% off of the standard

12) **Oxidation reduction potential (ORP) calibration** – when in use, the ORP meter will be calibrated daily, if required.

i. Rinse the probe in distilled/deionized water

ii. Remove the probe from the water and fling out drops clinging inside

iii. Immerse the probe in the ORP solution. Gently agitate vertically to remove entrapped air

iv. Repeat Steps 3 and 4 at least once more

v. Press calibration button, if reading is more than 2% off of the standard

13) Adjust the instrument to READ or LOGGING mode, per instruction manual and project plans; the instrument is now ready for use

Turbidity Calibration (if required)

Turbidity meters are generally calibrated weekly, unless required otherwise. However, daily checks are recommended to verify the accuracy. The turbidity meter will be calibrated per steps below:

1) Switch on instrument and allow time to warm-up

2) Check battery life and replace, if needed

3) Turbidity sample tubes will always be washed prior to use, but not the calibration standard tubes, using a mild detergent to remove any dirt or finger prints

4) Dry the outside of the sample turbidity tubes with a clean, lint-free cloth or disposable wipe and allow the turbidity tubes to air-dry in an inverted position to prevent dust from entering the tube, as allowable (but, not the calibration standard tubes)—dirt or fingerprints can lead to inaccurate results

5) Wipe the 1 Nephelometric turbidity unit (NTU) standard and place in the chamber after aligning the arrows (manufacturer dependent)

6) Place the light shield over the turbidity standard and allow the meter to stabilize

7) Press the read and/or CAL button, per instructions

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8) Repeat steps 3 thru 5 above

9) Adjust to READ mode and the instrument is now ready for use.

7.3 Operation

Water quality parameters can be measured ex-situ or in-situ in accordance with the FIP/work plan. The operating procedures for each method are described below. It is also possible to collect a depth-specific sample from a well or water body for ex-situ measurement.

Ex-situ Operation

Multimeter

1) Fill two 100-mL plastic disposable beakers or clean beakers with water from the sample
2) Insert the probe into the first beaker immersing all sensors and allow to stabilize (2 minutes at minimum)
3) Record readings
    i. Temperature – in degrees Celsius or Fahrenheit
    ii. pH – in standard units between 0 and 14, in 0.01 increments
    iii. Specific conductivity – in mS/cm or microsiemens per centimeter (uS/cm)
    iv. DO – in mg/L and percent (will typically read between 0 and 15 mg/L)
    v. ORP – in millivolts (mV; will typically read between -1,400 mV and + 1,400 mV), if required
4) Rinse probe off with distilled/deionized water
5) Repeat Steps 2 thru 4 for the other beaker
6) Log results on the water quality measurement log and/or in field notebook - the average will be the actual result
7) Rinse probe off with distilled/deionized water

NOTE: *If a flow through cell is used during low flow groundwater sampling, a single reading can be obtained from the multimeter during each step of the wells purging in accordance with TGI - Low Flow Groundwater Purging and Sampling.*

Turbidity Meter

1) Fill the two cleaned, manufacturer provided sample tubes with water from the sample
2) Wipe off and dry the outside of the sample turbidity tubes with a clean, lint-free cloth or disposable wipe
3) Insert the first sample tube and close the cover
4) Push the READ button
5) Record turbidity reading in NTUs (0 to 1,100 NTUs)

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i. If readings are over the instrument limit, a single 2X dilution can be run by mixing the sample with equal parts distilled or de-ionized water and gently mixing

ii. The resulting value will need to be doubled (for example, if the diluted reading is 750 NTUs, the estimated turbidity would be 750 x 2 = 1,500 NTUs. Diluted samples will be qualified as estimated)

6) Repeat steps 2 thru 5 with the second sample tube

7) Log the results on the water quality measurement log and/or in field notebook - the average will be the actual result

8) Rinse sample tubes with distilled/deionized water

NOTE: *If a flow through cell is used during low flow groundwater sampling, a single reading can be obtained from the multimeter during each step of the wells purging in accordance with TGI - Low Flow Groundwater Purging and Sampling. The turbidity sample is recommended to be collected prior to passing through the flow through cell.*

In-situ Operation

1) Connect extension cable and protective housing to meter

2) Measure water level from reference point

3) Lay out plastic sheeting as needed to keep the multimeter clean

4) Clean multimeter and cable per decontamination procedures and instruction manual and rinse with distilled/deionized water using caution, as most meters can only handle light washing with a mild soap and warm water

5) Organize work area to prevent dirt or objects from falling in the well

6) Measure and mark extension cable at planned measurement intervals

7) Slowly lower the probe into the well or water body to the desired measurement interval using caution to prevent rubbing of cable on the well and minimize water and sediment disturbance

8) Allow readings to stabilize (typically 1 to 3 minutes)

i. For many instruments, the instrument may need to be slowly oscillated up and down a few inches to circulate water around the probes

9) Record readings

i. Temperature – in degrees Celsius or Fahrenheit

ii. pH – in standard units between 0 and 14, in 0.01 increments

iii. Specific conductivity – in mS/cm or uS/cm

iv. DO – in mg/L and percent (will typically read between 0 and 15 mg/L)

v. ORP – in mV (will typically read between -1,400 mV and +1,400 mV), if required

10) Repeat steps 4 through 9 to complete targeted in-situ measurements

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11) Log results on the water quality measurement log and/or in field notebook

12) Slowly retrieve the multimeter

13) Clean multimeter and cable per decontamination procedures and instruction manual and rinse with distilled/deionized water using caution, as most meters can only handle light washing with a mild soap and warm water

7.4 Maintenance

Multimeter

1) After use, the meter will be inspected and maintained according to the manufacturer's specifications and the inspection/maintenance activities will be recorded in the field notebook

2) Keep records of usage, maintenance, calibration, problems, and repairs

3) Recharge/replace batteries on a regular basis

4) Store meters or electrodes in protective casing when not in use

5) DO membranes will be stored moist, unless specified otherwise by manufacturer

6) Focused robe cleaning may be necessary in accordance with the operation manual and may be needed more frequently in harsh conditions

7) A replacement meter will be available onsite or ready for rapid delivery/shipment

8) Periodic manufacturer calibration may be necessary per operation manual and/or field plans

Turbidity Meter

1) Recharge battery on a regular basis

2) Store in protective casing when not in use

3) Keep records of usage, maintenance, calibration, problems, and repairs

4) After use, the meter will be inspected with results recorded in the field notebook

5) Keep sample tubes clean inside and out replacing them when they become scratched or etched and avoid handling the tubes in the region where the light beam enters them.

6) Clean lens periodically per instruction manual

7) Turbidity meter will be sent back to the manufacturer for service when needed

8 WASTE MANAGEMENT

Investigative-Derived Waste (IDW), including rinse water, excess sample water, spent calibration solutions, and disposable materials (plastic sheeting, PPE, etc.) generated during the procedures outlined in this TGI will be collected and stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained

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(e.g., soil, PPE). Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field log book.

PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures activities will be placed in plastic bags. These bags will be disposed of as general waste unless specified otherwise.

9 DATA RECORDING AND MANAGEMENT

Management of the original documents from the field will be completed in accordance with the site-specific QAPP. Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

In general, documentation of the following information is required:

- Calibration – calibration information will be recorded on a calibration form, field log, or electronic device per project plans
    - Meter manufacturer and model
    - Serial number
    - Calibration personnel
    - Calibration date/time
    - Standard value, initial and final reading
    - Observations, if applicable
- Readings - data will be recorded on a field log, sampling form, or electronic device per project plans
    - Instrument model
    - Measurement date/time
    - Field personnel
    - Weather
    - Measurement location and depth, if applicable
    - Value of readings and average reading, if applicable
    - Units of readings
    - In-situ vs ex-situ measurement method
    - Key observations

All records will be provided to the project manager and retained in the project files. Any maintenance needs will be communicated to the project manager promptly.

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QUALITY ASSURANCE

Quality assurance procedures will be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

Refer to the QAPP or FIP/sampling plan/work plan for the frequency of calibrations.

10 REFERENCES

Not applicable.

11 ATTACHMENTS

Attachment 1 - Water Quality Measurement Log

Attachment 2 - Water Quality Meter Calibration Log

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ATTACHMENT 1

Water Quality Measurement Log

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WATER QUALITY MEASUREMENT LOG

GENERAL INFORMATION

Date _____ Weather _____

Project No _____ Sample Personnel _____

Site Name _____ Sample ID _____

Site Location _____ Start reading time _____

Site/Well No. _____ End reading time _____

MEASUREMENT DATA

Measuring Point (MP) description _____

Depth to Water (ft)/Time _____ Instrument model/serial no. _____

Well Screen Interval (ft) _____ Instrument model /serial no. 2 _____

Casing Diameter (in) _____ ☐ In-situ ☐ Ex-situ reading

Meters calibrated (Y/N) _____ (see calibration log, if applicable)

Water Quality Parameters

Time	Depth (ft)	pH (S.U.)	Spec. Cond. (mS/cm or uS/cm)	Temp (°C or °F)	DO (mg/L)	DO (%)	ORP (mV)	Turbidity (NTU)	Observations (Odor, clarity, etc., if applicable)

REMARKS

_____

_____

_____

_____

ATTACHMENT 2

Water Quality Meter Calibration Log

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WATER QUALITY METER CALIBRATION LOG

PROJECT NAME	
PROJECT NO.	
MODEL	
SERIAL #	
SAMPLER	
DATE	

TURBIDITY CALIBRATION

CAL. READING		CAL. READING		CAL. RANGE	TIME
(LOT #)		(LOT #)			
(EXP. DATE)		(EXP. DATE)			
PRE-CAL. / POST-CAL		PRE-CAL. / POST-CAL			
/		/		☐ WITHIN RANGE	
/		/		☐ WITHIN RANGE	
/		/		☐ WITHIN RANGE	
/		/		☐ WITHIN RANGE	

AUTOCALIBRATION

AUTOCAL SOLUTION		CAL. READING	CAL. RANGE	TIME	CALIBRATION RANGES (1)	
(LOT #)						
(EXP. DATE)						
CALIBRATED PARAMETERS		PRE-CAL. / POST-CAL				
☐	pH	/	☐ WITHIN RANGE		pH	± 0.2 S.U.
☐	CONDUCTIVITY	/	☐ WITHIN RANGE		COND	± 1% OF CAL. STANDARD
☐	ORP	/	☐ WITHIN RANGE		ORP	± 25 mV
☐	DO	/	☐ WITHIN RANGE		DO	Atmospheric
☐	TURBIDITY	/	☐ WITHIN RANGE		TURB	± 5% OF CAL. STANDARD
☐		/	☐ WITHIN RANGE			
☐		/	☐ WITHIN RANGE			

(1) CALIBRATION RANGES ARE SPECIFIC TO THE MODEL OF THE WATER QUALITY METER

NOTES:

SIGNED DATE

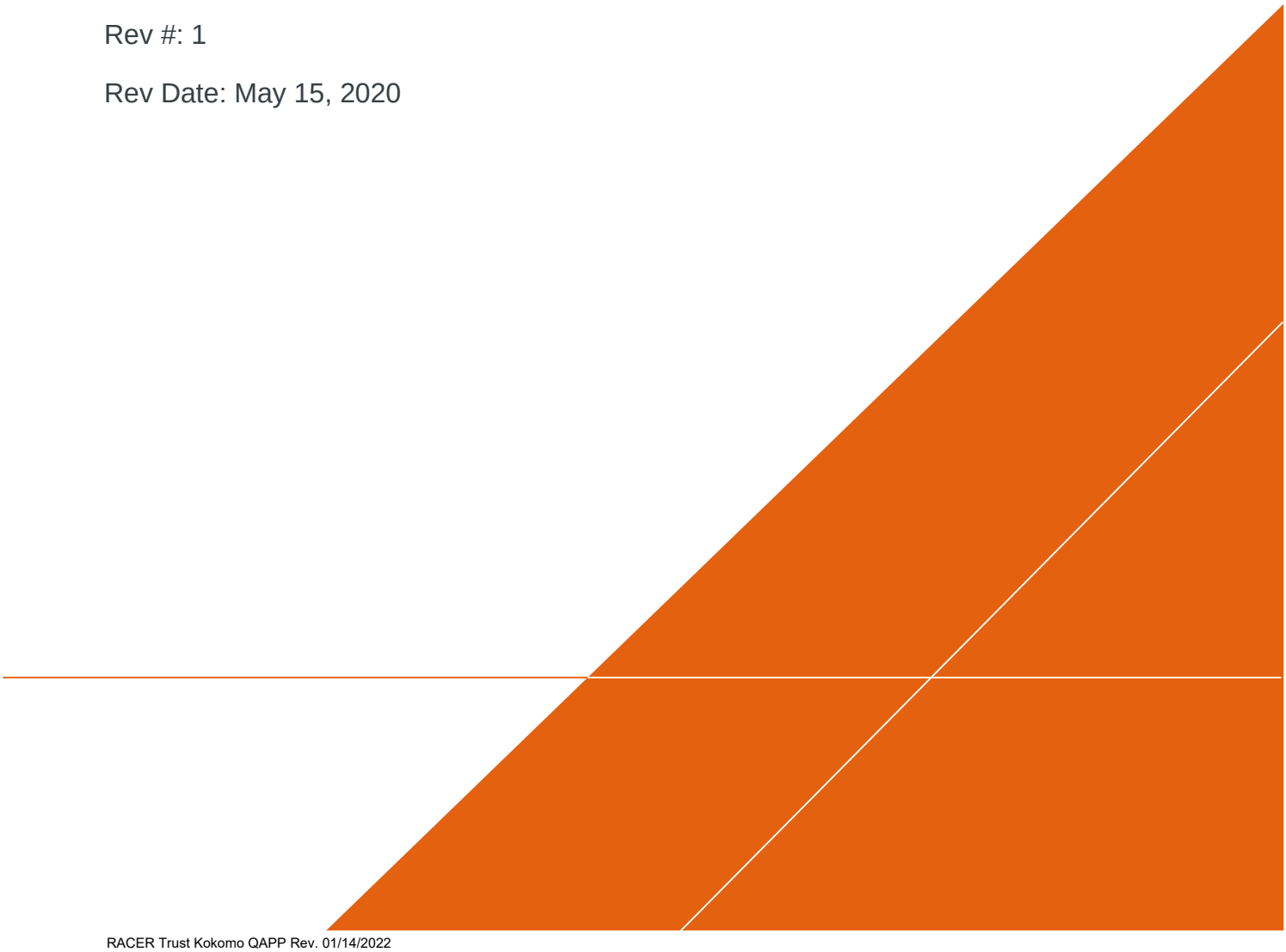
CHECKED BY DATE

ARCADIS Design & Consultancy for natural and built assets

TGI - INVESTIGATION-DERIVED WASTE HANDLING AND STORAGE

Rev #: 1

Rev Date: May 15, 2020



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	February 23, 2017	ALL	Conversion from SOP to TGI	Ryan Mattson / Peter Frederick
1	May 15, 2020	ALL	Updated to reflect regulatory changes	

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APPROVAL SIGNATURES

Prepared by:		02/23/2017
	Derrick Maurer	Date:
Technical Expert Reviewed by:		05/15/2020
	Ryan Mattson (Technical Expert)	Date:

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The objective of this Technical Guidance Instruction (TGI) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and nonhazardous, generated during site activities, which may include, but are not limited to: drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. For the purposes of this TGI, IDW is considered to be discarded materials which are defined as solid waste by United States Environmental Protection Agency (EPA) standard 40 CFR § 261.2 (which may include liquids, solids, or sludges). IDW may include soil, groundwater, drilling fluids, decontamination liquids, as well as contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Hazardous or uncharacterized IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary onsite storage area (discussed in further detail under Drum Storage) pending characterization and disposal. IDW materials will be characterized using process knowledge and appropriate laboratory analyses to determine the waste classification and evaluate proper safe handling and disposal methods.

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This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly transported from the project site and disposed. The procedures included in this TGI for handling and temporary storage of IDW are based on the EPA's guidance document *Guide to Management of Investigation Derived Wastes* (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). Although not comprehensive, the following laws and regulations on Hazardous Waste Management should be considered as potential ARAR. It is the Arcadis Certified Project Manager (CPM) and/or designated Technical Expert to determine which laws and regulations, at all levels of government, are applicable to each project site and activity falling under this TGI.

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987.
- Federal Hazardous Waste Regulations 40 CFR § 260-265

Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR

Occupational Safety and Health Administration (OSHA) Regulations 29 CFR

State Laws and Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Regional, County, Municipal, and Local Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.

Initial Storage

Pending characterization, IDW will be temporarily stored appropriately within each area of contamination (AOC). Under RCRA, "storage" is defined as the "holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere" (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Uncharacterized wastes are considered potentially hazardous wastes and must be stored in DOT approved packaging. Liquid wastes must be stored in DOT approved closed head drums or other approved containers (e.g., portable tank containers) that are compatible with the type of material stored therein. Solid materials must be stored in DOT approved open head drums where practicable. Larger quantities of solid IDW can be containerized in bulk containers (such as in a roll-off box). Soil from large excavation projects may be managed in stockpiles with within the AOC and does not need to be containerized until exiting the AOC.

Characterization

Waste characterization can either be based on generator knowledge, such as using historical process knowledge and safety data sheets (SDS), or can be based upon characterization sampling analytical results. IDW typically is not characterized using SDS as it is a mixture of aged chemicals and environmental media. Historical process knowledge should be used to determine if the IDW is a listed hazardous waste (40 CFR § 261.31-33). If the IDW is not a listed hazardous waste, waste

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characterization can be completed by laboratory analysis of representative samples of the IDW. The laboratory used for waste characterization analysis must have the appropriate state and federal accreditations and may be required to be pre-approved by the Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization determination.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Waste material classified as RCRA nonhazardous may be handled and disposed of as nonhazardous waste in accordance with applicable federal, state, and local regulations.

Storage Time Limitations

Containerized hazardous wastes can be temporarily stored for a maximum of 90 calendar days from the accumulation start date for a large quantity generator or a maximum of 180 calendar days from the accumulation start date for a small quantity generator. Wastes classified as nonhazardous may be handled and disposed of as nonhazardous waste and are not subject to storage time limitations.

This is TGI may be modified by the CPM and/or Technical Expert for a specific project or client program, as required, dependent upon client requirements, site conditions, equipment limitations, or limitations imposed by the procedure. The resulting procedure employed to execute the work will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the CPM and/or Technical Expert as soon as practicable, and if approved to be performed, be documented.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current regulatory- and Arcadis-required health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling and packaging hazardous waste and performing hazardous waste characterizations must have RCRA hazardous waste management training per 40 CFR § 264.16. Additional state-specific hazardous waste management training is required in certain states (i.e., California).

Although not common practice, in certain situations Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator. Arcadis personnel who sign waste profiles and/or waste manifests will have both current RCRA hazardous waste management training per 40 CFR § 264.16 and current DOT hazardous materials transportation training per 49 CFR § 172.704. Arcadis field personnel will also comply with client-specific training. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and Technical Guidance Instructions (TGIs) and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents will identify other training requirements or access control requirements.

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4 EQUIPMENT LIST

The Following Materials, as required, will be available for IDW handling and Storage:

- Appropriate personal protective equipment as specified in the Site Health and Safety Plan (HASP)
- DOT approved containers
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self-adhesive)
- Portable tank container
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Indelible ink and/or permanent marking pens
- Plastic sheeting
- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook

5 CAUTIONS

Filled drums can be very heavy, become unbalanced, or spill its contents. Therefore, use appropriate moving techniques and equipment for safe handling. Similar media (e.g. soils with other soils; or liquids with other liquids) will be stored in the same drums to aid in sample analysis and disposal. Drum lids must be secured to prevent rainwater from entering the drums and leakage during movement. Drums containing solid material may not contain any free liquids. Waste containers stored for extended periods of time may be subject to deterioration. Drum Over Packs may be used as secondary containment. All drums must be visually inspected for condition to ensure that they are in good condition without visible evidence of rusting, holes, breakage, etc., to prevent potential leakage and facilitate subsequent disposal. All drum lids must be verified as having a properly functioning secured lid prior to use.

6 HEALTH AND SAFETY CONSIDERATIONS

As determined by the site's known and suspected hazards, appropriate PPE must be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as required in the Site Health and Safety Plan. If soil excavation in areas with potentially hazardous contaminants is possible, contingency plans will be developed to address the potential for encountering gross contamination or non-aqueous phase liquids. All excavation activities shall be in compliance with OSHA standard 29 CFR 1926.651 Excavations, and any other applicable regulations.

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Arcadis field personnel and subcontractors will be trained in and perform their work in compliance with all applicable federal, state, and local health and safety regulations as well as Arcadis' HASP and applicable Client health and safety requirements.

7 PROCEDURE

Specific waste temporary storage and handling procedures to be used are dependent upon the type of generated waste, including type of media (e.g. soils or free liquids) and constituents of concern. For this reason, IDW can be stored in a secure location onsite in separate 55-gallon storage drums, where solids can be stockpiled onsite (if nonhazardous) and purge water may be stored in portable tank containers. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the project team during all phases of the project. Site managers may want to consider techniques such as replacing solvent based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be properly decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that minimize the generation of waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring.

Drum Storage

Drums containing hazardous waste will be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized onsite location that is readily accessible for vehicular pick-up. Drums confirmed as, or assumed to contain hazardous waste will be stored over an impervious surface provided with secondary spill containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA, 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific or local-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Very small quantity generators (VSQG) are generators who generate less than 100 kilograms of hazardous

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waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 calendar days or less without a permit and without having interim status, provided that such accumulation is in compliance with requirements in 40 CFR § 262.17. A SQG may accumulate hazardous waste on site for 180 calendar days or less without a permit or without having interim status, subject to the requirements of 40 CFR § 262.16. VSQG requirements are found in 40 CFR § 262.14. NOTE: The federal VSQG and SQG provisions may not be recognized by some states (e.g., California and Rhode Island). State-specific and local-specific regulations must be reviewed and understood prior to the generation of hazardous waste.

Satellite Accumulation of Hazardous Waste Satellite accumulation (SAA) will mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.15 and without any storage time limit, provided that the generator complies with 40 CFR § 262.15.

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable or reactive hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste should be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste).
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (e.g., polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or "Testing in Progress" label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Pending Analysis, Hazardous, or Nonhazardous)
- Waste generator's name (e.g., client name)
- Project Name
- Name and telephone number of Arcadis project manager
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date

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- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Pending Analysis” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied.

- Containers with waste determined to be non-hazardous will be labeled with a green and white "Nonhazardous Waste" label over the "Waste Container" label.
- Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label.

The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition, a DOT proper shipping name will be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g., Boring-1, Test Pit 3, etc.) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or Arcadis has knowledge of a spill that has reached surface water, Client or Arcadis must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.265. Other notifications to state and/or other local regulatory agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

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Excavated Solids

Excavated solids may include, but are not limited to: soil, fill, and construction and demolition debris. Prior to permitted treatment or offsite disposal, potentially hazardous excavated solids may be temporarily stockpiled onsite as long as the stockpile remains in the same AOC from where it was excavated. Potentially hazardous excavated solids removed from the AOC must be immediately containerized in labeled drums or closable top roll-offs lined with 9-mil polyvinyl chloride (PVC) sheeting and are subject to LQG storage time limits. Nonhazardous excavated solids can be stockpiled either inside or outside of the AOC, do not have to be containerized and are not subject to hazardous waste regulations. Potentially hazardous excavated solids must not be mixed with nonhazardous excavated solids. All classes of excavated solid stockpiles should be maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (USEPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner or sprayed dust control product. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in closed head drums compatible with the decontamination solution. Decontamination procedures, including personnel and field sampling equipment, must comply with applicable Arcadis procedural documents.

Disposable Equipment

Disposable equipment includes personal protective equipment (e.g., tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, contaminated disposable equipment will also be disposed of as a hazardous waste. If compatible with the original IDW waste stream (i.e., the IDW is a solid and the disposal equipment is a solid), the disposable equipment can be combined with the IDW. If these materials are not compatible (i.e., the IDW is a liquid and the disposal equipment is a solid), the disposable equipment will be stored onsite in separate labeled 55-gallon drums. Uncontaminated or decontaminated disposable equipment can be considered nonhazardous waste.

Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring

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well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert plastic materials. The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are described in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any visible sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.
- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

8 WASTE MANAGEMENT

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and local/state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific applicable regulatory agency thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 250 cubic yard basis for stockpiled soil or one per 55-gallon drum per different waste stream for containerized. A four-point composite sample will be collected per 250 cubic yards of stockpiled material and for each drum waste stream. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements and may be reduced for large volumes of waste with consistent properties. Waste characterization samples will be considered valid for consistent waste streams for a period of 1 year. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls (PCBs), as well as reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches.

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Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and local/state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility. Wastewater characterization samples may be analyzed for TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis. Site-specific constituents of concern including pesticides may require additional sampling. Please note that state- and/or local-specific regulations may require different or additional sampling approaches.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with current Arcadis sample chain of custody, handling, packing, and shipping procedures and guidance instructions.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please refer to the current Arcadis training requirements related to handling and shipping of samples, shipping determinations, and hazardous materials.

Preparing Waste Shipment Documentation (Hazardous and Nonhazardous)

Waste profiles will be prepared by the Arcadis CPM and forwarded, along with laboratory analytical data to the Client for approval/signature. The Client will then return the profile to Arcadis who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by Arcadis prior to forwarding to the Client for approval. Upon approval of the manifest, the Client will return the original signed manifest directly to the waste contractor or to the Arcadis CPM for forwarding to the waste contractor. Arcadis personnel may sign waste profiles and/or waste manifests on a case by case basis for clients, provided the appropriate agreement is in place between Arcadis and the client documenting that Arcadis is not the generator, but is acting as an authorized representative of the generator.

Final drum labeling and pickup will be supervised by an Arcadis representative who is trained and experienced with applicable waste labeling procedures. The Arcadis representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums. A copy of the Arcadis drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

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9 DATA RECORDING AND MANAGEMENT

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with relevant Arcadis procedures and guidance instructions as well as applicable client and/or project requirements, such as a Quality Assurance Project Plan or Sampling and Analysis Plan. Copies of the chain-of-custody forms will be maintained in the project file. Arcadis should photograph or maintain a copy of any hazardous waste manifest signed on behalf of Client in the corresponding office DOT record file.

10 QUALITY ASSURANCE

The CPM or APM will review all field documentation once per week for errors or omissions as compared to applicable project requirements including but not limited to: the proposal/scope of work, QAPP, SAP, HASP, etc. Deficiencies will be noted, tracked, and resolved. Upon correction, they will be noted for project documentation.

11 REFERENCES

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

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ARCADIS Design & Consultancy for natural and built assets

TGI - LOW-FLOW GROUNDWATER PURGING AND SAMPLING PROCEDURES FOR MONITORING WELLS

Rev: #1

Rev Date: May 8, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 12, 2018	All	Updated and re-written as TGI with new branding and content	Marc Killingstad
1	May 8, 2020	Pages 5, 10-11	Added clarification/details for equipment requirements and procedure steps based on USEPA guidance	Marc Killingstad

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APPROVAL SIGNATURES

Prepared by:		10/12/2018
	Ryan McKinney	Date:
Technical Expert Reviewed by:		May 8, 2020
	Marc Killingstad (Technical Expert)	Date:

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

Groundwater samples are collected from monitoring wells to evaluate groundwater quality. The protocol presented in this Technical Guidance Instruction (TGI) describes the procedures to purge monitoring wells and collect groundwater samples using the low flow purging/sampling methodology. This protocol has been developed in accordance with the United States Environmental Protection Agency (USEPA) Region I *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells* (EQASOP-GW4; September 19, 2017).

Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. Project teams will evaluate the last time the monitoring wells were developed and determine if additional development might be necessary. Water samples will not be taken immediately following well development. Sufficient time will be allowed for the groundwater flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

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3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, the groundwater sampling team will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the groundwater sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

Specific to this activity, the following materials (or equivalent) will be used:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP) that includes site map, well construction records, sampling plan (sample analyses, sample volume required, and sample holding time), and prior groundwater sampling records (if available)
- Field notebook and/or smart device (phone or tablet)
- Low-flow sampling field forms (**Attachment A**)
- Appropriate personal protective equipment (PPE) (e.g., latex or nitrile gloves, safety glasses, etc.) as specified in the HASP
- Well keys and other tools to remove manhole covers (manual torque wrench with 9/16” socket and flat head screwdriver typical)
- Photoionization detector (PID) or Flame ionization detector (FID) (as appropriate, depending on site-specific constituents of concern)
- Electronic water-level indicator (e.g., Solinist Model 101) or oil/water interface probe with 0.01-foot accuracy (oil/water as appropriate, note that sampling will not be performed when sheen or light non-aqueous phase liquid [LNAPL] is present)
- Down-hole multi-parameter water-quality sonde (temperature/pH/specific conductivity/oxidation reduction [ORP]/turbidity/dissolved oxygen) meter coupled with flow-through-cell for measurements, for example:

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  - YSI 6-Series Multi-Parameter Instrument
  - Horiba U-22 Multi-Parameter Instrument.
  - Hydrolab Series 3 or Series 4a Multiprobe and Display.

  NOTE: *Transparent, small volume flow-through-cells (e.g., 250 milliliters or less) are preferred as they allow for easy detection of air bubbles and sediment buildup in the cell, which can interfere with the monitoring instrument probes. A small volume cell also allows for quick turnover of water in the cell between measurements of the indicator field parameters. It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.*

- Plastic sheeting (e.g., Weatherall Visqueen) to protect all down-hole sampling equipment from contact with potential sources of contamination.
- Decontamination equipment
  - Non-phosphate laboratory soap (Alconox or equivalent), brushes, clean buckets or clean wash tubs—new buckets or tubs will be purchased if it cannot be determined if the present items are clean
  - Distilled or de-ionized water for equipment decontamination
- Indelible ink pen
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement)
- Sampling pump, which may consist of one or more of the following:
  - Submersible pump (e.g., Grundfos Redi-Flo 2)
  - Peristaltic pump (e.g., ISCO Model 150)
  - Bladder pump (e.g., Marschalk System 1, QED Micropurge, Geotech)
- Appropriate controller and power source for pump:
  - Submersible and peristaltic pumps require electric power from either a generator or a deep cell battery
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N2 or CO2 gas cylinders)
- Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used
  - For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will be used through the pump apparatus
  - Teflon® will not be used when sampling for per- and polyfluoroalkyl substances (PFAS)
- Graduated cylinder and stop watch or other device to measure time to determine pumping rate

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- Appropriate water sample containers (supplied by the laboratory)
- Appropriate blanks (trip blank supplied by the laboratory)
- Sample labels and Chain-of-Custody forms (COC)
- 0.45-micron disposable filters (if field filtering is required)
- A supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020) may be required for specific projects and will be specified in the project FIP/ work plan and the kick-off notes.
    - If used, in-line 'T' and valve allows for collection of water for turbidity measurements before the pump discharge enters the flow-through cell

NOTE: *The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.*

5 CAUTIONS

Different USEPA regions and/or state regulatory agencies may stipulate deviations from this document. It is the responsibility of the Project Team (Project Manager and Technical Lead) to be fully aware of the requirements from the applicable regulatory framework.

Weather

- If heavy precipitation occurs, and no cover over the sampling area and monitoring well can be erected, sampling may be discontinued until adequate cover is provided. Rain water could compromise groundwater samples.
- Avoid extreme weather situations. Be aware that thermal currents and vertical mixing of cold and warm water inside the well casing could create a convection cell within the well and compromise data collection (e.g., biological mechanisms).
    - Direct sunlight and hot ambient temperatures may cause the groundwater in the tubing or flow-through-cell to heat up and de-gas. This may result in the loss of volatile organic compounds (VOCs) and dissolved gases. Shade the equipment from direct sunlight, keep the tubing as short as possible, and avoid the hottest times of the day.
    - Sampling during freezing conditions may adversely impact the data quality objectives. USEPA recommends low-flow sampling be conducted at air temperatures above 32°F (0°C) or taking special precautions to prevent groundwater from freezing in the equipment.

Cross-Contamination

- To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, collect samples in order of up-gradient, then furthest down-gradient to source area locations.

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- Note that permanent markers could introduce volatile constituents into the samples; *therefore, indelible ink is recommended* to be used for labels on sample containers or sample coolers.
- When using a gasoline generator, this power source will be set-up at least 30 feet downwind from the well to avoid exhaust fumes to contaminate samples.

Pumps

- Preferred methods of extracting groundwater are adjustable rate, submersible pumps - such as centrifugal pumps or bladder pumps – constructed of stainless steel or polytetrafluoroethylene (PTFE, i.e. Teflon®). However, *PTFE will not be used when sampling for per- and polyfluoroalkyl substances (PFAS). PTFE could contain PFAS*.
- When using a bladder pump for collecting VOCs and dissolved gases, “best practice” is to set-up the pump to deliver sufficient water to fill a 40 mL VOC vial.
- The use of peristaltic pumps will be based on the type of data to be collected. *Because the use a peristaltic pump can result in de-gassing of VOC and / or dissolved gases from groundwater, a different type of pump will be considered if these compounds are of concern.*
- *Manual or motor driven inertial pumping devices are not recommended because they cause greater disturbance during purging and pumping than regular pumps and are less easily controlled. This could cause a higher degree of data variability.*

Tubing

- When sampling for VOCs, SVOCs, pesticides, PCBs and inorganics, use of PTFE (Teflon®) or PTFE-lined tubing is preferred. However, PTFE tubing will not be used when sampling for PFAS.
- PVC, polypropylene or polyethelene tubing may be used when sampling for metals or other inorganics.
- Tubing with inside diameters of 1/4 or 3/8 inch is recommended because this will help ensure tubing remains water filled when operating at very low pumping rates.

General Precautions

- Store and/or stage empty and full sample containers and coolers out of direct sunlight.
- It may be necessary to field filter the groundwater for some parameters (e.g., metals) during collection, depending on preservation, analytical method, and project quality objectives. The task-kick-off notes and the FIP/work plan will list the samples that require field filtering.
- Be careful not to overtighten lids with Teflon® liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon® seal.

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP.

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Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife)—open well caps slowly and keep face and body away to allow to vent any built-up pressure; only use non-toxic peppermint oil spray for stinging insect nests; review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives, and use appropriate hand protection.

Generators and cord and plug equipment will employ an overcurrent protection device such as an integrated ground fault circuit interrupter (GFCI) cord. Grundfos pump controllers will not run properly with a GFCI, so the power source will be equipped with other overcurrent protection means.

Overtightening of lids with Teflon® liners can cause the glass to shatter and create a risk for hand injuries.

7 PROCEDURE

Field personnel will set up and perform low-flow sampling in accordance with the following procedures.

1. Review FIP and groundwater sampling records from previous sampling events (if available) prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for each well to perform sampling as efficiently as possible (i.e., reach a stabilized pumping condition).
2. Calibrate field instruments according to manufacturer procedures for calibration and record calibration procedure and results in field log.
3. All equipment will either be new or decontaminated in accordance with appropriate guidance document (*TGI – Groundwater and Soil Sampling Equipment Decontamination)* prior to use.
4. Visually inspect the well to ensure that it is undamaged, properly labeled and secured
    a) Damage or other conditions that may affect the integrity of the well will be recorded in the Field Activity Daily Log and brought to the attention of the designated Field Manager and/or Project Manager
    b) Record well construction and conditions on the Low-Flow Sampling Field Form (**Attachment A**)
5. Place clean plastic sheeting on the ground near the well to keep monitoring and sampling equipment off the surface unless the equipment is elevated above the ground (e.g. on a table).
6. Open the well cover while standing upwind of the well. Remove the well cap and place it on the plastic sheeting. If appropriate or required for site-specific conditions, insert the photoionization detector (PID) probe approximately 4 to 6 inches into the casing or the well headspace and cover it with a gloved hand. Record the PID reading in the field log. Perform air monitoring in the breathing zone according to the HASP and/or JSA.
7. Measure and record the initial depth to groundwater prior to placing the pumps.

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8. Prepare and install the pump in the well.

   NOTE: *Groundwater will be purged from the wells using an appropriate pump. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet below ground surface), a submersible or bladder pump will be used, provided that the well is constructed with a casing diameter of at least two (2) inches (the minimum well diameter capable of accommodating such pumps). For smaller diameter wells, where the depth to water is below the sampling range of a peristaltic pump, alternative sampling methods (i.e., bailing or small diameter bladder pumps) will be used to purge and sample the groundwater. Bladder pumps are preferred over peristaltic and submersible pumps to prevent volatilization if sampling of VOCs and/or dissolved gasses is required. Purge water will be collected and containerized according to the direction of the project team.*

   a) For submersible and non-dedicated bladder pumps, decontaminate the pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new bladder and attachment of an air-line, sample discharge line, and safety cable prior to placement in the well. Attach the air-line tubing to the air-port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Take care not to reverse the air and discharge tubing lines during bladder pump setup, as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of pump (if present, depending on pump model used). Slowly lower the pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Avoid twisting and tangling of safety cable, tubing, and electrical lines while lowering the pump into the well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well, as this could lead to unintended contamination.

   b) If using a bladder pump, connect the air-line to the pump controller output port. The pump controller will be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon® tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Turn on the pump controller power (if an on/off switch is present) and verify that all batteries are charged and fully functioning before starting the pump.

   c) If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least two (2) feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

   d) If using an in-line ‘T’ and valve, install between pump discharge water line and the bottom inlet port of the flow-through cell. Attach a short piece of tubing to the outlet. This set-up will be used to collect samples for turbidity readings.

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9. Connect the pump discharge water line to the bottom inlet port on the flow-through cell connected to the multi-parameter water-quality sonde and make sure to record equipment/instrument identification (manufacturer and model number).

10. Before starting the pump, ensure that the water level inside the well has stabilized (i.e., measure the water level multiple times after deploying the pump in the well).

11. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified) and adjust the pumping rate to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement): the water level should stabilize, however, this is not always possible.

12. If the well diameter is of sufficient size, measure the water level every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping.

13. Maintain a steady flow rate to the extent practicable and do not break pump suction or cause entrainment of air in the sample.

14. Record pumping rate adjustments and depths to water.

    If necessary, reduce pumping rates to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters; if the recharge rate of the well is very low, use alternative purging techniques, which will vary based on the well construction and screen position.

    For wells screened across the water table, the well may be pumped dry and sampling can commence as soon as the volume in the well has recovered sufficiently to permit collection of samples.

    For wells screened entirely below the water table, the well can be pumped until a stabilized level (which may be greater than the maximum displacement goal of 0.3 feet) is maintained and monitoring for stabilization of field indicator parameters can commence; if a lower stabilization level cannot be maintained, the well may be pumped until the drawdown is at a level slightly higher than top of the well screen.

15. After water levels have stabilized and a sufficient volume has been purged (*see note below*), continue pumping and begin monitoring field indicator parameters using a multi-parameter water-quality sonde coupled with a flow-through-cell.

    NOTE: *The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.*

16. Use the flow to measure all indicator field parameters, except for turbidity, every 3 to 5 minutes (or after each volume of the flow-through cell has been purged or other appropriate interval); turbidity samples will be collected before the flow-through-cell using the T-valve and a clean container such as a glass beaker.

17. Record field indicator parameters on the groundwater sampling log.

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18. The well is considered stabilized and ready for sample collection when three consecutive readings are within the following limits:

    - **Turbidity** within ± 10% for values greater than 5 nephelometric turbidity units [NTUs] or if three turbidity values are less than 5 NTUs, consider the values stabilized
    - **Dissolved Oxygen (DO)** within ± 10% for values greater than 0.5 mg/L or if three DO values are less than 0.5 mg/L, consider the values stabilized
    - **Specific Conductance** within ± 3%
    - **Temperature** within ± 3%
    - **pH** within ± 0.1 unit
    - **Oxidation/Reduction Potential (ORP)** within ±10 millivolts (mV)

    NOTE: *Alternate stabilization goals may exist in different geographic regions, consult the site-specific FIP/work plan for stabilization criteria).*

    NOTE: *While achieving turbidity levels less than 5 NTU and a stable drawdown of less than 0.3 feet is desirable, sample collection may still take place provided the indicator field parameter criteria in this procedure are met.*

19. If the parameters have stabilized but turbidity remains relatively high (e.g., greater than 50 NTUs), the pump flow rate may be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible. If groundwater turbidity has been minimized (i.e., consecutive readings within ± 10%) and the values for all other parameters have stabilized, the well may be sampled; however, consult specifications in the FIP/work plan and/or the project technical lead prior to sampling.

20. If after one (1) hour of purging indicator field parameters have not stabilized, consult specifications in the FIP/work plan and/or the project technical lead prior to sampling.

    In general, three potential options are available if stabilization criteria are not met:

    a) Continue purging until stabilization is achieved.

    b) Discontinue purging, do not collect any samples, and record in field logbook/on the sampling form that stabilization could not be achieved (documentation must describe attempts to achieve stabilization).

    c) Discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization. *There is a risk that the analytical data obtained under these conditions, particularly metals and hydrophobic organic analytes, may reflect a sampling bias and, as a result, the data may not meet the data quality objectives of the sampling event.*

    NOTE: *DO is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); therefore, great care will be taken to minimize the agitation or other disturbance of water within the flow-through cell while collecting these measurements. If air bubbles are present on the DO probe or in the discharge tubing, remove them before taking a measurement. If DO values are not within acceptable range for the temperature of groundwater, again check for and remove air bubbles on the probe before re-measuring. The table below may be*

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used as a general guide for DO values under various temperatures; however, understand that the table corresponds to freshwater solubility and groundwater contaminants may affect oxygen solubility. If DO value is 0.00 or less, then the meter will be serviced and re-calibrated. If DO values are above possible results, then the meter will be serviced and re-calibrated.

NOTE: *During extreme weather conditions, stabilization of field indicator parameters may be difficult to attain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field logbook/on the sampling form.*

NOTE: *If other field conditions are suspected of preventing stabilization of certain parameters, detailed observations will be documented in the field logbook/on the sampling form.*

Oxygen Solubility in Fresh Water

Temperature (degrees C)	Dissolved Oxygen (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., *Introduction to Environmental Engineering*, PWS Publishing Company, Boston, 468 pages (1996).

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21. Complete the sample label(s) and cover the label(s) with clear packing tape to secure the label onto the container.
22. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container.
    a) If a flow-through analytical cell is being used to measure field parameters, the flow-through cell will be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection.
    b) Under no circumstances will analytical samples be collected from the discharge of the flow-through cell.
    c) If an in-line 'T' and valve are used, the valve needs to be removed as well.
    d) Samples will be collected in the following order: VOCs, total organic carbon (TOC), semi-volatile organic compounds (SVOCs), metals and cyanide, and others (or other order as defined in the site-specific FIP/work plan).
    e) When the container is full, tightly screw on the cap.
23. If sampling for total and filtered metals and/or polychlorinated biphenyls (PCBs), a filtered and unfiltered sample will be collected.
    a) Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected.
    b) Continue to run the pump until an initial volume of "flush" water has been run through the filter in accordance with the manufacturer's directions (generally 100 to 300 mL).
    c) Collect the filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample container.
    d) When the container is full, tightly screw on the cap.
24. Secure with packing material and store the samples on ice in an insulated transport container provided by the laboratory and include a temperature blank in each container to be shipped.
25. Record on the Low-Flow Sampling Field Form (and bound field logbook) the time at which sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (see **Attachment A**).
26. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump setup.
27. Slowly remove the pump, tubing, lines, and safety cable from the well.
    a) If using dedicated tubing, do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them.
    b) If using dedicated tubing, it will be folded - without pinching it - to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events.
    c) Use a length of rope or string to tie the tubing to the well cap.

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d) Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date, coil the tubing neatly and placed in a clean plastic bag that is clearly labeled with the well ID ensuring the bag is tightly sealed before placing it in storage.

28. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.

29. Complete the procedures for packaging, shipping, and handling with the associated Chain-of-Custody.

30. Complete decontamination for flow-through analytical cell and submersible or bladder pump, as appropriate (*TGI – Groundwater and Soil Sampling Equipment Decontamination*).

31. At the end of each day of the sampling event, perform calibration check of field instruments and record procedure and results in field log.

8 WASTE MANAGEMENT

Materials generated during groundwater sampling activities, including disposable equipment and excess purge water, will be stored on site in appropriately labeled containers and disposed of properly. Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field logbook.

9 DATA RECORDING AND MANAGEMENT

Management of the original documents from the field will be completed in accordance with the site-specific QAPP.

In general, forms (e.g., Low-Flow Sampling Field Forms), logs/notes (including daily field and calibration logs), digital records, and Chain-of-Custody records will be maintained by the field team lead.

Field logs and Chain-of-Custody records will be transmitted to the Arcadis Project Manager and/or Task Manager, as appropriate, at the end of each day unless otherwise directed. Electronic data files will be sent to the project team and uploaded to the electronic project folder daily.

Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

10 QUALITY ASSURANCE

Quality assurance procedures shall be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

Unless described otherwise in the project-specific FIP/work plan, QAPP, or Sampling and Analysis Plan, quality assurance/quality control samples will be collected as follows:

- One duplicate for every 10 samples

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- One laboratory matrix/matrix spike sample for every 20 samples

In addition to the quality control samples to be collected in accordance with this TGI, the following quality control procedures will be observed in the field:

- Collect samples from monitoring wells, in order of increasing concentration, to the extent known based on review of historical site information if available
- Equipment blanks will include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well)
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled
- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures—calibrate instruments at the beginning of each day, verify the calibration at the end of each day, and record all calibration activities in the field notebook
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well following the procedure for equipment decontamination

11 REFERENCES

USEPA. 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* (September 1986).

USEPA. 1991. *Handbook Groundwater, Volume II Methodology*, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July 1991).

USEPA Region I. 2017. *Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells* (EQASOP-GW4; September 19, 2017).

U.S. Geological Survey (USGS). 1977. *National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination*. Reston, Virginia.

12 ATTACHMENTS

A. Low-Flow Sampling Field Form

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GROUNDWATER SAMPLING FORM

ARCADIS

Project No. _____ Well ID _____ Date _____

Project Name/Location _____ Weather _____

Measuring Pt. Description _____ Screen Setting (ft-bmp) _____ Casing Diameter (in.) _____ Well Material ____ PVC ____ SS

Static Water Level (ft-bmp) _____ Total Depth (ft-bmp) _____ Water Column (ft) _____ Gallons in Well _____

MP Elevation _____ Pump Intake (ft-bmp) _____ Purge Method: _____ Sample Method _____

Pump On/Off _____ Centrifugal / Submersible / Other _____

Sample Time: _____ Volumes Purged _____

Purge Start _____ Gallons Purged _____ Sample ID _____ Sampled by _____

Purge End _____ Replicate/Code No. _____

Time	Minutes Elapsed	Rate (gpm)/(mL/min) 200mL/min +	Depth to Water (ft) -0.3	Gallons Purged	pH ± 0.1	Cond. (µMhos)/(mS/cm) ± 3%	Turbidity (NTU) ± 10%	DO (mg/L) ± 10%	Temp. (°C)/(°F) ± 3%	Redox (mV) ± 10mV	Appearance	
											Color	Odor
Stabilization Calculations (±)												
Stabilization Criteria					**± 0.1 s.u.**	**±3%**	**± 10% or within 1 NTU (1)**	**± 10%**	**±3%**	**±10 mV**		

(1) **Turbidity** < 50 NTU and ±10% or within 1 NTU of a previous reading when <10 NTU

Constituents Sampled	Container	Number	Preservative

Comments _____

Well Casing Volumes

Gallons/Foot					
	1" = 0.04	1.5" = 0.09	2.5" = 0.26	3.5" = 0.50	6" = 1.47
	1.25" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65	

Well Information

Well Location: _____ Well Locked at Arrival: Yes / No

Condition of Well: _____ Well Locked at Departure: Yes / No

Well Completion: Flush Mount / Stick Up Key Number To Well: _____

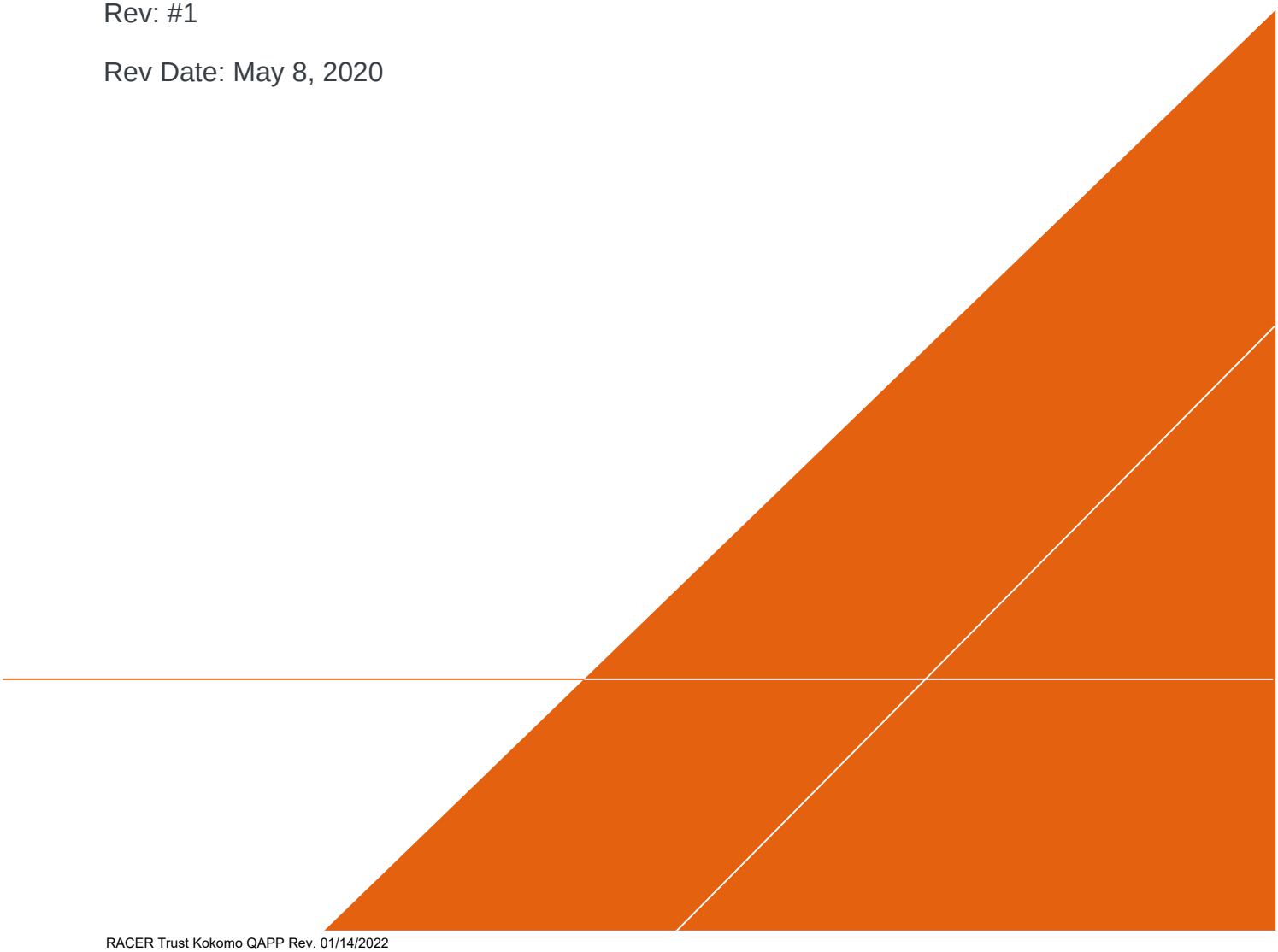
GW Samp Form 5/8/2020

ARCADIS Design & Consultancy for natural and built assets

TGI – MANUAL WATER-LEVEL AND NAPL MONITORING

Rev: #1

Rev Date: May 8, 2020



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 11, 2018	All	Updated and re-written as TGI	Marc Killingstad Everett H. Fortner III
1	May 8, 2020	All	Updated and added NAPL gauging	Marc Killingstad Everett H. Fortner III Andy Pennington

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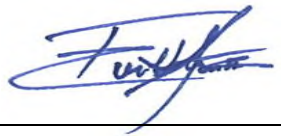
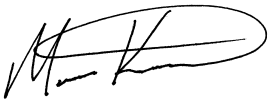
APPROVAL SIGNATURES

Prepared by:		05/08/2020
	Everett H. Fortner III, PG	Date:
Technical Expert Reviewed by:		05/08/2020
	Marc Killingstad (Technical Expert)	Date:

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

The objective of this Technical Guidance Instruction (TGI) is to describe procedures to measure and record water-levels (groundwater and surface-water) using manual water-level meters. Water levels may be measured using an electronic water-level probe or an oil-water level indicator from established reference points (e.g. top of casing). Reference points must be surveyed to evaluate fluid level elevations relative to a vertical datum (e.g. North America Vertical Datum of 1988 [NAVD88] relative to sea level). This TGI describes the equipment, field procedures, materials, and documentation procedures to measure and record water-levels using the aforementioned equipment. This TGI also describes procedures for measuring in-well thicknesses of non-aqueous phase liquid (NAPL), both light and/or dense (LNAPLs and DNAPLs, respectively).

Surface water-levels can be measured from stilling wells or fixed points (bridges, walls, etc.) and measuring from an established point of reference using a water-level meter. In some cases, surface water water-levels may be determined from a graduated stream gauge, attached to a pole located in open water with known elevation, without the use of a water-level meter.

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The use of pressure transducers or other automated devices for the collection of groundwater elevation data will be subject of *TGI – Water-Level Monitoring using Pressure Transducers and TGI – Water-Level Measurements using Sonic Meters*.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The HASP and other documents will identify other training requirements or access control requirements.

4 EQUIPMENT LIST

The following field equipment is suggested for water-level measurements:

- Site-specific Health and Safety Plan (HASP)
- Appropriate personal protective equipment (PPE) as specified in the HASP
- Electronic water-level indicator graduated in 0.01 ft. increments
- Electronic oil-water (interface) level indicator graduated in 0.01 ft. increments, if necessary
- Non-phosphate laboratory soap (Alconox or equivalent), brushes, clean buckets or clean wash tubs.
- Distilled or de-ionized (required for some sites) water for equipment decontamination
- Photoionization detector (PID) and/or organic vapor analyzer (optional)
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement) – if required for total depth measurements of deeper wells
- Solvent (methanol/acetone/isopropyl alcohol) rinse – optional
- Spray bottle for solvent - optional
- Plastic drop cloth (e.g. Weatherall Visqueen) to place beneath the buckets or tubs to reduce potential for contamination of the tape or probe
- Tools and/or keys required for opening wells
- Well construction summary table and/or well construction logs
- Summary table of previous water-level measurements
- Field notebook and/or smart device (phone or tablet) or appropriate field forms (see **Attachment 1**).

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- Indelible ink pen

5 CAUTIONS

Electronic water-level indicators and oil-water interface probes may sometimes produce false-positive readings. For example, if the inside casing surface of the well or stilling tube has condensation above the water level, then an electronic water-level probe may produce a signal by contacting the sidewall of the well, rather than the true water-level surface. For accuracy, the electronic water-level probe and/or interface probe should be raised and lowered several times at the approximate depth where the instrument produces a tone indicating a fluid interface to verify consistent, repeatable results (three or more times). Additionally, some wells may be constructed with a sump. If local/regional groundwater levels have declined such that the water-level is below the base of the well screen, a sump may still contain water and provide an erroneous measurement. Therefore, possessing and comparing measurements with a well construction summary table or well construction log is recommended for proper reporting.

If the presence of a NAPL is known or suspected within specific wells, *do not use* an electronic water-level indicator. Use an oil-water interface probe instead. If NAPL presents ignition or explosion hazards, an intrinsically safe oil-water interface probe is required to be used with grounding and following the manufacturer's instructions.

If the NAPL is known to be very viscous or problematic to gauge, the data quality will require additional consideration prior to measuring. Staff will consider the data quality objectives for the gauging activity – e.g., if quantifying NAPL thickness is necessary, or if assessing the presence/absence is sufficient. Alternate NAPL measurement methods (such as using drop pipes or temporary coatings for down-well equipment) may be considered.

When measuring total well depths with an electronic water-level indicator, the measurement must have a correction factor applied for post processing or completed at the time of measurement that is equal to the length of the probe beneath the circuit closing electrodes (if applicable to the instrument). This is necessary because the tape distance markings are referenced to the electrode, rather than the end of the probe. Some newer instruments do not have an offset electrode and this correction factor is needed. In addition, total depth measurements are difficult with wells that have large water columns due to buoyancy issues. In addition, the total depth measurement will include notes that indicate a soft or hard bottom if recognized during the measurement.

Ensure that the type of electronic water-level indicator is compatible with the depth and diameter of the wells to be measured. Some smaller piezometers or larger diameter well stilling tubes will accommodate only smaller diameter probes.

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel. Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or oil. Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards

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(e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife). Appropriate personal protective equipment (PPE) will be worn during these activities. Only use non-toxic peppermint oil spray for stinging insect nests. Open well caps slowly and keep face and body away to allow to vent any built-up pressure. Field personnel will thoroughly review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives.

Obtaining measurements from active pumping wells requires knowledge of the construction and design, as the indicator probe and tape can become intertwined within down-well equipment (such as pump impellers) causing a serious health and safety hazard and equipment damage. Ensure that stilling wells have a perforated end and capped bottom to inhibit tape from extending into the downhole pump depth. If a stilling tube is not present or the still tube construction is not known, determine a conservative “not to exceed” measurement depth based on the top of pump depth with an added safety factor. If all information is not known, a water-level will not be taken from the pumping well until clarification on depths are available.

7 PROCEDURE

Calibration procedures and groundwater level measurement procedures for electronic water-level indicators and oil-water indicators are described in the sections below. Calibration documentation can be requested from the rental or manufacturer.

Calibration Procedures

If the indicator requires length and markings verification is required by project data quality plan or other reasons, then the following steps may be used:

- Measure the lengths between each increment marker on the indicator with a measuring tape. The appropriate length of indicator measuring tape, suitable to cover the depth range for the wells of interest, will be checked for accuracy.
- If the indicator measuring tape is inaccurate, the probe will require to be sent back to the manufacturer or rental company. If a replacement can’t immediately be available, then an offset can be measured to correct the measurements.
- If multiple water-level indicators and/or oil-water interface probes are being used for an event, calibration of the multiple devices will be required by measuring a water-level at a single well contemporaneously with all indicators to be used and calculated correction factors provided for data processing (typical corrections are small and range from 0.01 to 0.03 foot).
- Equipment calibration will be recorded in the field logbook and/or smart device.

Water-Level Measurement Procedures

The general procedures to be followed for the collection of fluid level measurements and well depths from the monitoring wells are as follows:

- Check that the water-level/oil-water level indicator battery is functional, before mobilization and prior to each work day (e.g. turn power on and check that meter sounds when probe is lowered into a bucket

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of water – note that water-level meters will not work with low-electrical-conductivity liquids such as distilled water).

- Record instrument make, model, serial number and (if present) Arcadis ID number in the field form or electronic field form.
- Don disposable nitrile gloves. Decontaminate the water-level/oil-water indicator, any attached tape and the spool with laboratory-grade soap and distilled water (see *Initial Decontamination Procedures* below). The spool requires caution with cleaning as it is not water-proof and can be damaged during cleaning.
- The top of the monitoring well will be cleaned with a clean rag to prevent loose particulate matter from falling into the well.
- Perform a well inspection (note that a well inspection form may be required to be filled out along with a photo to document the conditions).
- Place clean plastic sheeting on the ground next to the well.
- Unlock and/or open the monitoring well cover while standing upwind from the well (note that some wells may be under pressure and precaution should be taken with opening well caps – see Section 6).
- Measure the volatile organics present in the monitoring well head space with a PID and record the PID reading (if applicable and requirement for the site).
- Allow the water-level in the well to equilibrate with atmospheric pressure for a few minutes (check previous field forms or field books for equilibration time, if noted).
- Locate the measuring reference point that correlates to the survey point on the well casing. If one is not found, make a reference point by notching the highest and/or north point on the inner casing (or outer if an inner casing is not present) or mark with a permanent mark. All downhole measurements will be taken from the reference point. Document any changes or new reference point addition.
- Measure to the nearest 0.01 foot and record the height of the inner well casing and outer protective casing to ground level (note that some well pads are raised and are not at true ground surface).
- Lower the indicator probe into the center of the well until contact with the water surface is indicated by either an audible alarm or light. The sensitivity of the probe may need adjustment if the alarm or light is not strong signal. Use and install a tape guide (available from some manufacturers) to help with accuracy and provide protection with damaging the measurement tape. If a tape guide is not available, make sure that the tape does rub on the inner or outer casing which could fray and damage the tape.
- If an oil-water interface probe is being used to measure depth and thickness of NAPL, lower the interface probe into the center of the well until a contact with the NAPL surface is indicated by either audible alarm or light. The sensitivity of the probe may need adjustment if the alarm or light is not strong signal. To gauge the water level in a well which contains LNAPL (LNAPL-water interface), advance the interface probe past the LNAPL-water interface until the probe produces a solid audible alarm indicating water. While slowly retrieving the probe upward, the equipment will produce a different tone when the LNAPL-water interface is reached (typically this is a multiple alarm sound or flashing light). This level should represent the depth to water. The depth indicating the bottom of the

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water column and top of DNAPL layer, if any, is indicated by the multiple alarm signal or flashing light emitted by the interface probe.

- Hold the tape at the measuring point and repeat the measurement two more times.
- Read and record measurement to the nearest 0.01 foot. Check the measurement with previous measurements, if available, and note any anomalies/discrepancies; if significant, contact the project staff.
- Measure and record total depth of well (see *Total Depth Measurement Procedures* below); note that measurement of total depth is not always performed at wells containing LNAPL or DNAPL, in order to reduce decontamination of the instrument and reduce potential exposure to NAPL.
- Record all measurements (**with date and time collected to the nearest minute**) and note any inconsistencies/anomalies and relevant observations in the field notebook and/or smart device or appropriate field forms.
- Follow decontamination procedure outlined below before measuring subsequent wells (see *Decontamination after Water Level and Total Depth Measurements* below).
- Replace cap and lock the well when all activities are completed.

Total Depth Measurement Procedures

- Weighted tape or electronic water-level indicator can be used to measure the total well depth.
- Follow initial procedures noted above in *Water-Level Measurements* above.
- Lower indicator probe (or tape) until weighted end is resting on the bottom of the well. Raise indicator slowly until there is no slack in the tape. Gently estimate the bottom of the well by slowly raising and lowering the indicator: great care should be taken to avoid damaging the sensor on the probe. The operator may find it easier to allow the weight to touch bottom and then detect the 'tug' on the tape while lifting the weight off the well bottom.
- Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the probe is in contact the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements.
- If total depth measurements are to be collected during low-flow sampling events, the measurement will be made only after low-flow sampling has been completed or at least 12 hours prior to initiating sample collection from the well, in order to minimize: 1) mixing of the stagnant water at the top of the well column with potential formation water underneath; and/or 2) agitation and subsequent entrainment of possible sediment collected at the well bottom).
- Read and record measurement to the nearest 0.1 foot. Please refer to the note regarding total depth measurements described in *Section 5 Cautions* above.
- Follow decontamination procedure outlined below before gauging the next well (see Decontamination after *Water Level, NAPL Level, and Total Depth Measurements* below).

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Initial Decontamination

- Note that there may be project specific decontamination procedure documents that will be followed in lieu of the below procedures.
- Set up a decontamination station consisting of three **clean** buckets (e.g. 5-gallon buckets). The buckets should not be used to containerize purge water; they will be used for decontamination purposes only.
- Fill the first bucket with one gallon of distilled water (use deionized water if metals are a contaminant at the site) and add non-phosphate laboratory-grade soap. Fill the second bucket with distilled water (use deionized water if metals are a contaminant at the site) and leave the third bucket empty. Place the drop cloth underneath.
- Unwind the entire tape from the spool into a bucket with non-phosphate laboratory-grade soap and distilled water; Brush the tape carefully to remove dirt and possible contamination, using a brush dedicated to the wash bucket.
- Carefully brush all dirt of the spool and wipe down with a soapy cloth or paper towel.
- Transfer the tape into the second bucket containing rinse water. Carefully brush the tape using a second brush, dedicated to the rinse bucket. Lift the tape out of the bucket and allow rinse water to drip off the tape.
- Transfer the tape to the third bucket. Wind the tape onto the spool while wiping excess water off the tape using a paper towel.

Decontamination after Water Level, NAPL Level, and Total Depth Measurements

- Set up a decontamination station consisting of three **clean** buckets, fill according to the initial decon procedure.
- Unwind the only the length of tape used for gauging from the spool into a bucket with laboratory-grade soap and distilled water. Brush the tape carefully to remove dirt and possible contamination, using a brush dedicated to the wash bucket.
- Continue as described above.
- Extra care should be taken to clean the probe after a total depth measurement. All sediment or dirt needs to be removed during decontamination.
- If an oil-water interface probe is used to gauge NAPL, a solvent may be necessary to remove all NAPL residue. After decontaminations steps above, use a spray bottle filled with chosen solvent (ex. isopropyl alcohol) and spray across all surfaces of the tape. Use paper towels to wipe off solvent and/or residue. This step may be repeated if necessary.

Notes:

- Collect equipment blanks if required by the work plan (minimum 1 per 20 samples or 1 per sampling event)

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- Prepare new wash solution and rinse water when necessary (e.g., every 10 to 20 wells). The spent wash and rinse solution should be discharged according to site practices.
- The decontamination station may be expanded by adding extra rinse and/or detergent stations (i.e. solvent wash station) to the set up. The addition of more stations depends on the requirements of the work plan or the site-specific Field Sampling and Quality Assurance Plan and outlined in the project field plan or kick-off meeting.
- Small crates or washtubs are a possible substitute for the buckets. In any case, it is recommended to use containers with a lid.

8 WASTE MANAGEMENT

Decontamination fluids, PPE, and other disposable equipment will be properly stored on site in labeled containers and disposed of properly. Be certain that waste containers are properly labeled and documented in the field log book. Review *TGI – Investigation Derived Waste Handling and Storage*, for additional information and state- or client-specific requirements.

9 DATA RECORDING AND MANAGEMENT

Fluid level measurements as well as all relevant observations should be documented in the field logbook, field forms and/or PDA as appropriate. The following information must be documented:

- Well or location identification;
- Measurement time;
- Total well depth or depth of the water body at the location;
- Depth to water and, where necessary, depth to NAPL.

Once all the data has been collected and recorded, all notes/forms/data must be uploaded to the appropriate project directory on the Arcadis server, and an email should be sent to the Task Manager and/or Technical Lead for notification. A summary of the work completed that day and any relevant observations noted (such as well inspections) during the daily activities as well as copies of the data mentioned above should be included with the email. The appropriate team member will review the data for accuracy and provide feedback.

10 QUALITY ASSURANCE

Suggested quality control measures are below; project teams may implement some or all of these at their discretion and based on project data quality needs.

- As described in the detailed procedure, the electronic water-level meter and/or oil-water interface probe can be calibrated prior to use versus an engineer's rule to ensure accurate length demarcations on the tape or cable. The results will be recorded.
- Measurements will be completed three times, with the final measurement recorded.

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- Fluid interface measurements will be verified by gently raising and lowering the instrument through each interface to confirm repeatable results.
- Field notes will be reviewed by the project team once the field data has been delivered.

11 REFERENCES

Cunningham, W.L., and Schalk, C.W., comps., 2011. *Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 pp*.

U.S. Environmental Protection Agency, 2013. *SESD Operating Procedure, Groundwater level and Well Depth Measurement.* January 29.

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ATTACHMENT A

Water-Level Measurement Form

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Water-Level Measurement Form

Project No.: _____ Field Personnel: _____

Site Location: _____ Date: _____

Instrument Model _____ Instrument Serial No.: _____

Well Number	Time	W.L. Measurements			Comments		
		TD (feet)	DTW (feet)	DTL (feet)	Well Locked	Lock Condition	Other Comments

W.L. Water Level
TD Total Depth
DTW Depth To Water
DTL Depth To NAPL

ARCADIS

Water-Level Measurement Form

Project No.: _____ Field Personnel: _____

Site Location: _____ Date: _____

Instrument Model _____ Instrument Serial No.: _____

Well Number	Time	W.L. Measurements			Comments		
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W.L. Water Level
TD Total Depth
DTW Depth To Water
DTL Depth To NAPL

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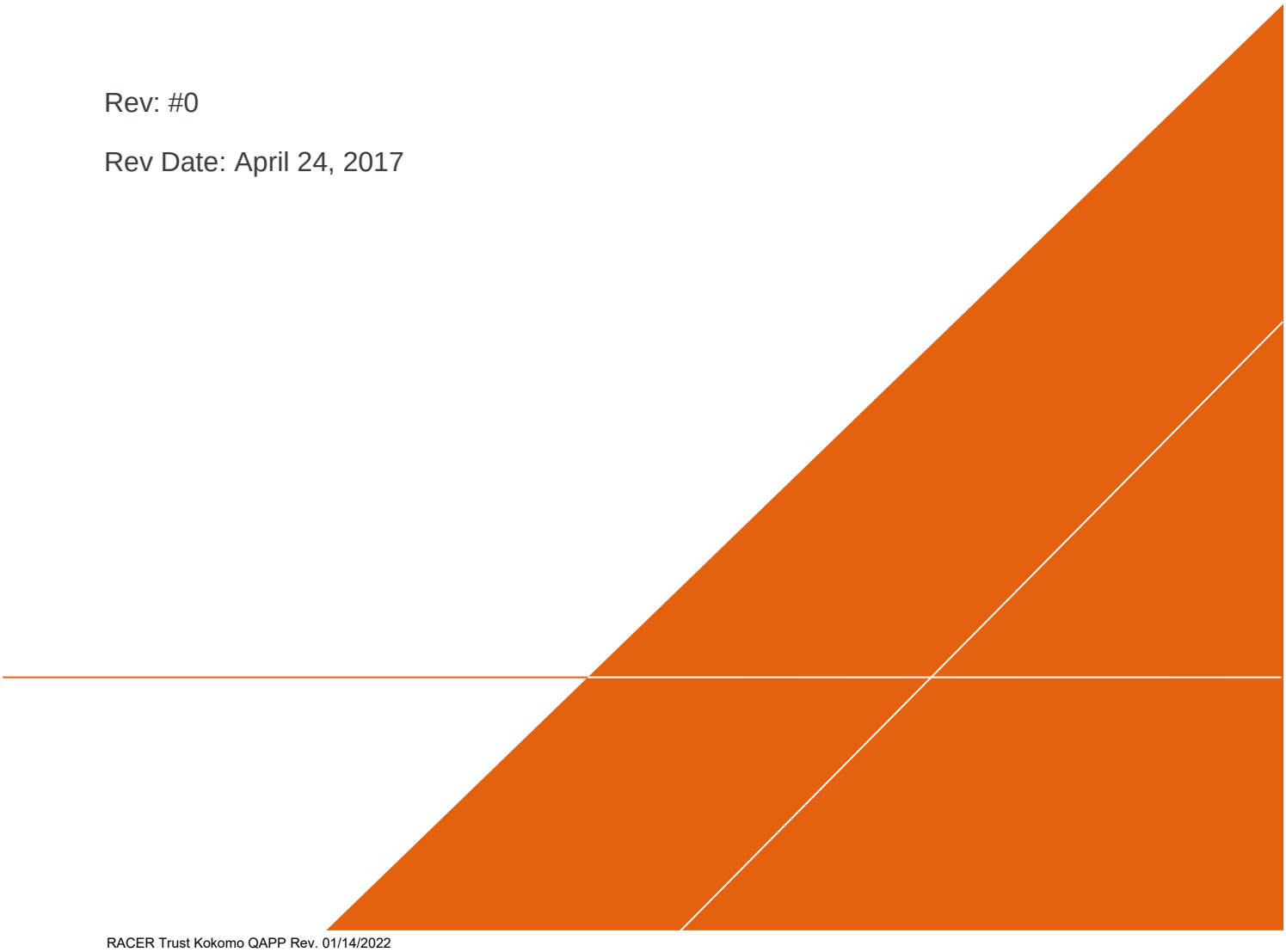
TECHNICAL GUIDANCE INSTRUCTION - MONITORING WELL DEVELOPMENT

Rev: #0

Rev Date: April 24, 2017



VERSION CONTROL

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0	4/24/2017	All	Re-written as TGI	Marc Killingstad

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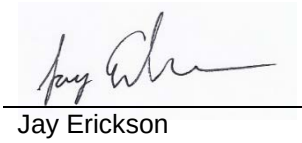
Prepared by:		4/24/2017
	Jay Erickson	Date:
Technical Expert Reviewed by:		4/24/2017
	Marc Killingstad	Date:

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1 INTRODUCTION

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In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) covers the development of screened wells used for obtaining representative groundwater information and samples from granular aquifers (i.e., monitoring wells). Note that this TGI only applies to monitoring well development and not remediation (injection/extraction) well development.

The purposes of Monitoring Well Development are:

1. Repair damage to the borehole wall from drilling that can include clogging, smearing or compaction of aquifer materials;
2. Remove fine grained sediment from the formation and filter pack that may result in high turbidity levels in groundwater samples;
3. To re-sort formation and filter pack material adjacent to the well screen;

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4. To recover any drilling fluids (if used) that may affect the permeability of the formation and filter pack or alter the water quality around the well; and
5. To optimize the well efficiency and hydraulic communication between the well screen and the formation.

Successful monitoring well development is dependent on the following:

1. Hydrostratigraphy – Permeable formations containing primarily sand and gravel are more easily developed due to lower percentages of silt and clay material. Water in permeable formations can be moved in and out of the screen and/or through the formation easier than in less permeable deposits
2. Well Diameter – Development tooling including brushes, surge blocks, pumps and jetting tools are more readily available for wells 4 inches in diameter and greater.
3. Well Design – Wells with filter packs and screens designed to match the formation through the analysis of formation sieve samples are easier to develop. An important aspect to well design is to minimize the size of the annular space between the formation and well screen. Adequate room must be allowed for the proper installation of well materials, but not too large as to prevent/reduce communication with the surrounding formation.
4. Drilling Methods – Different drilling methods result in varying amount of borehole damage and, therefore, impact the degree to which development will be successful.

Well development methods for monitoring wells include the following:

1. Bailing – use of a bailer to remove water and sediment from the well casing. This technique does little to remove fines from the filter pack and may lead to bridging of sediment since the flow in only in one direction, toward the well screen.
2. Pumping/overpumping – use of a pump to remove water and sediment from the well casing, overpumping involves pumping the well at a rate that exceeds the design capacity of the well. Similar to bailing, this technique does little to remove fines from the filter pack and may lead to bridging of sediment since the flow in only in one direction, toward the well screen. Small diameter monitoring wells have the additional constraint on pump size and flow rates.
3. Backwashing (rawhiding) – consists of starting and stopping a pump intermittently to produce rapid pressure changes in a well. This method can produce better results than pumping alone since the procedure involves movement of the water in and out of the screen and formation. However, in many cases the surging action is not rigorous enough to fully develop the well.
4. Surging/swabbing – use of a mechanical surge block or swabbing tool to operate like a piston with an up and down motion. The downstroke causes a backwash action that breaks up bridged sediment and the upstroke pulls the dislodged sediment into the well. This method works well for small and large diameter wells. Care should be taken on the downstroke so as not to force fines back into the formation, frequent pumping/purging during surging help to keep fines out of the well. Double surge blocks are recommended.
5. Jetting – use of a tool fitted with nozzles that direct streams of water horizontally into well screens at high velocity. Due to the size of the tooling, this method is better suited for wells 4 inch in diameter and larger. The method is also more effective with wire-wrapped/continuous slot screens due to the

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increased open area. Jetting requires specialized equipment and concurrent pumping to prevent reintroducing fines into the filter pack. Additionally, jetting requires subsequent surging to remove fines dislodged in the filter pack and formation.

For most situations, gentle surging coupled with bailing or pumping to remove dislodged materials is recommended.

Well development for properly designed and constructed monitoring wells may begin after the annular seal materials have been installed and allowed to cure, since these wells are designed to retain 90-99% of the filter pack material. This cure time is typically at least 24 to 48 hours after the sealing materials have been installed.

This TGI is meant to provide a general guide for proper monitoring well development. A site-specific field implementation plan for well installation and development detailing the specific methods and tools should be developed to provide site-specific instruction and guidance.

3 PERSONNEL QUALIFICATIONS

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

4 EQUIPMENT LIST

Required equipment depends on the selected method and should be detailed in the site-specific field implementation plan. However, the following are typically required.

- Health and safety equipment, as required by the site Health and Safety Plan (HASP):
- Cleaning equipment
- Field notebook and/or personal digital assistant (PDA)
- Monitoring well keys
- Water level indicator
- Field parameter meter (YSI)
- Well Development Logs
- Well construction logs/diagrams
- Weighted tape (measure depth)
- Turbidity meter
- Camera
- Watch/timing device.

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5 CAUTIONS

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases, it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Certified Project Manager (CPM) and/or Project Hydrogeologist must be notified and the CPM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the CPM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

7 PROCEDURE

As indicated above, for most monitoring wells, gentle surging coupled with bailing or pumping to remove dislodged sediment is recommended.

1 Ensure sufficient time has passed to allow for proper curing of the well seal.

2 Don appropriate PPE (as required by the site-specific HASP).

3 Place plastic sheeting around the well.

4 Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

5 Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

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6 Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book. It is recommended to use a weighted tape for the total well depth measurement.

7 The depth to the bottom of the well should be sounded and then compared to the completion form or construction diagram for the well. Any discrepancies should be reported immediately to the CPM and/or Project Hydrogeologist. If sand or sediment is present inside the well, it should first be removed by bailing. Do not insert bailers, pumps, or surge blocks into the well if obstructions, parting of the casing, or other damage to the well is suspected. Instead report the conditions to the CPM and/or Project Hydrogeologist and obtain approval to continue or cease well development activities.

8 Lower a double surge block into the screened portion of the well. Starting from the bottom of the screen using 2 foot throws, gently raise and lower the surge block to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes.

9 Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and contact at the bottom of the well feels solid. Alternatively, measurement of the well depth with a weighted tape can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

10 After surging the well for a minimum of two cycles and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

11 Remove formation water by pumping/bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Site-Specific Field Implementation plan are reached. Note: the project-specific field implementation plan may also specify a maximum turbidity requirement for completion of development. Unless otherwise specified the maximum turbidity should be 50 NTUs or less. Record the total volume of water purged from the well.

12 While developing, take periodic water level measurements (at least one every five minutes) to determine if drawdown is occurring and record the measurements on the Well Development Log.

13 While developing, calculate the rate at which water is being removed from the well. Record the volume on the Well Development Log.

14 While developing, water is also periodically collected directly from the well or bailer discharge and readings taken of the indicator parameters: pH, specific conductance, and temperature. Development is considered complete when the indicator parameters have stabilized (i.e., three consecutive pH, specific conductance, and temperature readings are within tolerances specified in the project work plans or within 10% if not otherwise specified), the extracted water is clear and free

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of fine sediment and most importantly, when acceptable volume of water has been removed and/or a sufficient amount of surging has been performed.

15 In certain instances, for slow recharging wells, the parameters may not stabilize. In this case, well development is considered complete when minimal amounts of fine-grained sediments are recovered and acceptable volume of water has been removed.

16 If the well goes dry, stop pumping or bailing. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping or bailing when sufficient water has recharged the well.

17 Contain all development water in appropriate containers.

18 When complete, secure the lid back on the well.

19 Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer

8 WASTE MANAGEMENT

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan/Field Implementation Plan or Field Sampling Plan.

9 DATA RECORDING AND MANAGEMENT

All well development activities should be documented on appropriate log forms as well as in a proper field notebook and/or PDA. Additionally, all documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before, during, and after pumping.

10 QUALITY ASSURANCE

All reused, non-disposable, downhole well development equipment should be cleaned in accordance with the procedures outlined in the project documents.

11 REFERENCES

American Society for Testing Materials (ASTM), Designation D5521-05. *Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

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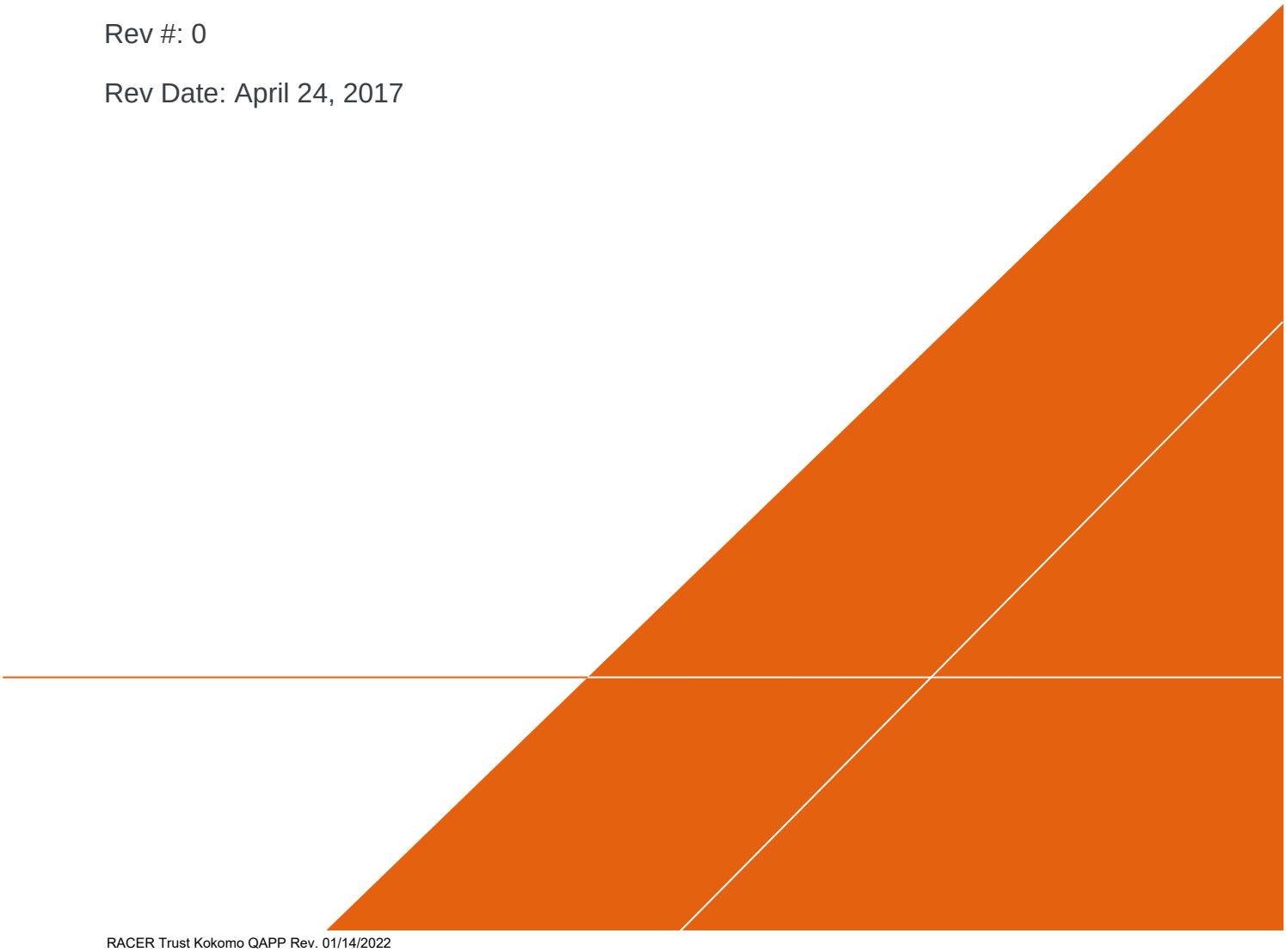
TGI - MONITORING WELL INSTALLATION

Rev #: 0

Rev Date: April 24, 2017



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Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	4/24/2017	All	Re-written as a TGI	Marc Killingstad Peter C. Frederick

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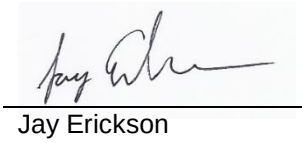
Prepared by:		4/20/17
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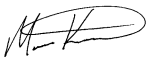
Technical Expert Reviewed by:		4/24/17
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2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes methods used to install groundwater monitoring wells in granular aquifers. It is assumed that the monitoring well has been properly designed, including sizing of the filter pack and screen, the length of the screen, total depth of the well, material strength and compatibility and surface completion. Typical monitoring wells are constructed of manufactured screen and engineered filter pack and are generally suitable for formations with granular materials having a grain size distribution with up to 50% passing a #200 sieve and up to 20% clay-sized material. Monitoring wells installed in formations finer than this may not be able to produce turbidity free water.

The monitoring well installation procedures set forth herein are consistent with the approach and methods presented in the American Society of Testing and Materials (ASTM) D5092 – *Standard Practice for Design and Installation of Groundwater Monitoring Wells* (ASTM D5092). As such, following this TGI in combination with proper well design (see appropriate TGI), well development (see appropriate TGI), groundwater sampling procedures (see appropriate TGI), and well maintenance and rehabilitation (see appropriate TGI), will result in a monitoring well suitable for: (1) collection of groundwater samples

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representative of the surrounding formation and free of artificial turbidity; (2) measurement of accurate groundwater levels; and (3) hydraulic conductivity testing of formation sediments immediately adjacent to the open interval of the well (e.g., slug testing).

Monitoring well boreholes in unconsolidated (overburden) materials are typically drilled using the hollow-stem auger drilling method. Other drilling methods that are also suitable for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions or project objectives, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells to be installed within consolidated materials such as fractured bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary or Rotasonic methods. For guidance when installing monitoring wells in consolidated materials, please refer to the appropriate document. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling/well depths, site or regional geologic knowledge, type of monitoring to be conducted using the installed well, project objectives, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the borehole will be obtained prior to mobilizing onsite; these materials generally include:

- Well casing (length, material, and diameter);
- Well screen (length, material, diameter, and slot size);
- Bentonite (type, as applicable, chips, non-coated and granular bentonite are acceptable);
- Filter pack (filter pack type and fine sand seal type, as applicable); and
- Grout (type, as applicable).

Well materials will be inspected and, if needed, cleaned or replaced prior to installation.

3 PERSONNEL QUALIFICATIONS

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate Standard Operating Procedures (SOPs) and/or TGIs for those activities.

4 EQUIPMENT LIST

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;

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- Work Plan (or equivalent), Field Sampling Plan (FSP), and site-specific Health and Safety Plan (HASP);
- Personal protective equipment (PPE), as required by the HASP;
- Traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- Appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- Soil and/or bedrock logging equipment as specified in the appropriate project documents;
- Appropriate sample containers and labels;
- Drum labels as required for investigation derived waste handling;
- Chain-of-custody forms;
- Insulated coolers with ice, when collecting samples requiring preservation by chilling;
- Photoionization detector (PID) or flame ionization detector (FID);
- Ziplock style bags;
- Water level or oil/water interface meter;
- Locks and keys for securing the well after installation;
- Decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels);
- Engineer's tape/measuring wheel;
- Weighted tape;
- Disposable bailers;
- Digital camera (or phone with camera)
- Field notebook or Personal Digital Assistant (PDA); and
- Appropriate field forms, consider including a photo of the well head and a Google Earth map showing the well location.

Prior to mobilizing to the site, Arcadis personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller is necessary to ensure that the materials provided will meet the project objectives. Equipment/materials typically provided by the driller could include:

- Drilling equipment required by the ASTM standard guidance document D1586, when performing split-spoon sampling;
- Disposable plastic liners (when drilling with direct-push equipment);
- Drums for investigation derived waste;

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- Drilling and sampling equipment decontamination materials;
- Decontamination pad materials, if required; and
- Well construction materials.

5 CAUTIONS

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See appropriate guidance for proper utility clearance protocol.

Prior to beginning field work, contact the project technical team to ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all team members.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the project specific documents for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Similarly, consider the compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel or are corrosive to metal well materials. If questions arise, contact the CPM and/or project technical lead to discuss.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling the borehole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present or in groundwater with high salinity. In these situations, neat cement grout is preferred.

As noted above, coated bentonite pellets will not be used in monitoring well construction, as the coating could impact the water quality in the completed well.

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Heat of hydration during neat cement grout curing must be considered to avoid damage to PVC well materials. The annular space for a typical monitoring well is small enough that heat of hydration should not create excessive temperature increases which may damage PVC well material. However, washouts in the borehole can lead to thick accumulations of grout which can produce enough heat during curing to weaken and potentially damage PVC casing. If heat of hydration is a concern, contact the project technical lead to address the issue.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

7 PROCEDURE

The procedures for installing groundwater monitoring wells are presented below:

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Prior to monitoring well installation, determine the expected volumes of filter pack and seal materials including bentonite (if applicable) and grout (neat cement or cement-bentonite).
2. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.
3. Advance boring to desired depth. Collect soil and/or bedrock samples at appropriate interval as specified in the Work Plan (or equivalent) and/or FSP. Collect, document, and store samples for laboratory analysis as specified in the Work Plan and/or FSP. Decontaminate equipment between samples in accordance with the Work Plan (or equivalent) and/or FSP. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is described in ASTM D1586 – *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586). Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary. Rotasonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks. Dual-rotary removes cuttings by compressed air or water/mud and allow only a general assessment of geology.
4. Describe each soil sample as outlined in the appropriate project records. Record descriptions in the field notebook and/or personal digital assistant (PDA). It is also beneficial to photo document the samples. It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data. During soil boring advancement, document all drilling events in field notebook, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages. Blow counts will not be available if Rotasonic, dual-rotary, or direct-push methods are used.

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5. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction should be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

6. Before installing a screened, it is important to confirm that the borehole has been advanced into the targeted saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled without using water (e.g., hollow-stem auger, cable-tool, air rotary, air hammer), verify the presence of groundwater (and /or LNAPL, if applicable) in the borehole using an electronic water level probe, oil-water interface probe, or a new or decontaminated bailer. For boreholes drilled using water (e.g., drive and wash, spun-casing with roller-bit wash, Rotasonic, or water rotary with core or roller bit), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. Document depth to water in the borehole on the appropriate field forms and field notebook. If there are questions concerning the depth of the well/screen interval, consult with the project technical lead prior to finalizing well depth/screen interval. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. When in doubt, err on the side of slightly deeper well installation.

7. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and casing assembly with sump through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter (although sometimes 4-inch), flush-threaded PVC or stainless steel slotted or wire wrapped well screen and blank riser casing. Smaller diameters may be used if wells are installed using direct-push methodology or if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan (or equivalent) or FSP based on regulatory requirements and specific monitoring objectives. Monitoring well screens are usually 5 to 10 feet long, but may be up to 25 feet long in very low permeability, thick

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geologic formations. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation and will (in most cases) be determined prior to the field mobilization.

The slot size and filter pack gradation should be predetermined in the Work Plan (or equivalent) or FSP and based on site-specific grain-size analysis (sieve analysis) or other geologic considerations or monitoring objectives. Typically, slot sizes for monitoring wells will range from 0.010 inches to 0.020 inches while the filter pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent filter pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent filter pack may be preferred. If the screen slot size and filter pack have not been based on site-specific grain-size analysis, consider collecting soil samples during well installation so future wells can be properly designed.

A blank sump may be attached below the well screen if the well is being installed for DNAPL recovery/monitoring purposes. If so, the annular space around the sump may be backfilled with neat cement grout using a tremie to the bottom of the well screen prior to placing the filter pack around the screen. A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centering the monitoring well in the borehole during construction.

8. When the monitoring well assembly has been set in place and the grout has been placed around the sump (if any), place a washed silica filter pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen (following specifications in the Work Plan) using a tremie. The filter pack is placed and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. Verify that the expected volume of filter pack matches with the actual amount installed. There can be differences due to irregularities in the borehole. Washout of the borehole will result in the need for greater than calculated well materials. If a difference of more than 10% is noted, consult with the project technical team. The filter pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan (or equivalent) or FSP. The well should be gently surged to prevent filter pack material bridging and to settled the filter pack prior to well seal installation.
9. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack (alternatively, in some cases a fine sand seal may be installed instead of bentonite—follow the specifications in the Work Plan). If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. *No coated bentonite pellets will be used in monitoring well drilling or construction*. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure.
10. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 ft. below groundwater surface (bgs) or as specified in the Work Plan (or equivalent). As with the filter pack, it is recommended that seal material be placed with a tremie pipe. Ensure that seal materials are mixed at the proper ratios with water following manufacturer's recommendations.

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11. Install the monitoring well completion as specified Work Plan (or equivalent). Typical completions are a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing, and should slope gently away to promote drainage away from the well.
12. Monitoring wells should be labeled using indelible ink or paint with the appropriate designation on both the inner and outer well casings or inside of the curb box lid.
13. When an above-grade completion is used, the riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the riser will be sealed using an unvented, expandable locking plug.
14. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook as well as appropriate field forms.
15. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section 7 below.

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff to medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for installing monitoring wells in soil using the direct-push method are described below.

1. Locate boring/well location, establish work zone, and set up sample equipment decontamination area.
2. Advance soil boring to designated depth, collecting samples at intervals specified in the Work Plan (or equivalent). Samples will be collected using dedicated, disposable, plastic liners. Describe samples in accordance with the procedures outlined in Step 3 above. Collect samples for laboratory analysis as specified in the Work Plan (or equivalent) and/or FSP.
3. Upon advancing the borehole to the desired depth, install the micro-well through the inner drill casing. The micro-well will consist of approximately 1-inch ID PVC or stainless steel slotted screen and blank riser. The sand pack, bentonite seal, and cement/bentonite grout will be installed as described, where applicable, in Steps 9 through 11 above.

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4. Install protective steel casing or flush-mount, as appropriate, as described in Step 12 above. During well installation, record construction details and tabulate materials used in field notebook as well as appropriate field forms.
5. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section 8 below.

Driven Well Point Installation

Well points will be installed by pushing or driving using a drilling rig or direct-push rig, or hand-driven where possible. The well point construction materials will consist of a 1- to 2-inch-diameter threaded steel casing with either 0.010- or 0.020-inch slotted stainless steel screen. The screen length will vary depending on the hydrogeologic conditions of the site. The casings will be joined together with threaded couplings and the terminal end will consist of a steel well point. Because they are driven or pushed to the desired depth, well points do not have annular backfill materials such as sand pack or grout.

8 WASTE MANAGEMENT

Investigation-derived wastes (IDW), including soil cuttings and excess drilling fluids (if used), decontamination liquids, and disposable materials (well material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan (or equivalent), FSP, and/or IDW management guidance document.

9 DATA RECORDING AND MANAGEMENT

Drilling activities should be documented on appropriate field/log forms as well as in a proper field notebook and/or PDA. Additionally, all documents (and photographs) should be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan (or equivalent). Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

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10 QUALITY ASSURANCE

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP. Well materials will also be cleaned prior to well installation.

11 REFERENCES

American Society for Testing Materials (ASTM) D5092 - *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

American Society of Testing and Materials (ASTM) D1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*. American Society for Testing Materials. West Conshohocken, Pennsylvania.

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TGI – MONITORING WELL INTEGRITY SURVEY

Rev #: 0

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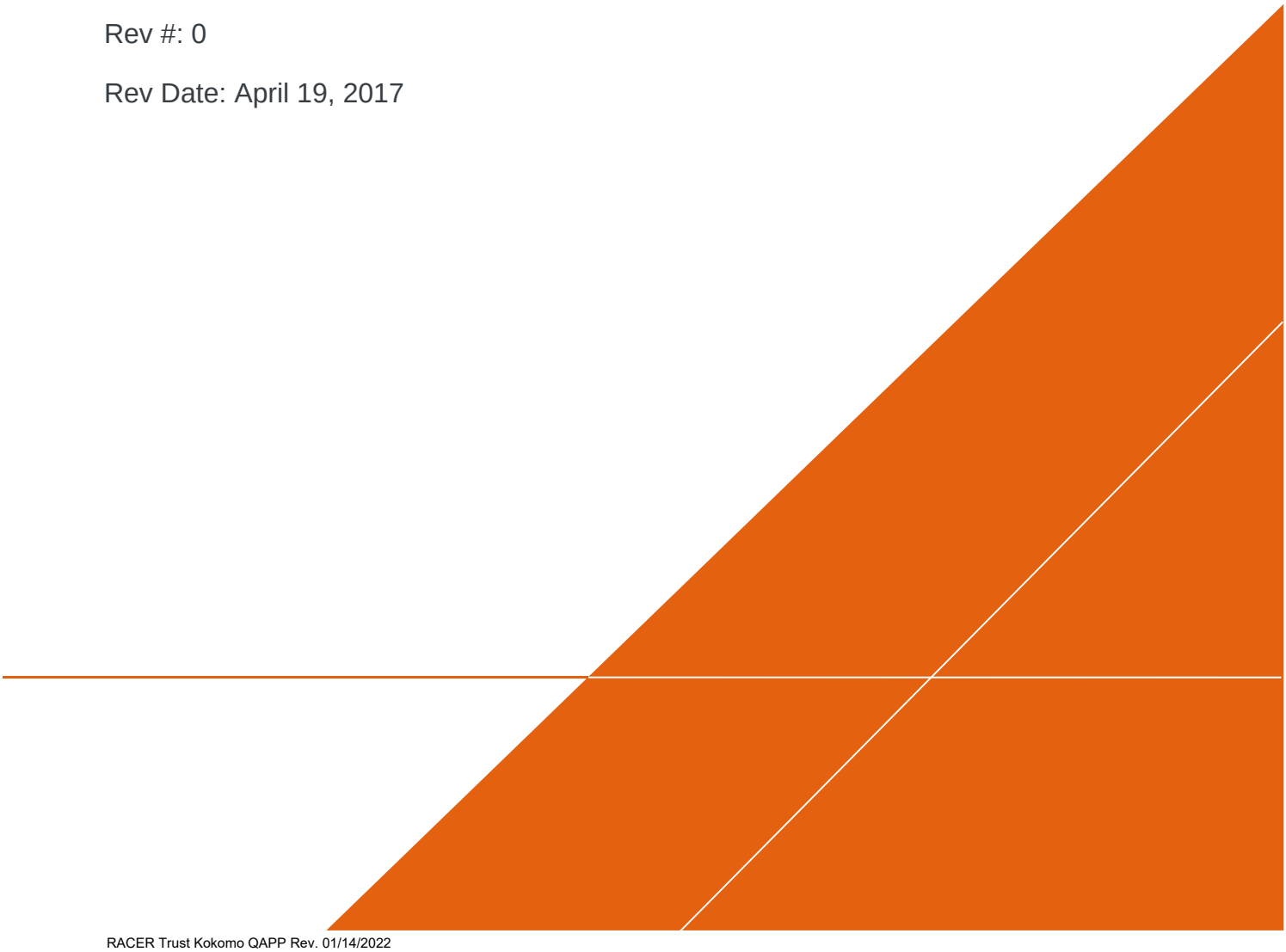

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	4/19/2017	All	Re-written as a TGI	Matthew McCaughey

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APPROVAL SIGNATURES

Prepared by:		4/19/2017
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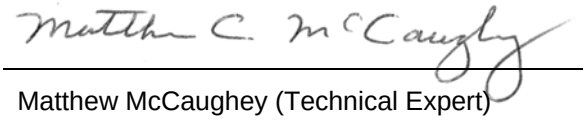
Technical Expert Reviewed by:		4/19/2017
	Matthew McCaughey (Technical Expert)	Date:

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) specifies the procedures for performing inspections/inventories of existing monitoring wells. This TGI also applies to piezometers that are constructed analogous to monitoring wells. For simplicity, such piezometers are also referred to as monitoring wells for the remainder of this document. For all other types of wells (e.g., remediation wells such as injection, extraction, sparge, etc.), please refer to the appropriate guidance document regarding procedures for conducting inspections on those specific wells.

Monitoring well inventories are periodically conducted to assess the integrity of existing monitoring wells and to identify the need for repairs, replacement of parts, or replacement of wells that are determined to no longer be usable. A well inventory involves an inspection of the overall condition of the well, comparison of measurable quantities (e.g., riser stickup relative to grade and total depth), general verification of survey coordinates and elevation, and measurement of depth to water in the well.

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3 PERSONNEL QUALIFICATIONS

All personnel shall meet the requirements of the site-specific Health and Safety Plan (HASP).

The CPM is responsible for ensuring that the activities described herein are conducted in accordance with this TGI and any other appropriate procedures. This will be accomplished through staff training and by maintaining quality assurance/quality control (QA/QC).

The Field Manager is responsible for periodic observation of field activities and review of field generated documentation associated with this TGI. The Field Manager is also responsible for implementation of corrective action if well conditions necessitate them.

4 EQUIPMENT LIST

The following materials will be available, as required, during performance of a monitoring well inventory:

- Health and safety equipment (as required by the site-specific Health and Safety Plan)
- Ruler or tape measure
- Water level indicator and/or interface probe
- Bailer
- Metal detector
- Indelible ink pen
- Paint pen
- Well keys
- Wrenches or ratchet set for accessing flush-mount well covers
- Cleaning equipment
- Well construction information (e.g., construction log, as-built, summary table, etc.)
- Digital camera (or phone with camera)
- Field notebook or Personal Digital Assistant (PDA)
- Appropriate field form(s) (see Attachment A)

If feasible, a supply of typical replacement parts (e.g., locks, bolts, well caps) should be available to enable immediate usage as necessary.

5 CAUTIONS

It is important to confirm the correct identity of wells, particularly when they are installed in a cluster. In these cases, however, the wells usually differ significantly in terms of depth below grade. During the well integrity survey, verify that all wells are properly labeled by comparing their measured depth to the reported depth as installed. If the well identity is incorrectly labeled or not labeled, provide a clear, correct

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label using an indelible ink pen on the inside of the steel protective cover for the well, or on the outside of the steel protective cover using a paint pen. Take photos to document as necessary.

One of the routine challenges encountered in performing this task is actually locating monitoring wells in the field. Oftentimes, field teams create an electronic file for new sites that will include a photo of the well head and a map image (e.g., Google Earth image) showing the well location. If such files exist, ensure that they are used as part of this task. Note that the Well Integrity Assessment Form (Attachment A) includes a sketch area to help locate wells in future surveys.

If present, remove standing water from the curb box using a bailer before opening the monitoring well. Refer to project waste management plan for proper disposal of water.

6 HEALTH AND SAFETY CONSIDERATIONS

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Care should be taken using tools to access flush-mount curb boxes. Wells in or near roadways must not be accessed without proper traffic cones and flagging. Access to wells containing chemicals of concern may pose a chemical exposure and biological hazard.

7 PROCEDURE

The typical procedure for assessing the integrity of a monitoring well is outlined below.

Step 1. Prior to mobilizing in the field, obtain a list of wells/piezometers to be inventoried and available information concerning their location and physical characteristics.

Step 2. Identify site and well identification number on the Well Integrity Assessment Form **(Attachment A).** Record all observations on this form, supplemented by notes in the field notebook if necessary.

Step 3. Locate the monitoring well using site maps and, if needed, a metal detector.

Step 4. Examine the well for the presence of an identification label. If absent, label the well with the appropriate well number after measuring the total depth of the well to verify that the depth matches the well number (see Step 8 below). If the well identity is incorrectly labeled or not labeled, provide a clear, correct label using an indelible ink pen on the inside of the steel protective cover for the well, and on the outside of the steel protective cover using a paint pen.

Step 5. Examine the surface condition of the well. Record the type of well (i.e., flush mount or above-grade stickup), condition of the well cover and surface seal. Confirm the protective casing is not bent or rusted through, the PVC casing is not broken or chipped, there is no evidence of frost heaving or subsidence.

Step 6. Unlock and open the well. Record the type (e.g., PVC or stainless steel), dimensions (i.e., casing diameter and riser stickup relative to grade), condition of the well casing, and type of

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well cap. Record any observations of recent modifications of the well casing. If the well cap is missing, replace with available parts or record the type of cap required.

Step 7. Measure the above-grade portion of the well riser stickup and compare to the known length of the stickup measured during well installation (surveyed top of inner casing elevation minus ground surface elevation). If the difference between the observed stickup length and the known stickup length is greater than 0.1 foot, the monitoring well location and elevation should be re-surveyed.

Step 8. Locate the marked measuring point along the top of the well casing. If no mark is visible, add a mark at the highest point of the casing using an indelible ink pen.

Step 9. Measure the depth to water, total depth of the well and any non-aqueous phase liquids (NAPL) thicknesses. For total depth measurements, account for any difference in calibration of the measuring tape on the probe (i.e., distance from part of probe that measures depth to water and the physical bottom of the probe that will measure total depth of the well). Record any obstructions encountered and a description of the feel of the well bottom (i.e., soft due to sediment or hard).

Step 10. Compare all observations concerning the measured dimensions of the well with the listed values. Based on these results as well as other observations concerning the condition of the well, record any appropriate recommendations on the Monitoring Well Integrity Assessment form **(Attachment A).** Perform any recommended maintenance activities that can be accomplished with available equipment.

Step 11. Remove all equipment from the well. If no additional maintenance activities are to be performed, close the well and collect all personal protection equipment (PPE) and other wastes generated for disposal (see Section 8 below).

Depending on the results of the well inventory, several additional activities may be warranted prior to future usage of the well. Typical follow-up activities include replacement of missing parts, removal of sediment from the base of the well, re-surveying of the well, or complete replacement if the well is determined to be unusable.

As stated above, a supply of locks, bolts, and well caps should be available for immediate usage during performance of the well inventories. However, it may not be feasible to maintain a supply of all potential replacement parts due to the variety of well types in use. Therefore, a list of required replacement parts should be compiled during the performance of a well inventory event. At the conclusion of the event, the necessary replacement parts for all wells should be obtained and installed.

8 WASTE MANAGEMENT

Materials generated during well inventory activities, including disposable equipment, will be disposed in appropriate containers.

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9 DATA RECORDING AND MANAGEMENT

Field observations will be recorded on the Well Integrity Assessment Form (Attachment A), and/or in an appropriate Field Notebook or PDA. Well integrity inventory results will be retained in the project file.

10 QUALITY ASSURANCE

To verify accurate measurements of well stickup, depth to bottom, depth to groundwater, etc., measurements must be double-checked periodically (e.g., at least one of these measurements per well should be repeated to verify accuracy).

11 REFERENCES

No references apply to this TGI.

12 ATTACHMENTS

A. Well Integrity Assessment Form

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ARCADIS

Monitoring Well Integrity Assessment Form

(For each item, check appropriate response or fill in the blank)

Date _____

Well ID _____ ID Clearly Marked? _____ Project Name _____

Photo filename _____ Project Number _____

Weather _____ Field Personnel _____

General Description of Surroundings _____

Well Condition:

Damaged? ☐ Abandoned? ☐
(Describe Below)

Stick Up ☐ Flush Mount ☐

Lockable cover? _____

Lock present? _____

Key number: _____

Stick up height _____

Casing material _____

Well diameter _____

Protective casing material: _____

Protective casing diameter: _____

Cap present? Type? _____

Vented? If so, how? _____

Measuring point clearly marked? _____

Total depth reported: _____

Total depth measured: _____

DTW: _____

Well obstructed? If so, depth? _____

Well bottom soft (sediment) or firm? _____

Flush Mount Wells Only

Gasket present? _____

Bolts present? _____

Teflon washers present?

Surface Condition:

Damaged? ☐
(Describe Below)

Pad/cement intact? _____

Curb box/well cover present? _____

Intact? _____

Seal condition _____

All bolts present? _____

Ground surface slopes away from well? _____

Location Sketch

Comments/Recommendations:

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TGI – MULTIPLE GAS AIR MONITORING AND FIELD SCREENING WHEN SAMPLING GROUNDWATER MONITORING WELLS

Rev: 1

Rev Date: May 8, 2020

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 19, 2018	All	Conversion to TGI format	Peter Frederick Kurt Merkle
1	May 8, 2020	5	Clarified Work Area Air Monitoring and Well Headspace Screening	Marc Killingstad

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APPROVAL SIGNATURES

Prepared by:		October 19, 2018
	Peter C. Frederick	Date:
Technical Expert Reviewed by:		May 8, 2020
	Marc Killingstad – Technical Expert	Date:

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

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In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

When opening and sampling groundwater monitoring wells, field screening with a multi-sensor air monitoring instrument is a procedure to measure relative concentrations of Total Volatile Organic Compounds (tVOCs), carbon monoxide, hydrogen sulfide, oxygen, and combustible gas, as well as other compounds to document if these potentially hazardous airborne contaminants are a concern when opening and sampling groundwater monitoring wells.

Field screening will be conducted on the following:

- Work area air to assess exposure to on-site workers of air contaminants via the air pathway;
- Well headspaces as a precautionary measure each time the well cover is opened; and
- Measuring ports of landfill gas monitoring locations.

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3 PERSONNEL QUALIFICATIONS

User personnel will be familiar with the multiple gas monitor and read through the operation manual that is provided with the instrument in order to properly calibrate and operate the monitor in accordance with manufacturer's requirements and recommendations. Training on such equipment is provided to personnel via a vendor and field verification of the usage from the business practice manager or supervisor.

4 EQUIPMENT LIST

The following materials, as required, will be available while performing multiple gas air monitoring and field screening:

- Personal protective equipment (PPE), as required by the site Health and Safety Plan (HASP)
- Multiple gas monitor, all appropriate ancillary accessories and equipment, and operating manual
- Calibration standards for the multiple gas monitor
- Field notebook

5 CAUTIONS

Selection of the appropriate type of multiple gas air monitor and selection of its sensors is the responsibility of the Arcadis Certified Project Manager (CPM) and, when necessary, in collaboration with other Arcadis technical experts with extensive knowledge, training, and experience in the specific service being performed. The CPM, technical expert(s), and/or person in charge for project health and safety will determine the appropriate make and model of multiple gas air monitor and sensors based upon the project requirements, site conditions, and airborne hazards anticipated to be encountered during the field activities performed.

Operators of the multiple gas air monitors will follow the manufacturer's operation manual and recommendations, where appropriate, and when necessary, consult with the Arcadis CPM, technical expert(s), and/or person in charge of health and safety for the project to ensure proper operation and maintenance of the instrument.

6 HEALTH AND SAFETY CONSIDERATIONS

Staff are required to comply with all Arcadis, client, regulatory, and site-specific established health and safety requirements. Care should be taken when handling calibration gas cylinders as contents may be under pressure and may be harmful if inhaled. Refer to the multiple gas monitor's operation manual and calibration standard SDSs for additional information regarding health and safety requirements.

The CPM, technical expert(s), and/or person in charge for project health and safety will determine the appropriate make and model of multiple gas air monitor and sensors based upon the project requirements, site conditions, and airborne hazards anticipated to be encountered during the field activities performed.

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7 PROCEDURE

Multiple Gas Air Monitor Calibration

Multiple gas air monitors contain multiple sensors to quickly analyze for volatile organic compounds (VOCs) which are typically reported as Total VOCs (tVOC). Operation, maintenance, and calibration of the multiple gas air monitor will be performed in accordance with the manufacturer's instructions and documented in the field log or project field notes. Any errors or correction factors identified for the specific instrument can referenced in the manufacturer's operation manual and documented on the calibration form.

Multiple gas air monitors will be calibrated or calibration-checked against the appropriate standard media in accordance with the manufacturer's operation manual, specific sampling and analysis plan (SAP), regulatory requirements, or other specified methods, but at a minimum, the monitor will be calibrated:

- Initially prior to collecting first reading of the day/shift;
- At least once during field activities; and
- After completion of collecting last reading of the day/shift.

Work Area Air Monitoring Procedures

1. Measure and record the background readings for each airborne contaminant being measured. Background readings are measurements collected away from the work zones, in areas that are expected to be free of the contaminants expected to be encountered. A brief on-site survey (or prior confirmation from project manager and/or project technical lead) should be conducted upon arrival to site to confirm that there are no visual indicators of nearby sources that could cause cross-contamination (e.g., running generators, etc). If wind direction is able to be identified, best practice is to collect the site ambient air conditions upwind from the site/well.
2. Measure and record the readings collected in the breathing zones of staff performing the activities. Ensure that these are collected at the appropriate elevation to capture a person's actual breathing zone as defined by OSHA. For example, if work is performed at or near the ground surface, the breathing zone readings will be collected at or near the ground surface to accurately measure airborne contaminants at those specific elevations where persons are breathing.

Well Headspace Screening Procedures

1. Measure and record the background readings for each airborne contaminant being measured. Background readings are measurements collected away from the work zones, in areas that are expected to be free of the contaminants expected to be encountered.
2. Unlock and open the well cover while standing upwind of the well.
3. Remove the well cap.
4. Place the multiple gas air monitor sensor/probe approximately six (6) inches above the top of the casing. *Be sure not to place the probe sensor any closer, or into, the well casing for measurements, as this would not provide results representative of the general breathing zone.*

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5. Record all of the sensors' readings and proceed with field activities based upon the measurements (frequency and actions level) in accordance with the HASP.

8 WASTE MANAGEMENT

All waste generated by the use of the multiple gas air monitor will be handled, packaged, and shipped in accordance with the manufacturer's operation manual, Arcadis policies and procedures, and applicable regulatory requirements.

9 DATA RECORDING AND MANAGEMENT

Most multiple gas air monitors have datalogging capabilities, which the frequencies at which a reading is collected can be programmed as well. Measurements that are datalogged can be downloaded to a computer for use in reporting. In addition, readings can be manually documented by hand as they are measured and documented on a field sampling form.

10 QUALITY ASSURANCE

After each use, the multiple gas air monitor should be wiped down with a clean cloth or paper towel.

An external pre-filter on the sensors will be used, where appropriate. Replace the external pre-filter when it looks dirty or when the multiple gas air monitor indicates that replacement is recommended.

11 REFERENCES

Air monitor instrument-specific manufacturer's operation manual

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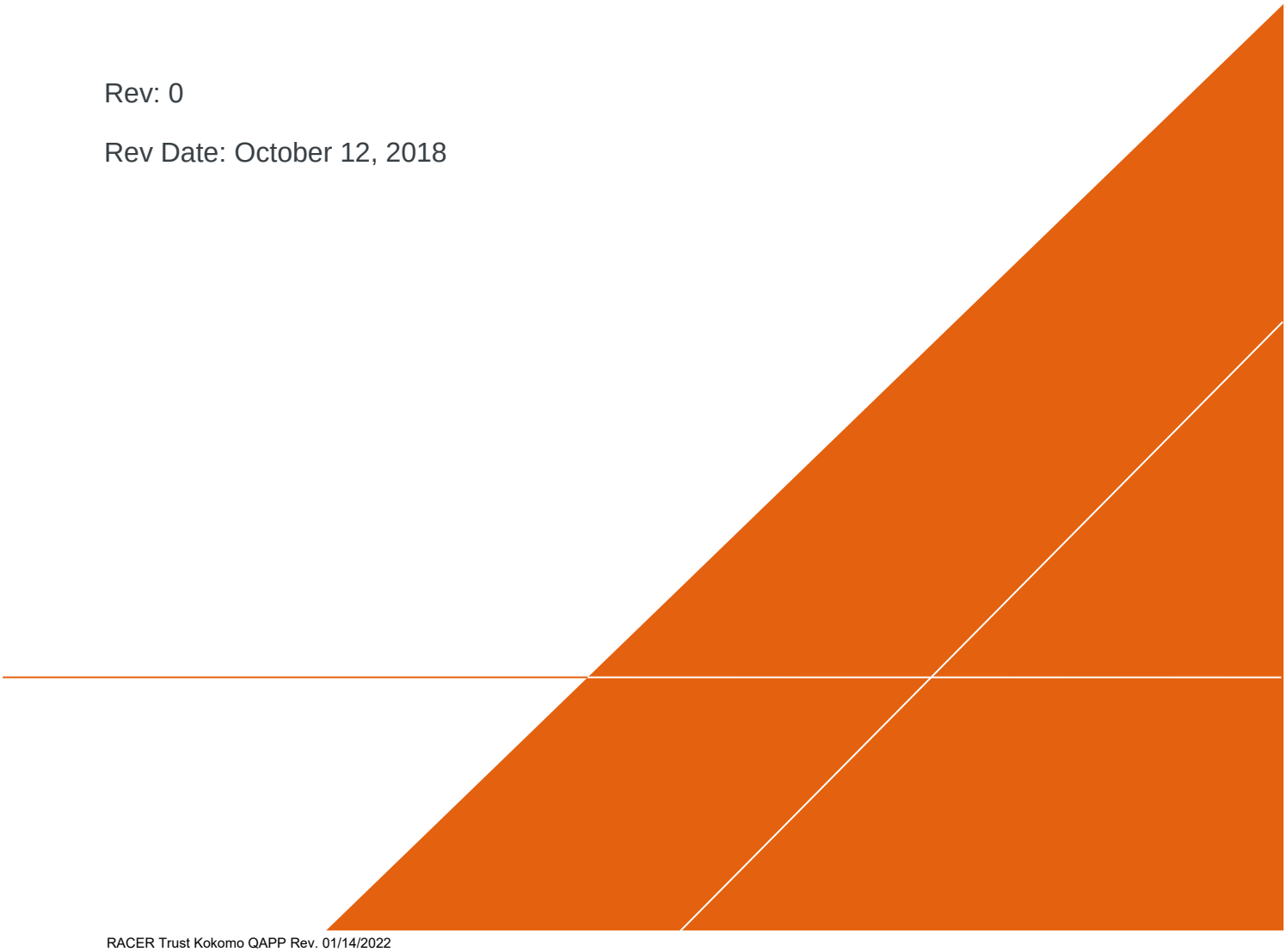
ARCADIS Design & Consultancy for natural and built assets

TGI - PASSIVE DIFFUSION BAG (PDB) SAMPLING

Rev: 0

Rev Date: October 12, 2018



SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 12, 2018	All	Updated and re-written as TGI	Marc Killingstad

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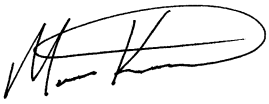
APPROVAL SIGNATURES

Prepared by:		10/12/2018
	Christian Seidel	Date:
Technical Expert Reviewed by:		10/12/2018
	Marc Killingstad (Technical Expert)	Date:

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1 INTRODUCTION

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2 SCOPE AND APPLICATION

The purpose of this Technical Guidance Instruction (TGI) is to establish protocols for the collection of groundwater samples from monitoring wells using passive diffusion bag (PDB) sampling techniques. A PDB is a semi-permeable low-density polyethylene (LDPE) bag filled with deionized water. When deployed within the screened interval of a monitoring well, volatile organic compounds (VOCs) in groundwater diffuse through the LDPE membrane into the deionized water in the bag. The PDB remains in the well for a time sufficient to reach equilibrium between VOC concentrations inside the PDB and surrounding groundwater (typically at least two weeks but will be based on site-specific hydrogeologic conditions). At that time, the PDB is retrieved from the well and the water from inside the bag is poured into sample bottles for laboratory analysis.

This TGI is based on the technical requirements provided in the USGS *User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells* (USGS 2001). Additional technical information on this topic can be found at the Interstate Technology and

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Regulatory Council's (ITRC) *Passive/Diffusion Samplers Resources and Links* webpage (https://www.itrcweb.org/Team/Resources?teamID=29&teamID=29).

Figure 1. Typical water-filled passive diffusion bag samplers used in wells, including (A) diffusion bag with polyethylene mesh, (B) diffusion bag without mesh, and (C) bag and mesh attached to bailer bottom.

The PDB sampling method has several technical and logistical benefits compared to standard well-purging methods; however, PDBs are not applicable for all contaminants or sites. See **Attachment 1** for ITRC's *Screening Worksheet for PDB Implementation*.

Because the PDB technology relies on diffusion of contaminants through the LDPE membrane, this approach is only applicable for volatile organics (including ethene, ethane, and methane). PDBs are not applicable for field parameters, ionic parameters (alkalinity, nitrate, sulfate, etc), or non-VOC contaminants (i.e. semi-volatiles).

The primary benefits of using PDBs as opposed to standard well purging methods include decreased sampling time, lack of investigation derived waste, and the ability to collect samples from multiple depths within a well screen while avoiding dilution concerns associated with well purging. If VOC contamination is stratified, multiple PDBs can be deployed within the screened interval or open bore hole. There is less equipment, and the devices are relatively inexpensive and disposable. Vendors can also modify the length and width of the sampler to meet specific sampling requirements.

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Figure 2. Example of multiple PDB samplers prepared for deployment.

Additionally, the effervescence associated with hydrochloric acid (HCl) preservation of VOC samples is avoided as dissolved ions that contribute to alkalinity in the well do not diffuse across the PDB membrane into the bag, thus reducing losses due to volatilization.

PDBs are typically best suited to sites where regular monitoring of VOCs is performed within a well characterized plume. This technique is typically not well suited to characterization activities, where vertical stratification of VOC contamination is not well understood, or for monitoring programs that include additional analytes besides VOCs.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed.

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Arcadis personnel performing groundwater PDB sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology. The supervisor of the groundwater sampling team should have at least 1 year of previous supervised groundwater sampling experience.

In addition, Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The HASP and other documents will identify other training requirements or access control requirements.

Prior to mobilizing to the field, the groundwater sampling team will review and be thoroughly familiar with relevant site-specific documents including but not limited to site work plans (e.g., Field Implementation Plan [FIP]), Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), HASP, historical information, and relevant site/task-related documents. Additionally, the groundwater sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

4 EQUIPMENT LIST

Specific to this activity, the following materials (or equivalent) is required:

- Health and safety documents and equipment (as identified in the site-specific HASP)
- Field Implementation Plan that includes site map, well construction records, and prior groundwater sampling records (if available)
- Personal protective equipment (e.g., latex or nitrile gloves, safety glasses, etc.) as specified in the site-specific HASP
- PDB Sampler made of 4-mil. low-density polyethylene (LDPE) flat tubing (NOTE: these samplers typically come pre-filled by the vendor and samplers may have a protective polyethylene mesh sleeve to protect the bags during deployment and recovery)
- Teflon-coated stainless-steel wire or low-stretch braided, polyester rope to be used to suspend the passive diffusion bag samplers in the well screen interval (NOTE: if rope is used it must be dedicated to a specific well)
- Stainless-steel weights to counterbalance the buoyancy of the PDB samplers
- Electronic water-level indicator, 0.01-foot accuracy
- Down-hole multiparameter sonde (e.g., YSI)
- 150-foot measuring tape (or sufficient length for the maximum site depth requirement)
- Safety cutting tools
- Nylon cable ties or stainless-steel clips to attach the PDB bag to the line
- Decontamination supplies

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  - Non-phosphate laboratory soap (Alconox or equivalent), brushes, clean buckets or clean wash tubs
  - New buckets or tubs will be purchased if it cannot be determined if the present items are clean
  - Distilled or de-ionized water for equipment decontamination
- Sample bottles, labels, and preservation supplies
- Field logbook, smart device (phone or tablet), appropriate field forms (see **Attachment 2**), and chain-of-custody forms
- Indelible ink pen
- Plastic sheeting (e.g., Weatherall Visqueen) to protect all down-hole sampling equipment from contact with potential sources of contamination

5 CAUTIONS

The PDB technology is only applicable to VOC contaminants. If there is a question regarding a specific analyte, please contact Technical Lead for resolution.

Determine well construction prior to ordering PDBs. In some older wells, the well screen could have a smaller diameter than the well casing. PDBs may not fit in the screen. Vendors can modify the length and width of the sampler to meet specific well requirements.

Analytical results for samples collected from PDBs could be higher or lower than those collected with conventional sampling methods. The conceptual site model (CSM) will provide the basis for understanding of the distribution of VOC contaminants and support predictions related to the potential differences between PDB vs. datasets from other sampling methods.

All parties involved in the deployment of PDBs for long term monitoring at regulated sites need to agree on data quality objectives, data evaluation techniques, and data end use before deployment at a site. Some sites may require the collection of “side-by-side” data to validate the applicability of PDBs to adequately monitor VOC concentrations compared to established well purging techniques.

Before placing PDBs in a well, vertical stratification needs to be considered. A single, 18-inch long PDB is sufficient for saturated well screens 5 feet or less. In general, when investigating vertical stratification of VOCs, a single 18-inch long PDB should not represent more than 5 feet of saturated screen.

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn during these activities.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or oil. Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife). Only use non-toxic peppermint oil spray for stinging insect nests. Open well caps slowly and keep face and body away to allow to vent any built-up pressure.

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Field personnel will thoroughly review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives.

Deploying and retrieving PDB samplers requires staff to lower and raise materials into and out of the monitoring well. Be sure to use proper bending and lifting techniques to avoid muscle strain and other potential injuries.

7 PROCEDURE

7.1 Initial Site Activities

- Check well for damage or evidence of tampering, record pertinent observations in the field logbook and, if possible, take digital photograph to document damage
- Lay out plastic sheeting and set up monitoring and sampling equipment
- Don appropriate personal protective equipment (PPE)
- Safely remove well cap
- If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), create one and record all measurements from this mark
- Measure and record the depth to water and the total depth of the groundwater monitoring well (to 0.01 ft) in all wells to be sampled being careful to minimize disturbance to the water column and to any particulates attached to the sides or at the bottom of the well
- Collect and record field parameters using a multiparameter down-hole sonde (e.g., YSI) prior to deploying PDBs

7.2 Deployment of Passive Diffusion Bag Samplers

- The PDB sampler assembly will be pre-determined and communicated to the vendor (NOTE: the assembly will be shipped to Arcadis to the size and depth specifications requested and outlined in the site-specific Work Plan/Field Implementation Plan and SAP)
- Compare the measured depth of the well to the as-built well construction details (well construction table) to determine if sediment has accumulated at the bottom of the well (NOTE: identify if wells have been constructed with sediment traps or sumps)
- Provide attachment points for deployment using loops in the weighted line at appropriate points or movable clamps with rings
    - Attach the PDB sampler using cable ties, stainless clamps, or simply tie in a way that prevents slipping
    - Take care to eliminate sharp points or ends of camps and cable ties to decrease the potential for punctures or tears to the PDB

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- Lower the assembly line of PDB samplers and weights down the well until the pre-measured cable is taught—the samplers will now be positioned at the expected depth.
- Secure the assembly in this position.
    - A suggested method is to attach the weighted line to a hook on the inside of the well cap and reattach the well cap
    - The well will be sealed in such a way as to prevent surface-water invasion—this is particularly important in flush-mounted well vaults that are prone to flooding
- After the samplers have been deployed, collect the trip blank and equipment blank sample from an unused extra pre-filled PDB sampler—the samplers used for the trip blanks will be transported and stored at all times with the other samplers
- Allow the system to remain undisturbed as the samplers equilibrate. The recommended equilibration period is two weeks.

Courtesy of EON Products, Inc.

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7.3 Sample Retrieval

- Measure and record the depth to groundwater within the monitoring well via the non-metallic water level indicator (weighted tape-measure)
- Collect and record field parameters using a multiparameter down-hole sonde (e.g., YSI) prior to retrieving PDBs
- Remove the sampler upward and out of the well using the deployment line
    - When removing multiple samplers from a single well, only one sampler will be removed and processed at a time withthe remaining samplers suspended in the well until they can be processed
- Do not expose the samplers to heat or agitate
- Examine samplers and note observations on field sampling form and field book
    - Examine the surface of the sampler for evidence of algae, iron or other coatings, and for tears in the membrane
    - If there are tears in the membrane, the sample will be rejected
- Record sample information for each sampler on the field sampling form
    - If multiple samplers are being retrieved from a single well, care must be taken to ensure the vertical placement of the sample within the well is accurately recorded on each sample vial and on the corresponding field sampling form
- If a protective outer coating is used during deployment, remove the sampler bag and dry excess water from the bag using a lab wipe
- Transfer water from the sampler bag to VOC sample vials using one of the following options—in all cases, use care to transfer the sample as the bags are not rigid and can bend or collapse during handling:
    1. Carefully cut the sampler bag at the top corner using a decontaminated safety cutting tools and carefully decant the sample into the VOC vials
    2. Some samplers are equipped with a removable end cap that can be removed to allow the sample to be gently poured into VOC sample vials
    3. Some samplers are equipped with a small lab-cleaned straw that has a sharpened end—the straw is used to pierce the bag at the bottom and the sample is decanted through the straw into sample vials
- To obtain a duplicate/blind duplicate sample, collect a duplicate from the same bag as an original sample and send for analysis with the appropriate labeling
- Place collected samples immediately in a sample cooler that is already full of ice or ice packs such that the samples are immediately chilled and stored at a temperature of 4° Celsius

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- Measure and record the depth to groundwater within the monitoring well via the non-metallic water level indicator (weighted tape-measure)
- Secure the well
- Decontaminate any cutting devices, reusable weights, teflon-coated lines, or bag attachment mechanisms after each usage as described in the *TGI – Groundwater and Soil Sampling Equipment Decontamination*

8 WASTE MANAGEMENT

Materials generated during groundwater sampling activities, including disposable equipment and excess water in the PDBs, will be properly stored on site in labeled containers and disposed of properly. Be certain that waste containers are properly labeled and documented in the field log book. Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage* as well as state- or client-specific requirements. Note that the PDB samplers and protective mesh covers will be shipped back to the vendor at the completion of the sampling event to be refilled and deployed again during the next groundwater sampling event.

9 DATA RECORDING AND MANAGEMENT

Field forms, logs/notes, digital records, and chain-of-custody records will be maintained by the field team lead and uploaded to the project directory on the Arcadis server at the completion of the groundwater monitoring event. Electronic data files will be sent to the project team and uploaded to the electronic project folder daily. Management of the original documents from the field will be completed in accordance with the site-specific QAPP.

10 QUALITY ASSURANCE

Quality assurance and quality control (QA/QC) samples collected during the retrieval and sampling of PDB samplers include: equipment blanks, field duplicates, and matrix spike/matrix spike duplicate (MS/MSD).

An equipment blank sample will be collected from a pre-filled PDB during the day of deployment.

Field duplicates and MS/MSDs will be collected during the sampling event.

QA/QC samples will be collected in accordance with the site-specific QAPP .

11 REFERENCES

USGS 2001. User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells, 2001.

ITRC 2004. Technical and regulatory Guidance for Using Polyethylene Diffusion Bag samplers to Monitor Volatile Organic Compounds in Groundwater. February 2004.

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12 ATTACHMENTS

Attachment 1 – PBD Screening Worksheet

Attachment 2 – PBD Field Form

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ATTACHMENT 1

PBD Screening Worksheet

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Screening Worksheet for PDB Implementation

A negative answer to any of the following questions will require further action or investigation before PDB samplers can be deployed. If all answers are affirmative PDB, sampling is likely to be a viable option for the site.

Question	YES	NO
1. Is sampling being done for long-term groundwater monitoring?		
2. Have the groundwater contaminants at the site been fully characterized?		
3. Is groundwater sampling at the site focused on VOCs?		
4. Can all target analytes at the site be expected to be taken up by PDB samplers? (Section 1.1, Table 1-1 and Section 4.2.2, Table 4-1)		
5. Is groundwater temperature anticipated to be above 10ºC (50ºF) during all sampling events?		
6. Have you discussed the potential use of PDB samplers with regulators?		
7. Are site regulators familiar with PDB sampling technology, and will they allow the data to be used for the same purposes as those obtained by conventional sampling?		
8. Are the monitoring wells to be sampled in an area where there is sufficient groundwater velocity? Low groundwater velocity can result from either a low hydraulic conductivity or a low hydraulic gradient.		
9. Are the monitoring wells currently free of dedicated pumps or other sampling equipment?		
10. Has a cost analysis shown PDB samplers to offer a cost savings compared to current sampling techniques?		

ATTACHMENT 2

PBD Field Form

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ARCADIS Design & Consultancy for natural and built assets

Passive Diffusion Bag (PDB) Sampling Form

Site: _____

Location: _____

Well ID: _____

Well Type: ☐Monitoring ☐Other: _____

Well Finish: ☐Stick Up ☐Flush Mount

Measuring Pt: ☐Top of Casing ☐Other (specify):_____

Total Depth (ft bgs): _____ **Screened Interval (ft bgs):**_____

Well Casing: Diameter: _____ Material: _____

Well Screen: Diameter: _____

Deployment

Date and Time of Deployment: Date: _____ Time: _____

Weather Conditions: _____

Depth to groundwater at time of deployment: _____

Depth to Top of PDB: _____

Downhole Field Parameters Prior to Deployment (*Collected via downhole sonde [e.g., YSI]*):

Temp:_____ (mV) **ORP:**_____ **(mV)** **Water quality meter:**_____

pH:_____ **DO:**_____ **(mg/L)** **Serial #:**_____

Type of PDB used: ☐Lab Filled (Modified Trip Blank must be taken at time of deployment)

☐Field Filled (Modified Equipment Blank of fill water must be taken at time of deployment)

Dimensions of PDB: Length (in.) _____ Diameter (in.) _____

Position of PDB weight: ☐Attached to bottom of PDB and suspended in well

☐Attached to bottom of deployment line and suspended in well

☐Attached to bottom of deployment line and resting on bottom of well

Retrieval (note: minimum deployment period is 2 weeks)

Date and Time of Retrieval: Date: _____ Time: _____

Total # of days deployed: _____

Weather Conditions: _____

Depth to groundwater at time of retrieval: _____

Downhole Field Parameters Prior to Retrieval (*Collected via downhole sonde [e.g., YSI]*):

Temp:_____ (mV) **ORP:**_____ **(mV)** **Water quality meter:**_____

pH:_____ **DO:**_____ **(mg/L)** **Serial #:**_____

Notes/Observations:

Field Sampling Technician: Name(s) and Company

Name Company

_____

_____

_____

TGI – Resource Conservation and Recovery Act (RCRA) Waste Characterization Sampling

Rev: 0

Rev Date: May 20, 2021

Version Control

Issue	Revision No.	Date Issued	Page No.	Description	Reviewed By
1	0	May 20, 2021	All	New TGI	Ryan Mattson

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Approval Signatures

Prepared by:		05/20/2021
	Ryan Mattson	Date:
Technical Expert Reviewed by:		05/21/2021
	Michelle Clayton	Date:

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1 Introduction

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 Scope and Application

The objective of this Technical Guidance Instruction (TGI) is to provide field sampling personnel procedures for collecting waste characterization samples from materials which are subject to the Resource Conservation and Recovery Act (RCRA) definition of solid waste at 40 CFR §261.2. Solid wastes, which include liquid, solid, or sludge – phase wastes, typically encountered by Arcadis are contaminated environmental media (soil and groundwater), contaminated building materials, drilling fluids, decontamination liquids, contaminated personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials. Arcadis may also be hired to sample client industrial or manufacturing wastes.

This TGI specifically excludes the following sampling which should be covered by more specific TGIs: polychlorinated biphenyl waste sampling under the Toxic Substances Control Act, radioactive waste sampling under the Atomic Energy Act, naturally occurring radioactive material or technologically enhanced naturally occurring radioactive material waste sampling, asbestos sampling, lead paint sampling, medical waste sampling, National Pollution Elimination Discharge permit sampling and publicly owned treatment works discharge sampling.

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Personnel utilizing this TGI should have a sampling plan, waste analysis plan or request that has been reviewed by a client or Arcadis hazardous waste Technical Expert and the sampler should understand location, scope, analytical testing laboratory, results timing, and data quality objectives for the particular sampling event prior to work. If this is not the case, stop work and contact the CPM for scope related questions or the hazardous waste Technical Expert for waste compliance questions. Arcadis hazardous waste Technical Expert advice is available by emailing regulatedwaste@arcadis.com.

This TGI describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures for waste characterization sampling. The procedures included in this TGI for waste characterizations sampling are based on the EPA's guidance document RCRA Waste Sampling Draft Technical Guidance (USEPA 2002). Waste characterization sampling provides data to help ensure the wastes are managed, transported and disposed in accordance with applicable federal, state, and local regulations. Although not comprehensive, the following laws and regulations pertaining to Hazardous Waste Management should be considered applicable. It is the Arcadis Certified Project Manager (CPM) and/or designated Technical Expert to determine which laws and regulations, at all levels of government, are applicable to each project site and activity falling under this TGI.

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC §6901-6987 (1976).
- Federal Hazardous Waste Regulations 40 CFR §260-261, Appendix I to §261, §264
- Department of Transportation (DOT) Hazardous Materials Transportation 49 CFR §171-173
- Occupational Safety and Health Administration (OSHA) Regulations 29 CFR §1910 and §1926

State Laws and Regulations

- To be determined based on location of site and location of treatment, storage, and/or disposal facility (TSDF) to be utilized.
- Regional, County, Municipal, and Local Regulations

This TGI may be modified by the CPM and/or Technical Expert for a specific project or client program, as required, dependent upon client requirements, site conditions, equipment limitations, or limitations imposed by the procedure. The resulting procedure employed to execute the work should be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes should be discussed with the CPM and/or Technical Expert as soon as practicable, and if approved to be performed, be documented.

3 Personnel Qualifications

Arcadis field sampling personnel will have current regulatory- and Arcadis-required health and safety training including 40-hour OSHA hazardous waste operations and emergency response (HAZWOPER) training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Personnel handling hazardous waste, including sampling, should have RCRA hazardous waste management training per 40 CFR §264.16. Additional state-specific hazardous waste management training may be required in certain states (i.e., California).

Arcadis personnel who ship samples that are subject to the definition of a DOT hazardous material (49 CFR 171.8) should have biennial DOT hazardous materials transportation training per 49 CFR § 172.704 (Arcadis

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requires every 2 years, DOT requires every 3 years). Arcadis field personnel should also comply with client-specific training. In addition, Arcadis field sampling personnel should be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The project health and safety plan (HASP) and other documents may identify other training requirements or access control requirements.

4 Equipment List

The following equipment and materials, as required, should be available for waste characterization sampling:

All sampling events:

- Appropriate personal protective equipment as specified in the HASP
- Leather gloves
- Nitrile gloves
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as determined by the CPM and/or Technical Expert.
- Decontamination equipment/tools including Alconox®/Liquinox®-band detergent spray bottle, deionized or distilled water spray bottle, brushes, buckets.
- Indelible ink and/or permanent marking pens
- Appropriate sample containers, labels, and forms
- Digital camera
- Field logbook

Additional equipment/materials for Container Sampling – Solid Phase Waste

- Hammer
- 5/8” drum wrench/socket
- Stainless steel or disposable plastic hand spade
- Stainless steel scoop
- Stainless steel bucket auger

Additional equipment/materials for Container Sampling – Liquid Phase Waste

- Hammer
- 5/8” drum wrench/socket
- Step stool or ladder
- Disposable bailer, coliwasa sampler, or dipper

Additional equipment/materials for Process Waste Streams

- Process diagram
- Lockout/tagout information
- Step stool or ladder
- Stainless steel or disposable plastic hand spade
- Stainless steel scoop
- Disposable bailer, coliwasa sampler, or dipper

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Additional equipment/materials for Uncontained Release Area

- Air monitoring equipment
- Underground utilities clearance checklist
- Long measuring tape or wheel
- Pin flags
- Stainless steel or disposable plastic hand spade
- Stainless steel scoop
- Stainless steel bucket auger

Additional equipment/materials for Destructive Building Material Sampling

- Plastic sheeting
- Hammer drill with appropriate bits
- Hammer
- Flathead screwdriver
- Chisel
- Putty knife
- Generator or other power source
- Zip seal plastic bags
- Paper plates

5 Cautions

This TGI does not provide procedures for sampling waste streams where there is no knowledge of waste origin or potential hazards. If such a situation arises, the sampler should stop work and consult the CPM and a Technical Expert.

6 Health and Safety Considerations

As determined by the site's known and suspected hazards, appropriate PPE should be worn by all field personnel within the designated work area. Exposure air monitoring may be required during certain field activities as stated in the Site HASP.

Arcadis field personnel and subcontractors will be trained in and perform their work in compliance with all applicable federal, state, and local health and safety regulations as well as Arcadis' HASP and applicable Client health and safety requirements.

Filled waste containers can be very heavy, become unbalanced, and/or spill contents. Waste containers stored for extended periods of time may be subject to deterioration. Personnel should attempt to sample waste containers without moving them and, if necessary, use appropriate moving techniques and equipment for safe handling. Container lids must be replaced after sampling to maintain RCRA compliance. Large containers such as rolloff bins and frac tanks may require climbing to access sampling ports. A second sampler is recommended as a spotter for such sampling events. Sampling wastes from active processes can involve opening valves or accessing confined spaces. Stop work and communicate with the CPM and process operator if there is any misunderstanding or change in scope of sampling. Destructive bulk sampling can generate projectiles, please make sure the area is clear of ancillary personnel and upgrade PPE as appropriate. Destructive sampling can

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also encounter hidden utilities. Sampling of uncontained wastes may result in exposure to airborne contamination or if the waste is in stockpiles may involve gravity hazards. Upgrade monitoring equipment and plan work in advance to minimize these hazards.

7 Procedure

Sampling Methodology

RCRA requires that waste characterization samples be representative of the waste stream. A representative sample is defined in 40 CFR 260.10 as a sample of a universe or a whole that can be expected to exhibit the average properties of the universe or whole. Arcadis personnel should work with the client, waste Technical Expert and disposal facility on an approach to collect representative waste characterization samples and prepare them for shipment for laboratory analysis. The laboratory used for waste characterization analysis should have the appropriate federal and state accreditations and may be required to be pre-approved by the Client.

Sampling Containerized Solid Wastes

1. Assess the integrity of the container for labels, bulging, leaks. If the container appears compromised or unlabeled, stop work and contact the CPM.
2. Open the container using appropriate tools.
3. Record visual appearance and volume of waste in field logbook.
4. Collect volatile constituent samples (volatile organic compounds, total petroleum hydrocarbons – gasoline range, etc.) as grab samples at a random location using a method to minimize the loss of volatiles, typically directly into laboratory provided sampling devices/containers.
5. Collect semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as grab samples for 4-point composites from random locations in the accessible waste layer. The nonvolatile sample compositing should be performed by the laboratory. A disposable or stainless-steel sampling tool or bucket auger may be used if deep container sampling is requested. Decontaminate any tool used between sampling different locations.
6. Place samples in laboratory provided sample containers.
7. Close the container by replacing all components disassembled to open it.
8. Take a photograph of the container.
9. Note the container sampled, photo number and sample ID in the field logbook.

Sampling Containerized Liquid Wastes

1. Assess the integrity of the container for labels, bulging, leaks. If the container appears compromised or unlabeled, stop work and contact the CPM.
2. If the container is a tank, sampling from a hatch or opening at the top is preferred over a valve at the bottom because of potential waste stratification.
3. Open the container using appropriate tools.
4. Record visual appearance and volume of waste in field logbook and assess the waste for separate phases (non-aqueous phase liquid [napl], liquid, sediment) and record percentages by volume of each in field logbook. If there are separate phases, contact CPM to advise if discrete sampling of each phase is required.
5. Open an unused disposable liquid sampling tool (such as a bailer, coliwasa or dipper). If discrete phase sampling is required, choose a sampling tool that is capable of collecting the desired phase only and

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insert the sampling end of the tool in the phase to be sampled. If discrete phase sampling is not required, choose a sampling tool, and stir the waste.

6. Collect a representative sample of the waste using the tool into laboratory provided sample containers.
7. If pH is requested by field test, apply some waste from the liquid sampler to pH paper/pH meter and photograph the paper result or equipment display screen showing the pH value for project records. Note if using pH paper, it must be capable of reading pH in the range of at least 1 to 13 pH units, with a larger range acceptable.
8. Close the container by replacing all components disassembled to open it.
9. Take a photograph of the container.
10. Note the container sampled, photo number and sample ID in the field logbook.

Sampling Process Waste Streams

Process waste streams typically have designated sample collection locations (built in sampling ports, covered pits, sumps etc.) to allow collection of waste characterization samples. The sampler should consult the process operator and receive authorization before collecting any samples from an active process.

1. Record the name of the sampling location in field notes and on sample labels.
2. Collect a sample directly from the sampling location into the laboratory-provided container, if possible. Some liquid processes may need to be sampled using a dipper which should be passed through the process waste in one continuous motion to collect the sample and transfer to laboratory-provided containers. A disposable flat scoop sampling tool can be used to collect solid process wastes off conveyors, etc. prior to transferring to laboratory-provided containers.
3. Take a photograph of the sample location.
4. Note the sample location, photo number and sample ID in the field logbook.

Sampling Uncontained Release Areas

Sampling of an uncontained release or spill area can be performed as follows:

New Releases:

1. Visually assess the horizontal boundaries of the spill. The first round of waste characterization is typically biased by collecting waste characterization samples that are most likely to be “worst case”, i.e., visually impacted and near the center of the spill. The samples should be collected as grab samples with ideally a minimum of four (4) grab samples to characterize a new waste stream to statistical significance.
2. Collect volatile constituent samples (volatile organic compounds, total petroleum hydrocarbons – gasoline range, etc.) semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as grab samples centered on the release location. A disposable or stainless-steel sampling tool may be used or a bucket auger if deep sampling is requested. Volatile constituent samples should be collected using a method to minimize the loss of volatiles, typically directly into laboratory provided sampling devices/containers. Decontaminate any tool used between sampling different locations.
3. Place samples in laboratory provided sample containers.
4. Take a photograph of the sampling location.
5. Note the sampling location, photo number and sample ID in the field logbook.

Stockpiles:

1. Assess the size of the stockpile and work with the client, waste Technical Expert and disposal facility on an approach to collect an appropriate number of representative samples.

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2. Collect volatile constituent samples (volatile organic compounds, total petroleum hydrocarbons – gasoline range, etc.) semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as grab samples from randomly selected places in the stockpile. A disposable or stainless-steel sampling tool may be used for samples near the outer edge of the stockpile and a bucket auger can be used for sampling deeper into the stockpile. Volatile constituent samples should be collected from stockpile material inside the outer "shell" of the stockpile that has had less exposure to air for using a method to minimize the loss of volatiles, typically directly into laboratory provided sampling devices/containers. Decontaminate any tool used between sampling different locations.
3. Collect semi and nonvolatile constituent samples (semi-volatile organic compounds, etc.) as either grab samples from randomly selected places in the stockpile, if characterization samples will be used to separate the stockpile into different waste streams, or as grab samples for 4-point composites from random locations, if the stockpile will be disposed collectively as one waste stream. Nonvolatile sample compositing should be performed by the laboratory. A disposable or stainless-steel sampling tool may be used for samples near the outer edge of the stockpile and a bucket auger can be used for sampling deeper into the stockpile. Decontaminate any tool used between sampling different locations.
4. Place samples in laboratory provided sample containers.
5. Take a photograph of the sampling location.
6. Note the sampling location, photo number and sample ID in the field logbook.

Historical Releases:

Waste characterization for historical release areas subject to future remediation is typically performed in accordance with a site investigation work plan and is out of scope for this TGI.

Destructive Sampling Building Materials

1. Assess the building material and area to be sampled. Surface coatings and softer material such as sheet rock can be sampled with hand tools (hammer, chisel, putty knife, etc.). Harder materials such as wood, masonry and concrete may require a hammer drill with an appropriate bit. Confirm the volume/mass requirements for the sample with the analytical lab to collect a sufficient amount of sample for analysis while minimizing damage to the sample area.
2. Sampling Vertical Surfaces:
    - Place plastic sheeting under the sampling area.
    - If directed to collect a surface coating sample, scrape material into a labeled laboratory provided sampling container or, if necessary, a new plastic bag beneath the sampling area.
    - If directed to collect a representative sample of the entire building material, drill into the full thickness of the material to be disposed, collecting shavings on a labeled new paper plate beneath the sampling area. Move to an adjacent area and drill another full thickness hole if additional sampling volume/mass is needed.
3. Sampling Vertical Surfaces:
    - Place plastic sheeting around the sampling area.
    - If directed to collect a surface coating sample, scrape material, and transfer it to a labeled laboratory provided sampling container.
    - If directed to collect a representative sample of the entire building material, place a labeled new paper plate directly over the sampling area and drill through the plate into the full thickness of the material to be disposed. Shavings should collect on the paper plate. Move to an adjacent area

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and drill another full thickness hole using a new paper plate each time if additional sampling volume/mass is needed.

4. Record visual appearance and volume of waste in field logbook.
5. Transfer samples from bags or plates to laboratory provided sample containers.
6. Take a photograph of the sampling location.
7. Note the sampling location, photo number and sample ID in the field logbook.

Sampling Frequency

The sampler should work with the client, waste Technical Expert and disposal facility on an approach to collect an appropriate number of representative samples. In the absence of any other frequency directive, waste characterization samples should be collected at the following frequencies:

- Large Volume Soil/Sludge Waste Steams (Uncontained, Stockpiles, Rolloff Bins, etc.): minimum one representative sample per 200 cubic yards.
- Large Volume Liquid Waste Streams (Tanks, Ponds, etc.): minimum one representative sample per waste stream.
- Small Volume Soil/Sludge Waste Streams (Drums, Totes, etc.):
    - 1-4 containers: one grab sample from one randomly selected container for volatile constituents; grab samples from each container to be combined by laboratory into 4-point composite for nonvolatile constituents.
    - More than 4 containers: grab samples for volatile constituents from randomly selected containers representing 20% of total number of containers; grab samples for nonvolatile constituents from the same 20% of total number of containers to be combined by laboratory into 4-point (or less) composites.
- Small Volume Liquid Waste Streams (Drums, Totes, etc.): minimum one representative sample from randomly selected containers representing 20% of total number of containers.

Waste Characterization Sample Analytical Parameters

Waste characterization should be conducted in accordance with the requirements of the client, waste handling facility, and local/state/federal governments. In general, wastewater should be analyzed by methods appropriate for the known or suspected contaminants in the waste stream. Solid phase waste characterization samples may be analyzed for toxicity characteristic leaching procedure (TCLP) VOCs, TCLP SVOCs, TCLP RCRA metals, and PCBs, as well as reactivity. Liquid and sludge phase waste characterization samples may be analyzed for TCLP VOCs, TCLP SVOCs, TCLP RCRA metals, and PCBs, as well as corrosivity (pH), reactivity and flammability (flashpoint). Project-specific constituents of concern including PCBs, herbicides and pesticides may require additional sampling. Please note that state- or local-specific regulations may require a different or additional sampling approaches such as total petroleum hydrocarbon sampling, fish bioassay sampling, etc.

Sample Handling and Shipping

All samples should be appropriately labeled, packed, and shipped in accordance with Arcadis sample cooler packing procedure/video available at the Arcadis Transportation Safety SharePoint site. The chain-of-custody should be filled out in accordance with current Arcadis sample chain of custody standard operating procedure (SOP) available from the Arcadis Virtual Library. Any sample compositing instructions for the laboratory should be included on the chain of custody. The Arcadis shipping determination form (Arcadis Transportation Safety SharePoint) should be completed prior to the first shipment of samples from a project site.

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As noted under the qualifications section above, biennial training is required by Arcadis for packaging and shipping of hazardous and/or dangerous materials. Please refer to the current Arcadis training requirements related to handling and shipping of samples, shipping determinations, and hazardous materials.

8 Data Recording and Management

Waste characterization sample handling, packing, and shipping procedures shold be documented in accordance with relevant Arcadis procedures and guidance instructions as well as applicable client and/or project requirements, such as a Quality Assurance Project Plan, Sampling and Analysis Plan, or Waste Analysis Plan. Copies of the chain-of-custody forms should be maintained in the project file. Arcadis should photograph or maintain a copy of any hazardous waste manifest signed on behalf of Client in the corresponding office DOT record file.

9 Quality Assurance

The CPM should review all field documentation once per week for errors or omissions as compared to applicable project requirements including but not limited to the proposal/scope of work, QAPP, SAP, WAP, HASP, etc. Deficiencies should be noted, tracked, and resolved. Upon correction, they should be noted for project documentation.

10 References

United States Environmental Protection Agency (USEPA). 2002. RCRA Waste Sampling Draft Technical Guidance. Office of Solid Waste. August.

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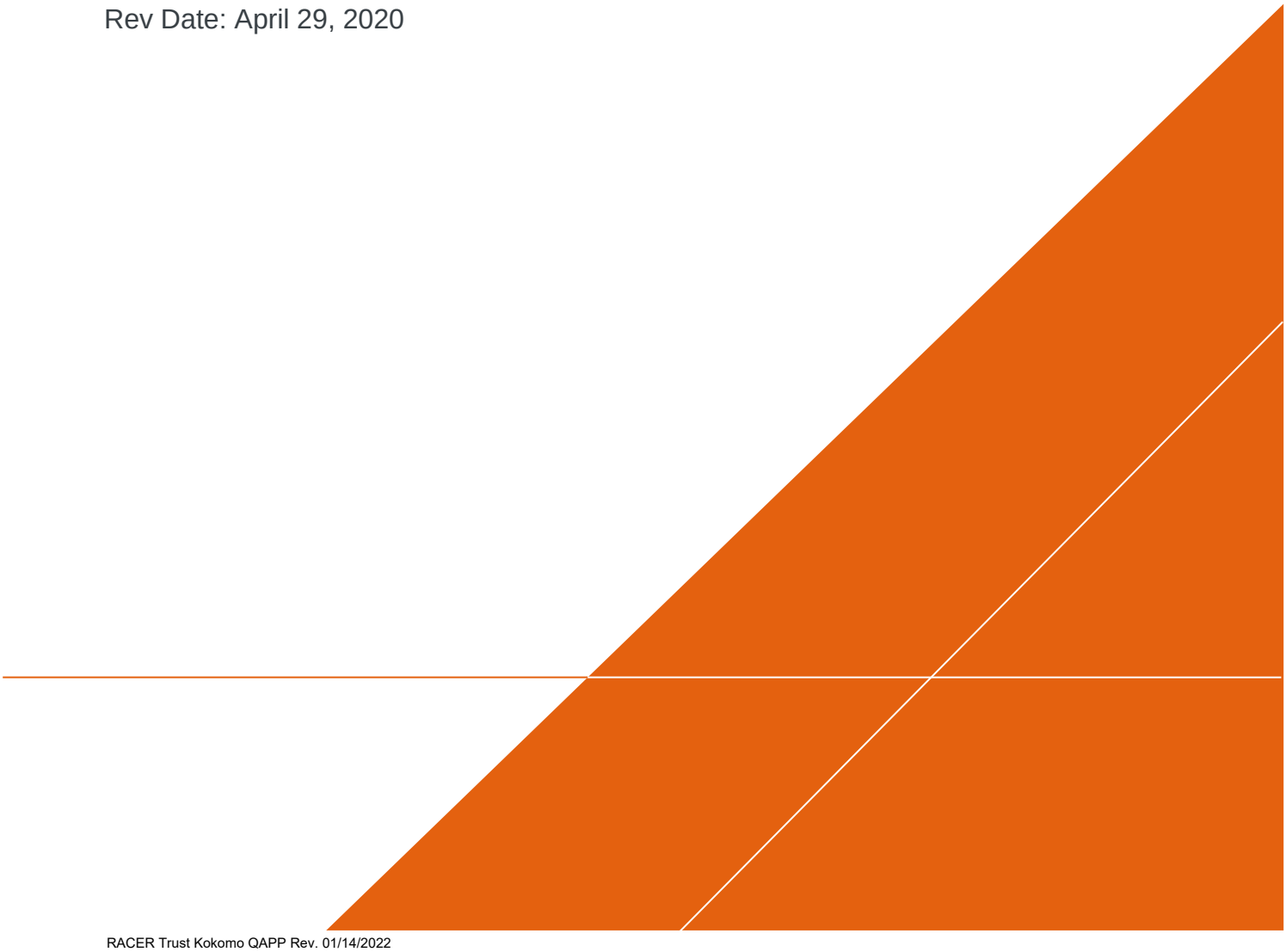
SOP - SAMPLE CHAIN OF CUSTODY

Rev: #2

Rev Date: April 29, 2020



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	April 19, 2017	All	Re-write to COC only	Richard Murphy
1	May 23, 2017	4	Add: Guidance on use of previous version of SOP.	Peter Frederick
		9	Add: Info on COCs for multiple shipping containers	
		7	Modify: Move letter i. to letter m. and change to “when appropriate”	
2	April 29, 2020	4	Remove obsolete link	Lyndi Mott
		11	Remove obsolete link	

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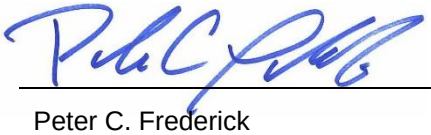
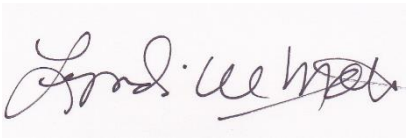
APPROVAL SIGNATURES

Prepared by:  05/23/2017

Peter C. Frederick Date:

Technical Expert Reviewed by:  05/29/2020

Lyndi Mott (Technical Expert) Date:

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1 INTRODUCTION

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2 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the general Chain of Custody (COC) procedures and guidance instructions for samples collected from project sites that are relinquished from Arcadis' possession.

COC is defined as the maintenance of an unbroken record of possession of an item from the time of its collection through some analytical or testing procedure. COC is typically documented by a written record of the collection, possession, and handling of samples collected from a project location. Each sample will be tracked by a documented record that efficiently documents the individuals who were responsible for the sample during each successive transfer of that sample to various recipients beyond Arcadis' possession. This information can be used to legally establish the integrity of the samples and therefore the analytical results derived from the samples. This information can be used in addition to other records and documentation regarding the samples, such as field forms, field logs, and photographs.

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A sample is considered under custody if:

- It is in your possession; or
- It is in your view, after being in your possession; or
- It was in your possession and then you then locked it up to prevent tampering; or
- It is in a designated secure area.

Continued use of previous version of SOP:

Although not recommended, Arcadis program-, project-, and client-teams may be able to use the previous version of this SOP provided that it meets all of the quality expectations of Arcadis and client, and meets applicable regulatory requirements. It is up to the program, project, and/or client-team leader to determine whether it is appropriate to adopt the current SOP or to continue using the previous version.

However, all new work not associated with the previous version of this SOP must be performed with the current version of the SOP.

When adopting this new SOP, users of the previous versions must be aware that specific handling, packing, and shipping procedures and guidance has been removed and that those should be addressed within program or project plans (e.g. QAPPs, Work Plans, SAPs, etc.) or in a more detailed SOP or TGI specific to that sampling activity, whether related to media, constituent/analyte, client, state, etc.

In addition, adopting this new SOP will require users to refer to the Arcadis DOT Safety Program for procedures and guidance on the determination and handling, packing, and shipping of samples that are or may be considered hazardous materials.

3 PERSONNEL QUALIFICATIONS

Arcadis personnel performing work under the purview of this SOP will have received appropriate training and have field experience regarding the collection of samples from project locations. Arcadis personnel will have all other applicable and appropriate training relevant to the sampling work and project site.

4 EQUIPMENT LIST

The following list provides materials that may be required for each COC. Project reporting and documentation requirements must be reviewed with the CPM prior to execution of work. Additional materials, tools, equipment, etc. may be required, and project staff are required to verify with the CPM and/or Technical Expert what specific equipment is required to complete the COC.

- Indelible ink pen (preferably either black or blue ink);
- COC form (**Appendix A**) from either Arcadis, laboratory receiving and analyzing the samples, or other applicable and appropriate entity for the work performed;
- When appropriate, such as for litigation or expert testimony work, custody seals or tape.

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5 CAUTIONS

One way in which the law tries to ensure the integrity of evidence is by requiring proof of the chain of custody by the party who is seeking to introduce a particular piece of evidence.

A proper chain of custody requires three types of affirmations: (1) affirmation that a sample is what it purports to be (for example, soil collected from a specified location and depth); (2) affirmation of continuous possession by each individual who has had possession of the sample from the time it is collected until the time it is analyzed or held by a laboratory; and (3) affirmation by each person who has had possession that sample remained in substantially the same condition and not contaminated or affected by outside influences from the moment one person took possession until the moment that person released the evidence into the custody of another (for example, affirmation that the sample was stored in a secure location where no one but the person in custody had access to it).

Proving chain of custody is necessary to "lay a foundation" for the samples in question, by showing the absence of alteration, substitution, or change of condition.

Ensure that appropriate sample containers with applicable preservatives, coolers, and packing material are planned for and provided at the site at the time of sample collection.

Understand the offsite transfer requirements of the samples for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation.

An Arcadis employee appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging, and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.

The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

6 HEALTH AND SAFETY CONSIDERATIONS

Follow the health and safety procedures outlined in the project/site Health and Safety Plan (HASP) as well as other applicable H&S requirements, such as:

- Arcadis Hazardous Material/DOT handling, packaging, and shipping training
- Project site-specific H&S training
- Client-specific H&S training
- Constituent-specific H&S training
- Media-specific H&S training

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7 PROCEDURE

Collected samples must be uniquely identified, and properly documented, containerized, labeled with unique identifier, possessed in a secure manner during remainder of sampling event, packaged, and shipped to recipient laboratory.

Sample Identification

The method of sample identification depends on the type of measurement or analyses performed. In some cases, in-situ measurements of existing conditions and/or sample location must be made during sample collection. These data will be recorded directly on field forms, logbooks, or other project record data sheets used to permanently retain this information for the project file. Examples of location identification information includes: latitude/longitudinal measurements, compass directions, well number, building number, floor number, room name, or proximity to a site feature unique to the site. Examples of in-situ measurements are pH, temperature, conductivity, flow measurement, or physical condition of the media being sampled. Physical samples collected are identified by a unique identifying number or code on a sample tag or label. These physical samples are removed from the sample location and transported to a laboratory for analyses.

In some cases, before samples are placed into individual containers and labeled as individual samples, samples may be separated into portions depending upon the analytical methods and required duplicate or triplicate analyses to be performed.

When completing a COC for samples, personnel must complete the following:

1. Written COCs must be completed with indelible ink (preferably either black or blue colored ink).
2. Written COCs must be completed using legible printed writing, and not cursive writing.
3. All entry fields on the COC form must be completed. If information is not applicable for a specific entry field, personnel will either put “N/A” or use a strike-out line or dash like “----------“ to indicate no applicable information is needed for that field.
4. Use of quotation marks or lines/down arrows to represent repetitive/duplicative text in similar fields.
5. Regardless of the type or specific COC form, the following pertinent information must be provided on the COC form:
    a. Arcadis project number
    b. Arcadis project name
    c. Project location, including street address, city, state, building number, providing as much detail as appropriate
    d. Recipient laboratory contact and sample receiving shipping location information
    e. Entities’/persons’ contact information for who will be receiving analytical results
    f. Name of sampler, i.e. person collecting sample and relinquishing possession of samples to the next entity in the chain of custody
    g. Date of sample collection

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h. If appropriate for the sample media, contaminant/constituent of concern, or analytical method, document time of sample collection using standard military time

i. Sample analytical method(s)

j. Turnaround time required for analyses and/or reporting

k. Instructions to laboratory regarding handling, timing, analyses, etc. as applicable and appropriate

l. Printed name and signature of the individual person who collected the samples and relinquishing possession of the samples

m. If appropriate or when documentation of the specific sample collection method will influence how the laboratory handles, prepares, or analyzes the samples, document the sample collection methodology used for collecting the samples (e.g. ASTM D5755)

6. The following additional specific information will be entered on the COC form, regardless of what type of COC is being used:

   a. Unique Sample Identifier – The sample identifier (ID) must be unique to the individual sample it is applied to. The information in which the sample ID conveys is determined by the CPM, Technical Expert, and/or other project team members in advance of sample collection so that sample identification is consistently applied for the project. The sample nomenclature may be dictated by a specific client, program, or project database and require unique identification for each sample collected for the project. Consult with the CPM and/or Technical Expert for additional information regarding sample identification.

      The sample ID could convey specific information regarding the sample to aid personnel in recognizing what the sample represents, or they may be arbitrary so as to facilitate the anonymity of the sample location, media, constituent of concern, project site, etc.

      Examples of unique identifiers include:

      1. Well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be “SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain of custody form. DO NOT use the apostrophe or quotes in the sample ID.

      2. Sample names may also use the abbreviations “FB,” “TB,” and “DUP” as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively.

   b. List the date of sample collection. All indicated dates must be formatted using either mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

   c. When appropriate for the analytical procedure used, list the local time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

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d. Samples should be indicated to be either “Grab” or “Composite”. Grab samples are collected from only one unique location at one specific point in time.

e. Composite samples are a group of individual samples that are combined for analysis in their totality. Composite samples need to be documented if they are either collected from a number of different locations over a broader area to be representative of the entire area being sampled, or if they are representative of a single location over an extended period of time.

f. If used, preservatives for the individual sample will be noted.

g. The requested analytical method(s) that the samples are being analyzed for must be indicated. As much detail, as necessary, should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “EPA Method 8082 – PCBs” or “EPA PLM 600-R93-116.” In cases where multiple analytical methods and/or analytical parameters are required for an individual sample, each method should be indicated for the sample (e.g., EPA 8082/8260/8270 or EPA PLM/400-point count).

h. If there are project-specific sample analytes to be reported, they should be specifically listed for each individual sample (e.g., 40 CFR 264 Appendix IX).

i. The total number of containers for each analytical method requested should be documented. This information may be included under the parameter or as a total for the sample.

j. When necessary, note which samples should be used for site specific matrix spikes.

k. Indicate special project-specific requirements pertinent to the handling, shipping, or analyses. These requirements may be on a per sample basis such as “extract and hold sample until notified,” or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG).

l. Indicate turnaround time (TAT) required for samples on COC. If individual samples have differing TATs, the different TATs for each sample or groups of samples must be clearly indicated.

m. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory. The person relinquishing possession of the samples or other member of the project team should contact the final recipient of the samples to confirm receipt and review any special provisions on the COC or questions that they may have.

n. If available, attach the Laboratory Task Order or Work Authorization forms.

o. The “Relinquished By” field must contain the signature of the Arcadis person who relinquished custody of the samples to the next entity in the chain of custody, which may be another person, the shipping courier, or the analytical laboratory.

p. Dates and times must be indicated using the following format:

   1) Date: either mm/dd/yy e.g., 01/01/17 OR mm/dd/yyyy e.g., 01/01/2017

   2) Time: use military format, e.g. 9:30 a.m. is 0930 and 9:30 p.m. is 2130

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q. The “Received By” section is signed by sample courier or laboratory representative who received the samples from the sampler or it is signed upon laboratory receipt from the overnight courier service.

4. When more than one page of the COC form is required to complete the total number of samples, use as many sheets as necessary to accurately and clearly document the samples and information. Some COCs may have a standard first page/cover page, and subsequent pages may not contain all the detailed fields as the first page/cover page. Ensure that any subsequent pages convey all of the necessary and pertinent information for each individual sample as required in this procedure document.
5. Pages of the COC must retain a page count of the total number of pages; e.g., Page 1 of 3, Page 2 of 3, Page 3 of 3.
6. Upon completing the COC forms, forward the original signed COC with the sample package. Ensure that the original COC form is secured with the sample package so that it remains with the physical samples for the duration of transport and handling to its final destination and ensure that the COC form will not be become damaged or rendered unreadable due to sample breakage/leakage if stored inside the sample shipping container or outside influences if COC is stored in an outside plastic pouch to the container.
7. If you’ve collected enough samples that would require more than one container to ship them all to the same laboratory or location, then each separate/individual container that contains any number of samples must have a separate COC representing only those samples contained within that specific container. For example, if you have 3 total shipping containers for all of your samples, you must have a total of 3 separate, individual COCs for each of the 3 containers representing only those samples in their representative container. Thus, every container holding samples must have its own, individual COC.
8. If electronic chain of custody (eCOC) forms are utilized, ensure that the requirements of this procedure and guidance instructions are followed to the extent possible. Verify that proper signature and COC procedures are maintained with the CPM and/or Technical Expert when using eCOC.

8 WASTE MANAGEMENT

Not Applicable.

9 DATA RECORDING AND MANAGEMENT

The original signed COC shall be submitted with the samples. Copies of COC records will be transmitted to the CPM or designee at the end of each day unless otherwise directed by the CPM. The sampling team leader retains copies of the chain of custody forms for filing in the project file. Record retention shall be in accordance with client- and project-specific requirements and Arcadis policies, the most stringent will apply.

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10 QUALITY ASSURANCE

COC forms will be legibly completed in accordance with this procedure and guidance instruction document, as well as other applicable and appropriate project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents.

COC records will be reviewed by the CPM or their appropriate designee for completeness and accuracy to the applicable requirements. Non-conformances will be noted and corrected in a timely manner on the copies retained by Arcadis as well as contacting the ultimate receiving entity for correction to the originally signed COC in their possession.

11 REFERENCES

Arcadis Client Document Retention Guide

Arcadis Transportation Safety Program requirements, procedures, and guidance instructions

EPA Samplers' Guide – Contract Laboratory Program Guidance for Field Samplers, EPA document EPA-540-R014-013 October 2014

EPA Region III – *Sample Submission Procedures for the Office of Analytical Services and Quality Assurance (OASQA) Laboratory Branch* revision 13.0 January 29, 2014

EPA Region I Office Environmental Measurement and Evaluation – *Standard Operating Procedures for Chain of Custody of Samples* revision 1 March 25, 2002

EPA Region IV Science and Ecosystem Support Division *Operating Procedure for Sample and Evidence Management* January 29, 2013

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APPENDIX A
Chain of Custody Form

ARCADIS

ID#

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ____ of ____

Lab Work Order #

Send Results to:

Contact & Company Name:

Telephone:

Address:

Fax:

City State Zip

E-mail Address:

Project Name/Location (City, State):

Project #:

Sampler's Printed Name:

Sampler's Signature

SAMPLE ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix

Preservative									
Filtered (✓)									
# of Containers									
Container Information									
PARAMETER ANALYSIS & METHOD									
									REMARKS

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: _____
G. Other: _____
H. Other: _____

Containment Information Key
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: _____
10. Other: _____

Matrix Key:
SO - Soil
W - Water
T - Tissue
SE - Sediment
SL - Sludge
A - Air
NL - NAPL/Oil
SW - Sample Wipe
Other: _____

Special Instructions/Comments

☐ **Special QA/QC Instructions (✓)**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Last Name:	Cooler Custody Seal (✓) ☐ Intact ☐ Not Intact	Printed Name:	Printed Name:	Printed Name:	Printed Name
☐ Cooler packed with ice (✓)		Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt	Firm:	Firm:	Firm:	Firm:
Shipping Tracking #:	Condition/Cooler Temp:_____	Date/Time:	Date/Time:	Date/Time:	Date/Time:

SOP – Sample Chain of Custody Rev1_May 23, 2017

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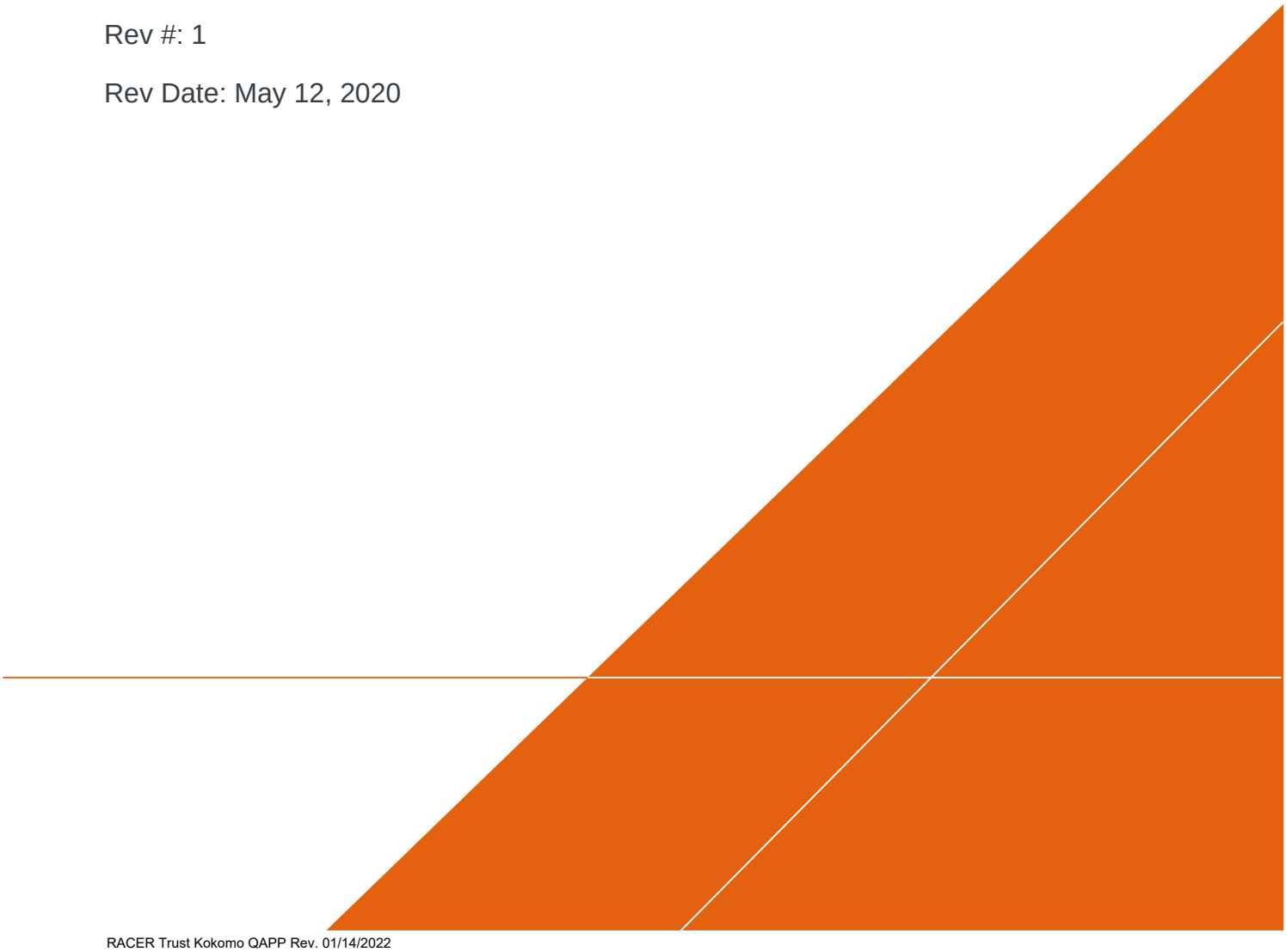
ARCADIS Design & Consultancy for natural and built assets

TGI – SOIL DRILLING AND SAMPLE COLLECTION

Rev #: 1

Rev Date: May 12, 2020



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 11, 2018	All	Updated and re-written as a TGI	Marc Killingstad
1	May 12, 2020	None	Review – no changes necessary	Marc Killingstad

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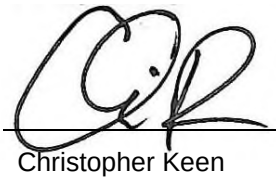
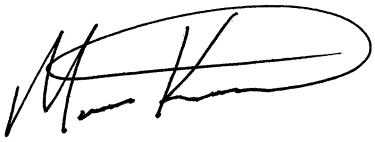
APPROVAL SIGNATURES

Prepared by:		10/11/2018
	Christopher Keen	Date:
Technical Expert Reviewed by:		05/12/2020
	Marc Killingstad (Technical Expert)	Date:

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2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes general drilling procedures and the methods to be used to field screen and collect soil samples for laboratory analysis in unconsolidated sediments. For soil description procedures, please refer to the *TGI - Soil Description*. For monitoring well installation in granular aquifers, please refer to the *TGI - Monitoring Well Installation*.

Overburden (unconsolidated sediments) drilling is commonly performed using the hollow-stem auger drilling method. Other drilling methods suitable for overburden drilling, which are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and hand tools may also be used. Drilling within consolidated materials such as fractured bedrock is commonly performed using water-rotary (coring or tri-cone roller bit), air rotary or rotasonic methods. For guidance when drilling in consolidated materials (i.e., bedrock), please refer to the *TGI – Bedrock Core Collection and Description*.

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The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, types of sampling to be conducted, required sample quality and volume, and cost.

Field screening of soil samples is commonly performed using a photoionization detector (PID) and/or a flame ionization detector (FID). These instruments are used to measure relative concentrations of volatile organic compounds (VOCs) for the selection of samples for further laboratory or field analysis. Field screening for dense non-aqueous phase liquids (DNAPL) may be performed using hydrophobic dye (Oil Red O or Sudan IV), which is pertinent at chlorinated solvent sites.

Collection of soil samples for laboratory analysis may be performed using a variety of techniques including grab samples and composite or homogenized samples. Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample. Samples for VOC analysis will not be homogenized or composited and are collected as discrete grab samples.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools).

3 PERSONNEL QUALIFICATIONS

Arcadis field personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or state/federal regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, Arcadis field personnel will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP), Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Personnel responsible for overseeing drilling operations will have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

Arcadis personnel directing, supervising, or leading soil sampling activities will have a minimum of 1 year of previous environmental soil sampling experience. Field employees with less than 6 months of experience will be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

Additionally, the Arcadis field team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

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4 EQUIPMENT LIST

The following materials will be available, as required, during soil boring drilling, field screening, and sampling activities:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP)/work plan that includes site map with proposed boring locations, field sampling plan (with corresponding depths, sample analyses, sample volume required, and sample holding time), and previous boring logs (as available)
- Appropriate personal protective equipment (PPE), as specified in the HASP
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)
- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP
- Drilling equipment required by *ASTM D1586*, when performing split-spoon sampling
- Disposable plastic liners, when drilling with direct-push equipment
- Appropriate soil sampling equipment (e.g., stainless steel spatulas/spoons/bowls, knife)
- Stainless steel hand auger and stainless-steel spade if using manual methods
- Indelible ink pens
- Engineer's ruler or survey rod
- Sealable plastic bags (e.g., Ziploc®)
- Air-tight sample containers and 8-oz. glass Mason jars or driller's jars
- Aluminum foil
- Plastic sheeting (e.g., Weatherall Visqueen)
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels)
- Appropriate sample blanks (trip blank supplied by the laboratory), as specified in the FSP
- Soil sample containers and labels (supplied by the laboratory) appropriate for the analytical method(s) with preservative, as needed (parameter-specific)
- Appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials;
- Appropriate soil boring log (**Attachment 1**)
- Chain-of-custody forms
- Field notebook.

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- Digital camera (or smart phone with camera)
- Drums or other containers appropriate for soil and decontamination water, as specified by the site investigation-derived waste (IDW) management plan, and appropriate drum labels

5 CAUTIONS

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See appropriate guidance for proper utility clearance protocol. Work will be performed in accordance with the Arcadis *Utility Location and Clearance Health and Safety Standard* and the *Utilities and Structures Checklist* will be completed before beginning any intrusive work.

Prior to beginning field work, the project technical team will ensure that all field logistics (e.g., access issues, health and safety issues, communication network, schedules, etc.) and task objectives are clearly understood by all team members. An internal call with the project technical team to review the FIP/work plan scope and objectives is strongly recommended prior to mobilization to ensure that the field work will be effectively and efficiently executed.

Some regulatory agencies have specific requirements regarding borehole abandonment and grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling plan.

If DNAPL is known or expected to exist at the site, refer to the project specific documents (e.g., DNAPL Contingency Plan) for additional details regarding drilling to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquid (LNAPL) is known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Water used for drilling, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply will be considered.

Specifications of materials used for backfilling the borehole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPL is likely to be present or in groundwater with high salinity. In these situations, neat cement grout is preferred.

Store and/or stage empty and full sample containers and coolers out of direct sunlight. Be careful not to over-tighten lids with Teflon® liners or septa. Over-tightening can impair the integrity of the seal and can cause the glass to shatter and create a risk for hand injuries.

NOTE: *Field logs and some forms are considered to be legal documents. All field logs and forms will therefore be filled out in indelible ink. Do not use permanent marker or felt-tipped pens for labels on*

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sample container or sample coolers. Permanent markers could introduce volatile constituents into the samples.

NOTE: *An Arcadis employee that is appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.*

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Working outside at sites with suspected contamination may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include biological hazards (e.g., stinging insects, ticks in long grass/weeds, etc.), and potentially the use of sharp cutting tools (scissors, knife). Only use non-toxic peppermint oil spray for stinging insect nests. Review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives and use appropriate hand protection.

If thunder or lighting is present, discontinue drilling and sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

7 PROCEDURE

The procedures for drilling and the methods to be used to field screen and collect soil samples for laboratory analysis are presented below:

DRILLING PROCEDURES

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area.
2. Advance boring to designated depth:
    a. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent)
    b. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent)

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c. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)

d. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is described in *ASTM D1586 – Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils* (ASTM D1586).

   i. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary

e. Rotasonic drilling produces soil cores that, for the most part, are relatively undisturbed, but note that when drilling in consolidated or finer-grained sediment the vibratory action during core barrel advancement may create secondary fractures or breaks

f. Dual-rotary removes cuttings by compressed air or water/mud and allow only a general assessment of geology

3. Describe each soil sample as outlined in the appropriate project records (refer to the description procedures outlined in the *TGI - Soil Description*)

   a. Record descriptions on the soil boring log (**Attachment 1**) and/or field notebook.

   b. When possible photo document the samples (e.g., soil cores, split-spoons)

   c. During soil boring advancement, document all drilling events in field notebook, including blow counts (i.e., the number of blows from a soil sampling drive weight [140 pounds] required to drive the split-barrel sampler in 6-inch increments) and work stoppages

   d. Blow counts will not be available if rotasonic, dual-rotary, or direct-push methods are used; however, if standard penetration testing is required during rotasonic drilling, an automatic drop hammer may be used in conjunction with the method to switch from core barrel advancement to standard penetration testing

4. The drilling contractor will be responsible for obtaining accurate and representative samples, informing the supervising Arcadis geologist of changes in drilling pressure, and keeping a separate general log of soils encountered, including blow counts

   a. The term “samples” means soil materials from particular depth intervals, whether or not portions of these materials are submitted for laboratory analyses

   b. Records will also be kept of occurrences of premature refusal due to boulders or construction materials that may have been used as fill

   c. Where a boring cannot be advanced to the desired depth, the boring will be abandoned, and an additional boring will be advanced at an adjacent location to obtain the required sample

   d. Where it is desirable to avoid leaving vertical connections between depth intervals (e.g., if DNAPL or perched LNAPL are known or expected to exist at the site), the borehole will be sealed using cement and/or bentonite (see **Section 5** above)

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e. Multiple refusals may lead to a decision by the supervising geologist to abandon that sampling location

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings. Examples of this technique include Geoprobe®, Diedrich Environmental Soil Probe (ESP) System, or AMS PowerProbe. Environmental probe systems typically use a hydraulically operated percussion hammer.

Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff to medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual tube liner for sampling soil (dual tube sampling system).

The outside diameter (OD) of the outer casing ranges from 2.25 to 6 inches and the OD of the inner sampling tube diameter ranges from 1.4 to 4.5 inches. The outer casing isolates overlying soil and permits the unit to continue to probe at depth. The dual tube sampling system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, a single rod system may be used that does not provide a cased boring and which does not allow for tremie-grouting from the bottom up.

The known or expected site conditions (e.g., presence of NAPL) will be evaluated when selecting the type of direct-push sampling system to be employed.

Direct-push drilling can generally achieve target depths 100 feet or less and the achievable depth is based on the site geology.

1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Advance soil boring to designated depth.
    a. Collect soil samples at appropriate interval as specified in in the FIP/work plan (or equivalent)
    b. Collect, document, and store samples for laboratory analysis as specified in in the FIP/work plan (or equivalent)
    c. Decontaminate equipment between samples in accordance with in the FIP/work plan (or equivalent)
    d. Samples will be collected using dedicated, disposable, plastic liners
3. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

Manual Methods

Manual methods may also be used to complete shallow soil borings. Examples of this technique include using a spade, spoon, scoop, hand auger, or slide hammer. Manual methods are typically used to collect surface soil samples (0 to 6 inches) or to complete soil borings/collect soil samples from a depth of 5 feet or less.

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1. Find/identify boring location, establish work zone, and set up sampling equipment decontamination area
2. Clear the ground surface of brush, root mat, grass, leaves, or other debris
3. Use a spade, spoon, scoop, hand auger, or slide hammer to collect a sample of the required depth interval
4. Use an engineer's ruler or survey rod to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface
5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval
    a. To prevent the hole from collapsing, it may be necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) pipe to maintain the opening
    b. Collect soil samples at appropriate interval as specified in the FIP/work plan (or equivalent)
    c. Collect, document, and store samples for laboratory analysis as specified in the FIP/work plan (or equivalent)
    d. Decontaminate equipment between samples in accordance with the FIP/work plan (or equivalent)
6. Describe samples in accordance with the procedures outlined in **Step 3** under ***Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods*** above (refer to the description procedures outlined in the *TGI - Soil Description*)

FIELD SCREENING PROCEDURES

PID and FID Screening

Soils are typically field screened with a PID or FID for a relative measure of the total VOCs at sites where VOCs are known or suspected to exist. The PID employs a UV lamp to measure VOCs and the ionization energy (IE) of the site constituents need to be considered when selecting the type of lamp (e.g., 10.6 eV, 11.7 eV) that will be used. In general, any compound with an IE lower than that of the lamp photons can be measured. The FID has a wide linear range and responds to almost all VOCs. Field screening is performed using one (or both) of the following two methods:

1. Upon opening the sampler, the soil is split open and the PID or FID probe is placed in the opening and covered with a gloved hand. Such readings will be obtained at several locations along the length of the sample.
2. A portion of the collected soil is placed in a jar, which is covered with aluminum foil, sealed, and allowed to warm to room temperature. After warming, the cover is removed, the foil is pierced with the PID or FID probe, and a reading is obtained.

Initial PID readings will be recorded on the soil boring log (**Attachment 1**) and/or in the field notebook. The soil sample will be separated from the slough material (if any) by using disposable gloves and a pre-cleaned stainless-steel spoon.

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For the second method, a representative portion of the sample will be placed in a pre-cleaned air-tight 8-ounce container (as quickly as possible to avoid loss of VOCs), filling the container half full to allow for the accumulation of vapors above the soil. An aluminum foil seal will be placed between the glass and metal cap and the cap will be screwed on tightly. Unless the screening will be performed immediately after the sample is placed in the container, the sample containers will be stored in a cooler chilled to approximately 4ºC until screening can be performed.

The headspace of the 8-ounce container will be measured using a PID or FID as follows:

1. Samples will be taken to a warm work space and allowed to equilibrate to room temperature for at least one hour.
2. Prior to measuring the soil vapor headspace concentration, the 8-ounce container will be shaken.
3. The headspace of the sample will then be measured directly from the 8-ounce container by piercing the aluminum foil seal with the probe of the PID or FID and measuring the relative concentration of VOCs in the headspace of the soil sample. The initial (peak) reading must be recorded.

The PID or FID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to collecting PID or FID readings. The PID will be calibrated to a benzene-related compound (isobutylene) while the FID will be calibrated to methane.

The time, date, and calibration procedure must be clearly documented in the field notebook and/or the calibration log book.

If at any time the PID or FID results appear erratic or inconsistent with field observations, then the instrument will be recalibrated.

If calibration is difficult to achieve, then the PID's lamp will be checked for dirt or moisture and cleaned, or technical assistance will be required. Maintenance and calibration records will be kept as part of the field quality assurance program.

NAPL Screening

To screen for the potential presence of non-aqueous phase liquid (NAPL) in soil, drilling procedures must allow for high-quality porous media samples to be taken. Split-spoon samplers or direct-push samplers will be collected continuously ahead of the auger, drill casing/rods, or probe rods.

Upon opening each split-spoon sampler or direct-push plastic liner sleeve, the soil will immediately be evaluated for the presence of visible NAPL. If NAPL is immediately visible in the sample, its depth will be noted.

Additionally, the soil will be screened for the presence of organic vapors using a PID or FID. During screening, the soil will be split open using a clean spatula or knife and the PID or FID probe will be placed in the opening and covered with a gloved hand (**Method 1** above). Such readings will be obtained along the entire length of the sample. Alternatively, **Method 2** for PID/FID screening (outlined above) may also be performed. If the PID or FID examination reveals the presence of organic vapors above 100 parts per million (ppm), the sample will undergo further detailed evaluation for visible NAPL.

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The assessment for NAPL will include the following tests/observations:

- Evaluation for Visible NAPL Sheen or Free-Phase NAPL in Soil Sampler
  - NAPL sheen will be a colorful iridescent appearance on the soil sample
  - NAPL may also appear as droplets or continuous accumulations of liquid with a color typically ranging from yellow to brown to black, depending on the type of NAPL
  - Creosote DNAPL (associated with wood-treating sites) and coal tar DNAPL (associated with manufactured gas plant [MGP] sites) are typically black and have a characteristic, pungent odor
  - Pure chlorinated solvents may be colorless in the absence of hydrophobic dye. Solvents mixed with oils may appear brown
  - Particular care will be taken to fully describe any sheens observed, staining, discoloration, droplets (blebs), or NAPL saturation
- Soil-Water Pan Test
  - A portion of the selected soil interval with the highest PID or FID reading above 100 ppm will be placed in a disposable polyethylene dish along with a small volume of potable or distilled water
  - The dish will be gently tilted back and forth to mix the soil and water, and the surface of the water will be viewed in natural light to observe the development of a sheen, if any
  - A small quantity of Oil Red O or Sudan IV hydrophobic dye powder will be added, and the soil and dye will be manually mixed for approximately 30 to 60 seconds and smeared in the dish to create a paste-like consistency
  - A positive test result will be indicated by a sheen on the surface of the water and/or a bright red color imparted to the soil following mixing with dye
- Soil-Water Shake Test
  - A small quantity of soil (up to 15 cc) will be placed in a clear, colorless, jar containing an equal volume of potable or distilled water (40-mL vials are well suited to this purpose, but not required)
  - After the soil settles into the water, the surface of the water will be evaluated for a visible sheen under natural light
  - The jar will be closed and gently shaken for approximately 10 to 20 seconds
  - Again, the surface of the water will be evaluated for a visible sheen or a temporary layer of foam
  - A small quantity (approximately 0.5 to 1 cc) of Oil Red O or Sudan IV powder will be placed in the jar
  - The sheen layer, if present, will be evaluated for a reaction to the dye (change to bright red color)
  - The jar will be closed and gently shaken for approximately 10 to 20 seconds
  - The contents in the closed jar will be examined under natural light for visible bright red dyed liquid inside the jar

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- A positive test result will be indicated by the presence of a visible sheen or foam on the surface of water, a reaction between the dye and the sheen layer upon first addition of the dye powder, a bright red coating on the inside of the vial (particularly above the water line), or red-dyed droplets within the soil

NOTE: *If NAPL is obviously present upon opening the soil sampler or evaluating the soil sample within the split-spoon sampler or direct-push liner sleeve, it is not necessary to perform a soil-water pan test or soil-water shake test. In addition, it is not necessary to perform both a soil-water pan test and a soil-water shake test; either test method is acceptable. The pan test may be preferred in some circumstances because the presence of a sheen may be easier to see on a wider surface.*

NOTE: *When using hydrophobic dye in the tests above, color will be assessed outdoors under natural light during the period between sunrise and sunset, regardless of the degree of cloud cover. The hydrophobic dye Safety Data Sheets (SDS) will be incorporated into the HASP and reviewed prior to use and the dyes will be carefully handled and disposed in accordance with regulations*.

SOIL SAMPLE COLLECTION FOR LABORATORY PROCEDURES

If not specifically identified in the FIP, soil samples will be selected for laboratory analysis based on:

1. Their position in relation to identified source areas
2. The visual presence of source residues (e.g., NAPL)
3. The relative levels of total VOCs based on field screening measurements
4. The judgment of the field coordinator

Samples designated for laboratory analysis will be placed in the appropriate containers.

Sample containers for VOC analysis will be filled first immediately following soil core retrieval to reduce loss of VOCs.

If samples will be collected for other analytical parameters, a sufficient amount of the remaining soil will then be homogenized as described below and sample containers will be filled for other parameters.

VOC samples will be collected as discrete samples using a small diameter core sampler (e.g., En Core® Sampler, Terra Core™ Sampler).

The En Core® Sampler is a disposable volumetric sampling device that collects, stores and delivers soil samples without in-field chemical preservation. The En Core® Sampler requires the use of a reusable T-handle.

The Terra Core™ Sampler is a one-time use transfer tool, designed to collect soil samples and transfer them to the appropriate containers for in-field chemical preservation (e.g., methanol).

The small diameter core sampler will be used according to the manufacturer's instructions (e.g., En Novative Technologies). Some regulatory agencies have specific requirements regarding VOC sample collection. Determine whether the oversight agency has specific requirements prior to commencing sampling and collect samples at appropriate interval as specified in the FIP/work plan (or equivalent). Samples may require homogenization across a given depth interval, or several discrete grabs (usually five) may be combined into a composite sample.

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NOTE: *Samples for VOC analysis will NOT be homogenized or composited and will be collected as discrete samples as described above*.

The procedure for mixing samples is provided below.

1. Mix the materials in a stainless steel (or appropriate non-reactive material) bowl using a stainless-steel spoon (or disposable equivalents)
    a. When dealing with large sample quantities, use disposable plastic sheeting and a shovel or trowel
    b. NOTE: *When preparing samples for metals analyses, do not use disposable aluminum (or metal tools or trays other than stainless steel), as it may influence the analytical results*
2. Flatten the pile by pressing the top without further mixing
3. Divide the circular pile by into equal quarters by dividing out two diameters at right angles
4. Mix each quarter individually using appropriate non-reactive bowls, spoons and/or sheeting
5. Mix two quarters (as described above) to form halves, then mix the two halves to form a composite or homogenized sample
6. Place composite or homogenized sample into specified containers
7. Remaining material will be disposed of in accordance with project requirements and applicable regulations
8. Sample containers will be labeled with sample identification number, date, and time of collection and placed on ice in a cooler (target 4° Celsius)
9. Samples selected for laboratory analysis will be documented (chain-of-custody forms), handled, packed, and shipped in accordance with the procedures outlined in the FIP/work plan (or equivalent).

8 WASTE MANAGEMENT

Investigative-Derived Waste (IDW) generated during drilling activities, including soil and excess drilling fluids (if used), decontamination liquids, and disposable materials (plastic sheeting, PPE, etc.) will be stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field log book.

9 DATA RECORDING AND MANAGEMENT

Management of the original documents from the field will be completed in accordance with the site-specific QAPP.

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In general, drilling activities will be documented on appropriate field/log forms as well as in a proper field notebook. All field data will be recorded in indelible ink. Field forms, logs/notes (including daily field and calibration logs), digital records, and chain-of-custody records will be maintained by the field team lead.

Initial field logs and chain-of-custody records will be transmitted to the Arcadis Certified Project Manager (CPM) and Technical Lead at the end of each day unless otherwise directed by the CPM. The field team leader retains copies of the field documentation.

Additionally, all documents (and photographs) will be scanned and electronically filed in the appropriate project directory for easy access. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of drilling activities, soil descriptions, soil boring information, and quantities of materials used.

In addition, the locations of soil borings will be documented photographically and in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

10 QUALITY ASSURANCE

Quality assurance procedures shall be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate TGI.

Field-derived quality assurance blanks will be collected as specified in the FIP/work plan and/or site-specific QAPP, depending on the project quality objectives. Typically, field rinse blanks (equipment blanks) will be collected when non-dedicated equipment (e.g., split-spoon sampler, stainless steel spoon) is used during soil sampling. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Trip blanks for VOCs, which aid in the detection of contaminants from other media, sources, or the container itself, will be kept with the coolers and the sample containers throughout the sampling activities and during transport to the laboratory.

Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.

11 REFERENCES

ASTM D1586 - *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*. ASTM International. West Conshohocken, Pennsylvania.

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12 ATTACHMENTS

Attachment 1. Soil Boring Log Form

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ATTACHMENT 1

Soil Boring Log Form

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SOIL BORING LOG

Boring/Well _____ Project _____ Page ___ of ___

Site Location _____ Drilling Started _____

Total Depth Drilled _____ Feet Hole Diameter _____ inches Drilling Completed _____

Type of Sample or Coring Device _____ Length and Diameter of Coring Device _____ Sampling Interval _____ feet

Drilling Method _____ Drilling Fluid Used _____

Drilling Contractor _____ Driller _____

Prepared By _____ Helper _____

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				**Udden-Wentworth Description:** principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, additional comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

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SOIL BORING LOG (CONT'D)

Boring/Well _____ Prepared By _____ Page ____ of ____

Core Recovery (feet)	PID Reading (ppm)	Sample Depth (ft bgs)	MUD		SAND					GRAVEL				Udden-Wentworth Description: principal components, (angularity, plasticity, dilatency); minor components, (angularity, plasticity, dilatency); sorting, moisture content, consistency/density, color, addtl. Comments
			clay	silt	very fine	fine	medium	coarse	very coarse	granular	pebble	cobble	boulder	

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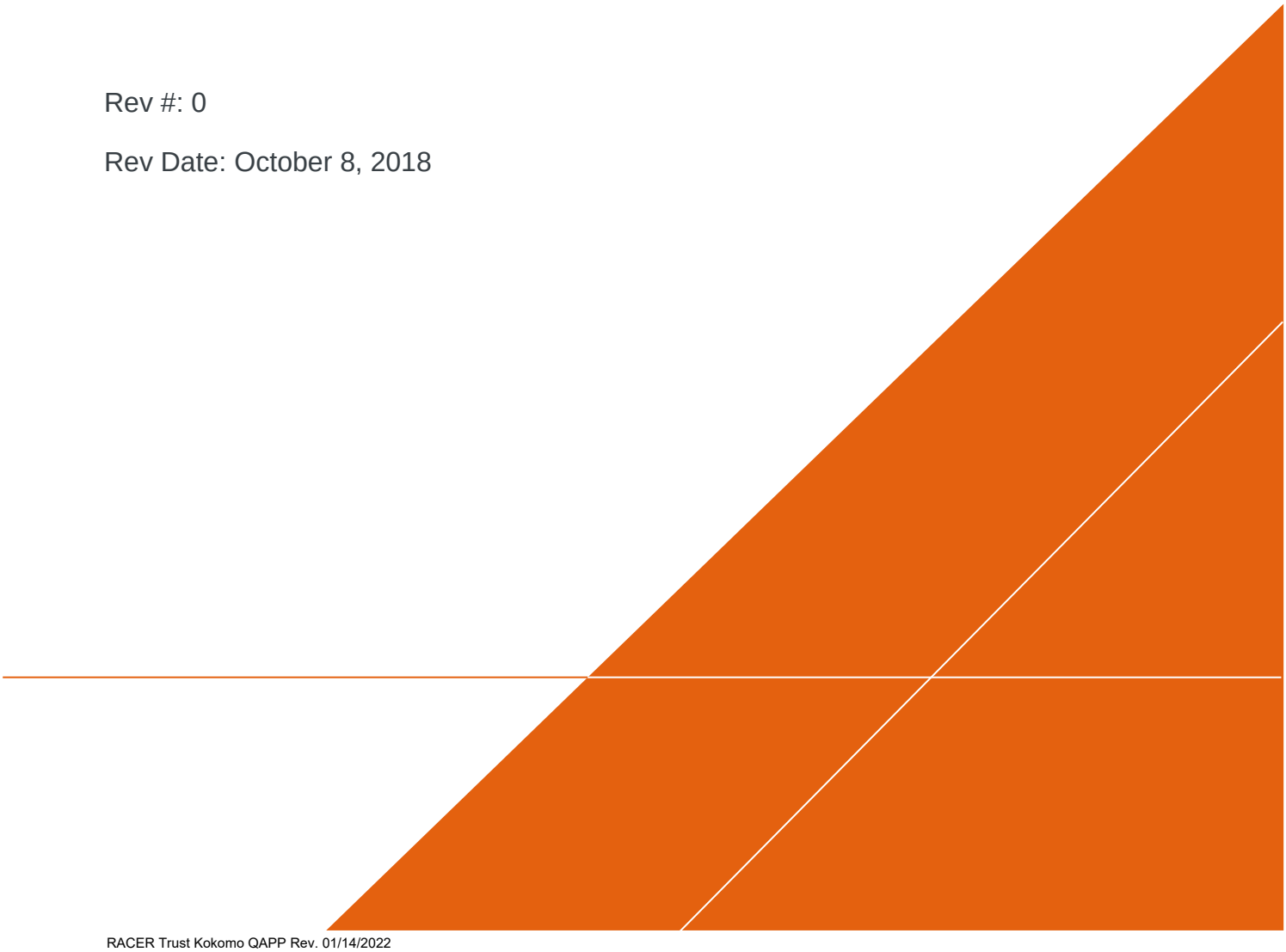
TGI - STANDARD GROUNDWATER SAMPLING FOR MONITORING WELLS

Rev #: 0

Rev Date: October 8, 2018



VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 8, 2018	All	Updated and re-written as a TGI	Marc Killingstad

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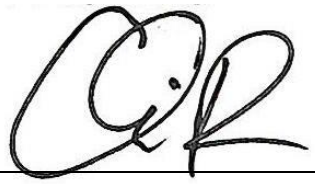
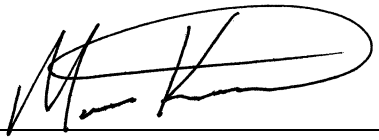
APPROVAL SIGNATURES

Prepared by:  10/08/2018

Christopher Keen Date:

Technical Expert Reviewed by:  10/08/2018

Marc Killingstad (Technical Expert) Date:

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1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes the methods to be used to collect groundwater samples using traditional purging and sampling techniques. For low-flow purging techniques, please refer to the *TGI - Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells*. For no-purge/passive sampling techniques such as passive diffusion bag (PDB), HydraSleeve™ and bailer-grab groundwater sampling please refer to: *TGI – Passive Diffusion Bag Sampling, TGI – Groundwater Sampling with HydraSleeves™*, and *TGI - Bailer-Grab Groundwater Sampling*.

NOTE: *Monitoring wells will not be sampled until the well has been properly developed. Monitoring wells must be appropriately developed after installation and at least one (1) week prior to groundwater sample collection (refer TGI – Monitoring Well Development). Project teams will consider the last time the wells were developed and if additional development may be required to ensure adequate communication with the surrounding formation and collection of representative groundwater samples.*

During precipitation events, groundwater sampling will be discontinued until precipitation ceases or a cover has been erected over the sampling area and monitoring well.

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Both filtered and unfiltered groundwater samples may be collected using this TGI. Filtered samples may be obtained using a 1.0-, 0.45-, or 0.1-micron disposable filter.

3 PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as identified in the site-specific Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed. The HASP will also identify any access control requirements.

Prior to mobilizing to the field, the groundwater sampling team will review and be thoroughly familiar with relevant site-specific documents including but not limited to the task-specific work plan or field implementation plan (FIP)/field sampling plan, Quality Assurance Project Plan (QAPP), HASP, historical information, and other relevant site documents.

Arcadis field sampling personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. Additionally, the groundwater sampling team will review and be thoroughly familiar with documentation provided by equipment manufacturers and become familiar with the operation of (i.e., hands-on experience) all equipment that will be used in the field prior to mobilization.

Ideally, Arcadis personnel directing, supervising, or leading groundwater sample collection activities will have a minimum of one (1) year of previous groundwater sampling experience. Field employees with less than six (6) months of experience will be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

4 EQUIPMENT LIST

The following materials will be available, as required, during groundwater sampling:

- Site-specific HASP and health and safety documents identified in the HASP
- Field Implementation Plan (FIP) that includes site map, well construction records (table or logs), sampling plan (sample analyses, sample volume required, and sample holding time), and prior groundwater sampling records (if available)
- Field notebook and/or smart device (smart phone or tablet)
- Groundwater sampling field forms (**Attachment A**)
- Appropriate personal protective equipment (PPE) (e.g., latex or nitrile gloves, safety glasses, etc.) as specified in the HASP
- Traffic cones, delineators, and caution tape as appropriate for securing the work area as specified in the Traffic Safety Plan (TSP)

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- Photoionization detector (PID), flame ionization detector (FID) or other air monitoring equipment, as needed, in accordance with the HASP
- Dedicated plastic sheeting (e.g., Weatherall Visqueen) or other clean surface to prevent sampling equipment from coming in contact with the ground
- If bailers are to be used in sampling:
    - appropriate number of dedicated bottom-loading, bottom-emptying bailers (i.e., polyvinyl chloride [PVC], polyethylene, Teflon®, or stainless steel)
    - polypropylene or nylon rope
- If submersible pumps are to be used in sampling:
    - appropriate amount of dedicated tubing (polyethylene, Teflon®, Teflon®-lined polyethylene, Tygon®) and other equipment necessary for purging selected in accordance with the FIP/sampling plan/work plan
    - generator or battery for operation of pumps (if required)
    - a pump selected in accordance with the FIP/sampling plan/work plan (parameter-specific [e.g., submersible, bladder, peristaltic])
- Graduated buckets to measure purge water volume
- Electronic water-level indicator (e.g., Solinist Model 101) or oil/water interface probe with 0.01-foot accuracy (oil/water as appropriate, note that sampling will not be performed when sheen or light non-aqueous phase liquid [LNAPL] is present)
- Down-hole multiparameter water-quality sonde (temperature/pH/specific conductivity/oxidation reduction [ORP]/turbidity/dissolved oxygen) meter and flow-through measurement cell; for example:
    - YSI 6-Series Multi-Parameter Instrument
    - Horiba U-22 Multi-Parameter Instrument.
    - Hydrolab Series 3 or Series 4a Multiprobe and Display.
- Groundwater sample containers and labels (supplied by the laboratory) appropriate for the analytical method(s) with preservative, as needed (parameter-specific)
- Filter, as needed, in accordance with the analytical method and parameter, and as specified in the FIP/sampling plan
- Decontamination equipment (buckets, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels)
- Appropriate blanks (trip blank supplied by the laboratory), as specified in the FIP/sampling plan
- Ziploc-type freezer bags for use as ice containers;
- Appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials

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- Chain-of-custody forms
- Digital camera (or phone with camera)
- Keys to wells and contingent bolt cutters for rusted locks and replacement keyed-alike locks
- Drums or other containers appropriate for purge water, as specified by the site investigation-derived waste (IDW) management plan and/or FIP/sampling plan and appropriate drum labels

5 CAUTIONS

Different USEPA regions and/or state regulatory agencies may stipulate deviations from this document. It is the responsibility of the Project Team (Project Manager and Technical Lead) to be fully aware of the requirements from the applicable regulatory framework.

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Avoid extreme weather situations. Be aware that thermal currents and vertical mixing of cold and warm water inside the well casing could create a convection cell within the well and compromise data collection (e.g., biological mechanisms).

- Direct sunlight and hot ambient temperatures may cause the groundwater in the tubing or flow-through-cell to heat up and de-gas. This may result in the loss of volatile organic compounds (VOCs) and dissolved gases. Shade the equipment from direct sunlight, keep the tubing as short as possible, and avoid the hottest times of the day. Store and/or stage empty and full sample containers and coolers out of direct sunlight.
- Sampling during freezing conditions may adversely impact the data quality objectives. USEPA recommends low-flow sampling be conducted at air temperatures above 32°F (0°C) or taking special precautions to prevent groundwater from freezing in the equipment.

It may be necessary to field filter the groundwater for some parameters (e.g., metals) during collection, depending on preservation, analytical method, and project quality objectives. The task-kick-off notes and the FIP/sampling plan will list the samples that require field filtering.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to more impacted based on previous analytical data. If no analytical data are available, samples are to be collected in the following order:

1. First sample the upgradient well(s).
2. Next, sample the well located furthest downgradient of the interpreted or known source.
3. The remaining wells will be progressively sampled in order from downgradient to upgradient, such that the wells closest to the interpreted or known source are sampled last.

When using a gasoline generator, this power source will be set-up at least 30 feet downwind from the well to avoid exhaust fumes to contaminate samples.

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Be careful not to over-tighten lids with Teflon® liners or septa (e.g., 40-mL vials). Over-tightening can cause the glass to shatter and/or impair the integrity of the seal.

NOTE: *Field logs and some forms are considered to be legal documents. All field logs and forms will be filled out in indelible ink. Do not use permanent marker or felt-tipped pens for labels on sample container or sample coolers. Permanent markers could introduce volatile constituents into the samples.*

NOTE: *An Arcadis employee that is appropriately trained at the correct level of internal hazardous materials/DOT (Department of Transportation) shipping must complete an Arcadis shipping determination to address applicable DOT and IATA (International Air Transport Association) shipping requirements. Review the applicable Arcadis procedures and guidance instructions for sample packaging and labeling. Prior to using air transportation, confirm air shipment is acceptable under DOT and IATA regulations.*

6 HEALTH AND SAFETY CONSIDERATIONS

The HASP will be followed, as appropriate, to ensure the safety of field personnel.

Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP.

Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work.

Access to wells may expose field personnel to hazardous materials such as contaminated groundwater or non-aqueous phase liquid (NAPL) (e.g., oil). Other potential hazards include pressurized wells, stinging insects that may inhabit well heads, other biologic hazards (e.g. ticks in long grass/weeds around well head), and potentially the use of sharp cutting tools (scissors, knife)—open well caps slowly and keep face and body away to allow to vent any built-up pressure; only use non-toxic peppermint oil spray for stinging insect nests; review client-specific health and safety requirements, which may preclude the use of fixed/folding-blade knives, and use appropriate hand protection. Overtightening of lids with Teflon® liners can cause the glass to shatter and create a risk for hand injuries.

Generators and cord and plug equipment will employ an overcurrent protection device such as an integrated ground fault circuit interrupter (GFCI) cord. Grundfos pump controllers will not run properly with a GFCI, so the power source will be equipped with other overcurrent protection means.

If thunder or lighting is present, discontinue sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

7 PROCEDURE

The general procedure for using traditional purging and sampling techniques to sample monitoring wells are outlined below:

1. Review equipment list (**Section 4** above) to confirm that the appropriate equipment has been acquired.
2. Don PPE as required in the HASP

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   a. NOTE: *Depending on site-specific security and safety considerations, this often must be done prior to entering the work area*

3. Calibrate field instruments according to manufacturer procedures for calibration and document accordingly on the calibration logs, field form, and/or field logbook
4. All equipment will either be new or decontaminated in accordance with appropriate guidance document (*TGI – Groundwater and Soil Sampling Equipment Decontamination)* prior to use
5. Record site and monitoring well identification on the groundwater sampling log (**Attachment A**), along with date, arrival time, weather conditions, personnel present, equipment utilized, and other relevant data requested on the log.
6. Label all sample containers with indelible ink
7. Place plastic sheeting adjacent to the well for use as a clean work area, if conditions allow, otherwise, exercise care to prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity
8. Visually inspect the well to ensure that it is undamaged, properly labeled and secured
   a. Damage or other conditions that may affect the integrity of the well will be recorded in the Field Activity Daily Log and brought to the attention of the designated Field Manager and/or Project Manager
   b. Record well construction and conditions on the Groundwater Sampling Field Form (**Attachment A**)
9. Remove lock from well and if rusted or broken, replace with a new brass keyed-alike lock
10. Safely open well
    a. Unlock and open the well cover while standing upwind of the well
    b. Remove well cap and place on the plastic sheeting
    c. Insert the PID probe approximately 4 to 6 inches into the casing or the well headspace and cover it with a gloved hand
    d. Record the PID reading on the field log
    e. Perform air monitoring in the breathing zone according to the HASP and/or JSA
11. Set the sampling device, meters, and other sampling equipment on the plastic sheeting
    a. If a dedicated sampling device stored in the well is to be used, this may also be set temporarily on the plastic sheeting
    b. If a dedicated sampling device is stored below the water table, removing it may compromise water-level data, so water-level measurements will be taken prior to removing the device (see next step)
12. Obtain a water-level depth and bottom-of-well depth using an electric well probe prior to placing the pump and record on the groundwater sampling log using indelible ink

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a. Make sure to decontaminate the probe(s) after each use in accord with the FIP/sampling plan or the equipment decontamination TGI

NOTE: *Water levels may be measured at all wells prior to initiating any sampling activities, depending on FIP requirements.*

13. Prepare for pump installation:
    a. For submersible and non-dedicated bladder pumps, decontaminate the pump according to site decontamination procedures
    b. Non-dedicated bladder pumps will require a new bladder and attachment of an air-line, sample discharge line, and safety cable prior to placement in the well
    c. Attach the air-line tubing to the air-port on the top of the bladder pump
    d. Attach the sample discharge tubing to the water port on the top of the bladder pump taking care not to reverse the air and discharge tubing lines during bladder pump setup, as this could result in bladder failure or rupture
    e. Attach and secure a safety cable to the eyebolt on the top of bladder pump (if present, depending on pump model used)
14. Slowly lower the pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well
    a. Avoid twisting and tangling of safety cable, tubing, and electrical lines while lowering the pump into the well; twisted and tangled lines could result in the pump becoming stuck in the well casing
    b. Make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well, as this could lead to well contamination
    c. If a peristaltic pump is being used, slowly lower the sample tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well
    d. The pump intake or sample tubing must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well
15. If using a bladder pump, connect the air-line to the pump controller output port
    a. The pump controller will then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose
    b. Tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon® tape may be used on the threads of the cylinder to provide a tighter seal
    c. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow
    d. Turn on the pump controller power if an on/off switch is present and verify that all batteries are charged and fully operating before beginning to pump

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16. Calculate the number of gallons of water in the well using the length of water column (in feet). Record the well volume on the groundwater sampling log using indelible ink
17. Remove the required purge volume of water from the well (measure purge water volume in measuring buckets)
    a. The required purge volume will be three to five well volumes (the water column in the well screen and casing) unless the well runs dry, in which case, the water that comes into the well will be sampled (USEPA, 1986)
    b. For wells screened across the water table, the well may be pumped dry and sampling can commence as soon as the volume in the well has recovered sufficiently to permit collection of samples
    c. For wells screened entirely below the water table, the well may be pumped until the drawdown is at a level slightly higher than top of the well screen
    d. Sampling may commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples
    e. In any case, the pumping rate will be decreased during sampling to limit the potential for volatilization of organics potentially present in the groundwater
18. Field parameter measurements will be periodically collected in accordance with FIP/sampling plan specifications
    a. Typical time intervals of field parameter measurement are (1) after each well volume removed, and (2) before sampling
    b. If the field parameters are being measured above-ground (rather than with a downhole probe), then the final pre-sampling parameter measurement will be collected at the reduced flow rate to be used during sampling
    c. Physical appearance of the purged water will be noted on the groundwater sampling log
    d. Water-level measurements will be collected and recorded to verify that the well purging is in accordance with the guidelines set forth in the previous step
19. Unless otherwise specified by the applicable regulatory agencies, all purge water will be containerized
    a. Containerized purge water will be managed in accordance with the FIP/sampling plan/work plan
    b. If historical concentrations in the well are less than federal- or state-regulated concentrations appropriate for current land use, *and permission has been granted by the oversight regulatory agency* to dispose of clean purge water on the ground next to the well(s), then purge water may be allowed to infiltrate into the ground surface downgradient from the monitoring well after the well is sampled—*this will be specified in the FIP/sampling plan*

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20. After the appropriate purge volume of groundwater in the well has been removed, or if the well has run dry and allowed to recover, obtain the groundwater sample needed for analysis via the dedicated bailer or from the dedicated sample tubing, pour the groundwater directly from the sampling device into the appropriate container in the order of volatilization sensitivity of the parameters sampled, and tightly screw on the cap (snug, but not too tight)

    NOTE: *The suggested order for sample parameter collection, based on volatilization sensitivity, is presented below:*

    a. *volatile organic compounds (VOCs);*
    b. *semi-volatile organic compounds (SVOCs);*
    c. *polychlorinated biphenyls (PCBs)/pesticides;*
    d. *metals; and*
    e. *wet chemistry*.

    NOTE: *When sampling for volatiles, water samples will be collected directly from the bailer or dedicated tubing into 40-mL vials with Teflon®-lined septa*.

    NOTE: *For other analytical samples, sample containers for each analyte type will be filled in the order specified by the FIP/sampling plan. If a bailer is used, then the sample for dissolved metals and/or filtered PCBs will either be placed directly from the bailer into a pressure filter apparatus or pumped directly from the bailer with a peristaltic pump, through an in-line filter, into the pre-preserved sample bottle. If dedicated sample tubing is used, then the filter will be installed in-line just prior to filtered sample collection.*

    NOTE: *If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Sample filtration for the filtered sample will be performed in the field utilizing a pump prior to preservation. Attach (clamp) a new 1.0-, 0.45-, or 0.1-micron filter to the discharge tubing of the pump (note the filter flow direction). Turn the pump on and allow 100 mL (or manufacturer recommended amount) of fluid to flow through the filter before sample collection. Dispense the filtered liquid directly into the laboratory sample bottles. If bailers are used for purging and sampling, a proper volume of purge water will be placed in a disposable or decontaminated polyethylene container and pumped through the filter and into the sample container using a peristaltic pump.*

21. As samples are collected, note the corresponding time on the sample label
22. Secure sample containers with packing material and maintain at approximately 4°C on wet ice contained in double Ziploc-type freezer bags stored in an insulated, durable transport cooler
23. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump setup.
24. Slowly remove the pump, tubing, lines, and safety cable from the well
    a. If using dedicated tubing/lines, do not allow them to touch the ground or any other surfaces which could result in contamination

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b. If tubing is to be dedicated to a well, it will be folded to a length – without pinching it – that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events

c. Use a length of rope or string to tie the tubing to the well cap

d. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date, they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID and tightly sealed before placing it in storage

25. Record the time sampling procedures were completed on the groundwater sampling field forms using indelible ink

26. Secure the well: replace the well cap and lock well or install a new lock if needed

    a. If new locks were installed, forward copies of the keys to the client Project Manager (PM) and Arcadis CPM at the end of the sampling activities

27. Complete the procedures for chain-of-custody, handling, packing, and shipping

    a. Chain-of-custody forms will be filled out and checked against the labels on the sample containers progressively after each sample is collected

28. Properly dispose of personal protective equipment (PPE) and disposable equipment—place all disposable sampling materials (e.g., plastic sheeting, disposable tubing or bailers, and PPE) in appropriate containers

29. Complete decontamination of sampling equipment (e.g., submersible or bladder pump) as appropriate (*TGI – Groundwater and Soil Sampling Equipment Decontamination*)

30. At the end of each day of the sampling event, perform calibration check of field instruments and record procedure and results in field log

8 WASTE MANAGEMENT

Investigation-Derived Waste (IDW), including purge water, decontamination liquids, and disposable materials (plastic sheeting, PPE, etc.) will be stored on site in appropriately labeled containers (disposable materials will be contained separately) and disposed of properly. Containers must be labeled at the time of collection and will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, PPE). Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that waste containers are properly labeled and documented in the field log book.

9 DATA RECORDING AND MANAGEMENT

Management of the original documents from the field will be completed in accordance with the site-specific QAPP. Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements.

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In general, sampling activities will be documented on appropriate field logs as well as in a proper field notebook. All field data will be recorded in indelible ink. Field forms, logs/notes (including daily field and calibration logs), digital records, and chain-of-custody records will be maintained by the field team lead.

Initial field logs and chain-of-custody records will be transmitted to the Arcadis CPM and/or Technical Lead at the end of each day unless otherwise directed by the CPM. The field team leader retains copies of the field documentation.

Additionally, all documents (and photographs) will be scanned and electronically filed in the appropriate project directory for easy access.

10 QUALITY ASSURANCE

Quality assurance procedures will be conducted in accordance with the Arcadis Quality Management System or the site-specific QAPP.

Field-derived quality assurance blanks will be collected as specified in the FIP/sampling plan, depending on the project quality objectives. Typically, field rinse blanks (equipment blanks) will be collected when non-dedicated equipment (e.g., submersible pump) is used during groundwater sampling. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Trip blanks for VOCs, which aid in the detection of contaminants from other media, sources, or the container itself, will be kept with the coolers and the sample containers throughout the sampling activities and during transport to the laboratory.

In addition to the quality control samples to be collected in accordance with this TGI, the following quality control procedures will be observed in the field:

- Collect samples from monitoring wells, in order of increasing concentration, to the extent known based on review of historical site information if available
- Equipment blanks will include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well)
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled
- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures
    - Calibrate instruments at the beginning of each day and verify the calibration at the end of each day
    - Record all calibration activities in the field notebook
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well following the procedures outlined for equipment decontamination

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11 REFERENCES

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA. 1991. Handbook Ground Water, Volume II: Methodology, Office of Research and Development, Washington, DC. EPA/625/6-90/016b (July 1991).

U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

12 ATTACHMENTS

Attachment 1 – Groundwater Sampling Field Form

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ATTACHMENTS 1

Groundwater Sampling Field Form

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GROUNDWATER SAMPLING FORM

ARCADIS

Project No. _____ Well ID _____ Date _____

Project Name/Location _____ Weather _____

Measuring Pt. Description _____ Screen Setting (ft-bmp) _____ Casing Diameter (in.) _____ Well Material ____ PVC ____ SS

Static Water Level (ft-bmp) _____ Total Depth (ft-bmp) _____ Water Column (ft) _____ Gallons in Well _____

MP Elevation _____ Pump Intake (ft-bmp) _____ Purge Method: _____ Sample Method _____

Pump On/Off _____ Volumes Purged _____ Centrifugal / Submersible / Other _____

Sample Time: Label _____ Gallons Purged _____

Purge Start _____ Replicate/ Code No. _____ Sampled by _____

Purge End _____

Time	Minutes Elapsed	Rate (gpm)/(mL/min) 200mL/min +	Depth to Water (ft) -0.3	Gallons Purged	pH ± 0.1	Cond. (µMhos)/(mS/cm) ± 3%	Turbidity (NTU) ± 10%	DO (mg/L) ± 10%	Temp. (°C)/(°F) ± 3%	Redox (mV) ± 10mV	Appearance	
											Color	Odor
Stabilization Calculations (±)												
Stabilization Criteria					**± 0.1 s.u.**	**±3%**	**± 10% or within 1 NTU (1)**	**± 10%**	**±3%**	**±10 mV**		

(1) **Turbidity** < 50 NTU and ±10% or within 1 NTU of a previous reading when <10 NTU

Constituents Sampled	Container	Number	Preservative

Comments _____

Well Casing Volumes

Gallons/Foot					
	1" = 0.04	1.5" = 0.09	2.5" = 0.26	3.5" = 0.50	6" = 1.47
	1.25" = 0.06	2" = 0.16	3" = 0.37	4" = 0.65	

Well Information

Well Location:		Well Locked at Arrival:	Yes / No
Condition of Well:		Well Locked at Departure:	Yes / No
Well Completion:	Flush Mount / Stick Up	Key Number To Well:	

ARCADIS Design & Consultancy for natural and built assets

TGI - INDOOR OR AMBIENT AIR SAMPLING AND ANALYSIS VIA USEPA METHOD TO-15

Rev #: 1

Rev Date: August 19, 2016

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
1	8/19/2016	All	Updated Rev0	Mitch Wacksman

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APPROVAL SIGNATURES

Prepared by: _____ Date: 8/19/2016

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Reviewed by: _____ Date: 8/19/2016

Mitch Wacksman

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I. INTRODUCTION

This Technical Guidance Instruction (TGI) document describes the procedures to conduct a building survey prior to indoor air sampling.

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what is described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, regulation-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

II. SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) document describes the procedures to collect indoor air or ambient air samples in passivated stainless steel canisters (e.g., SUMMA®) for the analysis of volatile organic compounds (VOCs) using United States Environmental Protection Agency (USEPA) Method TO-15 (TO-15).

III. PERSONNEL QUALIFICATIONS

Arcadis field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and cardiopulmonary resuscitation (CPR), as needed. Arcadis field sampling personnel will be competent in the relevant procedures and possess the required skills and experience necessary to successfully complete the

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desired field work. Arcadis personnel responsible for directing indoor air and/or ambient air sample collection activities must have previous indoor air sampling experience and be able to complete the field work without direct supervision.

IV. EQUIPMENT LIST

The equipment required for indoor air sample collection is presented below:

- 6-liter, stainless steel passivated canisters (e.g., SUMMA®). Request one canister for each sampling location, plus duplicate canisters per project-specific requirements. If feasible, order extra canisters at a rate of 10 to 20% of the total number of sampling canisters (including duplicates).
- Flow controllers with in-line particulate filters and vacuum gauges. Flow controllers are pre-calibrated by the laboratory to the sampling duration [e.g., 8 hours] specified by the project team). Vacuum gauges are also generally supplied by the laboratory.
- Open-end wrench. Typical canister caps require 9/16-inch wrenches.
- Chain-of-custody (COC) form.
- Sample collection log (attached).
- Box, chair, tripod, or similar to hold canister above the ground surface at approximate breathing height (3-5 feet).
- Camera (optional, if photography is permitted at sampling locations).
- Hand-held weather meter (optional)

For abnormal situations (i.e., sumps, crawlspaces with no access, where canisters must be hidden, etc.), Teflon tubing may be used to collect an air sample. In these situations, ¼-inch Swagelok fittings (including nut, front sleeve, and back sleeve) or other methods may be appropriate to affix tubing to canister.

V. CAUTIONS

Care must be taken to minimize the potential for introducing interferences during the sampling event. As such, keep canisters away from heavy pedestrian traffic areas (e.g., main entranceways, walkways), if possible. Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes before and/or during the sampling event.

Specify sample collection duration with the laboratory when ordering equipment, and confirm with the laboratory upon equipment receipt. Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target sample duration and a measurable vacuum (e.g., 5 inches Hg) remains in the canister when sample collection is terminated.

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VI. HEALTH AND SAFETY CONSIDERATIONS

All sampling personnel should review the appropriate health and safety plan (HASP) and job safety analysis (JSA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task.

VII. PROCEDURE

Preparation of Passivated Canister and Collection of Sample

1. Record the following information on the sampling form (use a hand-held weather meter, contact the local airport or other suitable information source [e.g., weatherunderground.com] to obtain the following information):
    - ambient temperature
    - barometric pressure
    - wind speed
    - relative humidity
    - significant recent precipitation
    - snow/ice cover
2. For indoor air sampling, note whether the heating, ventilation, and air conditioning (HVAC) system is operational and record settings.
3. Choose the sampling location in accordance with the project sampling plan. If a breathing zone sample is required, place the canister on a box, chair, tripod, or other similar stand to locate the canister orifice 3 to 5 feet above the ground or floor surface. The canister may be affixed to wall/ceiling support with nylon rope or placed on a stable surface. In general, areas near windows, doors, air supply vents, and/or other potential sources of “drafts” shall be avoided.
4. Record canister serial number and flow controller number on the sampling log and COC form. Assign sample identification (ID), and record on canister ID tag, sample collection log (Attachment A), and COC form.
5. Remove the brass dust cap from the canister with the wrench. Attach the flow controller and vacuum gauge to the canister with the wrench. Tighten with fingers first, then gently with the wrench (roughly a quarter turn). Use caution not to over tighten fittings.
6. Open the canister valve to initiate sample collection. Record the date and local time (24-hour basis) of valve opening on the sample collection log and COC form. Collection of duplicate samples will include collecting two samples side by side at the same time.
7. Check the initial canister pressure using the vacuum gauge. Record the initial pressure in the canister on the sample log and COC form. The initial pressure reading should be evaluated with respect to project-specific and jurisdictional requirements. If the initial pressure registers less

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than -25 inches of Hg, then the canister is not appropriate for use, and another canister should be used.

8. Photograph the canister and surrounding area, if photography is permitted at sampling locations.
9. If feasible, check the canister approximately half-way through the sample duration and note progress on sample logs.

Termination of Sample Collection

1. Arrive at the sampling location at least 1 to 2 hours prior to the end of the sampling interval (e.g., 6 hours following sample initiation for an 8-hour sampling duration).
2. Stop collecting the sample by turning the valve on the canister when the canister pressure reaches approximately -5 inches of Hg or when the desired sample time has elapsed, whichever comes first. Leaving some vacuum in the canister provides a way to evaluate whether the canister leaks before it reaches the laboratory.
3. Record the final canister pressure. Record the date and local time (24-hour basis) of valve closing on the sample collection log and COC form.
4. Remove the flow controller from the canister, re-install brass cap on canister fitting, and tighten with the wrench.
5. Package the canister and flow controller in accordance with Department of Transportation regulations available on the Transportation Health and Safety's Team Site on the Source for return shipment to the laboratory. The canister does not require preservation with ice or refrigeration during shipment.
6. Complete the forms and sample labels provided by the laboratory as directed (e.g., affix card with string).
7. Complete COC form; copy, photograph, or scan a version for the project file (if possible); and place the form in the shipping container. Close the shipping container and affix the custody seal to the container closure. Transmit canisters via courier delivery service (e.g., Federal Express or UPS) to laboratory for analysis.

VIII. WASTE MANAGEMENT

No specific waste management procedures are required.

IX. DATA RECORDING AND MANAGEMENT

Notes will be recorded on the sampling log form (attached), with notations of project name, sample date, sample time, and sample location (e.g., description and GPS coordinates if available) sample start and finish times, canister serial number, flow controller number, initial vacuum reading, and final vacuum reading. Sampling logs and COC records will be transmitted to the Task Manager or Project Manager and stored in the project file consistent with client and project requirements.

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X. QUALITY ASSURANCE

Conduct quality assurance as required by the project-specific work plan and/or Quality Assurance Project Plan (QAPP).

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Attachment 3

Laboratory Standard Operating Procedures

Document Information

Document Number: ENV-SOP-BTRO-0136 **Revision:** 00

Document Title: Dissolved Gas Analysis by Method AM20GAx

Department(s): VOA

Date Information

Effective Date: 29 Jan 2021

Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

Document Number: ENV-SOP-BTRO-0136 **Revision:** 00

Title: Dissolved Gas Analysis by Method AM20GAx

All dates and times are in Central Time Zone.

ENV-SOP-BTRO-0136

ENV-SOP-BTRO-0136 Rev 01 Dissolve Gas Analysis by AM20GAx

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Jacqueline Bendolph (006335)	Manager - Quality	12 Jan 2021, 09:34:36 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Jacqueline Bendolph (006335)	Manager - Quality	12 Jan 2021, 09:35:00 AM	Approved
Russell McNiece (005946)	General Manager 2	12 Jan 2021, 06:30:32 PM	Approved
Sean Reese (005958)	Supervisor	19 Jan 2021, 12:10:01 PM	Approved

ENV-SOP-BTRO-0136

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Jacqueline Bendolph (006335)	Manager - Quality	27 Jan 2021, 03:57:13 PM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Sean Reese (005958)	Supervisor	28 Jan 2021, 10:04:43 AM	Approved
Russell McNiece (005946)	General Manager 2	29 Jan 2021, 10:18:07 AM	Approved

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TEST METHOD STANDARD OPERATING PROCEDURE

TITLE: Dissolved Gas Analysis
METHOD AM20GAx
ISSUER: Pace-ENV-Quality Office-BTRO

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1. Purpose/Identification of Method

Method AM20GAx is used to determine the concentration of biodegradation indicator gases in water and vapor samples.

2. Summary of Method

2.1. A water sample is transferred from a 40 mL vial into a disposable syringe and an analyte -free inert gas is used to create headspace above the water. At equilibrium, the headspace should contain each of the analytes in proportion to the air/water-partitioning coefficient of the analyte. Agitation of the syringe accelerates the onset of equilibrium. Following that agitation, the equilibrated sample gas is ready for analysis or storage.

2.2. The sample gas is analyzed with a gas chromatograph capable of simultaneous analysis of all the target analytes from a single gas sample. A single injection of gas from integral, simultaneously filled sample loops is used to assure consistent injection volume. The uniform sample size achieved using the sample loop assures consistent and accurate results. The permanent gases are analyzed using a thermal conductivity detector (TCD). The light hydrocarbons are analyzed using a flame ionization detector (FID). Hydrogen is analyzed using a reduction gas detector (RGD). The data are transferred to a microcomputer, converted to digital format, stored, and processed using a chromatography data system.

3. Scope and Application

3.1. **Personnel**: This method is recommended for use by, or under the supervision of, analysts experienced in sample preparation, the operation of gas chromatographs and in the interpretation of chromatograms.

3.2. **Parameters:**

Light Hydrocarbons	CAS Number	Permanent Gases	CAS Number
Methane	74-82-8	Carbon Dioxide	124-38-9
Ethane	74-84-0	Oxygen	7782-44-7
Ethene	74-85-1	Nitrogen	7727-37-9
Propane	74-98-6	Methane	74-82-8
Propene	115-07-1	Carbon Monoxide	630-08-0
n-Butane	106-97-8	Hydrogen	1333-74-0
iso-Butane	75-28-5		
Acetylene	74-86-2		

4. Applicable Matrices

4.1. Sample vapor can be provided to the laboratory or generated by the laboratory through three matrices; vapor as directly sampled, headspace vapor generated from an aqueous sample or bubble-strip vapor generated from an aqueous source.

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5. Limits of Detection and Quantitation

5.1. Reporting Limits
The reporting limits for this analysis are listed in Table 5.0 below. Method detection limit studies are run annually in accordance with Standard Operating Procedure for the Determination of Method Detection Limits. MDL studies are also performed when there is reason to suspect that method sensitivity has changed. The MDL studies are kept on file in the Quality Systems Office.

Reporting Limits
Table 5.0

Analyte	Reporting Limit Vapor (units)	Reporting Limit Bubble (units)	Reporting Limit Water (units)
Carbon Monoxide	0.20 %	0.10 mg/L	1.0 mg/L
Carbon Dioxide	0.20 %	2.00 mg/L	5.0 mg/L
Oxygen	0.20 %	0.15 mg/L	0.50 mg/L
Nitrogen	0.50 %	0.40 mg/L	2.0 mg/L
Hydrogen	1.0 ppmv	1.0 nM	10 nM
Acetylene	0.20 ppmv	0.500 µg/L	0.50 µg/L
Methane	1.0 ppmv	0.10 µg/L	5.0 µg/L
Ethane	.10 ppmv	0.010 µg/L	1.0 µg/L
Ethene	.10 ppmv	0.010 µg/L	1.0 µg/L
Propane	0.10 ppmv	0.025 µg/L	0.10 µg/L
Propene	0.20 ppmv	0.025 µg/L	0.10 µg/L
Iso-Butane	0.20 ppmv	0.025 µg/L	0.20 µg/L
n-Butane	0.20 ppmv	0.025 µg/L	0.20 µg/L

6. Interferences

6.1. The most likely source of "interference" is ambient air. Due to the relatively high concentrations of oxygen and nitrogen, a very small amount of air as a contaminant will dramatically affect the results. The collector of samples must take great care and only use the sample containers outlined in this SOP. Also, the analyst must take great care to ensure that the presence of air has been eliminated from any integral step in the analysis process, prior to making injections into the gas chromatograph.

6.2. Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. An unrestricted flow (instrument flush) of pure carrier gas from a 10 psig source should be allowed to flow through each sample loop for a minimum of 2 minutes prior to each analysis. As required, the analyst should demonstrate the absence of carryover contamination by analysis of the contents of the sample loop when purged with carrier gas. This demonstration should

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be performed when carryover contamination is suspected (after high samples). If 'ghost peaks' (peaks like previous sample) appear when a pure carrier gas sample is analyzed (method blank), measures should be taken to eliminate the carryover contamination.

6.3. Another potential contaminant is very low concentrations of methane, ethane and ethene generated in field blanks that are not properly treated in the field. Even “purified” water purchased for field use is likely to have substantial light hydrocarbon or permanent gases concentrations. If field blanks are desired, arrangements should be made with laboratory customer service representatives when the bottle order is placed. These vials must be always treated as samples. That means they must stay on ice in the field.

6.4. The gas matrix for this analysis minimizes the opportunity for matrix effects. If the client suspects possible matrix affect, they should request that matrix spike (MS) and matrix spike duplicate (MSD) analyses be conducted and should supply sufficient sample volume. Since matrix effects are extremely site dependent, the MS and MSD are not part of the regular analytical quality assurance program.

7. Sample Collection, Preservation, Shipment and Storage

7.1. Samples directly collected as a vapor or prepared with the bubble strip technique are shipped and received at a positive pressure, which eliminates a cross-contamination issue during sample shipment. It is preferred that these samples be shipped without cooling, however it is not a sample receipt non-conformance if these samples are packed in ice (sample may experience slight loss in pressure.) These samples are stored in the laboratory at room temperature (23°C±4°). The pressure in the vials is not checked upon receipt in the laboratory because of the inherent risk of losing sample, or inadvertently introducing atmospheric gases, when the septum is pierced. The number of times the septum is pierced should be as few as possible. See Section 11.1 for a discussion on how the laboratory checks vial pressure. Holding time for these samples is fourteen days from the date of collection.

7.2. Water samples should be cooled upon collection and stored at a temperature of just above freezing but below 6°C. Holding time for water samples is 14 days from the date of collection.

- Water samples for light hydrocarbon analyses are collected in 40 mL clear glass VOA vials with zero headspace and preserved with HCL so the resulting pH is < 2. The vials are pre-preserved by an approved vendor.
- All vial types used for sample collection shall be capped with butyl septa.

General Requirements

Matrix	Routine Container	Minimum Sample Amount	Preservation	Holding time
Vapor	22 mL headspace vial w/ butyl septa	22 mL headspace vial	None	14 days after collection
Aqueous	Glass VOA vials	Full VOA Vial (No headspace)	Must be stored at ≤ 6°C (but not frozen). TSP preferred, HCL acceptable.	14 days from collection

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TEST METHOD STANDARD OPERATING PROCEDURE
TITLE: Dissolved Gas Analysis
METHOD AM20GAx
ISSUER: Pace-ENV-Quality Office-BTRO

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8. Definitions

8.1. **Analytical Batch:** A batch consists of twenty or fewer client samples, submitted to the laboratory for analysis.

8.2. **Instrument Flush:** The front end of the sample loop is flushed with ultra high purity helium injected into the loop directly from the cylinder to remove possible interference by ambient air and to avoid cross contamination between samples.

8.3. **Method Blank:** An injection that consists of ultra-high purity helium. The method blank is free from the analytes of interest.

8.4. **Laboratory Control Sample:** A sample of laboratory grade deionized water spiked with verified known amounts of analytes. A LCS is used to assess the performance of the measurement system.

8.5. **Matrix Spike and Matrix Spike Duplicate:** A sample prepared by adding a known concentration of target analyte to a specific amount of sample. Matrix spikes are used to determine the effect of sample matrix on a method's recovery efficiency.

9. Equipment and Supplies (Including Computer Hardware and Software)

Supplies

Item	Vendor	Catalog ID	Description
Syringes	BD Medical	309653	3, 5, 10, 30 and 60-mL or equivalent
Headspace vials	Agilent	9301-0721	22 c Crimp Top headspace vials
23 Gauge stainless steel needles	BD Medical	305145	
Traceable Memory Monitoring Thermometer	Fisher Scientific	0666411	
HPLC Grade Water	RICCA	9150-5	20 L ASTM Water
Crimp Top Caps	FISHER	15-111-628	Silver Headspace Vials

9.1. **Operating Conditions**

Room Temperature: 23°C±4°
Oven Temperature: 200°C (rest/bake-off)
Oven Temperature: 100°C (Isothermal program)
Detector Temperature: Not Applicable (non-programmable)
Injector Temperature: Not Applicable (non-programmable)
Quantification Software: Thermo-Fisher/Dionex Chromeleon

The remaining conditions related to column configuration and ultra-high purity (UHP) gas delivery are unique to each gas chromatograph currently supporting the performance of this SOP and can be made available upon request.

10. Reagents and Standards

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- Ultra-High Purity Gases (Helium, Nitrogen, Hydrogen, and compressed air)
- Certified Commercial Gas Standards
  Commercial Standards used for calibration or other method specific quality control shall be assign dates of expiration according to the following schedule:
- Single Analyte: Neat Gas at +99% purity: 60 months from date received
- Single Analyte: Fixed concentration with balance gas: 36 months from date opened
- Multiple Analytes: Fixed concentrations with balance gas: 24 months from date opened

The light molecular weight gases this analysis measures are known to be particularly stable. If they breakdown the breakdown products will be seen during the use of these standards and any such observation should be reported to the laboratory manager and the standard should not be used unless it is returned to service by the laboratory manager. The expiration date assigned by the vendor is based on different criteria then the laboratory uses, so expiration dates will be assigned according to the above schedule. While an inaccurate standard content would lead to an error in standardization, such an error is more likely to occur from the delivery equipment used to transfer the aliquot from the standard tank to the GC. For this reason, this analysis requires particular emphasis be placed on second source verification of all calibrations. This verification process is an excellent way to monitor the validity of standards and serves as a continual check of the laboratory assigned expiration dates.

Reagents are stored at room temperature (23°C±4°) and all standards are prepared fresh for each use immediately prior to each analysis. Standards are made up from compressed gas cylinders.

10.1. Commercial Standards

Table 10.1.1
Gas and Supply Lecture Bottle Standard
Light Hydrocarbon Mix A/B

Compound	High	Compound	Low
Methane	1000 ppmv	Methane	200 ppmv
Ethane	1000 ppmv	Ethane	200 ppmv
Ethene	1000 ppmv	Ethene	200 ppmv
Propane	1000 ppmv	Propane	200 ppmv
Propene	1000 ppmv	Propene	200 ppmv
iso-Butane	1000 ppmv	iso-Butane	200 ppmv
n-Butane	1000 ppmv	n-Butane	200 ppmv

Table 10.1.2
Gas and Supply Lecture Bottle Standard
Acetylene

Compound	High
Acetylene	1000 ppmv

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Nitrogen	Balance

Table 10.1.3
Gas and Supply Lecture Bottle Standard
Permanent Gas Mix

Compound	High
CO_2	15.0 %
Oxygen	3.96 %
Carbon Monoxide	7.00 %
Nitrogen	Balance
Methane	4.50 %

Table 10.1.4
Gas and Supply Lecture Bottle Standard
Hydrogen

Compound	High
Hydrogen	100 ppmv
Nitrogen	Balance

11. Calibration and Standardization

11.1. Vial Preparation

Headspace vials used for instrument calibration standards for this method are prepared as follows:

- Collect enough vials to complete the calibration procedure.
- Crimp and cap each vial, with stopper type butyl septa.
- Evacuate each vial to vacuum. Attach vials to the vacuum manifold for 10 minutes to achieve evacuation.
- Flush each vial to atmospheric pressure with the balance gas appropriate for the analytes being calibrated. (See Table 11.1)

Table 11.1

Detector	Balance Gas
FID	Nitrogen
TCD	Helium
RGD	Nitrogen

11.2. Preparing Calibration Standards

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Though it may be preferred to prepare all standards or other quality sources with Teflon lined, locking gas tight, glass syringes, it has been the laboratories experience that these syringes are not the most practical for day-to-day operations. Therefore, the laboratory shall use plastic syringes for all day-to-day use measurements' following verification of accuracy and imprecision.

The instrument is initially calibrated (ICAL) using dilutions of custom certified gas mixes. The calibration standards are made up in the following concentrations as specified in Tables 11.2 A, B, C, and D. Due to the nature of preparing custom gas standards, the component concentration can fluctuate between purchased lots. This is accounted for during method/calibration development. The values below are very close approximations.

Calibration standards are prepared by using the procedures below:

- Prepare the correct number of vials for the detector being calibrated.
- Remove the specified amount of standard by extracting it from the standard mix gas cylinder using a syringe and injecting it into a prepared vial.
- Add the specified amount of vial balance gas to the same vial.
- The dilution factor of one is achieved by directly injecting the standard gas mix from the cylinder into the GC.

Table 11.2 A
Light Hydrocarbons by FID
(Methane, Ethane, Ethene, Butane, Propane, Propene and Acetylene)

Stock-1000ppmv Hydrocarbon Mix in Nitrogen from Gas & Supply, or equivalent.
Stock-1000ppmv Acetylene in Nitrogen, Gas & Supply, or equivalent.

Std Level	Conc. (PPMV)	Std	Make-up Gas
Level 8	0.04	2cc (W/S#8)	248cc UHP Nitrogen (w/serum bottle)
Level 7	0.200	2cc (W/S#8)	48cc
Level 6	0.500	4cc (W/S#8)	36cc
Level 5	2.00	2cc (W/S#7)	38cc
Level 4	10.0	10cc (W/S#7)	30cc
Level 3	40.0	2cc (each stock)	46cc
Level 2	125	5cc (each stock)	30cc
Level 1	500	21cc (each stock)	Into an evacuated vial
W/S#7	40.0	8cc (each stock)	184cc (w/160cc serum bottle)
W/S#8	5.00	1cc (each stock)	198cc (w/160cc serum bottle)

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Table 11.2 B
Hydrogen by RGD
Stock-100 PPMV Hydrogen in Nitrogen, Gas & Supply, or equivalent.

Level	Conc.	Std	Make-up Gas
Working Sol #4	2.00	1cc Stock	49cc
Level 1	50.0	21cc Stock	21cc
Level 2	20.0	10cc Stock	40cc
Level 3	10.0	5cc Stock	45cc
Level 4	5.00	2cc Stock	38cc
Level 5	2.00	1cc Stock	49cc
Level 6	0.500	10cc Working Sol #4	30cc
Level 7	0.200	4cc Working Sol #4	36cc

Table 11.2 C
Permanent Gases by TCD
(Oxygen, Carbon Dioxide, Nitrogen, Methane, Carbon Monoxide)
Stock-Multi-component Mix at various conc. In Nitrogen, Gas & Supply, or equivalent.

Level	Std	Make-up Gas
Working Sol #5	1cc Stock	49cc
1	As received from cylinder	0
2	21cc Stock	21cc
3	5.0cc Stock	45cc
4	1.0cc Stock	49cc
5	0.5cc Stock	49.5cc
6	10cc Working Sol #5	40cc

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Table 11.3 A
FID Range 9 Calibration (In µg/L)
Aqueous Solution

Compound	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Methane	121.5	30.3	9.72	2.42	0.486	0.1215	.0486	0.0097
Ethane	235.9	58.9	18.9	4.71	0.943	0.235	.0944	0.0189
Ethene	262.6	65.6	21.0	5.25	1.05	0.262	.1050	0.021
Propane	338.9	84.7	27.1	6.77	1.36	0.339	.1356	0.027
Propene	381.1	95.3	30.5	7.62	1.52	0.381	.1524	0.0305
iso-Butane	422.5	105.6	33.8	8.45	1.69	0.422	.1690	0.0338
n-Butane	437.0	109.3	35.0	8.74	1.75	0.437	.1748	0.0350
Acetylene	740.0	185.0	59.2	14.8	2.96	0.740	.2960	-

- (For T = 298 °C and P = 1.00 atm.)

Table 11.3 B
TCD Range 9 Calibration (In mg/L)
Aqueous Solution

Compound	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Carbon Dioxide	327	163.5	32.7	6.54	3.27	1.308
Oxygen	19.28	9.644	1.928	.3858	.1929	.0772
Nitrogen	280.0	140.0	28.0	5.6	2.8	1.12
Methane	10935	5467.5	1093.5	218.7	109.35	-
Carbon Monoxide	28.88	14.44	2.88	.577	.288	-

- (For T = 298 °C and P = 1.00 atm.)

Table 11.3 C
RGD Range 9 Calibration (In nM)
Aqueous Solution

Compound	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Hydrogen	362.5	232.0	145.0	72.5	29.0	7.25	2.90

- (For T = 298 °C and P = 1.00 atm.)

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Table 11.4
RGD Range 9 Calibration (In nM)
Bubble Strip Matrix

Compound	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Hydrogen	47.5	30.4	19.0	9.0	3.8	.95	.38

- (For T = 298 °C and P = 1.00 atm.)

12. Conversion Factors

12.1. One calibration linear fit curve is built for each detector and its respective analytes. These curves are copied into each matrix calibration table based off the conversion tables to build the tables above (Table 11.3 – 11.4).

12.2. **Vapor**

12.2.1. The instrument is calibrated with this matrix, so no conversion factor is used.

12.3. **Water**

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Table 12.3.1
Conversion Factors

Analyte	Vapor Units	Conversion Factor	Water Units
Carbon Dioxide	% by volume	21.8	mg/L
Carbon Monoxide	% by volume	4.12	mg/L
Oxygen	% by volume	4.81	mg/L
Nitrogen	% by volume	4.03	mg/L
**Methane	% by volume	2430	µg/L
Methane	ppmv	0.243	µg/L
Ethane	ppmv	0.472	µg/L
Ethene	ppmv	0.525	µg/L
Propane	ppmv	0.676	µg/L
Propene	ppmv	0.762	µg/L
i-Butane	ppmv	0.845	µg/L
n-Butane	ppmv	0.874	µg/L
Acetylene	ppmv	1.48	µg/L
Carbon Monoxide	% by volume	0.663	mg/L
Hydrogen	ppmv	14.5	nM*

* nM (nanomoles per liter) is the industry standard unit for hydrogen.
**High level methane is quantified as % volume.

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Bubble Strip

Table 12.4.1 Conversion Factors

Analyte	Vapor Units	Conversion Factor	Water Units
Hydrogen	ppmv	1.90	nM*
Carbon Dioxide	% by volume	37.9	mg/L
Oxygen	% by volume	1.01	mg/L
Nitrogen	% by volume	0.450	mg/L
**Methane	% by volume	556	µg/L
Methane	ppmv	0.0558	µg/L
Ethane	ppmv	0.132	µg/L
Ethene	ppmv	0.334	µg/L
Propane	ppmv	0.170	µg/L
Propene	ppmv	0.482	µg/L
i-Butane	ppmv	0.121	µg/L
n-Butane	ppmv	0.183	µg/L
Acetylene	ppmv	2.70	µg/L
Carbon Monoxide	% by volume	0.663	mg/L
Helium	ppmv	0.00373	µg/L

* nM (nanomoles per liter) is the industry standard unit for hydrogen.
**High level methane is quantified as % volume.

13. Procedure

13.1. Sample Preparation

- Samples that are collected as direct vapors do not require additional preparation.
- Samples that are collected using the Bubble Strip Sampling Technique do not require additional preparation prior to analysis.
- Samples that are collected as waters and are to be analyzed for dissolved gases must be prepared according to 12.2.

13.2. Water Preparation

- Using a clean 50 mL plastic disposable syringe, withdraw a 30 mL volume of water from the bottom of the sample vial.
- Withdraw a 10 mL volume of helium from a reservoir and lock the syringe.
- Shake the syringe by hand (or use a wrist action shaker) for five minutes
- The equilibrated sample is now ready to be analyzed or injected into a vial for storage for analysis later.
  Note: Occasionally a sample will foam upon shaking. Under no circumstances is foam or water to be injected into the GC. Once the bubbles that form during shaking have dispersed, the headspace is ready to be injected. It is only necessary to inject 7-8 mL of headspace into the GC.

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If the foam does not disperse rapidly, the headspace can be injected into an evacuated 22 mL vial that has been filled with 1 atmosphere of helium. The sample can then be held until the foam disperses, once that occurs the sample is ready to be analyzed and reported with appropriate dilution correction.

13.3 Analysis

- If the sample is prepared via syringe, it can be injected from the syringe in which it is prepared by inserting the needle of the syringe through the septum on the "sample in" port. If the sample is a calibration standard, a bubble strip sample (SM9), or a direct vapor, the septum inlet to the "sample in" port of the GC must be removed and a luer-lock needle receptacle is plumbed to the "sample in" port. A needle is attached to the luer-lock receptacle and inserted through the septa of the calibration standard, bubble stripped sample, or direct vapor sample.
- In order to initiate analysis and introduce the sample into the GC sample loop, a needle is attached to the entry port on the GC and inserted through the sample septum. The flow through the sample loop is monitored by a flow meter connected to the sample-loop vent-port on the gas chromatograph. When a vial is sufficiently filled, the ball in the flow meter will shoot to the top of the column. This indicates that there is sufficient pressure in the vial to fill the sample loop. If the loop is not properly pressurized, this is reflected on the flow meter immediately. The ball in the flow meter will go up the column part way and drop back to the bottom. This indicates there is not sufficient pressure in the sample vial. If this happens, the analyst will remove the vial from the inlet port and vent any remaining positive pressure from the vial. The analyst will then add a measured volume of UHP Helium, resulting in dilution. This is then injected into the instrument. The lack of sufficient pressure in the vial and the means of sample injection are then documented on the case narrative.
- Once the flow out of the sample loop ceases (3 seconds) the sample loop valves are activated. Once the sample loop valves have been activated, the ports to and from the sample loop are flushed with ultra-high purity helium injected into the loop directly from the cylinder to remove any interference from ambient air and to avoid cross contamination between samples.
- Once all designated samples and associated quality assurance injections have been made to the GC, the instrument is placed into the "bake-out" configuration. With carrier gas continuously flushing through the GC, the temperature on the oven is manually turned up to 200 degrees Celsius. This assures column integrity for consistent day-to-day operations.

14. Quality Control

14.1. Calibration

Initial calibration is accomplished by analyzing multiple standards of appropriate concentration ranges, as outlined in Section 11.2, for each detector being readied for sample analysis.

Acceptance Criteria: A linear fit to an area response versus concentration plot is formed with the origin forced to zero and the calibration is accepted for use if r^2, the coefficient of determination is ≥ 0.995. If this criterion cannot be met using a linear fit, a quadratic fit can be used. For the quadratic fit, the acceptance criteria are also $r^2 \geq 0.995$.

Corrective Action: If the acceptance criteria specified above is not met, the instrument is examined for a cause and a new set of calibration standards are analyzed.

14.2. Initial Calibration Verification

The ICV is prepared from an alternate source, then that used for the ICAL standards. The concentration of the ICV is in the middle of the calibration range and is close to that of the ICAL

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midpoint, but because of the nature of gas standard it is not at exactly that concentration. The ICV standard follows the initial calibration.

Acceptance Criteria: Acceptance criterion for the ICV is an instrument response within ± 20% drift. Since the instrumentation used routinely monitors the percent recoveries and in this instance percent drift is equal to percent recovery less 100%, the control limits are 80%-120% recovery.
Corrective Action: If the instrument response for the ICV standard is outside the acceptance window of 80-120%, the analyst will not analyze samples until either the reason is determined and the problem is corrected, or a new multi-point calibration is analyzed and an acceptable ICV is run using that calibration.

14.3. Continuing Calibration Verification

The concentration of the CCV is the mid- point of the initial calibration. The CCV is analyzed at the beginning and end of each analytical shift and after every 20 field samples.

Acceptance Criteria: Acceptance criterion for the CCV is an instrument response within ± 20% drift. Since the instrumentation used routinely monitors the percent recoveries and in this instance percent drift is equal to percent recovery less 100%, the control limits are 80%-120% recovery.
Corrective Action: If the CCV fails, a new CCV is prepared and analyzed. If the new CCV falls within the acceptance criterion, analysis continues. If the new CCV fails, the instrument shall be recalibrated, and all samples since the last acceptable calibration verification shall be reanalyzed.

14.4. Laboratory Control Sample (LCS) and LCS Duplicate (LCSD)

14.4.1. Direct Vapor/Bubblestrip/Water Samples:

The LCS and LCSD are prepared at a mid-range concentration. The type of LCS/LCSD depends upon the original matrix of the sample. For samples that arrive as vapors, the LCS/LCSD is injected as a gas. For samples that arrive as waters, DI water is spiked with a gas mixture of target analytes and prepared the same as the samples. Both an LCS and an LCSD are to be run with each analytical batch.

Note: Deionized source water for LCS/LCSD should be “degassed” prior to the addition of the source headspace.

14.5. Method Blank:

A method blank is analyzed with each analytical batch. Water that is free of the principle atmospheric components of nitrogen and oxygen is very difficult to make and similarly difficult to store. Toward that end, the blanks are made up of instrument flush for all of the gases except for blanks for TIC. TIC blanks are made up of deionized water. The acceptance criterion for the blank is the result must be less than the reporting limits for all target compounds. For DoD projects the results for the method blank must be < ½ RL.

Corrective Action: If the blank does not meet the acceptance criterion, another blank is injected. If the second analysis also falls outside acceptance criteria, analysis is halted, and the issue corrected.

14.6. Matrix Spike (MS) and Matrix Spike Duplicate (MSD)

14.6.1. Water Samples:

For water samples, MS and MSDs are prepared, analyzed, and reported when clients’ request and send enough aliquots to prepare them (e.g., one 40 mL vial each for the MS and another for the MSD). The source used for MS/MSD will be based upon the methane concentration of the original field sample being spiked; depending upon the detector used for the methane determination.

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Source water is spiked with a gas mixture of target analytes and prepared the same as the field samples.

15. Data Analysis and Calculations

15.1. The output of the chromatograph is directed to a microcomputer where the signal is converted to digital format, stored, and processed using a chromatography data system.

15.2. Assignment of Retention Time and Windows

Following completion of the calibration injections, each instrument or column in use for the procedure must establish specific retention times and retention time windows for all target analytes being monitored. These shall be set to the calibration according to the following procedures:

Note: The steps outlined are applicable to the Thermo Fisher/Dionex Chromeleon data acquisition software.

15.2.1. Retention Time Windows

Retention time windows must be determined during initial instrument setup, when a new column is installed, when operating conditions are modified, or when major maintenance on the instrument occurs.

For all analytes, a retention time study is performed over a minimum of 72 hours. The standard deviation (SD) is calculated based on this study using at least three determinations, measured to 0.001 minutes. The width of the retention time window is 3 times the SD for each of the analytes. Alternatively, if the calculated SD is less than 0.01 minutes, a default window of +/- 0.03 minutes shall be employed.

The daily retention time window for the analyte is equal to the center of the retention window in the first CCV of the day, +/- 3 times the SD calculated from the retention time study or +/- 0.03 minutes when the default is employed. If an ICAL is analyzed in the batch, use the mid-level calibration standard to set the daily retention time window for the analytical batch.

16. Data Assessment and Acceptance Criteria for Quality Control Measures

16.1. Manual Integrations

16.1.1. See ENV-SOP-CORQ-0006 00 for Manual Integration Policy.

16.2. The analytes of this method are indicators. Every attempt to achieve and deliver precise results is made. However, it is realized that for indicator parameters measuring the range of the analyte concentration (i.e., is the concentration of methane gas >1 mg/L or < 0.1 mg/L) is the primary goal of employing these analyses. The calibration range is chosen to extend over most of the bio-indicator concentration range. If the concentration of an analyte exceeds that of the highest calibration standard, while employing a linear calibration fit, but does not saturate the instrument response, the concentration is calculated by assuming detector response linearity and using an extrapolation of the calibration plot. If the instrument response is saturated or the concentrations are determined from a quadratic calibration fit, the sample is diluted to bring the analyte concentration into the calibration range.

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17. Corrective Actions for Out-of-Control Data

17.1. Not applicable to this SOP.

18. Contingencies for Handling Out-of-Control or Unacceptable Data

18.1. If the requirements set forth in Section 13 are not met, the analytical program will be terminated until the cause is determined and a solution is affected. All samples associated with out-of-control quality control samples (except for matrix interference) must be reanalyzed provided sufficient sample containers have been provided by the client. If quality control acceptance criteria cannot be met using the corrective action above, a detailed check of the analytical system is made. Reagents, standards, and other quality control samples are re-prepared and analyzed. If problems persist, sample analysis will be halted, and the Laboratory Manager shall be contacted immediately to determine the cause and implement corrective action.

Any data submitted with unacceptable quality control sample results shall be qualified in a case narrative. The narrative should indicate the out-of-control event that occurred, the corrective action that was taken, and any other pertinent information to inform the client of exactly what occurred.

19. Method Performance

19.1. Analysts who use this method have been certified for the method by running Initial Demonstration of Proficiency (IDOP) Samples in accordance with Standard Operating Procedure for Administering and Documenting Training in Laboratory Procedures and Instrumentation. IDOPs are run any time there is significant change to an instrument, method, or in the training procedure for training a new analyst.

20. Method Modifications

20.1. Not applicable to this SOP.

21. Instrument/Equipment Maintenance

21.1. Instrument maintenance should be followed as suggested in the manufacturer's operation manual and in the laboratory SOP for Equipment Maintenance.

22. Troubleshooting

22.1. Not applicable to this SOP.

23. Safety

23.1. Safety glasses are required in all laboratory areas. Safety Data Sheets (SDS) for all compounds used in this procedure are available in the laboratory. The major hazard in this laboratory is stick from needles. All needles must be capped when not in use and when moving about the laboratory. The proper way of capping a needle is to place the cap on the laboratory bench and direct

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the needle into the cap. A needle is never to be directed into a cap while the cap is being held. For further information regarding safety issues, please refer to the company Chemical Hygiene Plan.

24. Waste Management

24.1. Unused portions of samples are kept for 30 days following final report generation. The samples are then removed from the laboratory and disposed of according to the SOP for Waste Disposal.

25. Pollution Prevention

25.1. The company wide Chemical Hygiene and Safety Manual contains information on pollution prevention.

26. References

Citing a reference does not imply that all the recommendations and/or requirements in those cited methods is required in this Standard Operating Procedure. This section simply refers to sources that were consulted to gather information or knowledge in order to write an informed technical procedure.

U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Waste. SW-846, 3rd ed., Office of Solid Waste and Emergency Response, Washington, DC. 1986.

Newel, B.S., RSK-SOP-175, Sample Preparation and Calculations for Dissolved Gas Analysis in Water Samples using GC Headspace Equilibration Technique. Revision No. 0, August 1994.

American Society for Testing and Materials, Standard Practice for Analysis of Reformed Gas by Gas Chromatography. Annual Book of ASTM Standards. Vol. 14.02, 1994.

Kampbell, D.H. and Vandegrift, S.A., Analysis of Dissolved Methane, Ethane, and Ethylene in Ground Water by a Standard Gas Chromatographic Technique. Journal of Chromatographic Science. Vol. 36 May 1998.

27. Tables, Diagrams, Flowcharts, and Validation Data

27.1. Not applicable to this SOP.

28. Revisions

Document Number	Reason for Change	Date
Section 14	Redefine sections to include actual calculations	11/16/2016

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TEST METHOD STANDARD OPERATING PROCEDURE
TITLE: Dissolved Gas Analysis
METHOD AM20GAx
ISSUER: Pace-ENV-Quality Office-BTRO

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ENV-SOP-PITTS-0018 Rev00	Removed front cover page and Table of Contents to conform to MC. Added verbiage to Section 6.1 to include importance of using provided containers/preservatives. Added to QC Section 13.3, 13.5 and 13.7, "If second analysis also falls outside acceptance criteria, analysis is halted, and the issue is corrected." Added reference to Equipment Maintenance SOP to Section 20. Added details of linear and quadratic fits to Section 15.2. Updated all SOP references throughout document to account for new numbering system through MC.	4/26/2019
Table 11.2	Changed the Supplier of Standard to Gas & Supply.	11/30/2020
Section 12.2	Added a Section for a Water Preparation Procedure.	11/30/2020
Section 14	Changed Retention Time Window Determination to reflect PACE GC Procedure.	11/30/2020
Section 15.1	Added Reference to PACE GC Manual Integrations SOP QA-010.	11/30/2020
ENV-SOP-PITTS-0018 Rev 00 changed to ENV-SOP-BTRO-0136 Rev 00	Added document number	12/29/2020
Section 7.2	Added more information on sample collection and preservation	12/30/2020
Section 9	Updated the Equipment and supplies information (including Computer Hardware & Software)	12/30/2020
Section 10.1	Added Table 10.1.1 Gas & Supply Lecture Bottle Standard Light Hydrocarbon Mix A/B Table 10.1.2 Gas & Supply Lecture Bottle Standard Acetylene Table 10.1.3 Gas & Supply Lecture Bottle Permanent Gas Mix Table 10.1.4 Gas & Supply Lecture Bottle Standard Hydrogen	12/30/2020
Section 12.4	Added Table 12.4.1 Conversion Factors	12/30/2020
ENV-SOP-BTRO-0136 Rev 00 changed to ENV-SOP-BTRO-0136 Rev 01	Updated Document number	01/08/2020
Section 7.2	Updated the hold time to 14-days from 28-days after a hold time study was conducted to comparing the recoveries over time.	01/08/20

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Document Information

Document Number: ENV-SOP-IND1-0014 **Revision:** 02

Document Title: Chloride

Department(s): Wet Chemistry

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Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

Document Number: ENV-SOP-IND1-0014 **Revision:** 02

Title: Chloride

All dates and times are in Central Time Zone.

ENV-SOP-IND1-0014 Chloride

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	09 Aug 2021, 04:22:42 PM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Steven Sayer (004775)	General Manager 2	10 Aug 2021, 07:30:35 AM	Approved
Sarah Potts (007977)	Manager	10 Aug 2021, 08:04:08 AM	Approved

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STANDARD OPERATING PROCEDURE
TITLE: CHLORIDE
METHOD: SM 4500-Cl^- E (2011)
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the laboratory procedure for the determination of chloride in aqueous samples while meeting the requirements specified in Standard Method 4500-Cl^- E (1997, Editorial Revisions 2011).

1.1 This method is applicable for the measurement of chloride in ground water, surface waters, domestic and industrial wastewaters, and has been modified for the analysis of soil samples.

1.2 The default reporting limit is 1mg/L for aqueous samples and 100mg/kg for solid samples. Refer to the LIMS for method detection limits.

1.3 Reporting limits, control limits, volumes/weights used, standard concentrations, vendors, instrumentation, equipment, and supplies are subject to change.

2.0 SUMMARY OF METHOD

Thiocyanate ion (SCN) is liberated from mercuric thiocyanate through sequestration of mercury by chloride ion to form un-ionized mercuric chloride. In the presence of ferric iron, the liberated SCN forms highly colored ferric thiocyanate in a concentration proportional to the original chloride concentration.

3.0 INTERFERENCES

3.1 Reducing agents such as sulfite and thiosulfate can interfere.

3.2 Color, turbidity, and particulate matter can cause a positive interference. Samples may be filtered to reduce these interferences.

3.3 Halides that complex with the mercury ion (Br, I) may create a positive interference.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

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Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous	125mL in plastic or glass container	None required	None required	Samples must be analyzed within 28 days of collection date.
Solid	50g in plastic or glass container	None required	None required	Samples must be analyzed within 28 days of preparation.

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Description / Comments
Autoanalyzer	Lachat Quikchem 8500 or equivalent equipped with autosampler, flow cell spectrophotometer for use at 480 nm, and data reduction system.
Balance	Ohaus or equivalent, capable of weighing to the nearest 0.1g
Magnetic stirrer	Fisher or equivalent, with Teflon stirring bars.

7.2 Supplies

Supplies	Description
Mechanical pipets	Eppendorf or equivalent, various sizes
Volumetric flasks	Class A, 100mL
Sample Cups	Disposable, 125mL capacity with lids and 50mL capacity, or equivalent

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Supplies	Description
Filter Paper	Whatman P4 or equivalent for filtration of soil samples
0.45um filters	Whatman or equivalent, for filtration of color reagent
Filtration equipment	Vacuum pump, filter funnel, and glass filter flask, for filtration of color reagent
Syringe filters	Environmental Express 0.45um or equivalent
Syringes	10mL disposable
Autosampler tubes	Glass or plastic for use with Lachat autosampler
Plastic beads	Environmental Express or equivalent, for use as a simulated solids matrix.

8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration / Description
Reagent water	ASTM Type II water or equivalent
Color Reagent	Mercuric thiocyanate solution; contains mercuric thiocyanate (0.42%), methanol, ferric nitrate and water. Ricca catalog #1940 or equivalent. Filter through a 0.45um filter prior to use. Expiration date as specified by the manufacturer.

8.2 Standards

Standard Type	Description	Expiration	Storage
Stock Chloride Calibration Standard	Environmental Express catalog #IC-CL-M; 1000ug/mL, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Intermediate Chloride Calibration Standards	Refer to Section 8.3.1	Expires one day from date of preparation.	Ambient
Working Chloride Calibration Standarda	Refer to Section 8.3.2	Expires one day from date of preparation.	Ambient
Stock Chloride ICV/LCS Standard	SPEX catalog #AS-CL9-2Y; 1000mg/L, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working Chloride ICV/LCS Standard	Refer to Section 8.3.3	Expires one day from date of preparation.	Ambient

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8.3 Standard Preparation Procedures

Refer to the standard preparation logbook or database for additional instructions regarding preparation of standards.

8.3.1 Intermediate Chloride Calibration Standards Preparation (for use with auto-dilutor)

100mg/L Chloride: Dilute 5mL of the Stock Chloride Calibration Standard (1000mg/L) to 50mL with reagent water.

200mg/L Chloride: Dilute 20mL of the Stock Chloride Calibration Standard (1000mg/L) to 100mL with reagent water.

8.3.2 Working Chloride Calibration Standard Preparation

Working calibration standards may be manually prepared using the Stock Chloride Calibration Standard (1000mg/L) and must be prepared fresh daily in reagent water. Lower concentration calibration standards may also be prepared by dilution of higher concentration calibration standards. Examples of possible calibration standards are as follows:

Standard	Volume of stock Chloride calib. std.	Final Volume	Final Concentration
CAL0	0mL	100mL	0 mg/L
CAL1	0.1 mL	100mL	1.0 mg/L
CAL2	0.5 mL	100mL	5.0 mg/L
CAL3 (CCVA)	1.0 mL	100mL	10 mg/L
CAL4	2.0 mL	100mL	20 mg/L
CAL5	5.0 mL	100mL	50 mg/L
CAL6 (CCVB)	8.0 mL	100mL	80 mg/L
CAL7	10 mL	100mL	100 mg/L

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Alternatively, calibration standards may be prepared using the instrument autodilution feature. Examples of possible calibration standards prepared using autodilution are as follows, using the 100mg/L Intermediate Standard and the 200mg/L Intermediate Standard:

Standard	Intermediate Standard Concentration	Auto-dilution Factor	Final Concentration
CAL0	reagent water	1	0 mg/L
CAL1	100 mg/L	100	1.0 mg/L
CAL2	100 mg/L	20	5.0 mg/L
CAL3 (CCVA)	100 mg/L	10	10 mg/L
CAL4	200 mg/L	10	20 mg/L
CAL5	200 mg/L	4	50 mg/L
CAL6 (CCVB)	200 mg/L	2.5	80 mg/L
CAL7	100 mg/L	1	100 mg/L

8.3.3 Working Chloride ICV/LCS Standard Preparation

Dilute 0.2 mL of the Stock Chloride ICV Standard (1000 mg/L) to 10mL with reagent water for a standard concentration of 20 mg/L.

9.0 PROCEDURE

9.1 Initial Calibration (ICAL)

9.1.1 Configure the instrument according to manufacturer's instructions. Allow the instrument to warm up.

9.1.2 A minimum of six initial calibration standards is required. The lowest calibration standard must be at or below the reporting limit. A new initial calibration curve is run on each working day.

9.1.3 Initial Calibration Evaluation

9.1.3.1 Non-Linear Calibration: Using the Lachat software, prepare a standard curve by plotting peak area of standard versus concentration. The regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. To be used for quantitative purposes, the coefficient of the determination must be $\geq$ 0.995.

9.1.3.2 Individual analyte calibration levels may be removed from the lowest and/or highest levels of the calibration curve provided the number of remaining calibration points meet the minimum requirements and the quantitation range is adjusted, as necessary.

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9.1.3.3 Evaluate the Relative Error of each calibration point as follows:

$$\% \text{ Relative Error} = \frac{\text{Calculated concentration} - \text{Theoretical concentration}}{\text{Theoretical concentration}} \times 100$$

9.1.3.4 Refer to Section 11.1 for acceptance criteria and corrective actions.

9.1.4 Initial Calibration Verification (ICV)

9.1.4.1 In addition to meeting the linearity requirement, any new calibration curve must be assessed for accuracy in the values generated. To assess the accuracy, a single standard from a secondary source must be analyzed and the results obtained must be compared to the known value of the standard. This step is referred to as Initial Calibration Verification. The ICV is analyzed immediately following an initial calibration curve.

9.1.4.2 The ICV is evaluated by calculating the percent recovery, as follows:

$$\% \text{ Recovery} = \frac{\text{Calculated concentration}}{\text{Theoretical concentration}} \times 100$$

9.1.4.3 Refer to Section 11.1 for acceptance criteria and corrective actions.

9.1.5 Initial Calibration Blank (ICB)

9.1.5.1 The ICB consists of reagent water. An ICB must be analyzed after each ICV. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.2 Continuing Calibration

9.2.1 Continuing Calibration Verification (CCVA and CCVB): The calibration must be verified after every 10 samples and at the end of the analytical sequence by analyzing a CCVA and CCVB. The CCVA and CCVB should be from the same material as the curve standards. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.2.2 Continuing Calibration Blank (CCB): The CCB consists of reagent water. A CCB must be analyzed after each CCVA/CCVB set. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.3 Solid Sample Preparation

9.3.1 Weigh 10.0g-10.5g of sample into a labeled sample cup and add 100mL of reagent water and a stir bar.

9.3.2 Prepare a method blank: weigh 10.0g-10.5g of beads into a sample cup. Add 100mL of reagent water and a stir bar.

9.3.3 Stir all samples and the method blank for 30 minutes. Allow them to settle before filtering through filter paper or a syringe filter.

9.3.4 Prepare an LCS: dilute 0.2mL of Stock Chloride ICV Standard (1000mg/L) to 10mL with the prepared Method Blank extract for a spike concentration of 200mg/kg.

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9.3.5 Prepare a Matrix Spike: dilute 0.2mL of Stock Chloride ICV Standard (1000mg/L) to 10mL with prepared solid sample extract for a spike concentration of 200mg/kg.

9.3.6 Proceed to Section 9.5.

9.4 Aqueous Sample Preparation

9.4.1 Filter any aqueous samples that contain suspended solids through filter paper or syringe filters. Alternatively, samples can be centrifuged. If filtration is necessary, the associated Method Blank and LCS must also be filtered.

9.4.2 Prepare aqueous batch QC:

9.4.2.1 Prepare a Method Blank by placing 10mL of reagent water into a labeled disposable beaker.

9.4.2.2 Prepare an LCS by bringing 0.2mL of Stock Chloride ICV Standard (1000mg/L) to 10mL with reagent water for a spike concentration of 20mg/L.

9.4.2.3 Prepare a Matrix Spike by bringing 0.2mL of Stock Chloride ICV Standard (1000mg/L) to 10mL with aqueous sample for a spike concentration of 20mg/L.

9.4.3 Proceed to Section 9.5.

9.5 Sample Analysis

9.5.1 Configure the instrument according to manufacturer's instructions. Allow the colorimeter and recorder to warm up. Run a baseline with all reagents, using reagent water to flush the tubing. Whenever new tubing is used, allow ample time to flush residual compounds from the tubing.

9.5.2 Establish initial calibration as described in Section 9.1.

9.5.3 Once initial calibration is established, analyze 10mL portions of each sample, Method Blank, LCS and Matrix Spike. An example sequence may be as follows:

Initial calibration standards
ICV
ICB
Method blank
LCS
Client samples
CCVA
CCVB
CCB
Client samples
CCVA
CCVB
CCB

9.5.4 Sample concentrations that exceed the highest calibration standard must be diluted and reanalyzed or reported as an estimated concentration.

9.5.5 When analysis is complete, flush all lines with reagent water, then air. Turn off pump and Lachat and release all tubing clamps.

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TITLE: CHLORIDE
METHOD: SM 4500-Cl^- E (2011)
ISSUER: Pace ENV – Indianapolis – IND1

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10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Calculations

10.1.1 Calculate the final concentration in the sample as follows:

Water Sample (mg/L) = $(X_s)(D)$

Soil Sample (mg/kg) = $\frac{(X_s)(V_f)(D)}{(W_s)}$

Where: X_s = Chloride concentration from instrument in mg/L
V_f = Final sample volume in Liters
D = Dilution factor of water sample or soil extract (final volume / initial volume)
W_s = Weight of solid sample extracted in kilograms

Moisture corrected concentration = $\frac{\text{(Final concentration as received)}}{\text{(100 - \%Moisture)}} \times 100$

10.1.2 LCS calculation:

$$R = (C / S) \times 100$$

Where: R = Percent Recovery
C = Observed LCS concentration
S = True LCS concentration

10.1.3 MS calculation:

$$R = \frac{(C_s - C)}{S} \times 100$$

Where: R = Percent Recovery
C_s = Observed MS concentration
C = Sample concentration
S = True spike concentration

10.1.4 RPD calculation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} \times 100$$

Where: RPD = Relative Percent Difference
D_1 = First Sample Result
D_2 = Second Sample Result

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Instrument Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration (ICAL)	Applicable target analyte	Daily	r ≥ 0.995 **Relative error:** Lowest curve point: +/- 50% All other curve points: +/- 10%	Analyze a new initial calibration curve. If the second curve does not meet the acceptance criteria, the analyst must consult the department manager. Instrument maintenance and/or preparation of new calibration standards must be considered. Samples associated with a failed initial calibration must be reanalyzed.
Initial Calibration Verification Standard (ICV)	Second Source Standard	Immediately following initial calibration	90-110% Recovery	Analyze another aliquot of the ICV. If the second ICV also exceeds the acceptance range, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICV must be reanalyzed. *Exception:* If the ICV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Initial Calibration Blank (ICB)	Reagent water	Immediately following each ICV	Target analyte must be less than reporting limit.	Reanalyze ICB. If target compound is still > RL in blank and associated samples, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICB must be reanalyzed. *Exception:* If a contaminant is present only in the blank and not the samples, no action is required.
Continuing Calibration Standard (CCVA and CCVB)	Applicable target analyte	After every 10 samples, and at end of run.	90-110% Recovery	Analyze another aliquot of the CCVA and/or CCVB that failed. If the response still fails the acceptance criteria, then a new initial calibration must be prepared and analyzed. Samples associated with a failed CCVA or CCVB must be reanalyzed. *Exception:* If the CCVA or CCVB is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Continuing Calibration Blank (CCB)	Reagent water	Immediately following each CCVA/CCVB.	Target analyte must be less than reporting limit.	Reanalyze CCB. If target compound is still > RL in blank and associated samples, a new initial calibration must be prepared and analyzed. Samples associated with a failed CCB must be reanalyzed. *Exceptions:* 1) If a contaminant is present only in the blank and not the samples, no action is required.

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11.2 Batch Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water or simulated soil matrix	One per preparation batch of up to 20 samples, per matrix.	Target analyte must be less than RL.	Reanalyze method blank. If method blank is still >RL, reanalyze associated samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 2) If a contaminant is present only in the method blank and not the samples, no action is required. 3) If the method blank concentration is less than 1/10 of the amount measured in the sample, corrective action is not required, affected data must be qualified.
Laboratory Control Standard (LCS)	Applicable target analyte	One per preparation batch of up to 20 samples, per matrix.	90-110% Recovery	Reanalyze LCS. If LCS is still outside acceptance criteria, reanalyze associated samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported LCS and samples must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified. 3) Batch may be acceptable based on matrix spike passing LCS criteria, with management approval.
Matrix Spike/ Matrix Spike Duplicate (MS/MSD)	Applicable target analyte	One MS/MSD set per batch plus an additional MS if >10 samples in the batch.	90-110% Recovery ≤20% RPD	No corrective action necessary. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.

11.3 Method Performance

11.3.1 Method Validation

Refer to the SOP for Method Validation and Instrument Verification for the procedures used for initial method validation. Method Detection Limits (MDL) must be determined per the procedure in 40CFR Part 136, Appendix B.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must

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document acceptable accuracy and precision by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

The analyst must perform primary review of data and calculated results for accuracy. Secondary review of the data and calculated results must be performed by another qualified analyst, the department supervisor, or the Quality Manager prior to release for reporting. Refer to the SOP for Data Review Process for more information.

12.2 Corrective Action

Corrective action is expected any time QC is not within acceptance criteria, when sample results exceed the calibration range, and when carryover is suspected. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Refer to Section 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

14.0 MODIFICATIONS

14.1 Method adapted for analysis of solid samples.

14.2 Certified stock standards and color reagent are purchased instead of being prepared in the lab.

15.0 RESPONSIBILITIES

Pace employees that perform any part of this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

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16.0 ATTACHMENTS

Not applicable to this SOP.

17.0 REFERENCES

17.1 Standard Methods for the Examination of Water and Wastewater; Method 4500-Cl⁻ E (1997, Editorial Revisions 2011).

17.2 Lachat method 10-117-07-1-B (2007).

17.3 Pace Analytical Quality Manual; latest revision.

17.4 NELAC/TNI Standards; Quality Systems section; 2003, 2009, and 2016.

18.0 REVISION HISTORY

This Version:

Section	Description of Change
All	Converted to new SOP format.
1.0	Updated method reference.
1.1	Removed saline water as an applicable matrix.
7.2	Updated supplies.
8.1	Updated preparation of color reagent.
8.2	Updated standards.
8.3	Updated standard preparation.
9.1	Added measurement of relative error.
9.3	Updated weight of sample used.
11.1	Added measurement of relative error and updated corrective actions.
17.0	Updated method reference and added reference to 2016 TNI Standard.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0014	Chloride	01

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Document Title: ICP Metals (6010)

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Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

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Title: ICP Metals (6010)

All dates and times are in Central Time Zone.

ENV-SOP-IND1-0025 ICP Metals (6010)

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Quality Manager	15 Oct 2019, 03:23:02 PM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Felicia Walker (005354)	Manager - Lab Services	15 Oct 2019, 04:19:43 PM	Approved
Steven Sayer (004775)	General Manager	16 Oct 2019, 07:24:58 AM	Approved

1. Purpose

1.1 The purpose of this SOP is to provide a laboratory specific procedure for determining the concentration of metals in aqueous and solid environmental samples while meeting the requirements specified in SW-846 method 6010B.

2. Summary of Method

2.1. Prior to analysis, samples must be solubilized or digested using appropriate sample preparation methods. When analyzing groundwater samples for dissolved constituents, acid digestion is not necessary if the samples are filtered and acid preserved prior to analysis.

2.2. This method describes multielement determinations by Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES). The instrument measures characteristic emission spectra by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the emission lines are monitored by photosensitive devices.

2.3. Background correction may be required to compensate for spectral interferences. Background is measured adjacent to analyte lines at a wavelength selected to be free of spectral interference and which reflects the same change in background intensity as occurs at the wavelength measured. Background correction is not required in cases of line broadening where a correction would actually degrade the analytical result.

3. Scope and Application

3.1. This method is applicable to the determination of most trace elements, including metals, in solution.

3.2. Reporting limits, control limits, volumes/weights used, standard concentrations, vendors, instrumentation, equipment and supplies are subject to change.

3.3. This procedure is restricted to use by, or under the supervision of, analysts experienced in the use of ICP systems and interpretation of ICP data. Each analyst must demonstrate the capability to generate acceptable results with this method to be considered qualified to report sample results.

4. Applicable Matrices

4.1. This method is applicable to groundwater, surface water, wastewater, extract, leachate, soil, sediment, sludge and other solid samples.

5. Limits of Detection and Quantitation

5.1. Refer to Table 1 for the list of metals and reporting limits. Refer to the LIMS for method detection limits.

6. Interferences

6.1. **Spectral interferences:** Overlap of emission lines from another element, unresolved overlap of molecular band spectra, background contribution from continuous or recombination phenomena and stray light can contribute to spectral interferences. These interferences can typically be minimized by careful selection of quantitation wavelengths, inter-element corrections, and background correction.

6.2. **Physical interferences:** Changes in sample viscosity, surface tension, or other effects associated with sample transport and nebulization can produce significant inaccuracies, especially in samples containing high concentrations of dissolved solids and acids. Dissolved solids may build up on the nebulizer tip, altering the sample flow rate and causing instrument drift. These effects can be minimized by sample

dilution or use of a specially designed high-solids nebulizer.

6.3. High Salt Concentrations: high salt concentrations in sample digestates can cause signal suppression and confuse interference tests.

6.4. Chemical interferences: Molecular compound formation, ionization effects, and solute vaporization effects are typically not significant with ICP determinations. If observed, they can be minimized by careful selection of plasma and spectrometer operating parameters.

6.5. Memory interferences: Sample deposition on the nebulizer tubing, spray chamber, and plasma torch can cause apparent sample carryover. Memory interferences can be minimized by flushing the system with rinse blanks between samples. If memory interference is suspected for a sample, the sample must be re-analyzed after a sufficient rinse period.

7. Sample Collection, Preservation, and Handling

Table 7.1 – Sample Collection, Preservation, Storage and Hold time.

Sample type	Collection per sample	Preservation	Storage	Hold time
Aqueous - Total	250mL in plastic container	- HNO_3 to pH of <2 - Samples received at pH>2 must be preserved to pH<2 with HNO_3 and equilibrate for 24 hours before being prepared for analysis. Record date/time of preservation in preservation logbook.	Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.
Aqueous - Dissolved	250mL in plastic container	- Filter; HNO_3 to pH<2	Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.
Solid	50 grams in glass or plastic container	- No chemical preservation	Ambient or Cool to ≤6°C	Must be analyzed within 6 months of the collection date.

Samples must be stored separately from all standards, reagents, and highly contaminated samples. To avoid contamination, no food or drink products can be located near samples.

8. Definitions

8.1. Refer to the Pace Quality Assurance Manual (QAM) for a comprehensive list of terms and definitions.

9. Equipment and Supplies

9.1. Equipment/Instrumentation

Equipment	Vendor	Description / Comments
ICP-AES	Thermo-Fisher iCAP6500 or equivalent	Equipped with and autosampler and data system

9.2. General Supplies

Item	Vendor	Description
Volumetric Flasks	Class A	Various capacities
Volumetric Pipettors	Eppendorf or equivalent	Various sizes
Autosampler Vials	Environmental Express or equivalent	
Analytical Balance	Ohaus or eqivalent	Capable of weighing to 0.01g
Graduated Cylinders	Class A	Various capacities
pH strips	Fisher or equivalent	Full range

10. Reagents and Standards

10.1. Reagents

Reagent	Concentration/ Description
Reagent water	ASTM Type II
Argon	High purity, liquefied
Nitric acid	Concentrated, trace metal analyzed or equivalent
Hydrochloric acid	Concentrated, trace metal analyzed or equivalent

10.2. Analytical Standards

10.2.1. Definitions

Standards are required for initial calibration, calibration verification, and for preparing LCS, MS, and MSD samples.

Table 10.2 Standard Definitions

Standard	Description	Comments
Initial Calibration Standards	Standards prepared at varying levels to determine calibration range of the instrument.	ICAL
Initial Calibration Verification Standard	A standard prepared from a source other than that used for the initial calibration. This standard verifies the accuracy of the calibration curve.	ICV
Continuing Calibration Verification Standard	A calibration standard prepared at mid-level concentration for all target compounds. This standard is used to verify the initial calibration.	CCV
Spiking Standard	This solution contains the target analytes and is used to spike MS/MSD sets.	Same solution can be used for the LCS and MS/MSD
Internal Standard	A solution added to all standards, samples, spikes, control samples, and method blanks prior to analysis. This standard is used to adjust response ratios to account for instrument drift.	Yttrium
Interference Check Standards	Prepared to contain a known amount of interfering elements that will provide an accurate test of the interelement correction factors. If the ICP will display overcorrection as a negative number, the additional spiking with interfered elements is not necessary.	ICSA (ICSAB for BP Samples only)

10.2.2. Storage Conditions

Table 10.3 – Analytical Standard Storage Conditions

Standard Type	Description	Expiration	Storage
Stock Calibration Standards	SPEX; catalog #'s MIXSTD1-100; MIXSTD2-100; MIXSTD3-100; MIXSTD4-100; MIXSTD5-100; PLS19-2Y; CLSN2-2Y; CLTI9-2Y; PLLI2-2Y; PLP9-3Y; CLAG2-2Y; PLSR2-2Y or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working Calibration Standards	Refer to Section 10.2.3.2	Must be prepared fresh weekly	Same as stock standards
Stock ICV Standard	Inorganic Ventures; catalog #s PA-STD-1B; PA-STD-2B; PA-STD-3B or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working ICV Standard	Refer to Section 10.2.3.4	Must be prepared fresh weekly	Same as stock standard
Working Second Source Spiking Solution	Refer to Section 10.2.3.5	Expires 6 months from date of preparation.	Same as stock standard

Standard Type	Description	Expiration	Storage
Stock Interference Check Standard A	SPEX; catalog # INT-A1 or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working Interference Check Standard A (ICSA)	Refer to Section 10.2.3.6	Must be prepared fresh weekly	Same as stock standards
Stock Interference Check Standard AB	SPEX; catalog #INT-A1, XFSMN-26-250A (mix 1B), XFSMN-27-250A (mix 2B), or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working Interference Check Standard AB (ICSAB)	Refer to Section 10.2.3.8	Must be prepared fresh weekly	Same as stock standards
Stock CRDL standards	SPEX individual standards for each element; 1000 or 10,000 mg/L, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Intermediate CRDL Standard	Refer to Section 10.2.3.11	Expires 6 months from date of preparation.	Same as stock standards
Working CRDL standard	Refer to Section 10.2.3.12	Must be prepared fresh weekly	Same as stock standards
Stock Internal Standard	SPEX; catalog # PLY2-2X; 1000mg/L yttrium or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working Internal Standard	Refer to Section 10.2.3.13	Must be prepared fresh weekly	Same as stock standards

10.2.3. Standard Preparation Procedures

10.2.3.1. Stock Calibration Standard Details

The following table shows the seven stock standard mixes that may be used to prepare the initial calibration and calibration check standards:

Analyte	Concentration (mg/L)
Catalog # MIXSTD1-100	
Lead	500
Selenium	200
Cadmium	150
Zinc	150
Manganese	100
Beryllium	50
Catalog # MIXSTD2-100 + strontium PLSR2-2Y	
Iron	10,000
Barium	100
Cobalt	100
Copper	100
Vanadium	100
Strontium	100
Catalog # MIXSTD3-100 + silicon PLSI9-2Y	
Arsenic	500
Molybdenum	100
Silicon	100
Catalog #MIXSTD4-100	
Calcium	1000
Potassium	400

Catalog #MIXSTD4-100 Cont'd	
Aluminum	200
Sodium	200
Chromium	20
Nickel	20
Catalog #MIXSTD5-100	
Magnesium	1000
Antimony	200
Thallium	200
Boron	100
Silver	50
Mix #6(combines: CLSN2-2Y; CLTI9-2Y, PLLI2-2Y, PLP9-3Y)	
Lithium	1000
Phosphorus	10,000
Tin	1000
Titanium	1000
Mix #7- Catalog #CLAG2-2Y	
Silver	1000

10.2.3.2. Working Calibration Standards Preparation

Prepared fresh weekly and diluted from the stock standard mixes listed above, using a reagent water mixture that is 5% nitric acid and 2% hydrochloric acid unless otherwise noted.

Working Std. ID	Stock Standard	Vol. of Stock Std.	Final Volume
Calibration Std. Mix 1	MIXSTD1-100	2mL	100mL
Calibration Std. Mix 2	MIXSTD2-100 Strontium PLSR2-2Y	1mL 0.1mL	100mL
Calibration Std. Mix 3	MIXSTD3-100 Silicon PLSI9-2Y	2mL 0.8mL	100mL
Calibration Std. Mix 4	MIXSTD4-100	5mL	100mL
Calibration Std. Mix 5	MIXSTD5-100	2mL	100mL
Calibration Std. Mix 6	Lithium PLLI-2Y Phosphorus PLP9-3Y Tin CLSN2-2Y Titanium PLTI9-2Y	1mL 0.1mL 1mL 1mL	100mL
Calibration Std. Mix 7	Silver CLAG2-2Y	0.2mL	100mL in 10% HCl solution

10.2.3.3. Stock ICV Standard Details

The following table shows the concentrations of the stock standards purchased from Inorganic Ventures as three mixes:

Analyte	Concentration (mg/L)
Inorganic Ventures PA-STD1B / SPEX XFSMN-26-250A	
Arsenic	200/100
Barium	200/100
Beryllium	200/100
Cadmium	200/100
Cobalt	200/100
Chromium	200/100
Copper	200/100
Manganese	200/100

Inorganic Ventures PA-STD1B Cont'd	
Nickel	200/100
Phosphorus	200/100
Lead	200/100
Selenium	200/100
Thallium	200/100
Lithium	200/100
Strontium	200/100
Vanadium	200/100
Zinc	200/100
Inorganic Ventures PA-STD2B / SPEX XFSMN-27-250A	
Silicon	1000/500
Boron	200/100
Molybdenum	200/100
Antimony	200/100
Tin	200/100
Titanium	200/100
Zirconium	200/100
Silver	100/50
Inorganic Ventures PA-STD3B / SPEX XFSMN-28-250A	
Aluminum	2000/1000
Calcium	2000/1000
Iron	2000/1000
Potassium	2000/1000
Magnesium	2000/1000
Sodium	2000/1000

10.2.3.4. Working ICV Standard Preparation

Add 0.5mL of each Stock ICV Standard mix to a 100mL volumetric flask and dilute to volume with a reagent water solution that is 5% nitric acid and 2% hydrochloric acid. If using SPEX stock standards, add 1.0 mL of each mix.

10.2.3.5. Working Second Source Spiking Solution

Add 25.0 mL of each Stock ICV Standard mix to a 100 mL volumetric flask and dilute to volume with reagent water solution that is 2% nitric acid.

10.2.3.6. Stock Interference Check Standard A (ICSA) Details

SPEX Interference Check Standard A (ICSA), mg/L	
Aluminum	5000
Calcium	5000
Magnesium	5000
Iron	2000

10.2.3.7. Working Interference Check Standard A (ICSA) Preparation

Dilute 10mL of the Stock ICSA Standard to 100mL with a reagent water solution that is 5% nitric acid and 2% hydrochloric acid.

10.2.3.8. Stock Interference Check Standard AB (ICSAB) Details

SPEX INT-A1	
Al, Ca, Mg	5000
Fe	2000
SPEX XFSMN-26-250A (Mix 1B)	
As, Ba, Be, B, Cd, Co, Cr, Cu, Mn, Ni, Pb, Se, Tl, V, Zn, Li, P	100
SPEX XFSMN-27-250A (Mix 2B)	
Mo, Sb, Sn, Ti, B	100
Ag	50
Si	500

10.2.3.9. Working Interference Check Standard AB (ICSAB) Preparation

Dilute 10mL of the stock INT-A1 standard and 0.5mLof the stock Mix 1B and Mix 2B to 100mL with a reagent water solution that is 5% nitric acid and 2% hydrochloric acid.

10.2.3.10. Stock CRDL Standards Detail

When specified by client or program requirements, a low-level check standard, also known as a CRDL standard, must be analyzed prior to sample analysis and at the end of each analytical batch to bracket the client samples. Acceptance limits for all target elements is 50-150% recovery. The Stock CRDL standards are as follows:

Element	Conc. (ug/mL)	SPEX Catalog #	Element	Conc. (ug/mL)	SPEX Catalog #
Aluminum	1000	CLAL2-2Y	Manganese	1000	CLMN2-2Y
Antimony	1000	CLSB7-2Y	Molybdenum	1000	CLMO9-2Y
Arsenic	1000	CLAS2-2Y	Nickel	1000	CLNI2-2Y
Barium	1000	CLBA2-2Y	Phosphorus	10,000	PLP9-3Y
Beryllium	1000	CLBE2-2Y	Potassium	10,000	PLK2-3Y
Boron	1000	PLB9-2Y	Selenium	1000	CLSE2-2Y
Cadmium	1000	CLCD2-2Y	Silicon	1000	PLSI9-2Y
Calcium	10,000	PLCA2-3Y	Silver	1000	CLAG2-2Y
Chromium	1000	CLCR2-2Y	Sodium	10,000	PLNA2-3Y
Cobalt	1000	PLCO2-2Y	Strontium	1000	PLSR2-2Y
Copper	1000	CLCU2-2Y	Thallium	1000	CLTL2-2Y
Iron	10,000	PLFE2-3Y	Tin	1000	CLSN2-2Y
Lead	1000	CLPB2-2Y	Titanium	1000	CLTI9-2Y
Lithium	1000	PLLI2-2Y	Vanadium	1000	CLV2-2Y
Magnesium	10,000	PLMG2-3Y	Zinc	1000	CLZN2-2Y

10.2.3.11. Intermediate CRDL Standard Preparation

Dilute the following volumes of the stock CRDL standards to 50mL with a reagent water solution that is 2% nitric acid:

Element	Volume (mL)	Final Conc. (mg/L)	Element	Volume (mL)	Final Conc. (mg/L)
Aluminum	2.5	50	Manganese	0.125	2.5
Antimony	0.075	1.5	Molybdenum	0.125	2.5
Arsenic	0.125	2.5	Nickel	0.125	2.5
Barium	0.125	2.5	Phosphorus	1.25	250
Beryllium	0.05	1	Potassium	1.25	250
Boron	1.25	25	Selenium	0.125	2.5
Cadmium	0.025	0.5	Silicon	2.5	50
Calcium	1.25	250	Silver	0.125	2.5
Chromium	0.125	2.5	Sodium	1.25	250
Cobalt	0.125	2.5	Strontium	0.125	2.5
Copper	0.125	2.5	Thallium	0.125	2.5
Iron	0.125	25	Tin	0.125	2.5
Lead	0.125	2.5	Titanium	0.125	2.5
Lithium	0.25	5	Vanadium	0.125	2.5
Magnesium	1.25	250	Zinc	0.25	5

10.2.3.12. Working CRDL Standard Preparation

Dilute 1mL of the Intermediate CRDL Standard to 250mL with a reagent water solution that is 5% nitric acid and 2% hydrochloric acid. Final concentrations are shown below.

Element	Final Conc. (ug/L)	Element	Final Conc. (ug/L)
Aluminum	200	Manganese	10
Antimony	6	Molybdenum	10
Arsenic	10	Nickel	10
Barium	10	Phosphorus	1000
Beryllium	4	Potassium	1000
Boron	100	Selenium	10
Cadmium	2	Silicon	200
Calcium	1000	Silver	10
Chromium	10	Sodium	1000
Cobalt	10	Strontium	10
Copper	10	Thallium	10
Iron	100	Tin	10
Lead	10	Titanium	10
Lithium	20	Vanadium	10
Magnesium	1000	Zinc	20

10.2.3.13. Working Internal Standard Preparation

Dilute 5mL of yttrium stock standard (1000mg/L) to 1L with a reagent water solution that is 2% nitric acid for a final concentration of 5mg/L.

11. Calibration

11.1. Initial Calibration: Calibrate the ICP each working day according to the instrument manufacturer's recommended procedures. Flush the system with the Calibration Blank solution prepared by acidifying reagent water to the same concentrations of the acids found in the standards and samples. The calibration curve must consist of a minimum of a calibration blank and a standard.

11.2. Linear Calibration: Using the instrumentation software, prepare a standard curve for each element by plotting absorbance versus concentration. The analyst may employ a regression equation that does not pass through the origin. If a multi-point calibration is performed, the regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. In order to be used for quantitative purposes, the correlation coefficient must be ≥ 0.995.

11.3. Initial Calibration Corrective Action: If the curve does not meet the acceptance criteria, then a new calibration curve must be analyzed. If the second curve attempt does not meet the acceptance criteria, the analyst must consult the department manager and instrument maintenance and/or preparation of new standards must be considered. Samples associated with a failed initial calibration must be reanalyzed.

11.4. Initial Calibration Verification (ICV): In addition to meeting the linearity requirement, any new calibration curve must be assessed for accuracy in the values generated. To assess the accuracy, a single standard from a secondary source must be analyzed and the results obtained must be compared to the known value of the standard. This step is referred to as Initial Calibration Verification. The ICV is analyzed immediately following an initial calibration curve. Acceptable recovery range for the ICV is 90-110% and the RSD of replicate readings must be <5%.

11.5. ICV Corrective Action: If the ICV is not acceptable, another ICV may be analyzed. If the second ICV fails, then a new initial calibration curve must be analyzed. Instrument maintenance and/or preparation of new standards must also be considered. Samples associated with a failed ICV must be reanalyzed. **Exception:** If the ICV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.

11.6. Initial Calibration Blank (ICB): The ICB consists of a reagent water solution that is 5% HNO_3 and 2% HCl. An ICB must be analyzed immediately following the ICV. If the ICB result is above the reporting limit, another ICB may be analyzed. If the second ICB fails, then a new initial calibration curve must be analyzed. Samples associated with a failed ICB must be reanalyzed. **Exception:** If the ICB is >RL, associated samples determined to be <RL are reportable. **If required by client or program, the ICB must be evaluated as follows: If the ICB result exceeds ½ the RL, the ICB is considered to be unacceptable. Only samples determined to be <RL are reportable. If the absolute value of a negative concentration exceeds twice the established MDL, the ICB is considered to be unacceptable. Samples associated with a failed ICB must be re-analyzed unless the concentration of the target analyte is greater than 10 times the absolute value of the ICB result.**

11.7. Continuing Calibration Verification (CCV): A CCV must be analyzed after every 10 samples and at the end of the analytical batch to verify the system is still calibrated. The acceptable recovery range for the CCV is 90-110% and the RSD of replicate readings must be <5%.

11.8. CCV Corrective Action: If a CCV fails the acceptance criteria, another CCV may be analyzed. If the second CCV fails, then a new initial calibration curve must be analyzed. Samples must be bracketed by acceptable CCVs in order to be reportable. Samples associated with a failed CCV must be reanalyzed. **Exception:** If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL are reportable.

11.9. Contract Required Detection Limit (CRDL) Standard: A CRDL standard must be analyzed with each analytical run, at a minimum, after calibration. Acceptance limits for all target elements is 50-150% recovery. If required by client or program, another CRDL standard must be analyzed after samples – not to exceed 8 hours between CRDL analyses.

11.10. CRDL Corrective Action: Samples associated with a failed CRDL must be re-analyzed unless the concentration of the target has failed high, then the associated samples determined to be <RL are reportable.

11.11. Interference Check Standard A (ICSA): An ICSA must be analyzed at the beginning of each analytical run. ICSA must be 80-120% of the true value for the elements in the mix. Non-ICSA elements must be within +/-2x the reporting limit.

11.12. ICSA Corrective Action: If the ICSA fails the acceptance criteria, another ICSA may be analyzed. If the second ICSA fails, then a new calibration curve must be analyzed. Instrument maintenance and/or preparation of new standards must also be considered. Samples associated with a failed ICSA must be reanalyzed. **Exception:** If the ICSA is >120% for any element in the mix or if any non-ICSA element is >2x the reporting limit, indicating high bias, associated samples determined to be <RL are reportable.

11.13. Interference Check Standard AB (ICSAB): If required by client or program an ICSAB must be analyzed at the beginning of each analytical run. ICSAB must be 80-120% of the true value for the elements in the mix.

11.14. ICSAB Corrective Action: If an ICSAB is required by client or program and the ICSAB fails the acceptance criteria, another ICSAB may be analyzed. If the second ICSAB fails, then a new calibration curve must be analyzed. Instrument maintenance and/or preparation of new standards must also be considered. Samples associated with a failed ICSAB must be reanalyzed. **Exception:** If the ICSAB is >120% for any element in the mix, indicating high bias, associated samples determined to be <RL are reportable.

11.15. Continuing Calibration Blank (CCB): The CCB consists of a reagent water solution that is 5% HNO_3 and 2% HCl. A CCB must be analyzed after every 10 samples following the CCV. If the CCB result is above the reporting limit, another CCB may be analyzed. If the second CCB fails, then a new calibration curve must be analyzed. Samples associated with a failed CCB must be reanalyzed. **Exception**: If the CCB is >RL, associated samples determined to be <RL are reportable. **If required by client or program, the CCB must be evaluated as follows: If the CCB result exceeds ½ the RL, the CCB is considered to be unacceptable. Only samples determined to be <RL are reportable. If the absolute value of a negative concentration exceeds twice the established MDL, the CCB is considered to be unacceptable. Samples associated with a failed CCB must be re-analyzed unless the concentration of the target analyte is greater than 10 times the absolute value of the CCB result.**

12. Procedure

12.1. Before using this procedure to analyze samples, there must be data available documenting initial demonstration of performance. The required data document the selection criteria of background correction points; analytical dynamic ranges; the applicable equations, and the upper limits of those ranges; the method and instrument detection limits; and the determination and verification of interelement correction equations or other routines for correcting spectral interferences. This data must be generated using the same instrument, operating conditions and calibration routine to be used for sample analysis.

12.2. Configure the ICP per manufacturer's instructions and allow it to become thermally stable.

12.3. Approximately 10mL portions of each standard, Method Blank, LCS, sample and MS/MSD are poured into autosampler tubes for analysis.

12.4. Establish initial calibration as described in Section 11.

12.5. Once initial calibration is established, analyze each sample, Method Blank, LCS and MS/MSD. An example sequence may be as follows:

Initial calibration blank
Mix 1
Mix 2
Mix 3
Mix 4
Mix 5
Mix 6
Mix 7
ICV
ICB
CRDL
ICSA
ICSAB (if required)
Method blank
LCS
Client samples
CCV
CCB
Client samples
CCV
CCB
CRDL (if required)
ICSA (if required)
ICSAB (if required)

12.6. The instrument performs two replicate readings for each analysis and the average of the two readings is used to derive the concentration. For samples, the difference between the two readings must be ≤20% RSD for values that are >4x the reporting limit. If the RSD is >20% for values that are >4x the reporting limit, the sample must be reanalyzed.

12.7. Samples with analyte concentrations above the upper linear range must be diluted and reanalyzed or the over range results must be qualified as estimated.

13. Quality Control

13.1. Batch Quality Control

Table 13.1 – Batch Quality Control Criteria

QA Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water or boiling chips	One per preparation batch of up to 20 samples, per matrix.	Target analyte must be less than reporting limits	Reanalyze method blank. Re-digest and reanalyze if target compound is still >RL in method blank and associated samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 2) If a contaminant is present only in the method blank and not the samples, no action is required. 3) If sample concentration is >10x blank level, sample and method blank may be reported, but sample must be qualified. (Not for VAP)
Laboratory Control Sample (LCS)	Applicable target analyte	One per preparation batch of up to 20 samples, per matrix.	80-120% Recovery	Reanalyze LCS. If LCS is still outside acceptance limits, re-prepare and reanalyze all associated samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported data must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified. 3) If the batch's associated MS or MSD recovery falls within LCS acceptance limits, associated samples may be reported. The LCS data must be qualified. (Not applicable to OH VAP projects)
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)	Applicable target analyte	One MS/MSD set per preparation batch of up to 20 samples, per matrix.	75-125% Recovery ≤20% RPD	No corrective actions necessary. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.
Internal Standard	Yttrium	Automatically added to each sample, blank, and standard as part of the analysis.	No acceptance criteria – used to monitor interferences. 60-140%	No corrective action required. Sample may be analyzed at a dilution if interference is indicated.

14. Data Analysis and Calculations

14.1. Calculate sample concentrations using the following equation:

$$\text{Aqueous Sample (ug/L)} = \frac{(X_s)(V_f)(D)}{(V_i)} \qquad \text{Solid Sample (ug/kg)} = \frac{(X_s)(V_f)(D)}{(W_i)}$$

Where: X_s = Element concentration, ug/L
V_f = Final volume of digestate, L
D = Dilution factor
V_i = Initial volume of aqueous sample digested, L
W_i = Initial weight of solid sample digested, kg

$$\text{Moisture corrected concentration} = \frac{\text{(Final concentration as received)}}{(100 - \%\text{Moisture})} \times 100$$

14.2. LCS equation:

$$\mathbf{R = (C/S) * 100}$$

Where R = percent recovery
C = spiked LCS concentration
S = concentration of analyte added to the clean matrix

14.3. MS/MSD equation:

$$\mathbf{R = \frac{(Cs - C)}{S} * 100}$$

Where R = percent recovery
Cs = spiked sample concentration
C = sample concentration
S = concentration of analyte added to the sample

14.4. RPD equation:

$$\mathbf{RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} * 100}$$

Where RPD = relative percent difference
D_1 = first sample result
D_2 = second sample result

15. Data Assessment and Acceptance Criteria for Quality Control Measures

15.1. Refer to Sections 11 and 13.

16. Corrective Actions for Out-of-Control Data

16.1. Refer to Sections 11 and 13.

17. Contingencies for Handling Out-of-Control or Unacceptable Data

17.1. Refer to Sections 11 and 13.

18. Method Performance

18.1. **Method Detection Limit (MDL) Study**: An MDL study must be conducted per 40 CFR Part 136, Appendix B.

18.2. **Demonstration of Capability (DOC)**: Every analyst who performs this method must first document acceptable accuracy and precision by passing a demonstration of capability study (DOC).

18.3. **Linear Dynamic Range Study**: A linear dynamic range study must be conducted for each element by analyzing increasing concentrations of at least three, preferably five different concentration standards across the range. One of these should be near the upper limit of the range. The upper range limit should be an observed signal no more than 10% below the level extrapolated from lower standards. Samples determined to be above the upper range limit must be diluted and reanalyzed. New dynamic ranges should be determined whenever there is a significant change in instrument response. For those analytes that periodically approach the upper limit, the range should be checked every six months. Refer to Section 7.2.5.4 of Method 6010B for more information.

18.4. **Interelement Correction Factors** must be verified and updated every 6 months or when an instrumentation change occurs. Refer to Section 3.1 of Method 6010B for more information.

18.5. **Post-Digestion Spike Addition:** An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within 75% to 125% of the known value. The spike addition should produce a minimum level of 10 times and a maximum of 100 times the instrument detection limit. If the spike is not recovered within the specified limits, a matrix effect should be suspected.

18.6. **Dilution test:** If the analyte concentration is sufficiently high, minimally, a factor of 10 above the instrument detection limit after dilution, an analysis of a 1:5 dilution should agree within +/-10% of the original determination. If not, a chemical or physical interference effect should be suspected.

19. Method Modifications

19.1. Mixed standard solutions are purchased as certified standards.

19.2. Instrument conditions may vary from those stated in the method.

19.3. Calibration blanks are evaluated to the reporting limit and not to three times the IDL.

20. Instrument/Equipment Maintenance

20.1. Refer to instrument maintenance logs and/or manufacturer's instructions.

21. Troubleshooting

21.1. Refer to instrument maintenance logs and/or manufacturer's instructions.

22. Safety

22.1. **Standards and Reagents**: The toxicity and carcinogenicity of standards and reagents used in this method have not been fully defined. Each chemical compound should be treated as a potential health hazard. Reduce exposure by the use of gloves, lab coats and safety glasses. Material Safety Data Sheets (SDSs) are on file in the laboratory and available to all personnel. Standard solutions should be prepared in a hood whenever possible. The stock metals standards are toxic and must be handled with extreme care. Also handle concentrated acids with care, making sure to wear appropriate personal protective

equipment.

22.2. **Samples**: Take precautions when handling samples. Samples must always be treated as potentially hazardous "unknowns". The use of personal protective equipment such as gloves**,** lab coats and safety glasses is required when handling samples. In the event a sample container must be opened, it is recommended to perform this in a hood whenever possible. All digestions must be conducted under a fume hood.

22.3. **Equipment**: Portions of the preparation and analytical equipment operate at high temperatures. Care must be taken to minimize accidents and injuries when working on or with this equipment. Equipment should be turned off or the temperatures lowered to reduce the risk of thermal burns. Allow adequate time for the equipment to cool prior to working on equipment.

23. Waste Management

23.1. Procedures for handling waste generated during this analysis are addressed in Waste Handling or other applicable SOP. All wastes are accumulated, managed and disposed of in accordance with all federal and state laws and regulations.

24. Pollution Prevention

24.1. In order to minimize the amount of waste generated during this procedure, analyst should prepare reagents in an amount which may be used in a reasonable amount of time (i.e. before a reagent expires).

24.2. The company wide Chemical Hygiene and Safety Manual contains additional information on pollution prevention.

25. References

25.1. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", EPA SW-846, latest revision, Method 6010B.

25.2. Pace Analytical Quality Manual; latest revision.

25.3. TNI Standard; Quality Systems section; 2003 and 2009.

26. Tables, Diagrams, Flowcharts, Attachments, Appendices, etc.

26.1. Table 1: Target Metals and Default Reporting Limits

26.2. Table 2: Target Metals Wavelengths

27. Revisions

Document Number	Reason for Change	Date
S-IN-I-019-rev.10	1. Section 3.1: added reference to MDLs. 2. Table 9.2: removed reference to Profiling Standard 3. Table 9.3: removed reference to Profiling Standard 4. Section 9.2.3: removed reference to Profiling Standard 5. Section 9.2.3.2: changed to a tabular format 6. Section 10: removed reference to Profiling Standard. 7. Section 11.9: added language that over range results can be reported if qualified as estimated. 8. Table 12.1: revised method blank corrective action. 9. Inserted new Method Modifications section.	19Sep2012
S-IN-M-019-rev.11	1. Converted SOP to Corporate 27-section format. 2. Cover page: changed phone number, changed effective date format and revised document control format. 3. Table 7.1: added requirement to record date/time of preservation. 4. Table 10.3: updated standard sources and added Li and P. 5. Section 10.2.3: updated standard preparation. 6. Section 11: removed linear regression equation, made CRDL a requirement for each analytical batch, and removed BP requirements and replaced with "If required by client or program." 7. Table 1: updated RLs and added Li, Sr, and P.	18Dec2015
S-IN-M-019-rev.12	1. Table 7.1: updated storage temperature format. 2. Table 10.3: update standard IDs. 3. Section 10.2.3: updated standard preparation to match current procedures. 4. Section 11.7: removed "immediately following ICB" language. 5. Section 12.5: updated example sequence order. 6. Table 13.1: updated corrective action for method blank and LCS. 7. Section 14.1: updated equation to be in like terms with instrument output. 8. Section 18: moved PDS and SD from Section 13 to Section 18. 9. Section 25.3: added years 2003 and 2009 to TNI reference. 10. Section 26.1: updated title of Table 1. 11. Table 1: added "Default" to the title and added "subject to change" footnote.	27Dec2017
ENV-SOP-IND1-0025-rev.01	1. Removed cover page, table of contents, and headers for use in Master Control. 2. Section 18.1: update MDL procedure reference. 3. Section 26: added Table 2 for wavelengths. 4. Attachments: added Table 2 for wavelengths.	15Oct2019

Table 1: Target Metals and Default Reporting Limits[1]

Metals	Aqueous (µg/L)	Solid (mg/kg)
Aluminum - Al	200	50
Antimony - Sb	6	1
Arsenic - As	10	1
Barium - Ba	10	1
Beryllium - Be	4	0.5
Boron - B	100	5
Cadmium - Cd	2	0.5
Calcium - Ca	1000	50
Chromium - Cr	10	1
Cobalt - Co	10	1
Copper - Cu	10	1
Iron – Fe	100	50
Lead – Pb	10	1
Lithium – Li	20	5
Magnesium – Mg	1000	50
Manganese – Mn	10	1
Molybdenum - Mo	10	1
Nickel – Ni	10	1
Phosphorus – P	N/A	50
Potassium - K	1000	50
Selenium - Se	10	1
Silver – Ag	10	0.5
Sodium – Na	1000	50
Strontium – Sr	10	1
Thallium - Tl	10	1
Tin – Sn	10	5
Titanium - Ti	10	1
Vanadium - V	10	1
Zinc – Zn	20	1

[1]**Subject to change**

Table 2: Target Metals Wavelengths[1]

Element	Wavelength
Aluminum - Al	308.215
Antimony - Sb	206.833
Arsenic - As	189.042
Barium - Ba	455.403
Beryllium - Be	313.042
Boron - B	249.678
Cadmium - Cd	228.802
Calcium - Ca	315.887
Chromium - Cr	267.716
Cobalt - Co	228.616
Copper - Cu	324.754
Iron – Fe	271.441
Lead – Pb	220.353
Magnesium – Mg	279.079
Manganese – Mn	257.610
Molybdenum - Mo	202.030
Nickel – Ni	231.604
Phosphorus – P	177.495
Potassium - K	766.490
Selenium - Se	196.090
Silicon – Si	288.158
Silver – Ag	328.068
Sodium – Na	589.592
Strontium - Sr	407.771
Thallium - Tl	190.856
Tin – Sn	189.989
Titanium - Ti	337.280
Vanadium - V	292.464
Zinc – Zn	206.200

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QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Quality Manager	01 Feb 2019, 08:29:51 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Steven Sayer (004775)	General Manager	01 Feb 2019, 08:33:46 AM	Approved
Rachel Wrede (008235)	Manager - Lab Services	01 Feb 2019, 09:51:33 AM	Approved

1. Purpose

1.1. This Standard Operating Procedure (SOP) documents the procedures used by Pace Analytical Services – Indianapolis to determine the concentration of Volatile Organic Compounds (VOCs) in environmental samples. The laboratory utilizes purge-and-trap GC/MS and bases these documented procedures on those listed in SW-846 Method 8260C, 5030A, 5030B, and 5035A.

2. Summary of Method

2.1. Volatile organic compounds are introduced into the gas chromatograph by a purge-and trap method. The analytes are purged from a sample aliquot or extract using an inert gas. The purged analytes are collected on an absorbent trap. At the completion of the purge time, the trap is rapidly heated and back flushed to drive out the trapped analytes. The analytes are transferred into the inlet of a capillary gas chromatography column. The carrier gas flow through the column is controlled and the temperature is increased according to a set program to achieve optimum separation of purged analytes. The mass spectrometer is operated in a repetitive scan mode. Analytes are identified by the GC/MS retention times and by a comparison of their mass spectra with spectra of authentic standards. Analytes are quantified by comparing the response of a selected primary ion relative to an internal standard against a calibration curve.

3. Scope and Application

3.1. This method is applicable to most organic compounds that have boiling points below 200 ºC and are insoluble or slightly soluble in water. Volatile water-soluble compounds may also be determined although quantitation limits are typically higher due to their hydrophilic properties (e.g. ketones, oxygenates).

3.2. Reporting limits, control limits, volumes/weights used, standard concentrations, vendors, instrumentation, equipment and supplies are subject to change.

3.3. This procedure is restricted to use by, or under the supervision of, analysts experienced in the use of purge-and-trap GC/MS systems and interpretation of GC/MS data. Each analyst must demonstrate the capability to generate acceptable results with this method to be considered qualified to report sample results.

4. Applicable Matrices

4.1. This method is applicable to most water and solid samples, regardless of moisture content. Matrices are groundwater, surface water, soil, sediment and waste. Procedures may need to be adapted to address limitations in the method or equipment that might hinder or interfere with sample analysis.

5. Limits of Detection and Quantitation

5.1. The list of target compounds and reporting limits is found in Table 1. Refer to the LIMS for method detection limits.

6. Interferences

6.1. Major contaminant sources are volatile materials in the laboratory and impurities in the inert purging gas and in the absorbent trap. Many common solvents, most notably acetone and methylene chloride, are frequently found in laboratory air at low levels. The use of polytetrafluoroethylene (PTFE, Teflon) as thread sealants, tubing, or in flow controllers is highly recommended since other materials can be sources of contamination which may concentrate in the trap during the purging.

6.2. A common source of interfering contamination is carryover. This may occur when a sample containing low concentrations of volatile organic compounds is analyzed immediately after a sample containing high concentrations of volatile organic compounds. The preventive action to this condition is rinsing the purging apparatus and sample syringes with organic free water between samples. Analyze one or more blanks to check for contamination prior to sample analysis. If the sample immediately following the high concentration sample does not contain the compounds present in the high level sample, freedom from carryover contamination has been established.

6.3. Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal of the sample container into the sample during shipment and storage. A trip blank prepared from organic-free reagent water and carried through the sampling, handling, and storage protocols can serve as a check on such contamination.

6.4. Since methylene chloride and acetone are common laboratory solvents, special precautions must be taken. The volatiles analysis and sample storage area must be located as far as possible from areas where these solvents are used or stored. Where possible, the volatiles analysis and sample storage area should be served by a separate HVAC system and maintained under positive pressure to prevent intrusion of contaminants. Laboratory clothing previously exposed to methylene chloride fumes during extraction procedures can contribute to sample contamination.

7. Sample Collection, Preservation, and Handling

Table 7.1 – Sample Collection, Preservation, Storage and Hold time.

Sample type	Collection per sample	Preservation	Storage	Hold time
5030B Aqueous	Minimum (3) VOA vials Additional sample is required if MS/MSD is requested	Acidified w/ 1:1 HCl to pH<2, no headspace	Cool to ≤6°C	pH>2: Analysis must be completed within 7 days of collection date. pH <2: Analysis must be completed within 14 days of collection date. (pH determined post analysis)
5035A Solid Terra Core Kits (Preferred)	One (1) 2-4 oz. wide mouth jar for % moisture **AND** Two (2) 5-g portions in vials with magnetic stir bar and 5.0mL reagent water plus one (1) 5 g portion in a vial with 5.0mL methanol. Additional sample is required if MS/MSD is requested.	Either no preservative or Methanol as a preservative.	Cool to ≤6°C for no more than 48 hours from collection then freeze at -7°C to -20°C. Methanol vials may be stored at 0° to 6°C.	Analysis must be completed within 48 hours if samples are not frozen or preserved with methanol prior to the expiration of the 48 hour period. The holding time may be extended to 14 days if the sample is frozen or preserved with methanol prior to the expiration of the 48 hour period.
5035A Solid Coring Devices (Alternate)	One (1) 2-4 oz. wide mouth jar for % moisture **AND** Two (2) EnCore, TerraCore or similar sampling tubes. Additional sample is required if MS/MSD is requested.	No preservative Sample is extruded into a vial with a magnetic stir bar and 5.0mL reagent water.	Freeze at -7°C to -20°C within 48 hours of collection.	Analysis must be completed within 14 days of collection date.
5030A Solid Bulk Jars	One (1) 2-4 oz. wide mouth jar for % moisture **AND** One bulk sample jar, usually 4 oz. or 8oz.	No preservative Sample is weighed into a vial with a magnetic stir bar and 5.0mL reagent water.	Cool to ≤6°C	Analysis must be completed within 14 days of collection date.

Samples must be stored separately from all standards, reagents, and highly contaminated samples. To avoid contamination, no food or drink products can be located near samples.

8. Definitions

8.1. Refer to the Pace Quality Assurance Manual (QAM) for a comprehensive list of terms and definitions.

9. Equipment and Supplies

9.1. Instrumentation

Equipment	Vendor	Model / Version	Description / Comments
Gas Chromatographs	Agilent	Lab uses models 6850 and 6890	Or equivalent system
P&T Concentrators	EST Analytical, Tekmar, OI	Tekmar 3000 series, Encon, Encon Evolution, and 4660 Eclipse	Or equivalent system
Data Systems	Agilent	Chemstation	Or equivalent system
Autosamplers	EST Analytical	EST 8100, Centurion, Centurion WS, 4551	Or equivalent system
Mass Spectrometers	Agilent	5973 and 5975	Or equivalent system

9.2. Chromatography Supplies

Item	Vendor	Model / ID	Description
Analytical Columns	Agilent	J&W Scientific DB-624	20m x 0.18mm x 1um or equivalent
Trap	Supelco	Trap K and OI #10	Or equivalent

9.3. General Supplies

Item	Description	Vendor/ Item # / Description
Gas tight syringes	Various sizes	Hamilton or equivalent
Syringe valves	2-way with Luer ends	Supelco or equivalent
Standard vials	stop/go vials, various sizes	Supelco or equivalent
Balance, Analytical/Top Load	Able to measure to nearest 0.001g/0.01g	Mettler, OHaus or equivalent
Sample vials	40mL vials; pre-cleaned	Eagle Picher, QEC, or equivalent

10. Reagents and Standards

10.1. Reagents

Reagent	Concentration/ Description
Reagent water	ASTM Type II water
Methanol	Purge-and trap grade or equivalent
Sand	Or equivalent material to be used as a simulated soil matrix.

10.2. Analytical Standards

10.2.1. Definitions

Standards are required for initial calibration, calibration verification, and for preparing LCS, MS, and MSD sample

Table 10.1 Standard Definitions

Standard	Description	Comments
Tune Standard	4-Bromofluorobenzene (BFB) solution used to verify ion response ratios prior to analysis	Must inject between 5 and 50ng
Initial Calibration Standards	Standards prepared at varying levels to determine response and retention characteristics of instrument	
Initial Calibration Verification Standard	A standard prepared from a source other than that used for the initial calibration. This standard verifies the accuracy of the calibration curve.	ICV
Continuing Calibration Verification Standard	A calibration standard prepared at mid-level concentration for all target compounds. This standard is used to verify the initial calibration.	CCV
Spiking Standard	This solution contains required spiking compounds, at a minimum, and is used to prepare MS/MSD sets.	Same solution can be used for the LCS, MS/MSD and CCV.

10.2.2. Storage Conditions

Table 10.2 – Analytical Standard Storage Conditions

Standard Type	Description	Expiration	Storage
Stock VOA calibration standards	Restek; catalog #31283, #30265, #30006, #30293, #572444, and #572941, 1000/2000/5000ug/mL or equivalent standards.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions
Stock Gas calibration standards	Restek; catalog #30439, #30216, and #30646, 200/2000/5000ug/mL, or equivalent standards.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions
Intermediate VOA calibration standard	Refer to Section 10.2.3.1.	Solution good for 1 month from preparation	Same as stock standard.
Intermediate Gas calibration standard	Refer to Section 10.2.3.2.	Solution good for 1 week from preparation	Same as stock standard
Working VOA calibration standards	Refer to Section 10.2.3.3.	One-time use	Not applicable
Stock VOA ICV/Spiking standards	o2si; catalog #121092-02-SS; 250-5000ug/mL and #121091-06-SS, 250-5000ug/mL or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions
Intermediate VOA ICV/Spiking standard	Refer to Section 10.2.3.4.	Solution good for 1 month from preparation	Same as stock standard
Working ICV/Spiking standard	Refer to Section 10.2.3.5.	One-time use	Not applicable
Stock VOATune/ Surrogate standard	Restek; catalog #30240, 2500ug/mL or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions
Stock VOA Internal standards	Restek; catalog #30241, 2500ug/mL or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions
Working Tune/Surrogate/Internal standard mix	Refer to Section 10.2.3.6.	Solution good for 1 month from preparation	Stored on autosampler under pressure in a 5mL vial.

10.2.3. Preparation Procedures

10.2.3.1. Intermediate VOA Calibration Standard Preparation (Example)

Dilute 1000uL of Restek #572941 (250-2000ug/mL) plus 1000uL of Restek #30293 (2000ug/mL) plus 1000uL of Restek #572444 (250-5000ug/mL) plus 250uL of Restek #30006 (5000ug/mL) plus 250uL of Restek #30265 (2000ug/mL) plus 250uL of Restek #31283 (1000ug/mL) to 5.0mL with Methanol for a final nominal concentration of 50mg/L.

10.2.3.2. Intermediate Gas Calibration Standard Preparation (Example)

Dilute 400uL of Restek #30216 (2000ug/mL) plus 800uL of Restek #30646 (5000ug/mL) plus 1000uL of Restek #30439 (200ug/mL) to 4.0mL with Methanol for a final nominal concentration of 50ug/mL.

10.2.3.3. Working VOA Calibration Standards Preparation

Refer to Tables 10.3a and 10.3b for examples of possible one-time use calibration standards.

Table 10.3a – Working Calibration Standards – Regular Level (examples only)

Standard	Int. VOA Cal. Standard amount	Int. Gas Cal. Standard amount	Final Total Volume	Nominal Final Concentration
CAL1	3uL	3uL	200mL	0.75 ug/L
CAL2	2uL	2uL	50mL	2 ug/L
CAL3	5uL	5uL	50mL	5 ug/L
CAL4	10uL	10uL	50mL	10 ug/L
CAL5	2uL	2uL	5mL	20 ug/L
CAL6 (CCV)	5uL	5uL	5mL	50 ug/L
CAL7	15uL	15uL	5mL	150 ug/L
CAL8	30uL	30uL	5mL	300 ug/L

Table 10.3b – Working Calibration Standards – Low Level (examples only)

Standard	Int. VOA Cal. Standard amount	Int. Gas Cal. Standard amount	Final Total Volume	Nominal Final Concentration
CAL1	2uL	2uL	200mL	0.5 ug/L
CAL2	2uL	2uL	100mL	1 ug/L
CAL3	4uL	4uL	100mL	2 ug/L
CAL4	10uL	10uL	100mL	5 ug/L
CAL5	20uL	20uL	100mL	10 ug/L
CAL6 (CCV)	100uL	100uL	100mL	50 ug/L
CAL7	300uL	300uL	100mL	150 ug/L
CAL8	600uL	600uL	100mL	300 ug/L

10.2.3.4. Intermediate VOA ICV/Spiking Standard Preparation (Example)

Dilute 1.0mL of o2si #121091-06-SS (250-5000ug/mL) plus 1.0mL of o2si #121092-02-SS (250-5000ug/mL) to 5.0mL with Methanol for a final nominal concentration of 50ug/mL.

10.2.3.5. Working ICV/Spiking Standard Preparation (Example)

Add 5uL of the Intermediate ICV standard per 5mL water for a final ICV concentration of 50ug/L.

10.2.3.6. Working Tune/Surrogate/Internal Standard Preparation (Examples only, may vary)

Centurion/Centurion WS Autosamplers: Dilute 100uL of Restek #30240 plus 100uL of Restek #30241 to 5mL with Methanol for a final concentration of 50mg/L.

8100 Soil Autosamplers: Dilute 500uL of Restek #30240 plus 500uL of Restek #30241 to 5mL with Methanol for a final concentration of 250mg/L.

11. Calibration and Standardization

11.1. Tune Verification: At the beginning of each analytical sequence, prior to the analysis of any standards or samples, the mass spectrometer must be hardware tuned by injecting 5-50ng BFB. This is done by analyzing a standard containing BFB. The BFB and calibration verification standard may be combined as long as both tuning and calibration verification acceptance criteria are met without interferences. Use the BFB mass intensity criteria in the table below as tuning acceptance criteria. Alternate tuning criteria may be used provided that method performance is not adversely affected.

Mass (m/z)	Ion Abundance criteria
50	15 to 40% of m/z 95
75	30 to 60% of m/z 95
95	Base peak, 100% relative abundance
96	5 to 9% of m/z 95
173	<2% of m/z 174
174	>50% of m/z 95
175	5 to 9% of m/z 174
176	95 to 101% of m/z 174
177	5 to 9% of m/z 176

The mass spectrum of BFB may be obtained by averaging three scans, the peak apex scan and the scans immediately preceding and following the apex. Background subtraction is required using this approach and must be accomplished using a single scan no more than 20 scans prior to the elution of BFB. Do not background subtract part of the BFB peak. Alternatively, the analyst may use other approaches suggested below:

1. A single scan within the BFB peak with background subtraction of a single scan no more than 20 scans prior to the elution of BFB.
2. An average of multiple scans within the BFB peak with background subtraction of a single scan no more than 20 scans prior to the elution of BFB.

If the ratios do not meet the criteria above, reanalyze the BFB tune. If the BFB still fails the criteria, instrument maintenance and/or preparation of new standards must be considered.

11.2. Initial Calibration: Initial Calibration standards are introduced into the GC/MS from the lowest to highest concentration of each working calibration standard. The lowest calibration standard must be at or below the required reporting limit. Five calibration points, at a minimum, are analyzed to evaluate linearity. Refer to the Quality Manual for more information regarding calibration curves. The response factor (RF) is calculated for each compound for each calibration standard as follows:

$$RF = \frac{(A_x)(C_{IS})}{(A_{IS})(C_x)}$$

where: A_x = Area of the quantitation ion for the compound being measured
A_{IS} = Area of the quantitation ion for the internal standard.
C_{IS} = Concentration of the internal standard
C_x = Concentration of the compound being measured.

11.3. The average response factor (RF_{avg}) is determined by averaging the response factors at the different concentrations for each target analyte

11.4. The percent relative standard deviation (%RSD) is calculated as follows:

$$\%RSD = \frac{(SD)}{RF_{avg}} \times 100$$

where: SD = Standard deviation of average RF for a compound
RF_{avg} = Mean of RFs for a compound

11.5. The %RSD should be $\leq$20% for each target analyte.

11.6. For each calibration standard, all reported compounds that appear in Table 3 must meet the minimum response factor criteria shown.

11.7. If the percent relative standard deviation (%RSD) of the RFs for a compound is $\leq$20% over the calibration range, then linearity through the origin is assumed and the RF_{avg} may be used to determine sample concentrations.

11.7.1. If the % RSD for any compound is >20%, the analyst may employ a linear regression equation, non-weighted or weighted 1/x or $1/x^2$, that does not pass through the origin. The regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. In order to be used for quantitative purposes, the correlation coefficient must be $\geq$ 0.99. Refer to Method 8000C for additional information regarding calibration.

11.8. When calculating the calibration curve using the linear regression model, a minimum quantitation check on the viability of the calibration standard that corresponds to the reporting limit should be performed by re-fitting the response from the calibration standard that corresponds to the reporting limit back into the curve. The recalculated concentration of the reporting limit standard should be within +/-30% of the standard's true concentration. Compounds that fail this criterion and are reported at a concentration that is <2x the reporting limit in associated samples must be qualified as estimated. Alternatively, the reporting limit can be raised to the level of a calibration standard that meets the criteria when re-fitted against the curve.

11.9. Non-linear or quadratic calibration: A non-linear or quadratic calibration model can only be used if the compound(s) have historically exhibited a non-linear response and cannot be used to extend the calibration range for any compound that normally exhibits a linear response in a narrower range. The non-linear regression calibration curve is derived from a least squares regression analysis of the calibration points. A calibration curve based on this technique will have the format of: $y= ax^2+bx+c$. In order to use this curve fit technique, a minimum of 6 calibration points must be used and the origin cannot be included as one of the points. Because the non-linear regression is not forced through the origin, very low levels of contaminants below the response of the lowest calibration point may generate erroneous reportable results. The "goodness of fit" of the polynomial equation is evaluated by calculating the coefficient of the determination (COD) or r^2. The COD or r^2 from the regression equation must be $\geq$0.99. Refer to Method 8000C for additional information regarding calibration.

11.10. If compounds fail to meet the criteria in Sections 11.5-11.9, the calibration fit must be set to average response factor and associated samples concentrations may be determined but they must be reported as estimated. In order to report non-detects, the compound must have been detected with a response greater than zero in the initial calibration standard that corresponds to the reporting limit.

11.11. Initial Calibration Corrective Action: If more than 10% of the compounds included with the initial calibration exceed the ≤20% RSD limit and do not meet the minimum correlation coefficient (0.99) for alternative curve fits, then the chromatographic system is considered too imprecise for analysis to begin. Instrument maintenance and/or preparation of new calibration standards must be considered prior to repeating the initial calibration procedure.

11.12. Each day that analysis is performed, the calibration standards and/or check standard(s) should be evaluated to determine if the chromatographic system is operating properly. Questions that should be asked are: Do the peaks look normal? Is the response obtained comparable to the response from previous calibrations? Are the retention times consistent over the range of calibration for each compound? Careful examination of the standard chromatogram can indicate whether the column is still performing acceptably. Additionally, examination of signal-to-noise ratio of analytes in low-level standards may be a useful diagnostic tool to monitor instrument performance. Signal-to-noise ratio is defined as the ratio of the analyte signal to the noise measured on a blank. It is recommended but not required that the signal-to-noise ratio be at least three to confirm detection.

11.13. Initial Calibration Verification (ICV): The initial calibration curve should be verified immediately after performing the standard analysis using a second source standard (ICV) that is prepared using standards from a different source than the calibration standards, with a concentration near the midpoint of the calibration range. The acceptance limits for the ICV are 70-130% recovery for all reported compounds, with the following exceptions:

Acetone	50-150%
Acrolein	50-150%
Bromomethane	50-150%
Iodomethane	50-150%
Methyl acetate	50-150%

11.14. ICV Corrective Action: If the ICV fails the criteria, another ICV may be analyzed. If the second ICV fails, a new initial calibration curve may be analyzed. Instrument maintenance and/or preparation of new calibration standards must also be considered. Quantitative sample analysis should not proceed for those analytes that fail in the ICV or associated results must be qualified as estimated if analysis continues. **Exception:** If the ICV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported. Alternatively, the allowance for use of the ICV when the criterion is not met is documented and is at the discretion of the Department Manager, Quality Manager, General Manager or designee.

11.15. Continuing Calibration Verification: The initial calibration is verified every 12 hours by analyzing a BFB tune that must meet the criteria in Section 11.1, followed by a Continuing Calibration Verification (CCV) standard. The CCV is normally prepared using the same standard solution used for the initial calibration but an ICV/LCS can be used as a CCV if it passes the required criteria for a CCV.

11.16. All target compounds in the CCV must be evaluated using a +/-20% variability criterion. Use percent difference when the average RF model calibration has been used. Use percent drift when a regression fit model has been used.

$$\%\ \text{Difference (\%D)} = \frac{\text{Calculated amount of standard} - \text{Expected amount of standard}}{\text{Expected amount of standard}} \times 100$$

$$\%\ \text{Drift} = \frac{\text{Calculated concentration} - \text{Theoretical concentration}}{\text{Theoretical concentration}} \times 100$$

11.17. If the percent difference or percent drift for a compound is ≤20%, then the initial calibration for that compound is considered to be valid and sample analysis can continue. If the criterion is not met for more than 20% of the compounds included in the calibration, then corrective action must be taken prior to sample analysis.

In cases where compounds are >20% difference or drift, they may still be reported as non-detects if the compound was detected with a response greater than zero in the initial calibration standard that corresponds to the reporting limit. For situations when the failed compound is present in samples at or above the reporting limit, reported concentrations must be qualified as estimated values. Alternatively, the sample may be reanalyzed and reported for the compounds in question with a CCV that meets the criteria.

11.18. All compounds that are reported and that appear in Table 3 must meet the minimum response factor criteria shown. If the minimum response factors are not met, the system should be evaluated and corrective action should be taken before sample analysis begins.

11.19. The internal standard areas in the CCV must be between 50%-200% of the internal standard areas of the corresponding standard in the initial calibration. In addition, the retention time of the internal standards in the CCV cannot shift by more than 10 seconds from the corresponding standard in the initial calibration. Failure in either of these two areas requires the analyst to evaluate their system and perform maintenance if necessary.

11.20. CCV Corrective Action: If a CCV fails the acceptance criteria, check the instrument operating conditions, and if necessary, restore them to the original settings, and analyze another CCV. Alternatively, an ICV/LCS may be used as a CCV if it passes the CCV acceptance criteria. If the response still fails the acceptance criteria, then a new initial calibration must be prepared. Samples associated with a failed CCV must be reanalyzed. Exception: If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.

12. Procedures

12.1. Configure the purge & trap system and GC/MS system per manufacturer's instructions. All samples must be analyzed at room temperature and the system must be calibrated and free of contamination before samples are analyzed.

12.2. Sample Preparation and Handling

12.2.1. Aqueous Samples

Water samples to be analyzed using the Centurion autosampler require no sample preparation and are loaded as full 40mL VOA vials, unless they require a dilution. Refer to Section 7 for additional information regarding sample handling.

Water samples to be purged on the Archon/8100 autosampler are prepared by quickly measuring a 5mL aliquot of the sample using a 5mL gastight syringe and transferring it to a 40mL VOA vial. This is done as quickly as possible to minimize analyte loss. The syringe is thoroughly rinsed inside and out with reagent water before measuring each sample.

Dilutions on aqueous samples must be prepared in a volumetric fashion. Sample aliquots are measured in either a volumetric pipet or gas-tight syringe and brought to volume in either a volumetric flask or gas-tight syringe.

After analysis, check the residue in the vial using pH paper. The pH should be <2 if HCl-preserved vials were used. Holding time for water samples with pH >2 is 7 days. Appropriately qualify on the sequence log and in LIMS any sample not meeting the pH requirement and/or holding time requirement.

12.2.1.1. Aqueous Method Blank Preparation

12.2.1.1.1. Aqueous Method Blank on Archon autosamplers: The Method Blank consists of a 40mL VOA vial containing 5mL reagent water.

12.2.1.1.2. Aqueous Method Blank on Centurion autosamplers: The Method Blank consists of an HCl-preserved 40mL VOA vial filled completely with reagent water.

12.2.1.2. Aqueous LCS Preparation: add 5uL of the Intermediate ICV/Spiking standard per 5mL reagent water for a nominal LCS concentration of 50ug/L.

12.2.1.3. Aqueous MS Preparation: add 5uL of the Intermediate ICV/Spiking standard per 5mL sample for a nominal MS concentration of 50ug/L.

12.2.2. Soil Samples

12.2.2.1. Low-Level Soils

Preferably, samples received for low level analysis should be contained in pre-weighed Terra Core vials with reagent water. Prior to analysis the sample weight must be determined and recorded by weighing the vial and recording the weight. Subtract the tare weight indicated on the vial and correct for the label weight to determine the sample weight. The sample is ready for analysis. Refer to Section 7 for additional information regarding sample handling.

Alternatively, samples received in coring devices, such as Encore, must be extruded into a pre-weighed VOA vial either with or without 5mL reagent water and a stir bar. Record the weight of the vial after the sample has been placed into it. Subtract the tare weight determined initially to determine the sample weight. The sample is ready for analysis.

Samples received in bulk soil jars are sub-sampled into a VOA vial. Place an empty VOA vial on the balance pan and tare the balance. Quickly add 5 +/-0.5g of sample to the vial. Record the sample weight. Add 5mL of reagent water and a stir bar and cap the vial. The sample is ready for analysis.

12.2.2.1.1. Low-Level Soil Method Blank Preparation: The Method Blank consists of a 40mL VOA vial containing 5 +/-0.5g simulated soil matrix and 5mL reagent water and a stir bar.

12.2.2.1.2. Low-Level Soil LCS Preparation: Place 5 +/-0.5g of simulated soil matrix, 5mL reagent water and a stir bar into a vial. Add 5uL of the Intermediate ICV/Spiking standard for a nominal LCS concentration of 50ug/kg.

12.2.2.1.3. Low-Level Soil MS Preparation: Place 5 +/-0.5g of sample, 5mL reagent water and a stir bar into a vial. Add 5uL of the Intermediate ICV/Spiking standard for a nominal MS concentration of 50ug/kg.

12.2.2.2. Medium-Level Soils

Preferably, samples received for medium-level analysis should be received in pre-weighed Terra Core vials with methanol as a preservative. Prior to analysis the sample weight must be determined and recorded by weighing the vial and recording the weight. Subtract the tare weight indicated on the vial and correct for the label weight to determine the sample weight. The sample is mixed well on a vortex mixer and allowed to settle. A maximum of 200uL of the methanol extract per 5mL reagent water is used for analysis. Refer to Section 7 for additional information regarding sample handling.

Alternatively, samples received in coring devices, such as Encore, must be extruded into a pre-weighed VOA vial with 5mL methanol. Record the weight of the vial after the sample has been placed into it. Subtract the tare weight determined initially to determine the sample weight. The sample is mixed well on a vortex mixer and allowed to settle. A maximum of 200uL of the methanol extract per 5mL reagent water is used for analysis.

Samples received in bulk soil jars are sub-sampled into a VOA vial. Place an empty VOA vial on the balance pan and tare the balance. Quickly add 5 +/-0.5g of sample to the vial. Record the sample weight. Add 5mL methanol and cap the vial. The sample is mixed well on a vortex mixer and allowed to settle. A maximum of 200uL of the methanol extract per 5mL reagent water is used for analysis.

12.2.2.2.1. Medium-Level Soil Method Blank Preparation: The Method Blank consists of a 40mL VOA vial containing 4.8mL reagent water and 200uL methanol.

12.2.2.2.2. Medium-Level Soil LCS Preparation: place 4.8mL reagent water and 200uL methanol into a vial. Add 5uL of the Intermediate ICV/Spiking standard for an LCS concentration of 50ug/kg.

12.2.2.2.3. Medium-Level Soil MS Preparation: place a maximum of 200uL methanol sample extract into a vial and add enough reagent water to bring the final volume to 5mL. Add 5uL of the Intermediate ICV/Spiking standard for an LCS concentration of 50ug/kg.

12.3. Qualitative Analysis: Compounds are identified as present when the following criteria are met:

12.3.1. The relative retention time (RRT) of the sample component must compare within +/- 0.06 RRT units of the RRT of the CCV component.

12.3.2. The intensities of the characteristic ions of a compound must maximize in the same scan or within one scan of each other. Refer to Table 2 for the characteristic ions.

12.3.3. The relative intensities of the characteristic ions agree within 30% of the relative intensities of these ions in the reference spectrum.

12.4. Quantitative Analysis: Quantitation is based on the integrated abundance of the target analyte's quantitation ion using the internal standard technique.

12.5. Refer to the Manual Integrations SOP for guidance on performing and documenting manual integrations.

12.6. If the sample concentration exceeds the linear range of the analysis, the sample must be diluted and reanalyzed or reported as an estimated concentration.

13. Quality Control

13.1. Batch Quality Control

Table 13.1 – Batch Quality Control Criteria

QA Sample	Components	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water	One per preparation batch of up to 20 samples, per matrix.	Target analytes must be less than reporting limits.	Reanalyze method blank. If target compound is still >RL in method blank and associated samples, reanalyze samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 2) If a contaminant is present only in the method blank and not the samples, no action is required. 3) If contaminant is present in the sample at a concentration >10x the method blank, sample may be reported with qualification.
Laboratory Control Sample (LCS)	Applicable target analytes	One per preparation batch of up to 20 samples, per matrix.	Lab-generated limits Refer to the LIMS for acceptance limits. Refer to Section 13.2 for allowable marginal exceedances.	Reanalyze the LCS. If LCS is still outside acceptance limits, reanalyze all associated samples. Refer to Section 13.2 for allowable marginal exceedances. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported data must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified. 3) If allowed by program or client, an associated matrix spike that passes LCS acceptance limits may be used in place of the LCS. LCS must be reported and qualified.
Matrix Spike (MS)/Matrix Spike Duplicate (MSD)	Applicable target analytes	One MS/MSD set per preparation batch of up to 20 samples, per matrix.	Lab-generated limits RPD ≤20% Refer to the LIMS for acceptance limits.	No corrective actions necessary for spiked compounds or surrogates. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.
Sample Duplicate (Dup)	Sample	One sample duplicate per batch of up to 20 samples if no MS/MSD.	RPD ≤20%	No corrective actions necessary. Qualify duplicate appropriately if RPD is out-of-control.
Surrogates	Applicable surrogate compounds	Added to each standard, sample, and method blank.	Lab-generated limits Refer to the LIMS for acceptance limits.	Samples with surrogate failures must be reanalyzed. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported surrogate data must be qualified. 2) If surrogate result is >QC limits, and sample or method blank results are non-detect, the sample or method blank results may be reported without qualifiers. The surrogate must be qualified. 3) If there is obvious visible chromatographic interference with a surrogate, results may be reported but must be qualified.
As required by client only: **Internal Standards**	Applicable Internal Standard compounds	Added to each standard, sample, and method blank.	Sample ISTD areas must be -50% to +100% from CCV. Sample ISTD RTs must be +/-0.5 minutes from CCV.	Samples with internal standard failures must be reanalyzed at the same dilution or more concentrated. *Exception:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported data must be qualified.

13.2. Allowable Marginal Exceedances: If a large number of analytes are in the LCS, it becomes statistically likely that a few will be outside control limits. A marginal exceedance (ME) is defined as being beyond the LCS control limit of +/-3 standard deviations, but within the ME limits of +/-4 standard deviations around the mean. The number of allowable MEs is based on the number of analytes in the LCS. If more analytes exceed the LCS control limits than is allowed, or if any one analyte exceeds the ME limits, the LCS fails and correction action is necessary. If the same analyte exceeds the LCS control limit consecutively, it is an indication of a systemic problem. The source of the error shall be located and corrective action taken.

The number of allowable marginal exceedances is as follows:

Number of Analytes in LCS	Number Allowed as Marginal Exceedances
> 90	5
71 – 90	4
51 – 70	3
31 – 50	2
11 – 30	1
< 11	0

NOTE: As allowed by client or program, the LCS may be outside the control limits but ≥10% recovery for up to four additional volatile compounds with the exception of benzene, toluene, ethylbenzene, m-xylene, p-xylene, o-xylene, total xylenes and any requested oxygenate without corrective action.

14. Data Analysis and Calculations

14.1. Calculate the final concentration in the sample as follows:

Aqueous Sample (ug/L) = $(X_s)(D)$ Solid Sample (ug/kg) = $\frac{(X_s)(V_f)(D)}{(W_s)}$

Where: X_s = On-column concentration of the analyte, ug/L
V_f = Final volume, L
D = Dilution factor
W_s = Weight of solid sample, kg

Moisture corrected concentration = $\frac{\text{(Final concentration as received)}}{\text{(100- \%Moisture)}} \times 100$

14.2. LCS equation:

R = (C/S) * 100

Where: R = percent recovery
C = spiked LCS concentration
S = concentration of analyte added to the clean matrix

14.3. MS/MSD equation:

$$R = \frac{(Cs - C)}{S} * 100$$

Where: R = percent recovery
Cs = spiked sample concentration
C = sample concentration
S = concentration of analyte added to the sample

14.4. RPD equation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} * 100$$

Where: RPD = relative percent difference
D_1 = first sample result
D_2 = second sample result

15. Data Assessment and Acceptance Criteria for Quality Control Measures

15.1. Refer to Sections 11 and 13.

16. Corrective Actions for Out-of-Control Data

16.1. Refer to Sections 11 and 13.

17. Contingencies for Handling Out-of-Control of Unacceptable Data

17.1. Refer to Sections 11 and 13.

18. Method Performance

18.1. MDLs must be determined per EPA *Definition and Procedure for the Determination of the Method Detection Limit, Revision 2*; December 2016.

18.2. Every analyst who performs this method must first document acceptable accuracy and precision by passing a demonstration of capability study (DOC).

19. Method Modifications

19.1. GC columns and chromatographic conditions may differ from those recommended.

19.2. Calibration solutions are purchased as certified standards.

20. Instrument/Equipment Maintenance

20.1. Refer to maintenance log and/or instrument manufacturer's instructions.

21. Troubleshooting

21.1. Refer to maintenance log and/or instrument manufacturer's instructions.

22. Safety

22.1. **Standards and Reagents**: The toxicity and carcinogenicity of standards and reagents used in this method have not been fully defined. Each chemical compound should be treated as a potential health hazard. Reduce exposure by the use of gloves, lab coats and safety glasses. Safety Data Sheets (SDSs) are on file in the laboratory and available to all personnel. Standard solutions should be prepared in a hood whenever possible.

22.2. **Samples**: Take precautions when handling samples. Samples should always be treated as potentially hazardous "unknowns". The use of personal protective equipment (gloves, lab coats and safety glasses) is required when handling samples. In the event a sample container must be opened, it is recommended to perform this in a hood whenever possible. All digestions must be conducted under a fume hood.

22.3. **Equipment:** Portions of the preparation and analytical equipment may operate at high temperatures. Care must be taken to minimize accidents and injuries when working on or with this equipment. Equipment should be turned off or the temperatures lowered to reduce the risk of thermal burns. Allow adequate time for the equipment to cool prior to working on equipment.

23. Waste Management

23.1. Procedures for handling waste generated during this analysis are addressed Waste Handling, or other applicable SOP. All wastes are accumulated, managed and disposed of in accordance with all federal and state laws and regulations.

24. Pollution Prevention

24.1. In order to minimize the amount of waste generated during this procedure, analyst should prepare reagents in an amount which may be used in a reasonable amount of time (i.e. before a reagent expires)

24.2. The company wide Chemical Hygiene and Safety Manual contains additional information on pollution prevention.

25. References

25.1. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Methods 8000C, 8260C, 5030A, 5030B, and 5035A.

25.2. Pace Analytical Quality Manual; latest revision.

25.3. NELAC/TNI Standard; 2003 and 2009.

26. Tables, Diagrams, Flowcharts, Attachments, Appendices, etc.

26.1. Table 1: Method 8260C Target Compounds and Reporting Limits
26.2. Table 2: Characteristic Ions and Internal Standard Association of Target Compounds
26.3. Table 3: Minimum Response Factor Criteria

27. Revisions

Document Number	Reason for Change	Date
S-IN-O-029-rev.18	1. Cover: changed 8260B to 8260C and added actual effective date. 2. Section 1.1: changed 8260B to 8260C 3. Section 4: revised to reflect 8260C 4. Table 8.3: revised balance specifications to match practice 5. Table 9.2: revised for standard mixes currently in use. 6. Section 9.2.3: revised recipes for standard mixes currently in use, changed approx. 5g to 5 +/- 0.5g, added batch QC details for medium-level soils, and detailed surrogate prep for both types of autosampler. 7. Section 10.1: added BFB acquisition guidance. 8. Section 10.13: added as guidance for evaluation of ICAL standards. 9. 10.5 - 10.21: revised to comply with Method 8260C, clarified use of LCS as CCV, and clarified requirement to correct vial TC vial weight for the label weight. 10. Section 11.2.2: added that tared soil vials need to be corrected for label weight and changed approx. 5g to 5 +/- 0.5g. 11. Section 11.5: added as a reference to the Manual Integrations SOP. 12. Section 11.6: added to require over range samples be diluted and reanalyzed or qualified as estimated. 13. Section 12.2: added to clarify the requirement for batch QC. 14. Section 12.3.2: clarified that blank is to be prepared using an HCl preserved vial. 15. Section 12.3.3: changed approx. 5g to 5 +/- 0.5g and added stir bar. 16. Section 13.1: added optional LOD/OQ verification. 17. Section 16.1: removed reference to 8000B and 8260A and changed 8260B to 8260C. 18. Section 17: changed 8260B to 8260C and added Table 3 attachment	31Oct2013
S-IN-O-029-rev.19	1. Converted to Corporate 27-section format. 2. Cover page: changed phone number and revised document control format. 3. Table 7.1: updated temperature format and preservation for 5035A. 4. Section 9.1: updated to include OI instrumentation. 5. Section 9.2: updated to include OI instrumentation. 6. Table 10.2: updated to current standards in use. 7. Section 10.2.3: updated to current standard preparation procedures. 8. Section 11: removed equations for different curve fits. 9. Section 11.7: added option of weighted linear. 10. Section 11.10: added requirement to set failing compounds to average fit. 11. Section 12.2.1: added OI and indicated that sample pH should be <2 if HCl vials were used. 12. Table 13.1: added an exception to MB when sample concentration is>10x MB concentration. Added sample duplicate to table and added RPD criteria. 13. Section 14: equations for water and solid final concentration fixed. 14. Table 1: added compounds for consistency between tables. 15. Table 2: added internal standard association and updated 1,2,3-TCP ions. 16. Table 3: revised minimum RF for TCE and PCE.	23Nov2016
ENV-SOP-IND1-0034-Rev.01	1. Removed cover, table of contents and headers for use in Master Control. 2. Table 10.2: updated stock calibration standards. 3. Section 10.2.3: updated preparation of intermediate and working calibration standards. 4. Section 11.7.1: clarified acceptable weighting for linear calibrations. 5. Section 11.8: clarified the term “reported compounds”. 6. Section 11.10: clarified the term “detected”. 7. Section 11.17: specified <20% difference or drift and clarified the term “detected”. 8. Section 12.2: moved batch QC prep from Section 13 and changed min. MeOH to 200uL. 9. Table 13.1: updated corrective action for MB, LCS and surrogates and added reference to LCS for marginal exceedances. 10. Section 18.1: updated reference to new MDL procedure. 11. Section 25.3: added years 2003 and 2009 to NELAC/TNI reference.	31Jan2019

Table 1: Method 8260C Target Compounds and Reporting Limits[1]

Analyte	RL water (ug/L)	RL soil Low-Level (ug/kg)	RL soil Medium-Level (ug/kg)
Dichlorodifluoromethane	5	5	125
Chloromethane	5	5	125
Vinyl Chloride	2	5	125
Bromomethane	5	5	125
Chloroethane	5	5	125
Trichlorofluoromethane	5	5	125
Acrolein	50	100	2500
1,1,2-Trichlorotrifluoroethane	5	5	125
1,1-Dichloroethene	5	5	125
Acetone	100	100	2500
Iodomethane	10	100	2500
Carbon Disulfide	10	10	250
Methylene Chloride	5	20	500
Acrylonitrile	100	100	2500
Methyl tert-butyl ether	4	5	125
trans-1,2-Dichloroethene	5	5	125
Vinyl Acetate	10	100	2500
1,1-Dichloroethane	5	5	125
2-Butanone (MEK)	25	25	625
cis-1,2-Dichloroethene	5	5	125
2,2-Dichloropropane	5	5	125
Bromochloromethane	5	5	125
Chloroform	5	5	125
Cyclohexane	100	100	2500
1,1,1-Trichloroethane	5	5	125
Carbon Tetrachloride	5	5	125
1,1-Dichloropropene	5	5	125
Benzene	5	5	125
1,2-Dichloroethane	5	5	125
Trichloroethene	5	5	125
Methylcyclohexane	50	50	1250
1,2-Dichloropropane	5	5	125
Dibromomethane	5	5	125
Bromodichloromethane	5	5	125
cis-1,3-Dichloropropene	5	5	125
4-Methyl-2-pentanone (MIBK)	25	25	625
Toluene	5	5	125
trans-1,3-Dichloropropene	5	5	125
Ethyl Methacrylate	100	100	2500
1,1,2-Trichloroethane	5	5	125
Tetrachloroethene	5	5	125
1,3-Dichloropropane	5	5	125
2-Hexanone	25	100	2500
Dibromochloromethane (Chlorodibromomethane)	5	5	125
1,2-Dibromoethane (EDB)	5	5	125
Chlorobenzene	5	5	125
1,1,1,2-Tetrachloroethane	5	5	125
Ethylbenzene	5	5	125
m&p-Xylene	5	5	125
o-Xylene	5	5	125

Analyte	RL water (ug/L)	RL soil Low-level (ug/kg)	RL soil Medium-level (ug/kg)
Styrene	5	5	125
Isopropylbenzene	5	5	125
Bromobenzene	5	5	125
trans-1,4-Dichloro-2-butene	100	100	2500
Bromoform	5	5	125
1,1,2,2-Tetrachloroethane	5	5	125
1,2,3-Trichloropropane	5	5	125
n-Propylbenzene	5	5	125
2-Chlorotoluene	5	5	125
1,3,5-Trimethylbenzene	5	5	125
4-Chlorotoluene	5	5	125
tert-Butylbenzene	5	5	125
1,2,4-Trimethylbenzene	5	5	125
sec-Butylbenzene	5	5	125
1,3-Dichlorobenzene	5	5	125
p-Isopropyltoluene	5	5	125
1,4-Dichlorobenzene	5	5	125
n-Butylbenzene	5	5	125
1,2-Dichlorobenzene	5	5	125
1,2-Dibromo-3-chloropropane	10	10	250
1,2,4-Trichlorobenzene	5	5	125
Hexachlorobutadiene	5	5	125
Naphthalene	5	5	125
1,2,3-Trichlorobenzene	5	5	125
2-Methylnaphthalene	10	10	250

[1]Target Compounds and Reporting Limits are subject to change.

Table 2: Characteristic Ions and Internal Standard Association of Target Compounds[2]

Analyte	Primary Ion	Secondary Ion(s)
Group 1 – Fluorobenzene (IS)	**96**	**-**
Dichlorodifluoromethane	85	87
Chloromethane	50	52
Vinyl Chloride	62	64
Bromomethane	94	96
Chloroethane	64	66
Trichlorofluoromethane	101	103
Acrolein	56	55
1,1,2-Trichlorotrifluoroethane	101	151
1,1-Dichloroethene	96	61, 63
Acetone	43	58
Iodomethane	142	127
Carbon Disulfide	76	78
Methylene Chloride	84	86, 49
Acrylonitrile	53	52, 51
Methyl tert-butyl ether	73	57
trans-1,2-Dichloroethene	96	61, 98
Vinyl Acetate	43	86
1,1-Dichloroethane	63	65, 83
2-Butanone (MEK)	43	57, 72
cis-1,2-Dichloroethene	96	61, 98
2,2-Dichloropropane	77	97
Bromochloromethane	49	128
Chloroform	83	85
Dibromofluoromethane (Surr)	113	111
Cyclohexane	56	84, 41
1,1,1-Trichloroethane	97	99, 61
Carbon Tetrachloride	117	119, 121
1,1-Dichloropropene	75	110, 77
Benzene	78	52, 77
1,2-Dichloroethane	62	98, 64
Trichloroethene	95	97, 130, 132
Methylcyclohexane	55	69, 83
1,2-Dichloropropane	63	62, 112
Dibromomethane	93	95, 174
Bromodichloromethane	83	85, 127
Group 2 – Chlorobenzene-d5 (IS)	**117**	**82, 119**
cis-1,3-Dichloropropene	75	77
4-Methyl-2-pentanone (MIBK)	43	58, 85
Toluene-d8	98	99, 100
Toluene	91	92
trans-1,3-Dichloropropene	75	77
Ethyl Methacrylate	69	99, 114
1,1,2-Trichloroethane	83	97, 85
Tetrachloroethene	166	129, 168
1,3-Dichloropropane	76	78
2-Hexanone	43	58, 100
Dibromochloromethane (Chlorodibromomethane)	129	127
1,2-Dibromoethane (EDB)	107	109
Chlorobenzene	112	77, 114

Analyte	Primary Ion	Secondary Ion(s)
Group 2 – Chlorobenzene-d5 (IS) Continued	**117**	**82, 119**
1,1,1,2-Tetrachloroethane	131	133, 119
Ethylbenzene	106	91
m&p-Xylene	106	91
o-Xylene	106	91
Styrene	104	78
Isopropylbenzene	105	120
4-Bromofluorobenzene (Surr)	95	174, 176
Bromobenzene	77	156, 158
trans-1,4-Dichloro-2-butene	53	88, 75
Group 3 – 1,4-Dichlorobenzene-d4 (IS)	**152**	**115, 150**
Bromoform	173	175, 254
1,1,2,2-Tetrachloroethane	83	131, 85
1,2,3-Trichloropropane	110	75, 77
n-Propylbenzene	91	120
2-Chlorotoluene	91	126
1,3,5-Trimethylbenzene	105	120
4-Chlorotoluene	126	91
tert-Butylbenzene	119	91, 134
1,2,4-Trimethylbenzene	105	120
sec-Butylbenzene	105	134
1,3-Dichlorobenzene	146	111, 148
p-Isopropyltoluene	119	134, 91
1,4-Dichlorobenzene	146	111, 148
n-Butylbenzene	91	92, 134
1,2-Dichlorobenzene	146	111, 148
1,2-Dibromo-3-chloropropane	155	75, 157
1,2,4-Trichlorobenzene	180	182, 145
Hexachlorobutadiene	225	223, 227
Naphthalene	128	127
1,2,3-Trichlorobenzene	180	182, 145
2-Methylnaphthalene	142	141, 115

[2]Subject to change.

Table 3: Minimum Response Factor Criteria

Analyte	Minimum Response Factor (RF)
Dichlorodifluoromethane	0.100
Chloromethane	0.100
Vinyl Chloride	0.100
Bromomethane	0.100
Chloroethane	0.100
Trichlorofluoromethane	0.100
Methylene Chloride	0.100
1,1-Dichloroethene	0.100
trans-1,2-Dichloroethene	0.100
1,1-Dichloroethane	0.200
cis-1,2-Dichloroethene	0.100
Chloroform	0.200
1,1,1-Trichloroethane	0.100
Cyclohexane	0.100
Carbon Tetrachloride	0.100
Benzene	0.500
1,2-Dichloroethane	0.100
*Trichloroethene	0.100
1,2-Dichloropropane	0.100
Bromodichloromethane	0.200
Toluene	0.400
1,1,2-Trichloroethane	0.100
*Tetrachloroethene	0.100
Dibromochloromethane (Chlorodibromomethane)	0.100
1,2-Dibromoethane (EDB)	0.100
Chlorobenzene	0.500
Ethylbenzene	0.100
m&p-Xylene	0.100
o-Xylene	0.300
Styrene	0.300
Bromoform	0.100
Isopropylbenzene	0.100
1,1,2,2-Tetrachloroethane	0.300
1,3-Dichlorobenzene	0.600
1,4-Dichlorobenzene	0.500
1,2-Dichlorobenzene	0.400
1,2,4-Trichlorobenzene	0.200
trans-1,3-Dichloropropene	0.100
cis-1,3-Dichloropropene	0.200
*Acetone	0.010
*2-Butanone (MEK)	0.010
*4-Methyl-2-pentanone (MIBK)	0.050
*2-Hexanone	0.050
Methyl tert-butyl ether	0.100
Carbon Disulfide	0.100
1,2-Dibromo-3-chloropropane	0.050
Methylcyclohexane	0.100
1,1,2-Trichlorotrifluoroethane	0.100
Methyl acetate	0.100

*Alternate minimum RF criteria based on compound performance.

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ENV-SOP-IND1-0044 Mercury in Water and Soil

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	19 Jul 2021, 10:23:23 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Felicia Walker (005354)	Manager	20 Jul 2021, 11:55:52 AM	Approved
Steven Sayer (004775)	General Manager 2	26 Jul 2021, 07:53:05 AM	Approved

Pace Analytical®

STANDARD OPERATING PROCEDURE
TITLE: MERCURY IN WATER AND SOIL
METHOD: SW-846 7470A, 7471A
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

1.1 The purpose of this Standard Operating Procedure (SOP) is to provide a laboratory specific procedure for determining total mercury concentration while meeting the requirements specified in EPA method 7470A for aqueous samples and method 7471A for solid samples.

1.2 This SOP is applicable for the measurement of mercury in groundwater, surface and saline waters, domestic and industrial wastes, TCLP extracts, soil, sediment, bottom deposits, and sludge-type materials.

1.3 The default reporting limits for mercury are 0.002 mg/L for aqueous samples and 0.20 mg/kg for solid samples. Refer to the LIMS for method detection limits.

1.4 Reporting limits, control limits, volumes/weights used, standard concentrations, vendors, instrumentation, equipment, and supplies are subject to change.

2.0 SUMMARY OF METHOD

Prior to analysis, all samples are digested by heating with appropriate acids and oxidizing agents to dissolve and oxidize mercury contents.

This cold-vapor method is based on the absorption of radiation at 253.7nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.

3.0 INTERFERENCES

3.1 High concentrations of sulfide may interfere in some water or solid samples. Potassium permanganate is added during digestion to eliminate sulfide interference. Concentrations as high as 20mg/L have been demonstrated to cause no interference in spiked samples.

3.2 High concentrations of copper have been reported to interfere with mercury determinations. Concentrations as high as 10mg/L in water or 10mg/kg in soil have been demonstrated to cause no interference in spiked samples.

3.3 High concentrations of chloride present in samples may require additional potassium permanganate or dilution. The free chlorine produced during digestion should be removed with excess hydroxylamine hydrochloride solution.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

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STANDARD OPERATING PROCEDURE
TITLE: MERCURY IN WATER AND SOIL
METHOD: SW-846 7470A, 7471A
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5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous	500mL in plastic container	-HNO_3 to pH<2 -Samples received at pH >2 must be preserved to pH <2 with HNO_3 and equilibrate for 24 hours before digestion. Record date/time of preservation in preservation logbook.	Ambient	Must be analyzed within 28 days of collection.
Aqueous-Dissolved **Field Filtered**	500mL in plastic container	-Field filter using 0.45um filter within 15 minutes of collection, then add HNO_3 to pH<2. -Samples received at pH >2 must be preserved to pH <2 with HNO_3 and equilibrate for 24 hours before digestion. Record date/time of preservation in preservation logbook.	Ambient	Must be analyzed within 28 days of collection.

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Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous-Dissolved Lab Filtered	500mL in plastic container	-Unpreserved samples are lab filtered using 0.45um filter then preserved to pH<2 with HNO_3 and allowed to equilibrate for 24 hours before being digested. -Date/time of filtration recorded in filtration prep log, date/time of preservation recorded in the metals digestion prep log.	Ambient	Must be analyzed within 28 days of collection.
Solid	100g in 4oz glass container	None	Cool to ≤6°C	Must be analyzed within 28 days of collection.

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Description / Comments
Automated Mercury Analyzer	CETAC/Teledyne M-7500, M-6100, M-7600 or equivalent; to include an atomic absorption spectrophotometer, mercury lamp, absorption cell, air pump, flow meter, drying tube, autosampler and data system.
Hot Block	Environmental Express 56-well or equivalent; adjustable and capable of maintaining a temperature of 90°C to 95°C.
Balance	OHaus GT400 or equivalent; capable of reading to 0.01g
Vacuum pump	Gast diaphragm compressor/vacuum pump, or equivalent

7.2 Supplies

Supplies	Description
Volumetric flasks	Class A, 1L
Graduated cylinder	Class A, 25mL
Mechanical pipets	Eppendorf or equivalent, various sizes
Digestion cups	Environmental Express 50mL and 100 mL capacity, volumetrically certified, or equivalent
Autosampler tubes	Moldpro 17x100 mm, or equivalent
Plunger filters	Environmental Express or equivalent, for use with digestion cups
0.45um Flipmate filters	Environmental Express or equivalent, for use with vacuum pump and 100mL digestion cups

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8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration / Description
Reagent water	ASTM Type II water or equivalent
Sulfuric acid	Concentrated, trace metal grade or equivalent
Hydrochloric acid	Concentrated, trace metal grade or equivalent
Hydrochloric acid (3%)	Dilute 30mL of concentrated HCl to 1L with reagent water. Used for dilution preparation.
Nitric acid	Concentrated, trace metal grade or equivalent
Aqua Regia	Carefully add one volume of nitric acid to three volumes of hydrochloric acid. Must be prepared in a hood and must be prepared immediately before use each day.
Stannous Chloride	Powder, reagent grade or equivalent
Stannous Chloride solution	Add 100g stannous chloride and 70 mL conc. HCl in reagent water and dilute to 1L. This solution is good for up to 3 days. Refrigerate when not in use, per manufacturer's recommendation.
Sodium Chloride	Granular, reagent grade or equivalent
Hydroxylamine hydrochloride	Granular, reagent grade or equivalent
Sodium Chloride/ Hydroxylamine Hydrochloride solution	Dissolve 120g sodium chloride and 120g hydroxylamine hydrochloride in reagent water and dilute to 1L. This solution is good for 6 months from preparation (hydroxylamine sulfate may be substituted for hydroxylamine hydrochloride).
Potassium permanganate solution (5%)	Commercially purchased Mercury-free, 5% solution (w/v)
Potassium persulfate	Granular, reagent grade or equivalent
Potassium persulfate solution	Dissolve 50g potassium persulfate in reagent water and dilute to 1L. Expires 6 months from the date of preparation. May be stored at room temperature.
Rinse/Probe Wash Solution	Add 25mL HNO3 and 10mL HCl to 500mL reagent water and dilute to 1L.
Plastic beads	Environmental Express or equivalent, to be used as a simulated soil matrix.

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8.2 Standards

Standard Type	Description	Expiration	Storage
Stock Mercury Calibration standard	Environmental Express; cat # HP100033-1; 1000mg/L or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Intermediate #1 Mercury Calibration standard	Refer to Section 8.3.1	Solution expires 6 months from date of preparation.	Same as for stock standard.
Intermediate #2 Mercury Calibration standard	Refer to Section 8.3.2	Must be prepared fresh weekly.	Same as for stock standard.
Working Mercury Calibration standards	Refer to Section 8.3.3	One-time use standards.	Not Applicable
Stock Mercury ICV/Spiking standard	SPEX; catalog # PLHG4-2Y; 1000mg/L or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Intermediate #1 Mercury ICV/Spiking standard	Refer to Section 8.3.4	Solution expires 6 months from date of preparation.	Same as for stock standard.
Intermediate #2 Mercury ICV/Spiking standard	Refer to Section 8.3.5	Must be prepared fresh weekly.	Same as for stock standard.
Working Mercury ICV standard	Refer to Section 8.3.6	One-time use standard.	Not Applicable

8.3 Standard Preparation Procedures

Refer to the standard preparation logbook or database for specific instructions regarding preparation of standards for Mercury analysis.

8.3.1 Intermediate #1 Mercury Calibration Standard Preparation

Dilute 1mL of the Stock Mercury Calibration Standard (1000mg/L) to 100mL with 2% HNO_3 for a final concentration of 10mg/L.

8.3.2 Intermediate #2 Mercury Calibration Standard Preparation

Dilute 1mL of the Intermediate #1 Mercury Calibration Standard (10mg/L) to 100mL with 2% HNO_3 for a final concentration of 100ug/L.

8.3.3 Working Mercury Calibration Standards Preparation

Working calibration standards are prepared by diluting the Intermediate #2 Mercury Calibration Standard (100ug/L) with reagent water. Examples of possible calibration standards are as follows but may vary:

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Aqueous:

Standard ID	Amount of Intermediate #2	Final Volume in reagent water	Final Concentration
CAL0 (ICB/CCB)	0 mL	30mL	0.0ug/L
CAL1 (CRDL)	0.06mL	30mL	0.2ug/L
CAL2	0.3mL	30mL	1.0ug/L
CAL3	0.6mL	30mL	2.0ug/L
CAL4 (CCV)	1.5mL	30mL	5.0ug/L
CAL5	2.25mL	30mL	7.5ug/L
CAL6	3.0mL	30mL	10.0ug/L

Solid:

Standard ID	Amount of Intermediate #2	Final Volume in reagent water	Final Concentration
CAL0 (ICB/CCB)	0 mL	50mL	0.0ug/L
CAL1 (CRDL)	0.06mL	50mL	0.2ug/L
CAL2	0.3mL	50mL	1.0ug/L
CAL3	0.6mL	50mL	2.0ug/L
CAL4 (CCV)	1.5mL	50mL	5.0ug/L
CAL5	2.25mL	50mL	7.5ug/L
CAL6	3.0mL	50mL	10.0ug/L

8.3.4 Intermediate #1 Mercury ICV/Spiking Standard Preparation

Dilute 1mL of the Stock Mercury ICV/Spiking Standard (1000mg/L) to 100mL with 2% HNO_3 for a final concentration of 10mg/L.

8.3.5 Intermediate #2 Mercury ICV/Spiking Standard Preparation

Dilute 1mL of the Intermediate #1 Mercury ICV/Spiking Standard (10mg/L) to 100mL with 2% HNO_3 for a final concentration of 100ug/L. This standard is also used to prepare the LCS and MS/MSD.

8.3.6 Working Mercury ICV Standard Preparation

Aqueous: Dilute 1.5mL of the Intermediate #2 Mercury ICV Standard (100ug/L) to 30mL with reagent water for a standard concentration of 5.0ug/L.

Solid: Dilute 2.5mL of the Intermediate #2 Mercury ICV Standard (100ug/L) to 50mL with reagent water for a standard concentration of 5.0ug/L.

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9.0 PROCEDURE

9.1 Aqueous Sample Preparation

9.1.1 Transfer a 30mL aliquot of well-mixed sample to a 50mL graduated digestion cup.

9.1.2 Prepare a Method Blank by adding 30mL of reagent water to a digestion cup.

9.1.3 Prepare an LCS by adding 1.5mL of the Intermediate #2 Mercury ICV/Spiking Standard (100ug/L) to a digestion cup and diluting to 30mL with reagent water for a spike concentration of 5.0ug/L.

9.1.4 Prepare an MS/MSD set by transferring 30mL aliquots of well-mixed sample to separate digestion cups and adding 1.5mL of the Intermediate #2 Mercury ICV/Spiking Standard (100ug/L) for a spike concentration of 5.0ug/L.

9.1.5 Add 0.75mL concentrated nitric acid to each digestion cup, then add 1.5mL concentrated sulfuric acid acid to each digestion cup. Mix after each addition.

9.1.6 Add 5mL potassium permanganate solution to each digestion cup. Swirl to mix. Ensure that equal amounts of permanganate solution are added to Method Blank and LCS.

9.1.7 Add 2.5mL potassium persulfate solution to each digestion cup.

9.1.8 Cap loosely and heat samples for 2 hours in the Hot Block at 95°C. If the purple color does not persist after 15 minutes of being heated, start over at Section 9.1.1 using a diluted aliquot of sample.

9.1.9 If the purple color does not persist for the entire 2-hour digestion period, qualify the reported result. **For WI DNR compliance samples:** If the purple color does not persist for the entire 2-hour digestion period, start over at Section 9.1.1 using a diluted aliquot of the sample.

9.1.10 Cool samples and add 1.8mL of the sodium chloride/hydroxylamine hydrochloride solution to each sample to reduce the excess potassium permanganate. CAUTION: perform this addition in a fume hood, as chlorine gas could be produced. Proceed to Section 9.4.

9.1.11 All sample volumes, reagent volumes, spiking standard volumes, standard/reagent ID numbers, hot block ID numbers, hot block temperature, thermometer ID number, and preparation date and time must be recorded in the electronic prep log.

9.2 Solid Sample Preparation

9.2.1 Weigh 0.3g of sample into a labeled 50mL digestion cup. To ensure the sample is representative of the entire container, the analyst should weigh out three 0.1g aliquots from different parts of the same container.

9.2.2 Prepare a Method Blank by placing several boiling chips into a labeled digestion cup.

9.2.3 Prepare an LCS by placing several boiling chips into a labeled digestion cup and adding 1.5mL of the Intermediate #2 Mercury ICV/Spiking Standard (100ug/L) for a final concentration of 0.5mg/kg.

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9.2.4 Prepare an MS and MSD by weighing 0.3g portions of a sample into separate labeled digestion cups and adding 1.5mL of Intermediate #2 Mercury ICV/Spiking Standard (100ug/L) for a spike concentration of 0.5mg/kg.

9.2.5 Add 5mL of reagent water to each digestion cup.

9.2.6 Add 2.5mL of aqua regia to each digestion cup.

9.2.7 Heat samples for 2 minutes in the Hot Block at 95°C.

9.2.8 Cool samples and add 25mL reagent water then add 7.5mL of 5% potassium permanganate solution. Swirl to mix and let sample stand at least 15 minutes. If the purple color does not persist after 15 minutes, then start over at Section 9.2.1 using a reduced portion of sample.

9.2.9 Return the samples to the Hot Block and heat for 30 minutes at 95°C.

9.2.10 Cool samples again and add 3mL of the sodium chloride/hydroxylamine hydrochloride solution to each sample to reduce the excess potassium permanganate. **CAUTION**: perform this addition in a fume hood, as chlorine gas could be produced.

9.2.11 Adjust the digestate volumes to 50mL with reagent water and mix. Proceed to Section 9.4. If needed, a plunger filter may be used to filter the digestate. The Method Blank and LCS must also be filtered if any client samples are filtered in the batch. Alternatively, reduce the effect of particulates by centrifuging samples for approximately 5 minutes at 3500rpm.

9.2.12 All sample volumes, reagent volumes, spiking standard volumes, standard/reagent ID numbers, hot block ID numbers, hot block temperature, thermometer ID number, and preparation date and time must be recorded in the electronic prep log.

9.3 Calibration Standard Preparation:

9.3.1 Prepare calibration standards in 50mL digestion cups per the instructions in Section 8.3.3.

9.3.2 Follow steps in Section 9.1 to prepare calibration standards for aqueous matrix.

9.3.3 Follow steps in Section 9.2 to prepare calibration standards for solid matrix.

9.3.4 All sample volumes, reagent volumes, spiking standard volumes, standard/reagent ID numbers, hot block ID numbers, hot block temperature, thermometer ID number, and preparation date and time must be recorded in the electronic prep log.

9.4 Equipment Preparation

Configure the instrument according to manufacturer's recommendations. Allow the colorimeter and recorder to warm up. Run a baseline with all reagents, using reagent water to flush the tubing. Whenever new tubing is used, allow ample time to flush the tubing.

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9.5 Initial Calibration (ICAL)

9.5.1 Analyze a blank and a minimum of 5 calibration standards. The lowest calibration standard must be at or below the reporting limit. A new initial calibration curve with freshly prepared standard is analyzed on each working day.

9.5.2 Initial Calibration Evaluation

9.5.2.1 Using the instrumentation software, prepare a standard curve by plotting absorbance versus mercury concentration of each calibration standard. The analyst may employ a regression equation that does not pass through the origin. The regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.5.2.2 Individual analyte calibration levels may be removed from the lowest and/or highest levels of the calibration curve provided the number of remaining calibration points meet the minimum requirements and the quantitation range is adjusted as necessary.

9.5.2.3 Removal of interior calibration levels is not permitted unless a standard introduction error or preparation error can be documented.

9.5.2.4 A calibration level may be replaced provided that the replacement calibration standard is analyzed within the same calibration event.

9.5.2.5 Evaluate the Relative Error of the calibration by one of the following options:

Option 1: Relative Error (%RE)

$$\%\ Relative\ Error = \frac{x_i' - x_i}{x_i}\ x\ 100$$

Where: x_i = True value of the calibration standard
x'_i = Measured concentration of the calibration standard

Calculate %RE for two (2) initial calibration levels, the standard at the mid-point and the standard at the lowest point.

Option 2: Relative Standard Error (%RSE)

$$\%\mathrm{RSE} = 100\ x \sqrt{\sum_{i=1}^{n} \frac{\left[\frac{x_i' - x_i}{x_i}\right]^2}{(n-p)}}$$

Where: x_i = True value of the calibration level i
x'_i = Measured concentration of calibration level i
p = Number of terms in the fitting equation (avg.=1, linear=2)
n = Number of calibration points

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Refer to Section 11.1 for acceptance criteria and corrective actions.

9.5.2.6 Initial Performance and Recovery (IPR) at the mid-point of the calibration curve (5 ug/L) and CRDL at the lowest calibration point (0.2 ug/L) will be analyzed immediately after calibration to verify %RE in instances where software limitations do not allow for %RSD calculation.

9.5.3 Initial Calibration Verification (ICV)

In addition to meeting the linearity requirement, any new calibration curve must be assessed for accuracy in the values generated. To assess the accuracy, a single standard from a secondary source must be analyzed and the results obtained must be compared to the known value of the standard. This step is referred to as Initial Calibration Verification. The ICV is prepared per Sections 8.3.6 and 9.1 analyzed immediately following an initial calibration curve. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.5.4 Initial Calibration Blank (ICB)

The ICB consists of reagent water that is prepared per Sections 8.3.3 and 9.1. An ICB must be analyzed immediately following the ICV. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.6 Continuing Calibration Verification (CCV)

9.6.1 Continuing Calibration Verification (CCV): A CCV must be analyzed after every 10 samples and at the end of the analytical batch to verify the system is still calibrated. The CCV should be from the same material as the curve standards and is prepared per Sections 8.3.3 and 9.1. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.6.2 Continuing Calibration Blank (CCB): The CCB consists of reagent water that is prepared per Sections 8.3.3 and 9.1. A CCB must be analyzed after each CCV. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.6.3 Reporting Limit Verification Standard (CRDL): The CRDL is an optional check standard at or below the concentration of the reporting limit. The CRDL is prepared per Sections 8.3.3 and 9.1. If required by client or program, the CRDL must be analyzed at the beginning and the end of the analytical run. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.7 Determination of Mercury

9.7.1 Instrument configuration must be the same for sample analysis as for initial calibration.

9.7.2 Pour approximately 10mL portions of each standard, Method Blank, LCS, sample and MS/MSD into autosampler tubes for analysis.

9.7.3 Once initial calibration is established, analyze each sample, Method Blank, LCS and MS/MSD. An example sequence may be as follows:

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Initial calibration standards
IPR (if required)
ICV
ICB
CRDL (if required)
Method blank
LCS
Client samples 1-10
MS/MSD
CCV
CCB
Client samples 11-20
MS
CCV
CCB
CRDL (if required)

9.7.4 Any sample with a mercury concentration that exceeds the linear range of the calibration curve must be diluted with 3% HCl solution and re-analyzed, or over range results must be qualified as estimated. Alternatively, the sample can be re-digested at a dilution. **WI DNR:** Any sample digestate with a Hg concentration >90% of the linear range of the calibration must be diluted and reanalyzed.

9.7.5 Flush all lines with a 20% nitric acid solution for several minutes, followed by a DI water rinse several minutes. Remove lines from rinse and pump until dry.

10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Calculations

10.1.1 The instrument software calculates the Mercury concentration in the sample aliquot as follows:

$$X_s = (y - b)/a$$

Where: X_s = Concentration of the analyte
y = Total area or response of the analyte
a = slope of the line (the coefficient of x)
b = intercept of the line

10.1.2 Calculate the final concentration in the samples as follows:

$$\text{Aqueous Sample (ug/L)} = \frac{(X_s)(V_f)(D)}{(V_i)} \qquad \text{Solid Sample (mg/kg)} = \frac{(X_s)(V_f)(D)}{(W_s)} \times 1000$$

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Where: X_s = Mercury concentration from instrument in ug/L
V_f = Final sample volume of digestate in Liters
D = Dilution factor of the digestate
V_i = Initial volume of aqueous sample digested, in Liters
W_s = Weight of solid sample digested, mg

$$\text{Moisture-corrected concentration} = \frac{\text{(Final concentration as received)}}{\text{(100 - \%Moisture)}} \times 100$$

10.1.3 LCS calculation:

$$R = (C / S) \times 100$$

Where: R = Percent Recovery
C = Observed LCS concentration
S = True LCS concentration

10.1.4 MS calculation:

$$R = \frac{(C_s - C)}{S} \times 100$$

Where: R = Percent Recovery
C_s = Observed MS concentration
C = Sample concentration
S = True spike concentration

10.1.5 RPD calculation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} \times 100$$

Where: RPD = Relative Percent Difference
D_1 = First Sample Result
D_2 = Second Sample Result

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Instrument Quality Control*

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration	Applicable target analyte	Each day of analysis and as needed	r ≥ 0.995 **%RE:** Lowest point: +/-50% Midpoint: +/-10% **OR** **%RSE:** ≤20%	Analyze a new initial calibration curve. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed initial calibration must be reanalyzed.
Initial Calibration Verification Standard (ICV)	Second Source Standard	Immediately following initial calibration of the instrument	90-110% Recovery	Reanalyze ICV. If the second ICV also exceeds the acceptance range, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICV must be reanalyzed or qualified. **Exception:** If the ICV is outside the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Initial Calibration Blank (ICB) **Continuing Calibration Blank (CCB)**	Reagent water	ICB Immediately following an ICV. CCB Immediately following each CCV.	Target analyte must be <RL. **If required by client or program**: ICB/CCB must be <1/2 the RL. **WI DNR compliance samples:** ICB/CCBs must be evaluated to the most current MDL (LOD).	Reanalyze ICB/CCB. If the second ICB/CCB is also >RL, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICB/CCB must be reanalyzed or qualified. **Exception:** If the ICB/CCB is >RL, associated samples determined to be <RL are reportable. **WI DNR:** If the absolute value of an ICB/CCB result exceeds the established MDL but is <RL (LOQ), associated samples are reportable but must be qualified to indicate that an associated blank exceeds the MDL (LOD).
Continuing Calibration Standard (CCV)	Applicable target analyte	Every 10 samples and at end of run	90-110% Recovery	Check instrument operating conditions, and if necessary, restore them to the original settings. Reanalyze CCV. If the second CCV still exceeds the acceptance criteria, then a new initial calibration must be analyzed. Samples associated with a failed CCV must be reanalyzed or qualified. **Exception:** If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Reporting Limit Verification Standard (CRDL)	Applicable target analyte	If required by client or program: At the beginning of the run and at end of run.	50-150% Recovery Acceptance range may vary; refer to client-specific technical requirements.	If the CRDL is required by client or program and fails the acceptance criteria, another CRDL may be analyzed. If the second CRDL fails, associated samples must be qualified. **Exception:** If the CRDL is outside of the upper control limit, indicating high bias, associated samples determined to be <RL are reportable without qualification.

*NOTE: Failure of the initial calibration, ICV, CCV, ICB, CCB, or CRDL due to instrument malfunction requires the instrument to be restored to proper working order and the reanalysis of samples associated with the failed QC.

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11.2 Batch Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water or simulated soil matrix	One per preparation batch of up to 20 samples, per matrix.	Target analyte must be less than the reporting limit.	Reanalyze method blank. Re-digest and reanalyze if target compound is still >RL in method blank and associated samples. **Exceptions:** 1) If the method blank concentration is less than 1/10 of the amount measured in the sample, corrective action is not required, affected data must be qualified. This allowance is not applicable to samples associated with some state programs or client technical specifications 2) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 3) If a contaminant is present only in the method blank and not the samples, no action is required.
Laboratory Control Standard (LCS)	Applicable target analyte	One per preparation batch of up to 20 samples, per matrix.	80-120% Recovery	Re-analyze LCS. Re-digest and re-analyze associated samples if LCS is still outside acceptance limits. **Exceptions:** 1) If no additional sample remains for re-analysis or if re-extraction/re-analysis cannot take place within holding time, reported data must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified. 3) If LCS recovery is outside of QC limits but a matrix spike recovers within LCS recovery limits, the sample data may be reported without qualifiers. The LCS data must be qualified with "L5". This allowance is not applicable for samples associated with some state programs or client technical specifications.
Matrix Spike/ Matrix Spike Duplicate (MS/MSD)	Applicable target analyte	One MS/MSD set per preparation batch.	75-125% Recovery ≤20% RPD	No corrective action necessary. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.

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11.3 Method Performance

11.3.1 Method Validation

Refer to the SOP for Method Validation and Instrument Verification for the procedures used for initial method validation. Method Detection Limits (MDL) must be determined per the procedure in 40CFR Part 136, Appendix B.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must document acceptable accuracy and precision by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

The analyst must perform primary review of data and calculated results for accuracy. Secondary review of the data and calculated results must be performed by another qualified analyst, the department supervisor, or the Quality Manager prior to release for reporting. Refer to the SOP for Data Review Process for more information.

12.2 Corrective Action

Corrective action is expected any time QC is not within acceptance criteria, when sample results exceed the calibration range, and when carryover is suspected. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Refer to Section 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

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14.0 MODIFICATIONS

14.1 Digestion procedure modified to use digestion cups in a hot block instead of BOD bottles in a water bath.

14.2 Standards and some reagents purchased as certified solutions.

14.3 Stannous Chloride solution not stirred continually because it is a solution and not a suspension.

14.4 Stannous Chloride solution is prepared per instrument manufacturer's instructions.

14.5 Interference tests and MSA from method 7000A Sections 8.6 and 8.7 are not routinely performed.

15.0 RESPONSIBILITIES

Pace employees that perform any part of this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

16.0 ATTACHMENTS

Not applicable to this SOP.

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Methods 7000A, 7470A and 7471A.

17.2 Pace Analytical Quality Manual; latest revision.

17.3 NELAC/TNI Standards; Quality Systems section; 2003, 2009, and 2016.

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18.0 REVISION HISTORY

This Version:

Section	Description of Change
3.0	Added dilution as a corrective action for high chloride.
6.0	Clarified preservation for field filtered and added lab filtered details.
7.1	Added vacuum pump for filtration.
7.2	Updated supplies and added 0.45um Flipmate filters.
8.1	Updated reagent specifications to match practice.
8.2	Added Intermediate #2 standard with updated expiration.
8.3	Updated standard preparation to match practice and include Intermediate #2 standard.
9.1	Updated batch QC preparation and clarified actions if purple color does not persist.
9.2	Updated batch QC preparation and added centrifugation as an alternative to filtering.
9.5	Added ICAL point dropping rules, %RE and %RSE equations, and IPR and CRDL for %RE.
9.7	Added instrument configuration and instrument shutdown clarification. Added IPR (if required) to example sequence. Added WDNR linear range requirement.
11.1	Added %RE and %RSE criteria, updated ICV/CCV corrective action, and updated footnote.
11.2	Updated MB and LCS corrective action.
14.0	Added modifications for stannous chloride recipe and interference tests/MSA not performed.
17.3	Added reference to SW-846 7000A and 2016 TNI Standard.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0044	Mercury by SW-846 7470A/7471A	01

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Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

Document Number: ENV-SOP-IND1-0055 **Revision:** 01
Title: TCLP Extraction

All dates and times are in Central Time Zone.

ENV-SOP-IND1-0055 TCLP Extraction

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	25 Feb 2020, 07:12:41 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Steven Sayer (004775)	General Manager 2	25 Feb 2020, 07:31:16 AM	Approved
Felicia Walker (005354)	Manager	25 Feb 2020, 12:25:59 PM	Approved

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STANDARD OPERATING PROCEDURE
TITLE: TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)
METHOD: SW-846 1311
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide a laboratory specific procedure for extracting organic and inorganic compounds from samples using the Toxicity Characteristic Leaching Procedure (TCLP) as stated in EPA SW-846 Method 1311.

1.1 The TCLP is designed to determine the mobility of organic and inorganic constituents present in liquid, solid and multiphasic wastes. This SOP is applicable for all waste matrices.

1.2 If a total analysis of the waste sample demonstrates that individual analytes are not present or are at such low levels that the regulatory limits will not be exceeded, the TCLP need not be run.

1.3 If the analysis of any liquid fraction of the waste shows analytes of concern at such high concentrations that, even after accounting for dilution from the other fractions of the extract, the concentration would be above the regulatory limit for that compound, then the remaining fractions do not need to be analyzed.

1.4 Extraction using the Zero Headspace Extractor (ZHE) for volatiles is not necessary if an analysis of the bottle extract shows a concentration of a regulated volatile compound above the regulatory limit for a compound. The bottle extract cannot be used to demonstrate that the concentrations of volatile compounds are below regulatory limits.

1.5 Volumes/weights used, standard concentrations, vendors, instrumentation, equipment and supplies are subject to change.

2.0 SUMMARY OF METHOD

2.1 An aliquot of waste sample is tumbled in a sealed vessel containing extraction fluid to leach out compounds of interest from the sample. The leachate is then the sample that is analyzed by the required determinative method.

2.2 Bottle extractors are used for non-volatile analytes and a special ZHE extraction device is used to facilitate extraction of samples for volatile analysis.

2.3 Liquid wastes, those containing <0.5% solid material, after filtration through a 0.6 to 0.8um glass filter, are defined as the TCLP extract.

2.4 For wastes containing ≥0.5% solids, the liquid portion, if any, is separated from the solid phase and stored for later analysis. The solid phase is extracted with an amount of the appropriate extraction fluid equal to 20 times the weight of the solid phase.

2.5 If compatible, the initial liquid phase and the extracted water from the solid phase are combined and analyzed as one sample. If the wastes are not compatible, they are analyzed separately and results are mathematically combined to give a volume-weighted average concentration.

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3.0 INTERFERENCES

No significant interferences are listed for the preparation of the TCLP extracts. Potential interferences during analyses are discussed in the individual determinative method SOPs.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

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STANDARD OPERATING PROCEDURE
TITLE: TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)
METHOD: SW-846 1311
ISSUER: Pace ENV – Indianapolis – IND1

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6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Solids and Semi-solids	**Non-volatiles:** >200g preferably in a glass container (to avoid phthalates in SVOA analysis). **Volatiles:** >50g in a glass container.	No preservation required.	Cool to ≤6°C unless refrigeration causes irreversible physical change.	**Volatile:** TCLP extraction within 14 days of collection date and VOA analysis within 14 days of SPLP extraction date. **Non-Volatile:** TCLP extraction within 14 days of collection date, SVOA extraction within 7 days of TCLP extraction date SVOA analysis within 40 days of SVOA extraction date. **Mercury:** TCLP extraction within 28 days of collection date and Hg analysis within 28 days of SPLP extraction date. **Metals:** TCLP extraction within 180 days of collection date and metals analysis within 180 days of TCLP extraction date.
Aqueous and Liquid	**Non-volatiles:** Minimum 1L preferably in a glass container. **Volatiles:** Minimum 1L preferably in a glass container.	No preservation required.	Cool to ≤6°C unless refrigeration causes irreversible physical change.	**Volatile:** TCLP extraction within 14 days of collection date and VOA analysis within 14 days of TCLP extraction date. **Non-Volatile:** TCLP extraction within 14 days of collection date, SVOA extraction within 7 days of TCLP extraction date SVOA analysis within 40 days of SVOA extraction date. **Mercury:** TCLP extraction within 28 days of collection date and Hg analysis within 28 days of TCLP extraction date. **Metals:** TCLP extraction within 180 days of collection date and metals analysis within 180 days of TCLP extraction date.

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7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Description / Comments
Zero Headspace Extraction (ZHE) vessels	Used for volatile extractions; must have an internal volume of 500-600mL and be equipped to accommodate a 90-110mm filter. ZHEs contain o-rings that should be replaced frequently. The piston within the ZHE should be able to be moved with approx. 15psi or less. Refer to Attachment 1.
Bottle Extraction vessels	Used for non-volatile extractions; borosilicate glass bottles of sufficient size to fit into the agitation apparatus. Plastic bottles shall not be used if organics are to be determined.
Agitation apparatus	Device capable of rotating the extraction vessels in an end-over-end fashion at 30 +/- 2rpm. Refer to Attachment 1.
Filtration Device	For non-volatile extractions; the filtration device should have a minimum internal volume of 300mL, be able to accommodate a minimum filter size of 47mm, must be capable of exerting pressures of up to 50psi or more and shall be constructed of inert material.
pH meter	Accurate to +/- 0.05 units at 25˚C
Gas-tight syringes	Used for ZHE extract transfer
Analytical balance	Accurate to within +/- 0.01g
Magnetic stirrer	Including stir bars
Water Bath	Capable of maintaining water temperature at 50 +/-5˚C
Thermometer	Capable of recording minimum and maximum temperatures of the room while samples are tumbled

7.2 Supplies

Supplies	Description
Graduated cylinders	Class A, glass, various sizes
Filters	Filters shall be made of borosilicate glass fiber, shall contain no binder material, and shall have an effective pore size of 0.6 to 0.8um, or equivalent.
Glass vials	40mL, for ZHE extract collection
Tedlar bags (optional)	For ZHE extract collection
Plastic cups and lids	5-oz or equivalent

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8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration / Description
Reagent water	ASTM Type II water
Hydrochloric acid, HCl	1N, Fisher item #SA481 reagent grade, or equivalent
Sodium Hydroxide, NaOH	1N, Fisher item #SS266-4 reagent grade, or equivalent
Acetic acid, CH_3COOH	Glacial, reagent grade, Fisher
Extraction Fluid #1	Add 5.7mL of glacial acetic acid to 500mL of reagent water then add 64.3mL of 1N sodium hydroxide and dilute to 1L with reagent water. **When correctly prepared, the pH of this fluid will be 4.93 +/- 0.05. The pH should be checked prior to use. If the pH is not 4.93 +/-0.05, the fluid shall be discarded and fresh extraction fluid prepared. Expires 6 months from preparation date.**
Extraction Fluid #2	Dilute 5.7mL of glacial acetic acid to 1L with reagent water. **When correctly prepared, the pH of this fluid will be 2.88 +/- 0.05. The pH should be checked prior to use. If the pH is not 2.88 +/-0.05, the fluid shall be discarded and fresh extraction fluid prepared. Expires 6 months from preparation date.**

8.2 Standards

Reagent	Concentration / Description
pH 2 Calibration Buffer	Fisher #SB96-1, or equivalent
pH 4 Calibration Buffer	Fisher #SB101-4, or equivalent
pH 7 Calibration Buffer	Fisher #SB107-4, or equivalent
pH 10 Calibration Buffer	Fisher #SB115-4, or equivalent
pH 12 Calibration Buffer	Ricca #1615.3-2, or equivalent
pH 7 ICV Buffer	Ricca #1551.4-1, or equivalent

9.0 PROCEDURE

9.1 Preliminary Evaluations

Preliminary evaluations must be made on a 100g aliquot of the waste sample. If a minimum of 100g of sample is not available, the client must be contacted for their consent to perform the extraction using less than 100g. Before the extraction can proceed, the client must return a signed copy of the *TCLP Deficiency Release,* as seen in Attachment III.

Preliminary evaluations include determination of the percent solids of the sample; determination of whether the waste sample contains insignificant solids and is therefore its own TCLP extract after filtration; determination if there is a need for particle size reduction;

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and determination of which of the two extraction fluids are required when non-volatile TCLP is requested. Refer to Attachment II for additional information.

Refer to the Sample Homogenization, Subsampling, and Compositing SOP for guidelines to obtain a well-mixed sample portion for all preliminary evaluations, and for TCLP extraction.

9.1.1 Percent Solids Determination

If the waste will obviously yield no liquid when subjected to pressure filtration, indicating that the waste is 100% solids, then skip to Section 9.1.2.

If the sample is a liquid or is multiphasic, separation to make a preliminary determination of percent solids is required. Filter the sample as follows, and record all measurements in the TCLP Percent Solids and Add-back Calculations spreadsheet. See Attachment V.

9.1.1.1 Pre-weigh the filter to be used and the container that will collect the filtrate.

9.1.1.2 Assemble the filtering device per manufacturer's specifications and place the filter on the support screen.

9.1.1.3 Weigh out a well-mixed subsample of the waste, 100g minimum, and record the exact weight.

9.1.1.4 Allow slurries to stand to permit the solid phase to settle.

9.1.1.5 Quantitatively transfer the sample to the filtration device. Spread the sample evenly over the surface of the filter. Begin applying gentle vacuum or pressure to the filtration device of 1-10psi until air or pressurized gas moves through the filter. If air does not pass through the filter or if no additional liquid comes through in a 2-minute period, slowly increase the pressure in 10psi increments to a maximum of 50psi until liquid flow has ceased.

NOTE: If >1% of the sample material has adhered to the container used to transfer the sample to the filtration apparatus, determine the weight of this residue and subtract it from the sample weight determined in Section 9.1.1.3.

9.1.1.6 The material in the filter holder is defined as the solid phase of the waste and the filtrate is defined as the liquid phase.

NOTE: Some samples such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid, but even after applying vacuum or pressure filtration, this material may not filter. In this case, the material within the filtration device is defined as the solid. Do not replace the original filter with a new filter under any circumstances. Use only one filter.

9.1.1.7 Determine the weight of the liquid phase by subtracting the weight of the filtrate container from the total weight of the filtrate-filled container. Determine the weight of the solid phase by subtracting the weight of the

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liquid phase from the total weight of sample used. Record the weight of the liquid and solid phases and calculate the percent solids as follows:

$$\text{Percent solids} = \frac{\text{weight of solid phase}}{\text{total weight of sample}} \times 100$$

NOTE: The TCLP Percent Solids and Add-back Calculation spreadsheet will automatically calculate these values. See Attachment V.

9.1.1.8 If the percent solids determined in Section 9.1.1.7 is ≥0.5%, then proceed either to Section 9.1.2 to determine if the material requires particle size reduction or to Section 9.1.1.10 if it is noticed that an amount of the filtrate is entrained in wetting of the filter.

9.1.1.9 If the percent solids determined in Section 9.1.1.7 is <0.5%, then proceed to Section 9.2 if non-volatile TCLP is to be performed and to Section 9.3 with a fresh portion of the waste if volatile TCLP is to be performed.

9.1.1.10 If it appears that the filtrate is entrained in wetting of the filter and the calculated percent solids is between 0.5% – 2%, determine the percent dry solids. Remove the solid phase and filter from the filtration apparatus and place them into an oven located in a fume hood. Dry the solid phase and filter at 100 +/-20°C. Record the final weight. Calculate the percent dry solids as follows:

$$\text{Percent dry solids} = \frac{(\text{weight of dry waste + filter}) - \text{tared wt. of filter}}{\text{Initial weight of waste}} \times 100$$

NOTE: The TCLP Percent Solids and Add-back Calculation spreadsheet will automatically calculate this value.

Repeat step 9.1.1.10 a second time if calculated dry solids is still greater than 0.5% on a second, separate spreadsheet with the sample number and "(2)" designation.

9.1.1.11 If the percent dry solids determined is <0.5%, proceed to Section 9.2 if non-volatile TCLP is to be performed, and to Section 9.3 with a fresh portion of the waste if volatile TCLP is to be performed.

9.1.1.12 If the percent dry solids are ≥0.5%, and if non-volatile TCLP is to be performed, proceed to the Section 9.1.2 with a fresh portion of waste. If only volatile TCLP is to be performed, proceed to Section 9.3 with a fresh portion of the waste.

9.1.2 Particle Size Reduction Determination

This is required unless the solid portion of the sample is capable of passing through a minimum 9.5mm sieve or is smaller than 1 cm in its narrowest dimension. If it will not pass through, the sample must be ground, crushed or cut until it will pass through.

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9.1.3 Extraction Fluid Determination for Non-Volatile TCLP

For determining pH, refer to ENV-SOP-IND1-0030 or its replacement. The pH meter must be calibrated to bracket the range of use according to the SOP or manufacturer's instructions each day of use.

The same 100g sample portion used for percent solids determination can be used for the extraction fluid determination process and the extraction process if the sample is not 100% solid.

For non-volatile TCLP, the following steps are used to determine the appropriate fluid:

9.1.3.1 If the sample was found to have greater >0.5% solids, weigh out a 5g aliquot of the solid phase of the waste into a plastic cup.

9.1.3.2 Add 96.5mL of reagent water to the cup and stir for 5 minutes using a magnetic stirrer. Determine the pH and record it on the TCLP bench sheet (See Attachment IV). If the pH is <5.0, use extraction fluid #1. Proceed to Section 9.2.

9.1.3.3 If the pH is >5.0, add 3.5mL of 1N HCl, stir briefly and cover with a plastic lid. Heat without stirring in water bath to 50 +/-5˚C and hold at 50 +/-5˚C for 10 minutes.

9.1.3.4 Let the solution cool to room temperature in an ice bath, determine the pH, and record it on the TCLP bench sheet. If the pH is <5.0, use extraction fluid #1. If the pH is >5.0, use extraction fluid #2. Proceed to Section 9.2.

9.2 Extraction Procedure for Non-volatile Analysis

9.2.1 A minimum sample size of 100g (solid + liquid phases) is recommended. In some cases, a larger sample size may be appropriate, depending on solids content of the waste sample, whether the initial liquid phase of the waste will be miscible with the aqueous extract of the solid, and whether inorganics and organics are analytes of concern. Enough solids should be generated for extraction such that the volume of TCLP extract will be sufficient to support all of the analyses required. If the amount of extract generated by a single TCLP extraction is insufficient, additional extractions may be performed and the extracts from each combined and aliquoted for analysis. Refer to Attachment II for additional information.

9.2.2 If the waste will obviously yield no liquid when subjected to pressure filtration, indicating that the waste is 100% solids, transfer a minimum 100g well-mixed aliquot of the waste directly into an extractor bottle and proceed to Section 9.2.4.

9.2.3 If the sample is liquid or multiphasic, separation is required per the filtration procedure described in Section 9.1.1. Transfer the solid material resulting from the filtration procedure, including the filter, into the bottle extractor and proceed to Section 9.2.4. Refer to Section 9.2.9 regarding handling of the filtrate.

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9.2.4 Determine the amount of extraction fluid to add to the extraction vessel as follows:

$$\text{Weight of extraction fluid} = \frac{20 \times \text{percent solids} \times \text{unfiltered sample weight}}{100}$$

Use the TCLP Percent Solids Determination and Add-back spreadsheet to complete this calculation. See Attachment V.

9.2.5 Slowly add this amount of the appropriate extraction fluid to the extractor bottle. Close the bottle tightly with a lid.

9.2.6 Secure the sealed extractor bottle in the agitation device and rotate at 30 +/- 2 rpm for 18 +/-2 hours. The temperature of the room where TCLP extractions are performed shall be maintained at 23 +/- 2˚C during the extraction period.

NOTE: As agitation continues, pressure may build up within the extractor bottle. To relieve excess pressure, the extractor bottle may be periodically opened and vented into a hood.

9.2.7 Following the 16-20-hour tumble, record the min/max temperatures of the room during the entire tumbling period on the TCLP bench sheet (See Attachment IV). Separate the material in the extractor bottle by filtration, using a clean glass filter. More than one filter may be used to facilitate final filtering of the TCLP extract, if necessary. Filters shall be acid rinsed with 1N nitric acid if metals are to be determined, or use an acid pre-washed filter from supplier.

9.2.8 If the original waste contained no liquid, then the tumbled and filtered extract is defined as the TCLP extract.

9.2.9 If the original waste contained an initial liquid phase that is compatible to mix with the tumbled extract, combine the liquid extract resulting from Section 9.2.7 with the initial liquid phase of the waste obtained in Section 9.2.3. Use the TCLP Percent Solids Determination and Add-back spreadsheet to determine amounts of each liquid to combine. This combined liquid is then defined as the TCLP extract. If the two liquid fractions are not compatible, analyze the two fractions separately and combine their results mathematically using the equation in Section 9.2.13.

9.2.10 Following collection of the TCLP extract, the pH of the extract should be determined and recorded on the TCLP bench sheet. The pH meter must be calibrated to bracket the range of use according to the SOP or manufacturer's instructions each day of use.

9.2.11 Fill containers with TCLP extract according to the analyses requested. An aliquot for metals analysis may be stored at room temperature in the metals lab until digestion takes place. All other aliquots must be stored under refrigeration until analyzed. The TCLP extract shall be prepared and analyzed according to the appropriate analytical method.

9.2.12 TCLP extracts to be analyzed for metals must undergo acid digestion, unless the analysis of the undigested aliquot produces results for metallic analytes above the regulatory limits. Data on undigested extracts alone cannot be used to demonstrate that the waste is not hazardous.

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9.2.13 If the individual phases are to be analyzed separately, determine the volume of the individual phases (to +/-0.5%), conduct the appropriate analysis, and combine the results mathematically by using a simple volume-weighted average:

$$\text{Final analyte concentration} = \frac{(V1)(C1) + (V2)(C2)}{V1 + V2}$$

Where: V1 = The volume of the first phase, L
C1 = The concentration of the analyte of concern in the first phase, mg/L
V2 = The volume of the second phase, L
C2 = The concentration of the analyte of concern in the second phase, mg/L

9.3 Extraction Procedure for Volatile Analysis

9.3.1 Use the ZHE device to obtain the TCLP extract for analysis of volatile compounds. The ZHE device has approximately a 500mL internal capacity and can accommodate a maximum of 25g of solid. Charge the ZHE with sample only once and do not open the device until the final extract has been collected. Repeated filling of the ZHE to obtain 25g of solid is not permitted. Do not allow the waste, the initial liquid phase, or the extract to be exposed to the atmosphere for any more time than is absolutely necessary. See 9.1.2 for particle size reduction if solids are not capable of passing through a minimum 9.5mm sieve. Any manipulation of these materials should be done when cold to minimize loss of volatiles. All samples for TCLP Volatiles analysis must be prepared by means of extraction and/or filtration through the ZHE apparatus. Refer to Attachment II for additional information.

9.3.2 Pre-weigh the filtrate collection container and set aside.

9.3.3 Before use each ZHE extractor must be pressure tested. Fully assemble each ZHE extractor without the piston and charge to 50psi. The ZHE vessel must maintain pressure at 50psi for one hour in order to be suitable for use.

9.3.4 Place the ZHE piston within the body of the ZHE to a height that minimizes the distance the piston must move once the ZHE is charged with sample. Secure the glass fiber filter between the support screens and set aside.

9.3.5 If the waste is 100% solids, weigh out a well-mixed subsample of a maximum of 25g. Record the weight and proceed to Section 9.3.8.

9.3.6 If the waste contains <0.5% solids, the liquid portion of the waste, after filtration, is defined as the TCLP extract. Filter enough of the sample so that the amount of filtered liquid will support all of the volatile analyses required.

9.3.7 For wastes containing $\geq$0.5% solids, use the percent solids information obtained in Section 9.1.1 to determine the optimum sample size to charge into the ZHE. The recommended sample size is as follows:

9.3.7.1 For wastes containing <5% solids, weigh out a well-mixed 500g subsample of waste and record the weight on the TCLP bench sheet (See Attachment IV).

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9.3.7.2 For wastes containing >5% solids, determine the amount of waste to charge into the ZHE as follows:

$$\text{Weight of waste to charge ZHE} = \frac{25}{\text{Percent Solids}} \times 100$$

9.3.7.3 Weigh out a well-mixed subsample of the waste of the appropriate size and record the weight on the TCLP bench sheet.

9.3.8 Perform particle size reduction per Section 9.1.2, if necessary. If reduction of the waste is necessary, exposure of the waste to the atmosphere should be avoided to the extent possible. Sieving of the waste is not recommended due to the possibility that volatiles may be lost.

9.3.9 Quantitatively transfer the entire sample, liquid and solid phases, quickly to the ZHE. Secure the filter and support screens then secure the top flange. Tighten all ZHE fittings.

9.3.10 Attach the gas line to the gas inlet/outlet valve on the bottom flange making sure the liquid inlet/outlet valve on the top flange is open. Begin applying gentle pressure of 1-10psi (or more if necessary to a maximum of 50psi) to force all headspace slowly out of the ZHE. This operation should be performed in a hood. At the first appearance of liquid from the liquid inlet/outlet valve, quickly close the valve and discontinue pressure.

9.3.11 If the waste sample in the ZHE contains a liquid phase, record the weight of an empty filtrate collection container on the TCLP Percent Solids Determination and Add-back spreadsheet. Attach the container to the liquid inlet/outlet valve and open the valve. Begin applying gentle pressure of 1-10psi to force the liquid phase of the sample into the filtrate collection container. It no additional liquid has passed through the filter in any 2-minute period, slowly increase the pressure in 10psi increments to a maximum of 50 psi until liquid flow has ceased. Close the liquid inlet/outlet valve, discontinue pressure to the piston and disconnect and weigh the filtrate collection container.

9.3.12 The material in the ZHE is defined as the solid phase of the waste and the filtrate, if any, is defined as the liquid phase. If the original waste contained <0.5% solids, the filtrate is defined as the TCLP extract and is analyzed directly. The liquid phase may now be either analyzed immediately or refrigerated under minimal headspace conditions until the time of analysis.

9.3.13 Determine the weight of extraction fluid #1 to add to the ZHE as follows:

$$\text{Weight of extraction fluid \#1} = \frac{20 \times \text{percent solids} \times \text{weight of waste filtered}}{100}$$

Use the TCLP Percent Solids Determination and Add-back spreadsheet to complete this calculation. See Attachment V.

9.3.14 With the ZHE in the vertical position, release gas pressure on the ZHE piston and deliver the appropriate amount of extraction fluid #1 into the ZHE through the liquid inlet/outlet valve. Once the extraction fluid has been added, immediately close the

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liquid inlet/outlet valve. Check the ZHE to ensure that all valves are closed. Manually rotate the ZHE in an end-over-end fashion 2 or 3 times. With the ZHE in the vertical position, pressurize the ZHE to 5-10psi and slowly open the liquid inlet/outlet valve to bleed off any headspace. This bleeding shall be done quickly in a fume hood, and shall be stopped at the first appearance of liquid from the valve. Re-pressurize the ZHE with 5-10 psi and check all ZHE fittings to ensure that they are closed. Record an initial pressure in the electronic TCLP logbook.

9.3.15 Place the ZHE in the agitation apparatus and rotate the ZHE for 18 +/-2 hours at 30 +/-2 rpm. Temperature of the room where tumbling occurs shall be maintained at 23 +/- 2°C.

9.3.16 Following the 16-20-hour agitation period, record the min/max temperatures of the room during the entire tumbling period on the TCLP bench sheet (See Attachment IV). Record the final pressure on the ZHE in the electronic TCLP logbook. If no pressure has been maintained (pressure gauge reads zero) and no gas release is noted, perform the extraction again with a new aliquot of waste.

9.3.17 Filter the extract through the glass fiber filter using the ZHE device as discussed in Section 9.3.11. All extract should be filtered and collected if the extract is multiphasic or if the waste contained an initial liquid phase. If the original waste contained no initial liquid phase, the filtrate is defined as the TCLP extract. If the waste contained an initial liquid phase, the filtrate and the initial liquid phase are collectively defined as the TCLP extract.

9.3.18 Following collection of the TCLP extract, immediately prepare the extract for analysis and store refrigerated with minimal headspace. If the individual phases are to be analyzed separately, determine the volume of the individual phases, conduct the analysis and combine the results mathematically using the equation shown in Section 9.2.13.

10.0 DATA ANALYSIS AND CALCULATIONS

Refer to calculations in Section 9.

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Extraction (Tumble) Blank	Extraction fluid	**Volatile ZHE Vessel:** Minimum of 1 blank per 20 extractions per extraction vessel unless a tumble blank is required per batch by program/client. **Non-Volatile Glass Vessel:** Minimum of 1 blank per 20 extractions per reusable glass extraction vessel unless a tumble blank is required per batch by program/client. **Disposable Glass/Plastic Vessels:** Minimum of 1 blank per lot number received.	Target analytes must be less than reporting limits.	Re-tumble associated samples if blank result is >RL. If sample cannot be re-tumbled, blank and samples must be qualified. **Exception:** If blank result is >RL but associated sample(s) are ND, no action is required.

11.2 The required rotation speed of the agitation device is 30 +/- 2rpm. The rotation speed is checked monthly and recorded on a monitoring sheet. A supervisor should be alerted if the rotation speed is unacceptable and corrective actions must be taken.

11.3 The minimum room temperature and maximum room temperature over the duration of each tumbling event is recorded. If the room temperature exceeds the required 23 +/- 2˚C, samples tumbled during that event must be qualified (T9) or re-prepared and re-tumbled.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must document proficiency by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

12.0 CORRECTIVE ACTION

12.1 Corrective Action

Refer to Section 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

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14.0 MODIFICATIONS

Not applicable to this SOP.

15.0 RESPONSIBILITIES

Pace employees that perform any part of this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

16.0 ATTACHMENTS

16.1 Attachment I: Diagram of agitation apparatus and ZHE apparatus

16.2 Attachment II: TCLP Preliminary Evaluations Flow Diagram

16.3 Attachment III: TCLP Deficiency Release Form

16.4 Attachment IV: Examples TCLP Preparation Bench Sheets

16.5 Attachment V: TCLP Percent Solids and Add-back Calculation spreadsheet

17.0 REFERENCES

17.1 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846 Method 1311, Toxicity Characteristic Leaching Procedure, 3rd edition, December 1996.

17.2 Pace Analytical Quality Manual; latest revision.

17.3 NELAC/TNI Standards; Quality Systems section; 2003 and 2009.

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18.0 REVISION HISTORY

This Version:

Section	Description of Change
All	Converted to new SOP format.
6.0	Added Aqueous and Liquid matrix.
7.1	Added thermometer for determining room temperature.
7.2	Added graduated cylinders and plastic cups with lids.
8.1	Added catalog numbers to reagents and shelf life to fluids.
9.1.1	Added reference to add-back spreadsheet and some additional detail from the method.
9.1.3	Added references to bench sheet and pH SOP.
9.2	Added references to bench sheet, add-back spreadsheet, and pH SOP.
9.3	Added reference to bench sheet and add-back spreadsheet. Added detail from method.
11.4	Changed accuracy and precision to proficiency.
16.0	Added add-back spreadsheet as Attachment V.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0055	Toxicity Characteristic Leaching Procedure (TCLP)	00

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STANDARD OPERATING PROCEDURE
TITLE: TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)
METHOD: SW-846 1311
ISSUER: Pace ENV – Indianapolis – IND1

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Attachment I: Diagram of Agitation Apparatus and ZHE Apparatus

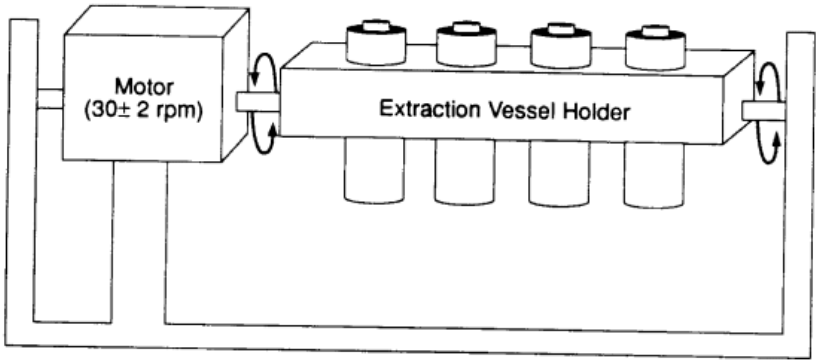

Figure 1. Rotary Agitation Apparatus

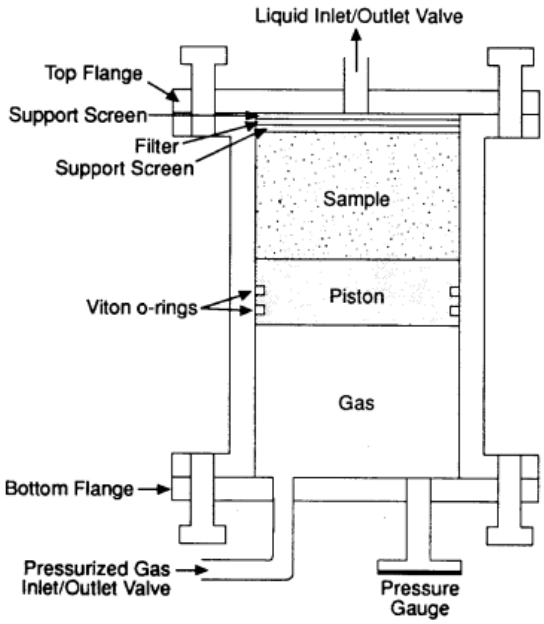

Figure 2. Zero-Headspace Extractor (ZHE)

CD-ROM 1311- 33 Revision 0
July 1992

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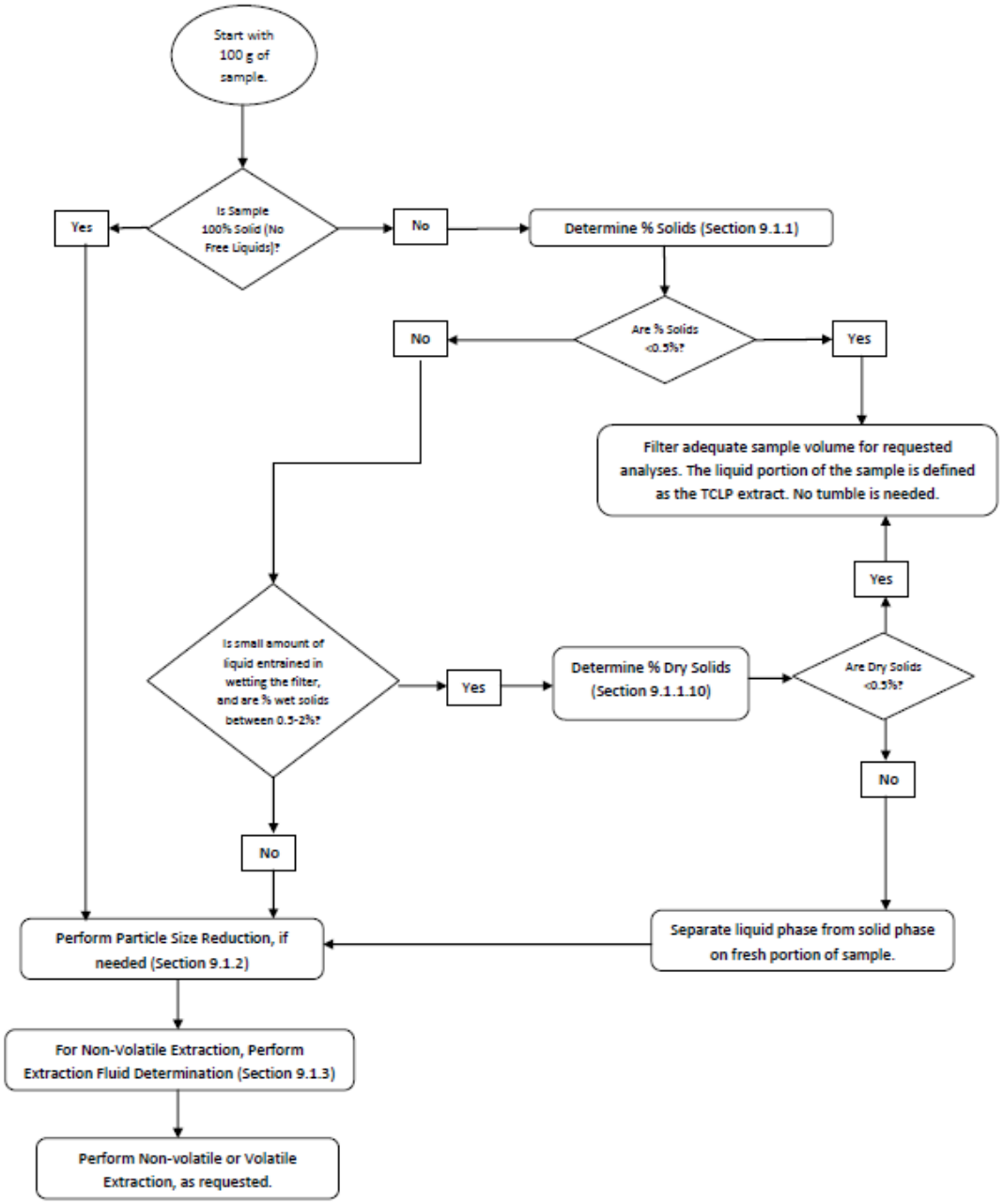
Attachment II: TCLP Preliminary Evaluations Flow Diagram



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Attachment III: TCLP Deficiency Release Form

Pace Analytical Services, LLC
7726 Moller Road
Indianapolis, IN 46268
Phone: 317-228-3100
Fax: 317-872-6189

TCLP DEFICIENCY RELEASE

DATE:

TO:

RE: NOTE OF TCLP DEFICIENCY

This memo is in notice of a deficiency in the TCLP extraction for the sample identified:

PROJECT# **LAB#:**

CLIENT ID:

In accordance with the TCLP Method 1311, the required weight to be used with a sample is 100 grams. The sample identified above does not have sufficient weight to comply with this requirement. In order to proceed with the TCLP extraction, your written approval is needed. The sample will then be processed with a reduced weight and the extraction fluid volume adjusted accordingly.

Should your decision be to provide additional sample for extraction, please contact your customer service representative to request containers, evaluate holding time constraints, or specify turnaround time needs.

Thank you.

Approval to proceed with TCLP extraction using reduced weight has been granted by:

Signature: _____

Name (Print): _____

Date: _____

F-IN-C-293-rev.03, 27Feb2018

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Attachment IV: Examples TCLP Preparation Bench Sheets

Analyst _____ Pace Analytical Services - Indianapolis Batch _____
Date_____ Benchsheet HBN _____
TCLP(1311) ☐ SPLP (1312) ☐ Neutral Leachates (ASTM D3987-12) ☐

Sample ID	Analysis	If filtered: Sample Weight (grams)	If filtered: Liquid Fraction (grams)	Extracted Sample (g)	% Solids	Pullthrough ?	Passed 1 mm Sieve	Passed 9.5 mm Sieve	Fluid determ. weight (g)	Initial pH/ Adjusted pH	Fluid Solution pH*/Sol'n ID	Final pH	Buffer Solution (mL)	Extract Filtered (mL)	Aq Add back (mL)	Glass/ Plastic vessel ID or lot #	Client/ Comments
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																
	Metals					Yes No	Yes No	Yes No									
	SVOA																

*check daily before use

Start Date/Time _____ Stop Date /Time_____ Total Hours Tumbled_____ Final Filtration Date_____ 1N HCl ID_____
pH Meter: **50MET1** Balance ID: **SC-04 and SC-23** Water Bath Thermometer:_____ Room Thermometer:_____ Corrected R.T. *Min*_____ *Max*_____
0.7um Flipmate ID _____Cup ID _____ 142mm ID_____ 150mm ID_____ Tumbler ID _____ Amber Glass Bottle ID _____

F-IN-Q-445-Rev.03,17Jan2019

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METHOD: SW-846 1311
ISSUER: Pace ENV – Indianapolis – IND1

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Analyst _____ Pace Analytical Services - Indianapolis Batch _____
Date_____ Benchsheet HBN _____
TCLP(1311)☐ SPLP (1312)☐ Neutral Leachates (ASTM D3987-12) ☐

Sample ID	Analysis	If filtered: Sample Weight (grams)	If filtered: Liquid Fraction (grams)	Extracted Sample (g)	% Solids	Pullthrough?	Passed 1 mm Sieve	Passed 9.5 mm Sieve	Fluid Solution pH*/ Solution ID	Buffer Solution (mL)	Extract Filtered (mL)	Aq. Addback (mL)	ZHE Vessel ID	Client/ Comments
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						
	ZHE					Yes No	Yes No	Yes No						

*check daily before use

Start Date/Time _____ Stop Date /Time_____ Total Hours Tumbled_____ Final Filtration Date_____
pH Meter: **50MET1** Balance ID: **SC-04 and SC-23** Water Bath Thermometer: _____ Room Thermometer:_____ Corrected R.T. *Min*_____ *Max*_____
90mm ID_____Tumbler ID _____ 40mL Vial ID _____

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Attachment V: TCLP Percent Solids and Add-back Calculation spreadsheet

Pace Analytical	7726 Moller Road Indianapolis, IN 46268	Document Name: TCLP Percent Solids Determination and Add-back Calculation	Date Revised: January 21, 2020
		Document Number: F-IN-M-441-rev.02	Issuing Authority: Pace Indianapolis Quality Department

Analyst		EPIC sample #		Batch #	
Date		Client name		HBN #	

Percent Solids Determination:

A. container 1 + sample (g)		g	(container with sample)
B. container 1 (g)		g	
C. filter (g)		g	
D. sample used (g)	0.000	g	[A - B]
E. container 2 (g)		g	(container to hold filtrate)
F. container 2 + filtrate (g)		g	
G. filtrate (g) [=initial liquid phase]	0.000	g	[F - E]
H. wet solids (g)	0.000	g	[D - G]
I. % solids (wet)	#DIV/0!	%	[(H/D)*100]
J. % liquid	#DIV/0!	%	[100 - I]

if <0.5%, no tumble is required. ←

STOP - Proceed only if wet solids are between 0.5% - 2%.

C. filter (g)	0.000	g	
K. dry solids + filter (g)		g	
L. dry solids (g)	0.000	g	[K - C]
M. % solids (dry)	#DIV/0!	%	[(L/D)*100]
N. % liquid	#DIV/0!	%	[100 - M]

if <0.5%, no tumble is required. ←

Filtrate Add-back Calculations (if compatible):

O. solids tumbled (g)		g		
P. extraction fluid added (ml)	0.000	ml	[O *20]	
Q. amount of initial liquid phase to add back to tumbled TCLP extract (g)	#DIV/0!	g	[(O*G)/H]	(weight of initial liquid phase (G) added to the tumbled TCLP extract if all tumbled TCLP extract is to be filtered)
R. actual amount of tumbled TCLP extract filtered (ml)		mL		
S. amount of initial liquid phase to add back to tumbled TCLP extract (g)	#DIV/0!	g	[(R*Q)/P]	(weight of initial liquid phase (G) added to the amount of tumbled TCLP extract filtered (R)

TCLP ZHE Filtration:

1. wt of 40ml vial		g
2. wt of sample used		g (25g minimum)
3. wt of 40ml vial + filtrate		g
4. filtrate in vial	0	g [step 3. - step 1.]
5. solid in ZHE vessel	0	g [step 2. - step 4.]
6. amt ext fl #1 to use	0	ml [step 5. x 20]

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Document Information

Document Number: ENV-SOP-IND1-0057 **Revision:** 01

Document Title: Semivolatiles by GC/MS 8270

Department(s): SVOA

Date Information

Effective Date: 30 Jan 2020

Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

Document Number: ENV-SOP-IND1-0057 **Revision:** 01
Title: Semivolatiles by GC/MS 8270

All dates and times are in Central Time Zone.

ENV-SOP-IND1-0057 Semivolatiles by GC/MS 8270

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	29 Jan 2020, 11:44:43 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Timothy Pinckert (003677)	Manager	29 Jan 2020, 11:45:17 AM	Approved
Steven Sayer (004775)	General Manager 2	30 Jan 2020, 12:02:18 PM	Approved

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STANDARD OPERATING PROCEDURE
TITLE: SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS
METHOD: EPA SW-846 8270C
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

1.1 This standard operating procedure (SOP) describes the laboratory procedure for the determination of semivolatile organic compounds in sample extracts while meeting the requirements specified in EPA method 8270C.

1.2 This method can be used to quantitate most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted without derivatization from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone. Such compounds include polynuclear aromatic hydrocarbons, chlorinated hydrocarbons and pesticides, phthalate esters, organophosphate esters, nitrosamines, haloethers, aldehydes, ethers, ketones, anilines, pyridines, quinolines, aromatic nitro compounds, phenols, and nitrophenols.

1.3 The following compounds may require special treatment when being determined by this method. Benzidine can be subject to oxidative losses during solvent extraction and exhibits poor chromatographic behavior. Hexachlorocyclopentadiene is subject to thermal decomposition in the inlet of the gas chromatograph, chemical reaction in acetone solution, and photochemical decomposition. N-nitrosdiphenylamine decomposes in the gas chromatographic inlet and cannot be separated from diphenylamine. Pentachlorophenol, 2,4-dinitrophenol, 4-nitrophenol, 4,6-dinitro-2-methylphenol, 4-chloro-3-methylphenol, benzoic acid, 2-nitroaniline, 3-nitroaniline, 4-chloroaniline, and benzyl alcohol are subject to erratic chromatographic behavior, especially if the GC system is contaminated with high boiling material.

1.4 The following compounds are analyzed using this procedure but are not 8270C listed compounds: Carbazole, Biphenyl (Diphenyl), Caprolactam, Atrazine, Benzaldehyde, Diethyl Aniline, 2,3-Dichloroaniline, 1-Methylnaphthalene, 4-Chlorobenzotrifluoride, n-Octadecane, and Pentachloroethane.

1.5 The following Appendix IX compounds may require special treatment when being determined by this method. Famphur, Kepone, Hexachlorphene, p-Phenylenediamine, and a,a-Dimethylphenylethylamine break down easily in the calibration mix and may not be detected in low concentration standards.

1.6 The list of compounds and reporting limits analyzed by this laboratory using method 8270C is found in Table 1 and Table 3. Other analytes may be analyzed by this method but must have quality control documentation to support the performance of this method for those analytes. Refer to LIMS for method detection limits.

1.7 Reporting limits, control limits, volumes used, standard concentrations, vendors, instrumentation, equipment and supplies are subject to change.

2.0 SUMMARY OF METHOD

Semivolatile compounds are introduced into a gas chromatograph by injection of a sample extract onto a narrow-bore capillary column for analysis. The column is temperature programmed to separate the analytes that are then detected with a mass spectrometer. Identification of the analytes is made by comparing their mass spectra with spectra of known standards. Quantitation is

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accomplished by comparing the response of a major ion relative to the internal standard response using a multi-point calibration curve

Method 8270C provides chromatographic conditions for the detection of semivolatile compounds in organic extracts of groundwater, surface water, soil and sediment. Aqueous samples are extracted by using SW-846 method 3510 Separatory Funnel Extraction or other applicable method. Solid samples are extracted using SW-846 method 3546 Microwave Extraction or other applicable method.

3.0 INTERFERENCES

Glassware for the preparatory steps for this method should be thoroughly cleaned and rinsed. Soap products can leave phthalates on the glassware that may interfere chromatographically. Hits for phthalates should be closely scrutinized and continuous hits should warrant checking on the glassware cleaning procedure.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

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METHOD: EPA SW-846 8270C
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6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous	Amber glass container with Teflon-lined lid, 100mL widemouth	No preservation required	Cool to ≤6°C	Sample must be extracted within 7 days of collection date and extract must be analyzed within 40 days of extraction date.
Solid	200 grams in 4oz or 8oz glass jar	No preservation required	Cool to ≤6°C	Sample must be extracted within 14 days of collection date and extract must be analyzed within 40 days of extraction date.

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Vendor	Model / Version	Description / Comments
Gas Chromatographs	Agilent	Lab uses models 6890 and 7890	Or equivalent system
Mass Spectrometers	Agilent	Lab uses models 5973 and 5975	Or equivalent system
Autosamplers	Agilent		Or equivalent system
Data Systems	Agilent		Or equivalent system
Analytical Columns	Restek	Rti-5 Sil MS	15m x 0.25mm, or equivalent column
	Phenomenex	ZB semivolatiles	15m x 0.25mm, or equivalent

7.2 Supplies

Supplies	Vendor/ Item #	Description
Gas tight syringes	Hamilton or equivalent	Various sizes
Syringe valves	Supelco or equivalent	2-way with Luer ends
Standard vials	Supelco or equivalent	2mL stop/go vials (clear vials)
Autosampler vials		1.8mL clear vials

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8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration/ Description
Methylene Chloride	Pesticide grade or equivalent
Acetone	Pesticide grade or equivalent
Methanol	Pesticide grade or equivalent

8.2 Standards

Standard Type	Description	Expiration	Storage
Internal Standard, Surrogate, and Tune Mixes			
Stock Internal Standards	Restek; catalog # 31006; 4000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Working LVE Internal Standards	Refer to Section 8.3.1	Solution expires 6 months from date of preparation.	Refrigerate
Stock Surrogate Standards	Accustandard; catalog #M-8270-SS; 4000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock DFTPP Tuning Standard	O2si; catalog #113000-01, 50 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Standard Compound List Mixes			
Stock 8270 Mega Mix Calibration Standard	Restek; catalog # 31850; 1000 ug/mL or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock 8270 Mix #1 Calibration Standard	Restek; catalog #572178, 2000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock 8270 Mix #2 Calibration Standard	Restek; catalog #572448, 2000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Intermediate 8270 Calibration Standard	Refer to Section 8.3.2	Solution expires 6 months from date of preparation.	Refrigerate
Working 8270/Intermediate 8270 LVE Calibration Standards	Refer to Section 8.3.3	Solution expires 6 months from date of preparation.	Refrigerate
Working 8270 LVE Calibration Standards	Refer to Section 8.3.4	Solution expires 6 months from date of preparation.	Refrigerate

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Standard Type	Description	Expiration	Storage
Standard Compound List Mixes - continued			
Stock 8270 ICV Standard-Stock A	NSI; catalog #C-701, 1000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock 8270 ICV Standard-Stock B	NSI; catalog #C-402, 2000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock 8270 ICV Standard-Stock C	NSI; catalog #C-639, 2000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock 8270 ICV Standard-Stock D	NSI; catalog #541H, 2000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock 8270 ICV Standard-Lilly ICV	Crescent; catalog #CCS-2579, 1000 ug/mL, or equivalent	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Working 8270/Intermediate 8270 LVE ICV Standard	Refer to Section 8.3.5	Solution expires 6 months from date of preparation.	Refrigerate
Working 8270 LVE ICV Standard	Refer to Section 8.3.6	Same expiration date as Intermediate 8270 LVE ICV standard.	Refrigerate
Appendix IX Compound List Mixes			
Stock APP IX Calibration Standard Mix 1	Restek; catalog #32459, 2000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX Calibration Standard Mix 2	Restek; catalog #31806, 1000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX Calibration Standard Mix 3	Restek; catalog #32419, 2000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX Methapyrilene Calibration Standard	Restek; catalog #32459, 2000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX Dinoseb Calibration Standard	Restek; catalog #32251, 1000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX Hexachlorophene Calibration Standard	Restek; catalog #31811, 2000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Intermediate APP IX Calibration Standard	Refer to Section 8.3.7	Solution expires 6 months from date of preparation.	Refrigerate

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Standard Type	Description	Expiration	Storage
Appendix IX Compound List Mixes - continued			
Working APP IX Calibration Standards	Refer to Section 8.3.8	Solution expires 6 months from date of preparation.	Refrigerate
Working APP IX LVE Calibration Standards	Refer to Section 8.3.9	Same expiration date as Working APP IX Calibration standards.	Refrigerate
Stock APP IX ICV Standard Mix 1	NSI; catalog #C-731, 2000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX ICV Standard Mix 2	*NSI; catalog #C-732, 1000ug/mL, or equivalent.*	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX ICV Standard Mix 3	*NSI; catalog #C-417, 2000ug/mL, or equivalent.*	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Stock APP IX ICV Standard Mix 4	NSI; catalog #323, 2000ug/mL, or equivalent.	Manufacturer's recommended expiration date.	Manufacturer's recommended storage conditions. Refrigerate after opening.
Working APP IX ICV Standard	Refer to Section 8.3.10	Solution expires 6 months from date of preparation.	Refrigerate
Working APP IX LVE ICV Standard	Refer to Section 8.3.11	Same expiration date as Working APP IX ICV.	Refrigerate

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8.3 Standard Preparation Procedures

8.3.1 Working LVE Internal Standards Preparation

Dilute 300uL of the Stock internal standards (4000 ug/mL) to 3mL with methylene chloride for a final concentration of 400 ug/mL.

8.3.2 Intermediate 8270 Calibration Standard

Dilute 1000uL of Stock 8270 MegaMix calibration standard (1000 ug/mL), 500uL of Stock 8270 Mix #1 (2000 ug/mL), 500uL of Stock 8270 Mix #2 (2000 ug/mL) and 250uL of Stock Surrogate standard (4000 ug/mL) to 5mL with Methylene Chloride for a final concentration of 200 ug/mL.

8.3.3 Working 8270/Intermediate 8270 LVE Calibration Standards

The following are examples of calibration standards and could vary based on requirements:

Standard	Intermed. 8270 Cal. Std. Amount	Final Volume in Methylene Chloride	Final Nominal Cal Std Concentration	Stock Internal Standard amount added to Cal. Std.	Internal Standard Concentration
8270 CAL1	25uL	1000uL	5 ug/mL	10uL	40 ug/mL
8270 CAL2	50uL	1000uL	10 ug/mL	10uL	40 ug/mL
8270 CAL3	100uL	1000uL	20 ug/mL	10uL	40 ug/mL
8270 CAL4	250uL	1000uL	50 ug/mL	10uL	40 ug/mL
8270 CAL5	400uL	1000uL	80 ug/mL	10uL	40 ug/mL
8270 CAL6	500uL	1000uL	100 ug/mL	10uL	40 ug/mL
8270 CAL7	750uL	1000uL	150 ug/mL	10uL	40 ug/mL

8.3.4 Working 8270 LVE Calibration Standards

Prepare using the Working 8270/Intermediate 8270 LVE Calibration Standards from Section 8.3.3. The following are examples of calibration standards and could vary based on requirements:

Standard	Cal. Std. ID from Section 8.3.3	Intermediate Cal. Std. Amount	Final Volume in Methylene Chloride	Final Calibration Standard Concentration	Internal Standard Concentration
8270 LVE CAL1	8270 CAL1	100uL	1mL	0.5 ug/mL	4 ug/mL
8270 LVE CAL2	8270 CAL2	100uL	1mL	1.0 ug/mL	4 ug/mL
8270 LVE CAL3	8270 CAL3	100uL	1mL	2.0 ug/mL	4 ug/mL
8270 LVE CAL4	8270 CAL4	100uL	1mL	5.0 ug/mL	4 ug/mL
8270 LVE CAL5	8270 CAL5	100uL	1mL	8.0 ug/mL	4 ug/mL
8270 LVE CAL6	8270 CAL6	100uL	1mL	10 ug/mL	4 ug/mL
8270 LVE CAL7	8270 CAL7	100uL	1mL	15 ug/mL	4 ug/mL

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8.3.5 Working 8270/Intermediate 8270 LVE ICV Standard Preparation

Dilute 50uL of 8270 ICV Standard-Stock A (1000 ug/mL), 25uL of 8270 ICV Standard-Stock B (2000 ug/mL), 25uL of 8270 ICV Standard-Stock C (2000 ug/mL), 25uL of 8270 ICV Standard-Stock D (2000 ug/mL), 50uL of 8270 ICV Standard-Lilly ICV (1000 ug/mL), and 25uL of Stock Surrogate Standard (4000 ug/mL) to 1mL with methylene chloride for a final concentration of 50-100 ug/mL.

8.3.6 Working 8270 LVE ICV Standard Preparation

Dilute 100uL of the Intermediate 8270 LVE ICV Standard (50-100 ug/mL) to 1mL with methylene chloride for a final concentration of 5-10 ug/mL.

8.3.7 Intermediate APP IX Calibration Standard Preparation

Dilute 250uL of Stock APP IX Calibration Standard Mix 1 (2000ug/mL), 500uL of Stock APP IX Calibration Standard Mix 2 (1000ug/mL), 250uL of Stock APP IX Calibration Standard Mix 3 (2000ug/mL), 250uL of Stock APP IX Methapyrilene Calibration Standard (2000ug/mL), 500uL of Stock APP IX Dinoseb Calibration Standard (1000ug/mL), and 1500uL of Stock APP IX Hexachlorophene Calibration Standard (2000ug/mL) to 4mL with methylene chloride for a final concentration of 125-750ug/mL.

8.3.8 Working APP IX Calibration Standards Preparation

The following are examples of calibration standards and could vary based on requirements:

Standard	Intermed. APP IX Cal. Std. Amount	Final Volume in Methylene Chloride	Final Nominal Cal Std Concentration	Working Internal Standard amount added to Cal. Std.	Internal Standard Concentration
APP IX CAL1	80uL	1mL	10 ug/mL	10uL	4000 ug/mL
APP IX CAL2	160uL	1mL	20 ug/mL	10uL	4000 ug/mL
APP IX CAL3	400uL	1mL	50 ug/mL	10uL	4000 ug/mL
APP IX CAL4	640uL	1mL	80 ug/mL	10uL	4000 ug/mL
APP IX CAL5	800uL	1mL	100 ug/mL	10uL	4000 ug/mL
APP IX CAL6	1000uL	1mL	125 ug/mL	10uL	4000 ug/mL

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8.3.9 Working APP IX LVE Calibration Standards Preparation

Prepare using the Working APP IX Calibration Standards from Section 8.3.7. The following are examples of calibration standards and could vary based on requirements:

Standard	Cal. Std. ID from Section 8.3.7	Cal. Std. Amount	Final Volume in Methylene Chloride	Final Calibration Standard Concentration	Internal Standard Concentration
APP IX LVE CAL1	APP IX CAL1	100uL	1mL	1 ug/mL	400 ug/mL
APP IX LVE CAL2	APP IX CAL2	100uL	1mL	2 ug/mL	400 ug/mL
APP IX LVE CAL3	APP IX CAL3	100uL	1mL	5 ug/mL	400 ug/mL
APP IX LVE CAL4	APP IX CAL4	100uL	1mL	8 ug/mL	400 ug/mL
APP IX LVE CAL5	APP IX CAL5	100uL	1mL	10 ug/mL	400 ug/mL
APP IX LVE CAL6	APP IX CAL6	100uL	1mL	12.5 ug/mL	400 ug/mL

8.3.10 Working APP IX ICV Standard Preparation

Dilute 50uL of Stock APP IX ICV Standard Mix 1 (2000ug/mL), 100uL of Stock APP IX ICV Standard Mix 2 (1000ug/mL), 50uL of Stock APP IX ICV Standard Mix 3 (2000ug/mL), and 50uL of Stock APP IX ICV Standard Mix 4 (2000ug/mL) to 1mL with methylene chloride for a final concentration of 100ug/mL.

8.3.11 Working APP IX LVE ICV Standard Preparation

Dilute 100uL of Working APP IX ICV Standard (100ug/mL) to 1mL with methylene chloride for a final concentration of 10ug/mL.

9.0 PROCEDURE

9.1 Equipment Preparation

9.1.1 Gas Chromatography conditions: Configure the GC/MS per manufacturer's instructions.

9.1.2 **DFTPP Tune Verification:** At the beginning of each analytical sequence, prior to the analysis of any standards or samples, the mass spectrometer must be hardware tuned using a 50ng injection of DFTPP. Analysis must not begin until the tuning criteria are met. Use the DFTPP mass intensity criteria in the table below as tuning acceptance criteria. Alternate tuning criteria may be used provided that method performance is not adversely affected. The 12-hour window during which standards and samples may be analyzed begins with the injection of DFTPP. All subsequent standards, samples MS/MSDs, and blanks associated with a DFTPP analysis must use the identical mass spectrometer instrument conditions.

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Mass (m/z)	Ion Abundance criteria
51	30-60% of mass 198
68	<2% of mass 69
70	<2% of mass 69
127	40-60% of mass 198
197	<1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	>1% of mass 198
441	Present but less than mass 443
442	>40% of mass 198
443	17-23% of mass 442

If the DFTPP ratios do not meet the criteria, reanalyze the DFTPP tune. If the DFTPP still fails the criteria, autotune adjustment, instrument maintenance, and/or preparation of new standards must be considered.

The mass spectrum of DFTPP may be obtained by averaging three scans, the peak apex scan and the scans immediately preceding and following the apex. Background subtraction is required using this approach and must be accomplished using a single scan no more than 20 scans prior to the elution of DFTPP. Do not background subtract part of the DFTPP peak. Alternatively, the analyst may use other approaches suggested below:

1. A single scan within the DFTPP peak with background subtraction of a single scan no more than 20 scans prior to the elution of DFTPP.
2. An average of multiple scans within the DFTPP peak with background subtraction of a single scan no more than 20 scans prior to the elution of DFTPP

9.2 Initial Calibration

9.2.1 Initial Calibration standards are introduced into the GC/MS from the lowest to highest concentration, by direct injection of each working calibration standard. The lowest calibration standard must be at or below the required reporting limit. Five calibration points, at a minimum, are analyzed to evaluate linearity. Refer to the Quality Manual for more information regarding calibration curves.

9.2.2 The response factor (RF) is calculated for each compound for each calibration standard as follows:

$$RF = \frac{(A_x)(C_{IS})}{(A_{IS})(C_x)}$$

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Where: A_x = Area of the quantitation ion for the compound being measured
A_{IS} = Area of the quantitation ion for the internal standard
C_{IS} = Concentration of the internal standard
C_x = Concentration of the compound being measured

9.2.3 The average response factor (RF_{avg}) is determined by averaging the response factors at the different concentrations for each target analyte.

9.2.4 The percent relative standard deviation (%RSD) of the response factors is calculated as follows:

$$\%RSD = \frac{(SD)}{RF_{avg}} \times 100$$

Where: SD = Standard deviation of the RFs for a compound
RF_{avg} = Mean of RFs for a compound

9.2.5 The %RSD should be should be ≤15% for each target analyte. However, the %RSD for each individual Calibration Check Compound (CCC) must be ≤30%. If the RSD of any CCC is >30%, then the chromatographic system is too reactive and instrument maintenance or preparation of new standards may be necessary before attempting recalibration. The CCCs are:

Base/Neutral Fraction	Acid Fraction
Acenaphthene	4-Chloro-3-methylphenol
1,4-Dichlorobenzene	2,4-Dichlorophenol
Hexachlorobutadiene	2-Nitrophenol
Diphenylamine	Phenol
Di-n-octyl phthalate	Pentachlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Benzo(a)pyrene	

9.2.6 System Performance Check Compounds (SPCCs) are checked for a minimum average response factor (RF_{avg}) to determine potential instability and/or degradation caused by deterioration of instrument conditions or standard material. The minimum RF_{avg} for the semivolatile SPCCs are as follows:

N-nitroso-di-n-propylamine	0.050
Hexachlorocyclopentadiene	0.050
2,4-Dinitrophenol	0.050
4-Nitrophenol	0.050

If the minimum response factors are not met, the system must be evaluated and corrective action must be taken before sample analysis begins. Instrument maintenance or preparation of new standards may be necessary. The SPCC criteria must be met for sample analysis to begin.

9.2.7 If the %RSD of the RFs for a compound is ≤15% over the calibration range, then linearity through the origin is assumed and the RF_{avg} may be used to determine sample concentrations.

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9.2.8 If the %RSD of the RFs for any compound is >15%, the analyst may employ a regression equation that does not pass through the origin. The regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. In order to be used for quantitative purposes, the correlation coefficient must be $\geq$ 0.99.

9.2.9 Non-linear or quadratic calibration: A non-linear or quadratic calibration model can only be used if the compound(s) have historically exhibited a non-linear response and cannot be used to extend the calibration range for any compound that normally exhibits a linear response in a narrower range. The non-linear regression calibration curve is derived from a least squares regression analysis of the calibration points. A calibration curve based on this technique will have the format of: $y= ax^2+bx+c$. In order to use this curve fit technique, a minimum of 6 calibration points must be available and the origin cannot be included as one of the points. Because the non-linear regression is not forced through the origin, very low levels of contaminants below the response of the lowest calibration point may generate erroneous reportable results. The "goodness of fit" of the polynomial equation is evaluated by calculating the coefficient of the determination (COD) or r^2. The COD or r^2 from the regression equation must be $\geq$ 0.99. Refer to Method 8000C for additional information regarding calibration.

9.2.10 For calibration compounds that required the linear regression model or the quadratic model, a minimum quantitation check on the viability of the calibration standard that corresponds to the reporting limit should be performed by re-fitting the response from the calibration standard that corresponds to the reporting limit back into the curve. The recalculated concentration of the reporting limit standard should be within +/-50% of the standard's true concentration. Compounds that fail this criterion and are reported at a concentration that is <2x the reporting limit in associated samples must be qualified as estimated. Alternatively, the reporting limit can be raised to the level of a calibration standard that meets the criteria when re-fitted against the curve.

9.3 Initial Calibration Evaluation

9.3.1 Each day that analysis is performed, the calibration standard(s) should be evaluated to determine if the chromatographic system is operating properly. Questions that should be asked are: Do the peaks look normal? Is the response obtained comparable to the response from previous calibrations? Are the retention times consistent over the range of calibration for each compound? Careful examination of the standard chromatogram can indicate whether the column is still performing acceptably. Additionally, examination of signal-to-noise ratio of analytes in low-level standards may be a useful diagnostic tool to monitor instrument performance. Signal-to-noise ratio is defined as the ratio of the analyte signal to the noise measured on a blank. It is recommended but not required that the signal-to-noise ratio be at least three to confirm detection.

9.3.2 **Initial Calibration Corrective Action:** If the initial calibration curve does not meet the required criteria to be used for quantitative purposes, a new initial calibration curve must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed initial calibration must be reanalyzed.

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9.4 Initial Calibration Verification (ICV)

9.4.1 In addition to meeting the response and linearity criteria, any new calibration curve must be assessed for accuracy in the values generated. To assess the accuracy, a single standard from a secondary source must be analyzed and the results obtained must be compared to the known true value. This step is referred to as the Initial Calibration Verification. The ICV must be from an alternative vendor or, in the event an alternative vendor is not available, from a different lot from the same vendor. The accuracy of the standard is assessed as a percent recovery (%Rec) of the observed ICV according to the following equation:

$$\% \text{ Recovery} = \frac{\text{Observed concentration}}{\text{Theoretical concentration}} \times 100$$

The ICV is analyzed immediately following the initial calibration curve. The ICV recoveries are evaluated against a default acceptance range of 70-130% recovery. Alternative acceptance limits may be appropriate for some compounds.

9.4.2 **ICV Corrective Action:** If the ICV exceeds the acceptance range, another ICV may be analyzed. If the second ICV also exceeds the acceptance range, a new initial calibration should be prepared. Alternatively, the allowance for use of the ICV when the criterion is not met is documented and is at the discretion of the Department Manager, Quality Manager, General Manager or designee.

9.5 Continuing Calibration Verification

9.5.1 The initial calibration is verified every 12 hours by analyzing a DFTPP tune verification as described in Section 9.1.2, followed by a Continuing Calibration Verification (CCV) standard. The CCV is prepared using the same standard solution used for the initial calibration. The 12 hour clock during which standards and samples may be analyzed begins with the injection of the tune.

9.5.2 If the % Difference (%D) or % Drift for each CCC is ≤20%, then the initial calibration is assumed to be valid. The response factors for all SPCCs in the CCV standard must meet the criteria in Section 10.6. The % difference (%D) or % Drift for each non-CCC compound should be ≤40%. If non-CCC compounds fail to meet this criterion, the concentrations above the reporting limit in associated samples must be qualified as estimated.

$$\% \text{ Difference} = [RF_v - RF_{avg}] / RF_{avg} * 100$$

9.5.3 The internal standard areas in the CCV must be between 50%-200% of the internal standard areas of the corresponding standard in the initial calibration. In addition, the retention time of the internal standards in the CCV cannot shift by more than 30 seconds from the corresponding standard in the initial calibration. Failure in either of these two areas requires the analyst to evaluate their system and perform maintenance if necessary.

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9.5.4 **CCV Corrective Action:** If a CCV fails the acceptance criteria, check the instrument operating conditions, and if necessary, restore them to the original settings, and inject another aliquot of the CCV. If the response still fails the acceptance criteria, then a new initial calibration must be prepared. Samples associated with a failed CCV must be reanalyzed. **Exception:** If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.

9.6 Sample Analysis

9.6.1 All sample extracts must be analyzed at room temperature. The system must be tuned and calibrated, and free of contamination before samples are analyzed.

9.6.2 Gas Chromatography conditions: The GC/MS configuration settings used for sample analysis must be the same as from initial calibration.

9.6.3 The extract obtained from sample preparation for 8270 should be fortified with the appropriate amount of internal standard just prior to analysis.

9.6.4 Load vials in sequence on the autosampler, and analyze each extract by injecting an appropriate volume onto the column corresponding to the extraction technique used.

10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Qualitative Analysis: Compounds are identified as present when the following criteria are met:

10.1.1 The relative retention time (RRT) of the sample component must compare within +/- 0.06 RRT units of the RRT of the CCV component.

10.1.2 The intensities of the characteristic ions of a compound must maximize in the same scan or within one scan of each other. See Table 2 and Table 4 for primary and secondary ions.

10.1.3 The relative intensities of the characteristic ions agree within 30% of the relative intensities of these ions in the reference spectrum.

10.2 Quantitative analysis: Quantitation is based on the integrated abundance of the target analyte's quantitation ion using the internal standard technique.

10.3 When compound concentrations exceed the calibration range, the sample extract should be rerun at a dilution or reported as an estimated concentration. Additional internal standard must be added to the diluted extract to maintain the same concentration as the calibration standards.

10.4 Refer to the Manual Integrations SOP for guidance on performing and documenting manual integrations.

10.5 Calculations

10.5.1 Calculate the final concentration in the samples as follows:

$$\text{Aqueous Sample (ug/L)} = \frac{(X_s)(V_f)(D)}{(V_i)} \qquad \text{Solid Sample (ug/kg)} = \frac{(X_s)(V_f)(D)}{(W_s)}$$

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Where: X_s = Concentration of the analyte from the instrument, ug/mL
V_f = Final volume of extract, mL
D = Dilution factor (Final Volume/Initial Volume)
V_i = Volume of aqueous sample extracted, L
W_s = Weight of solid sample extracted, kg

$$\text{Moisture corrected concentration} = \frac{\text{(Final concentration as received)}}{(100 - \%\text{Moisture})} \times 100$$

10.5.2 LCS calculation:

$$R = (C / S) \times 100$$

Where: R = Percent Recovery
C = Observed LCS concentration
S = True LCS concentration

10.5.3 MS calculation:

$$R = \frac{(C_s - C)}{S} \times 100$$

Where: R = Percent Recovery
C_s = Observed MS concentration
C = Sample concentration
S = True spike concentration

10.5.4 RPD calculation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} \times 100$$

Where: RPD = Relative Percent Difference
D_1 = First Sample Result
D_2 = Second Sample Result

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STANDARD OPERATING PROCEDURE
TITLE: SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS
METHOD: EPA SW-846 8270C
ISSUER: Pace ENV – Indianapolis – IND1

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Instrument Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Tune	DFTPP	Every 12 hours of instrument operation	Refer to Section 9.1.2	Reanalyze the DFTPP tune. If the DFTPP still fails the criteria, autotune adjustment, instrument maintenance, and/or preparation of new standards must be considered.
Initial Calibration	All target analytes	As needed	Refer to Section 9.2	Analyze a new initial calibration curve. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed initial calibration must be reanalyzed.
Initial Calibration Verification Standard (ICV)	Second Source Standard	Immediately following initial calibration of the instrument	70-130% Recovery	Inject another aliquot of the ICV. If the second ICV also exceeds the acceptance range, a new initial calibration should be prepared. Alternatively, the allowance for use of the ICV when the criterion is not met is documented and is at the discretion of the Department Manager, Quality Manager, General Manager or designee.
Continuing Calibration Standard (CCV)	All target analytes	Every 12 hours of instrument operation	Refer to Section 9.5	Check instrument operating conditions, and if necessary, restore them to the original settings. Inject another aliquot of the CCV. If the response still fails the acceptance criteria, then a new initial calibration must be prepared. Samples associated with a failed CCV must be reanalyzed. *Exception:* If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.

11.2 Batch Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water	One per preparation batch of up to 20 samples, per matrix.	Target analytes must be less than reporting limits.	Reanalyze blank. Re-extract and re-analyze if target compound is still >RL in method blank and associated samples. *Exceptions:* 1) If the method blank concentration is less than 1/10 of the amount measured in the sample, corrective action is not required, affected data must be qualified. 2) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 3) If a contaminant is present only in the method blank and not the samples, no action is required.

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STANDARD OPERATING PROCEDURE
TITLE: SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS
METHOD: EPA SW-846 8270C
ISSUER: Pace ENV – Indianapolis – IND1

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QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Laboratory Control Standard (LCS)	Target analytes	One per preparation batch of up to 20 samples, per matrix.	Lab-generated limits Refer to the LIMS for acceptance limits. Refer to Section 11.2 for additional information.	Re-analyze LCS. Re-extract and re-analyze associated samples if LCS is still outside acceptance limits. *Exceptions:* 1) If no additional sample remains for re-analysis or if re-extraction/re-analysis cannot take place within holding time, reported data must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified.
Matrix Spike (MS) / Matrix Spike Duplicate (MSD)	Target analytes	One MS/MSD set per preparation batch of up to 20 samples, per matrix.	Lab-generated limits Refer to the LIMS for acceptance limits.	No corrective action necessary. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.
Surrogates	Applicable surrogate compounds	Added to each standard, sample, and method blank.	Lab-generated limits Refer to the LIMS for acceptance limits.	Samples with surrogate failures must be re-extracted and reanalyzed. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported surrogate data must be qualified. 2) If surrogate result is >QC limits, and sample or method blank results are non-detect, the sample or method blank results may be reported without qualifiers. The surrogate must be qualified. 3) MS/MSD surrogate recovery failures do not constitute the re-extraction or reanalysis of samples but the surrogate data must be qualified.
As required by client or program only: **Internal Standards**	Applicable Internal Standard compounds	Added to each standard, sample, and method blank.	Sample ISTD areas must be -50% to +100% from CCV. Sample ISTD RTs must be +/-0.5 minutes from CCV.	Samples with internal standard failures must be reanalyzed undiluted or more concentrated. The laboratory may only dilute a sample prior to reanalysis if matrix interference is present. *Exception:* If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported data must be qualified.

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11.2 **Allowable Marginal Exceedances:** If a large number of analytes are in the LCS, it becomes statistically likely that a few will be outside control limits. A marginal exceedance (ME) is defined as being beyond the LCS control limit of +/-3 standard deviations, but within the ME limits of +/-4 standard deviations around the mean. The number of allowable MEs is based on the number of analytes in the LCS. If more analytes exceed the LCS control limits than is allowed, or if any one analyte exceeds the ME limits, the LCS fails and correction action is necessary. If the same analyte exceeds the LCS control limit consecutively, it is an indication of a systemic problem. The source of the error shall be located and corrective action taken.

The number of allowable marginal exceedances is as follows:

Number of Analytes in LCS	Number Allowed as Marginal Exceedances
> 90	5
71 – 90	4
51 – 70	3
31 – 50	2
11 – 30	1
< 11	0

NOTE: As allowed by client, the LCS shall be allowed to be outside the control limits but ≥10% for hexachlorocyclopentadiene, N-nitrosodimethylamine, pentachlorophenol, 2,4-dinitrophenol, 4-nitrophenol, benzoic acid, 4-chloro-3-methylphenol, 2-nitroaniline, 3-nitroaniline, and 4-chloroaniline without corrective action. The LCS shall be allowed to be outside the control limits but >10% for up to four additional compounds, with the exception of any PAH, without corrective action.

11.3 Method Performance

11.3.1 Method Validation

Refer to the SOP for Method Validation and Instrument Verification for the procedures used for initial method validation. Method Detection Limits (MDL) must be determined per the procedure in 40CFR Part 136, Appendix B.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must document acceptable accuracy and precision by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

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12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

The analyst must perform primary review of data and calculated results for accuracy. Secondary review of the data and calculated results must be performed by another qualified analyst, the department supervisor, or the Quality Manager prior to release for reporting. Refer to the SOP for Data Review Process for more information.

12.2 Corrective Action

Corrective action is expected any time QC is not within acceptance criteria, when sample results exceed the calibration range, and when carryover is suspected. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Refer to Sections 9 and 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

14.0 MODIFICATIONS

14.1 Standards are purchased as certified stock solutions and not prepared from neat materials.

14.2 Microwave Method 3546 is used for the preparation of solid samples for analysis by 8270C.

14.3 Phenol-d5 is used as a surrogate instead of Phenol-d6.

14.4 Extract final volumes, volume of internal standards added to extracts, and volume of extract injected into the instrument may vary from those identified in Method 8270C.

15.0 RESPONSIBILITIES

Pace ENV employees that perform any part this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

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16.0 ATTACHMENTS

16.1 Table 1: Target Compounds and Reporting Limits

16.2 Table 2: Characteristic Ions and Internal Standard Association of Target Compounds

16.3 Table 3: Appendix IX Target Compounds and Reporting Limits

16.4 Table 4: Characteristic Ions and Internal Standard Association of Appendix IX Compounds

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Methods 8000D and 8270C.

17.2 Pace Analytical Quality Manual; latest revision.

17.3 NELAC/TNI Standards; Quality Systems section; 2003 and 2009.

18.0 REVISION HISTORY

This Version:

Section	Description of Change
All	Converted to new SOP format and combined with Appendix IX SOP.
1.0	Added problem compound for Appendix IX and added reference to Table 3.
7.1	Added an alternative column.
9.2.10	Added criteria for evaluation of compounds with linear or quadratic fit.
9.5.1	Added details for the 12 hour tune.
9.5.2	Added %D calculation.
9.6	Added requirement to maintain same instrument settings for ICAL and samples and added instructions for commencement of sequence.
10.1.2	Added reference to Table 4.
11.2	Updated corrective action for MB and LCS allowing one reanalysis.
16.0	Added Attachments 3 and 4 for Appendix IX.
17.1	Updated 8000C to 8000D.
Att.	Added Attachments 3 and 4 for Appendix IX.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0057	The Determination of Semivolatile Organics by GC/MS	00
ENV-SOP-IND1-0110	Appendix IX Semivolatile Compounds by GC/MS	00

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STANDARD OPERATING PROCEDURE
TITLE: SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS
METHOD: EPA SW-846 8270C
ISSUER: Pace ENV – Indianapolis – IND1

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Table 1
Target Compounds and Reporting Limits[1]

Analyte	RL water (ug/L)	RL soil (ug/kg)
Phenol	10	330
Bis (2-chloroethyl) ether	10	330
2-Chlorophenol	10	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
Benzyl Alcohol	20	660
1,2-Dichlorobenzene	10	330
2-Methylphenol (o-Cresol)	10	330
Bis (2-chloroisopropyl)ether	10	330
3&4-Methylphenol (m&p-Cresol)	20	660
N-Nitroso-di-n-propylamine	10	330
Hexachloroethane	10	330
Nitrobenzene	10	330
Isophorone	10	330
2-Nitrophenol	10	330
2,4-Dimethylphenol	10	330
Benzoic Acid	50	1670
Bis(2-chloroethoxy)methane	10	330
2,4-Dichlorophenol	10	330
1,2,4-Trichlorobenzene	10	330
Naphthalene	10	330
4-Chloroaniline	20	660
Hexachlorobutadiene	10	330
4-Chloro-3-methylphenol	20	660
1-Methylnaphthalene	10	330
2-Methylnaphthalene	10	330
Hexachlorocyclopentadiene	10	330
2,4,6-Trichlorophenol	10	330
2,4,5-Trichlorophenol	10	330
2-Chloronaphthalene	10	330
2-Nitroaniline	50	1600
Dimethyl phthalate	10	330
Acenaphthene	10	330
Acenaphthylene	10	330
2,4-Dinitrophenol	50	1670
4-Nitrophenol	50	1670
Dibenzofuran	10	330
2,4-Dinitrotoluene	10	330
2,6-Dinitrotoluene	10	330
3-Nitroaniline	50	1600

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Analyte	RL water (ug/L)	RL soil (ug/kg)
Diethyl phthalate	10	330
4-Chlorophenyl phenyl ether	10	330
Fluorene	10	330
4-Nitroaniline	20	670
4,6-Dinitro-2-methylphenol	50	1600
N-Nitrosodiphenylamine	10	330
4-Bromophenyl phenyl ether	10	330
Hexachlorobenzene	10	330
Pentachlorophenol	50	1670
Phenanthrene	10	330
Anthracene	10	330
Di-n-butyl phthalate	10	330
Fluoranthene	10	330
Pyrene	10	330
Butyl benzyl phthalate	10	330
3,3'-Dichlorobenzidine	20	670
Benzo(a)anthracene	10	330
Chrysene	10	330
Bis(2-ethylhexyl)phthalate	10	330
Di-n-octyl phthalate	10	330
Benzo(b)fluoranthene	10	330
Benzo(k)fluoranthene	10	330
Benzo(a)pyrene	10	170
Indeno(1,2,3-cd)pyrene	10	330
Dibenz(a,h)anthracene	10	170
Benzo(g,h,i)perylene	10	330
N-Nitrosodimethylamine	10	330
Pyridine	10	1600
Benzidine	20	670
Acetophenone	10	330
2,6-Dichlorophenol	10	330
1,2-Diphenylhydrazine	10	330
2-Picoline	50	1600
1,2,4,5-Tetrachlorobenzene	10	330
1,3-Dinitrobezene	50	1600
2,3,4,6-Tetrachlorophenol	10	330

[1] Target Compounds and Reporting Limits are subject to change.

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Table 2
Characteristic Ions and Internal Standard Association of Target Compounds[2]

Analyte	Primary Ion	Secondary Ion(s)
Group 1 - 1,4-Dichlorobenzene-d4 (IS)	152	150, 115
N-Nitrosodimethylamine	42	74,44
Pyridine	79	52
2-Picoline	93	66, 92
4-Chlorobenzotrifluoride[3]	180	161,182
2-Fluorophenol (S)	112	64
Phenol-d5 (S)	99	71, 42
Benzaldehyde[3]	77	105, 106
Phenol	94	65.66
Aniline	93	66, 65
Bis(2-Chloroethyl) ether	93	63.95
2-Chlorophenol	128	64,130
n-Decane[3]	57	43, 142
1,3-Dichlorobenzene	146	148, 111
1,4-Dichlorobenzene	146	148, 111
Benzyl alcohol	108	79, 77
1,2-Dichlorobenzene	146	148, 111
Bis(2chloro1methylethyl) ether[3]	45	77, 121
Bis(2-chloroisopropyl) ether	45	77, 121
3&4-methylphenol (m&p cresol)	108	107,77
Acetophenone	105	77, 120
N-Nitroso-di-n-propylamine	70	130, 101
Hexachloroethane	117	201, 199
Group 2 - Naphthalene-d8 (IS)	136	68
Nitrobenzene-d5 (S)	82	128, 54
Nitrobenzene	77	123, 65
Isophorone	82	95, 138
2-Nitrophenol	139	109, 65
2,4-Dimethylphenol	122	107, 121
Bis(2-chloroethoxy) methane	93	95, 123
Benzoic Acid	105	122, 77
2,4-Dichlorophenol	162	164, 98
1,2,4-Trichlorobenzene	180	182, 145
Naphthalene	128	129, 102
Apha-Terpineol[3]	59	93, 121
2-Chloroaniline	127	65, 92
Hexachlorobutadiene	225	223, 227
Caprolactam[3]	113	55, 56

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STANDARD OPERATING PROCEDURE
TITLE: SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS
METHOD: EPA SW-846 8270C
ISSUER: Pace ENV – Indianapolis – IND1

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Analyte	Primary Ion	Secondary Ion(s)
Diethyl Aniline[3]	134	106, 77
4-Chloro-3-methylphenol	107	144, 142
2-Methylnaphthalene	142	141, 115
1-Methylnaphthalene[3]	142	141, 115
Group 3 - Acenaphthene-d10 (IS)	164	160, 162
Hexachlorocyclopentadiene	237	235, 272
1,2,4,5-Tetrachlorobenzene	216	179, 108
2,3-Dichloroaniline[3]	161	163, 90
2,4,6-Trichlorophenol	196	198, 200
2,4,5-Trichlorophenol	196	198, 200
2-Fluorobiphenyl (S)	172	171
2-Chloronaphthalene	162	127, 164
2-Nitroaniline	65	92, 138
Dimethylphthalate	163	194, 164
1,3-Dinitrobenzene	168	76, 50
2,6-Dinitrotoluene	165	63, 89
Acenaphthylene	152	150, 153
3-Nitroaniline	138	108, 92
Biphenyl (Diphenyl)[3]	154	153, 152
Acenaphthene	153	154, 152
2,4-Dinitrophenol	184	154, 63
4-Nitrophenol	109	139, 65
2,4-Dinitrotoluene	165	63, 89
Dibenzofuran	168	139, 169
2,3,4,6-Tetrachlorophenol	232	131, 230
Diethylphthalate	149	177, 150
4-Chloropheyl-phenylether	204	206, 141
Fluroene	166	165, 139
4-Nitroaniline	138	108, 65
Group 4 - Phenanthrene-d10 (IS)	188	80,94
4,6-Dinitro-2-methylphenol	198	51,105
N-Nitrosodiphenylamine	169	168, 167
Azobenzene3	77	182, 105
1,2-Diphenylhydrazine	77	105, 182
2,4,6-Tribromophenol (S)	330	332, 141
4-Bromophenyl-phenyl ether	248	250, 141
Hexachlorobenzene	284	142, 249
Atrazine[3]	200	215, 202
Pentachlorophenol	266	264, 268
n-Octadecane[3]	57	43, 71
Phenanthrene	178	179, 176

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METHOD: EPA SW-846 8270C
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Analyte	Primary Ion	Secondary Ion(s)
Anthracene	178	176, 179
Carbazole[3]	167	166, 139
Di-n-butylphthalate	149	150, 104
Fluoranthene	202	101, 203
Benzidine	184	92, 185
Group 5 - Chysene-d12 (IS)	240	120, 236
Pyrene	202	101, 203
p-Terphenyl-d14 (S)	244	122, 212
Butylbenzylphthalate	149	91, 206
3,3'-Dichlorobenzidine	252	254, 126
Bis(2-Ethylhexyl) phthalate	149	167, 279
Benzo(a)athracene	228	229, 226
Chrysene	228	226, 229
Group 6 - Perylene-d12 (IS)	264	260, 265
Di-n-ocytlphthalate	149	279, 43
Benzo(b)fluoranthene	252	253, 125
Benzo(k)fluroanthene	252	253, 125
Benzo(a)pyrene	252	253,125
Indeno (1,2,3-cd)pyrene	276	138, 277
Dibenz (a,h) athracene	278	139, 279
Benzo(g,h,i)perylene	276	138, 277

[2] Target Compounds are subject to change.
[3] Compound is not listed in Method 8270C.

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Table 3
Appendix IX Target Compounds and Reporting Limits[1]

Analyte	RL water (ug/L)	RL soil (ug/kg)
7,12-Dimethylbenz(a)anthracene	20	330
Diallate	10	330
2,6-Dichlorophenol	10	330
2-Acetylaminofluorene	10	330
Aramite	10	330
Chlorobenzilate	10	330
Dimethoate	10	330
p-Dimethylaminoazobenzene	10	330
3,3'-Dimethylbenzidine	20	670
a,a-Dimethylphenylethylamine	20	330
Dinoseb	10	330
Ethyl methanesulfonate	10	330
Hexachloropropene	10	330
Isodrin	10	330
Isosafrole	10	330
Methapyrilene	10	330
3-Methylcholanthrene	10	330
Methyl methanesulfonate	10	330
Methyl parathion	10	330
1-Naphthalenamine	10	330
2-Naphthalenamine	10	330
1,4-Naphthoquinone	20	670
4-Nitroquinoline-n-oxide	10	330
N-Nitrosodiethylamine	10	330
N-Nitroso-di-n-butylamine	10	330
N-Nitrosomethylethylamine	10	330
N-Nitrosomorpholine	10	330
N-Nitrosopyrrolidine	10	330
O,O,O-Triethylphosphorothioate	10	330
Parathion (Ethyl parathion)	10	330
Pentachlorobenzene	10	330
Pentachloroethane	10	330
Pentachloronitrobenzene	10	330
Phenacetin	10	330
p-Phenylenediamine	200	6700
Phorate	10	330
Pronamide	10	330
Safrole	10	330
Sulfotep	10	330
Thionazin	10	330

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Analyte	RL water (ug/L)	RL soil (ug/kg)
o-Toluidine	10	330
1,3,5-Trinitrobenzene	20	670
Disulfoton	10	330
5-Nitro-o-toluidine	10	330
N-Nitrosopiperidine	10	330
4-Aminobiphenyl	10	330

[1] Target Compounds and Reporting Limits are subject to change.

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Table 4
Characteristic Ions and Internal Standard Association of Appendix IX Compounds[2]

Analyte	Primary Ion	Secondary Ion(s)
Group 1 - 1,4-Dichlorobenzene-d4 (IS)	152	150, 115
2-Fluorophenol (S)	112	64
Phenol-d5 (S)	99	71, 42
N-Nitrosomethylethylamine	88	42, 43
Methyl methanesulfonate	80	79, 65
N-Nitrosodiethylamine	102	42, 57
Ethyl methanesulfonate	79	109, 97
Pentachloroethane[3]	167	165, 169
N-Nitrosopyrrolidine	100	41, 42
N-Nitrosomorpholine	56	116, 86
o-Toluidine	106	107, 77
Group 2 - Naphthalene-d8 (IS)	136	68
Nitrobenzene-d5 (S)	82	128, 54
N-Nitrosopiperidine	114	42, 55
O,O,O-Triethylphosphorothioate	198	121, 115
a,a-Dimethylphenylethylamine	58	91, 65
2,6-Dichlorophenol	162	164, 63
Hexachloropropene	213	211, 215
N-Nitrosodi-n-butylamine	84	57, 41
p-Phenylenediamine	108	80, 53
Safrole	162	104, 77
Group 3 - Acenaphthene-d10 (IS)	164	160, 162
2-Fluorobiphenyl (S)	172	171
Isosafrole	162	131, 104
1,4-Naphthoquinone	158	104, 102
Pentachlorobenzene	250	248, 252
2-Naphthalenamine	143	115, 116
1-Naphthalenamine	143	115, 89
Thionazin	96	97, 143
5-Nitro-o-toluidine	152	77, 79
Sulfotep	322	202, 266
1,3,5-Trinitrobenzene	75	74, 213
Diallate	86	234. 43
Group 4 - Phenanthrene-d10 (IS)	188	80,94
2,4,6-Tribromophenol (S)	330	332, 141
Phorate	121	97, 93
Phenacetin	108	180, 179
Dimethoate	87	93, 125
4-Aminobiphenyl	169	168, 170
Pentachloronitrobenzene	237	142, 214

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Analyte	Primary Ion	Secondary Ion(s)
Pronamide	173	175, 145
Disulfoton	88	97, 89
Dinoseb	211	163, 147
Methyl parathion	109	125
Parathion (Ethyl parathion)	109	125
4-Nitroquinoline-n-oxide	190	163, 160
Methapyrilene	97	50, 191
Isodrin	193	66, 195
Group 5 - Chrysene-d12 (IS)	240	120, 236
p-Terphenyl-d14 (S)	244	122, 212
Aramite	185	191, 139
p-Dimethylaminoazobenzene	120	225, 77
Chlorobenzilate	251	139, 253
3,3'-Dimethylbenzidine	212	106, 196
2-Acetylaminofluorene	181	180, 223
Group 6 - Perylene-d12 (IS)	264	260, 255
7,12-Dimethylbenz(a)anthracene	256	241, 239
3-Methylcholanthrene	268	252, 126

[2] Target Compounds are subject to change.
[3] Compound is not listed in Method 8270C.

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Document Information

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Document Title: Sulfate (Turbidimetric)

Department(s): Wet Chemistry

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All Dates and Times are listed in: Central Time Zone

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Document Number: ENV-SOP-IND1-0061 **Revision:** 02

Title: Sulfate (Turbidimetric)

All dates and times are in Central Time Zone.

ENV-SOP-IND1-0061 Sulfate (Turbidimetric)

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	28 May 2021, 03:03:16 PM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Sarah Potts (007977)	Manager	28 May 2021, 04:29:54 PM	Approved
Steven Sayer (004775)	General Manager 2	08 Jun 2021, 11:19:54 AM	Approved

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STANDARD OPERATING PROCEDURE
TITLE: SULFATE, TURBIDIMETRIC
METHOD: SW-846 9038, ASTM D516
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the laboratory procedure for the determination of Sulfate by the Turbidimetric method in aqueous samples and solid samples while meeting the requirements specified in ASTM methods D516-07/11 and EPA Method 9038.

1.1 This method is suitable for all concentration ranges of sulfate. To obtain reliable readings, a sample aliquot containing no more than 40mg/L of sulfate should be used.

1.2 This method is applicable for the measurement of turbidimetric sulfate in groundwater, drinking and surface waters, domestic and industrial wastes. The method has been modified to determine the turbidimetric sulfate concentration in aqueous extracts of soil samples.

1.3 The default reporting limit is 10mg/L for aqueous samples and 100mg/kg for solid samples. Refer to the LIMS for method detection limits.

1.4 Reporting limits, control limits, volumes/weights used, standard concentrations, vendors, instrumentation, equipment, and supplies are subject to change.

2.0 SUMMARY OF METHOD

Sulfate ion is converted to barium sulfate suspension under controlled conditions. The resulting turbidity is determined by a spectrophotometer at a wavelength of 420nm and compared with a calibration curve prepared from a standard sulfate solution.

3.0 INTERFERENCES

3.1 Insoluble suspended matter in the sample must be removed. Dark colors that cannot be compensated for in the procedure interfere with the measurement of suspended barium sulfate.

3.2 Polyphosphates will inhibit barium sulfate precipitation causing a negative interference. Phosphonates may also cause a negative interference. Silica that exceeds 500mg/L may precipitate along with the barium sulfate causing a positive interference. Chloride that exceeds 5000mg/L will cause a negative interference. Aluminum, polymers, and large quantities of organic material present in the sample may cause barium sulfate to precipitate non-uniformly. In the presence of organic matter certain bacteria may reduce sulfate to sulfide. To minimize the action of sulfate reducing bacteria, samples should be refrigerated at 4oC when the presence of bacteria is suspected.

3.3 Although other ions normally found in water do not appear to interfere, the formation of the barium sulfate suspension is critical. Determinations that are in doubt may be checked by an alternate method.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

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STANDARD OPERATING PROCEDURE
TITLE: SULFATE, TURBIDIMETRIC
METHOD: SW-846 9038, ASTM D516
ISSUER: Pace ENV – Indianapolis – IND1

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5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous	>100mL in plastic container	None required	Cool to ≤6°C	Samples must be analyzed within 28 days of collection date.
Solid	50g in a glass container	None required	Cool to ≤6°C	Samples must be analyzed within 28 days of collection date.

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METHOD: SW-846 9038, ASTM D516
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7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Description / Comments
Spectrophotometer	Hach DR3900 or equivalent, for use at 420nm with a cell providing a light path of 1cm or longer.
Balance	Ohaus or equivalent, capable of weighing to the nearest 0.1g
Magnetic stirrer	Fisher or equivalent, with Teflon stirring bars.

7.2 Supplies

Supplies	Description
Graduated cylinders	Class A, various sizes
Mechanical pipets	Eppendorf or equivalent, various sizes
Syringe filters	Environmental Express 0.45um or equivalent
Syringes	10mL disposable
Disposable sample vials	Fisher or equivalent, 25mL
Plastic beads	Environmental Express or equivalent, for use as a simulated solids matrix.

8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration / Description
Reagent water	ASTM Type II water or equivalent
SulfaVer 4 reagent packets	Hach cat. #12065-99 or equivalent reagent

8.2 Standards

Standard Type	Description	Expiration	Storage
Stock Sulfate calibration standard	LabChem LC25510-1; 1000mg/L, or equivalent	Manufacturer's expiration date	Manufacturer's storage conditions
Working Sulfate calibration standards	Refer to Section 8.3.2	Must be prepared fresh daily.	Not applicable
Stock Sulfate ICV/LCS standard	Ricca; catalog #8112; 1000mg/L, or equivalent	Manufacturer's expiration date	Manufacturer's storage conditions
Working Sulfate ICV/LCS Standard	Refer to Section 8.3.3	Must be prepared fresh daily.	Not applicable

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8.3 Standard Preparation Procedures

Refer to the standard preparation logbook or database for additional instructions regarding preparation of standards for Sulfate analysis. Instructions for preparation of fresh daily standards are detailed below.

8.3.1 Working Sulfate Calibration Standard Preparation

Working calibration standards are prepared fresh daily from the Stock Sulfate Calibration Standard (1000mg/L) and are diluted to 25mL with reagent water. These concentrations are examples only and may vary.

Standard	Volume of stock Sulfate calibration standard	Final Volume	Final Concentration
CAL1	0.125 mL	25mL	5 mg/L
CAL2	0.250 mL	25mL	10 mg/L
CAL3	0.375 mL	25mL	15 mg/L
CAL4 (CCV)	0.500 mL	25mL	20 mg/L
CAL5	0.625 mL	25mL	25 mg/L
CAL6	0.750 mL	25mL	30 mg/L
CAL7	0.875 mL	25mL	35 mg/L
CAL8	1.00 mL	25mL	40 mg/L

8.3.2 Working Sulfate ICV/LCS Standard Preparation

Dilute 0.50mL of the Stock Sulfate ICV Standard (1000mg/L) to 25mL with reagent water for a final concentration of 20mg/L. This standard is also used as the LCS.

9.0 PROCEDURE

9.1 Initial Calibration (ICAL)

9.1.1 Configure the instrument according to manufacturer's instructions. Allow the instrument to warm up.

9.1.2 A minimum of five initial calibration standards is required. The lowest calibration standard must be at or below the reporting limit. A new initial calibration must be analyzed every 6 months at a minimum.

9.1.3 Initial Calibration Evaluation

9.1.3.1 Linear Calibration: After zeroing the spectrophotometer with reagent water, prepare a standard curve by plotting absorbance versus concentration of each calibration standard. The analyst may employ a regression equation that does not pass through the origin. The regression will produce the slope and intercept terms for a linear equation in the form:

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$$y = ax + b$$

where: y = instrument response
a = slope of the line (the coefficient of x)
x = concentration of the calibration standard
b = y-intercept of the line

The regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. To be used for quantitative purposes, the correlation coefficient must be $\geq$ 0.995.

9.1.3.2 Individual analyte calibration levels may be removed from the lowest and/or highest levels of the calibration curve provided the number of remaining calibration points meet the minimum requirements and the quantitation range is adjusted, as necessary.

9.1.3.3 Removal of interior calibration levels is not permitted unless a standard introduction error or preparation error can be documented.

9.1.3.4 A calibration level may be replaced provided that the replacement calibration standard is analyzed within the same calibration event.

9.1.3.5 Evaluate the Relative Error of the lowest calibration point and the mid-point of the curve as follows:

$$\% \text{ Relative Error} = \frac{\text{Calculated concentration} - \text{Theoretical concentration}}{\text{Theoretical concentration}} \times 100$$

9.1.3.6 Refer to Section 11.1 for acceptance criteria and corrective actions.

9.1.4 Initial Calibration Verification (ICV)

9.1.4.1 In addition to meeting the linearity requirement, any new calibration curve must be assessed for accuracy in the values generated. To assess the accuracy, a single standard from a secondary source must be analyzed and the results obtained must be compared to the known value of the standard. This step is referred to as Initial Calibration Verification. The ICV is analyzed immediately following an initial calibration curve.

9.1.4.2 The ICV is evaluated by calculating the percent recovery, as follows:

$$\% \text{ Recovery} = \frac{\text{Calculated concentration}}{\text{Theoretical concentration}} \times 100$$

9.1.4.3 Refer to Section 11.1 for acceptance criteria and corrective actions.

9.1.5 Initial Calibration Blank (ICB)

9.1.5.1 The ICB consists of 25mL reagent water. An ICB must be analyzed after each ICV. Refer to Section 11.1 for acceptance criteria and corrective actions.

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9.2 Continuing Calibration

9.2.1 Continuing Calibration Verification (CCV): When an ICAL is not analyzed, the calibration must be verified by analyzing a CCV at the beginning of the analytical sequence. In all cases, a CCV must be analyzed after every 4 samples and at the end of the analytical sequence to verify the system is still calibrated. The CCV should be from the same material as the curve standards. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.2.2 Continuing Calibration Blank (CCB): The CCB consists of 25mL reagent water. A CCB must be analyzed after each CCV. Refer to Section 11.1 for acceptance criteria and corrective actions.

9.3 Sample Analysis

9.3.1 Allow sample to reach room temperature.

9.3.2 Aqueous Sample Preparation

9.3.2.1 If samples are turbid, samples may be filtered through a 0.45um filter. If any samples in a batch are filtered, the associated Method Blank and LCS must also be filtered.

9.3.2.2 Place a 25mL aliquot of sample, or suitable portion of sample diluted to 25mL with reagent water, into a labeled disposable vial.

9.3.2.3 Prepare a Method Blank: Place 25mL reagent water into a labeled disposable vial.

9.3.2.4 Prepare a Laboratory Control Sample (LCS): dilute 0.50mL of the Stock Sulfate ICV Standard (1000mg/L) to 25mL with reagent water in a labeled disposable vial, for a final concentration of 20mg/L.

9.3.2.5 Prepare a Matrix Spike (MS): dilute 0.50mL of the Stock Sulfate ICV Standard (1000mg/L) to 25mL with sample in a labeled disposable vial, for a final spike concentration of 20mg/L.

9.3.3 Solid Sample Preparation

9.3.3.1 Weigh 10g of sample into a beaker and add 100mL of reagent water. Stir for 30 minutes and then allow it to settle before filtering the sample through a 0.45um filter. Place a 25mL aliquot of filtrate, or suitable portion of filtrate diluted to 25mL with reagent water, into a labeled disposable vial.

9.3.3.2 Prepare a Method Blank: weigh 10g of plastic beads into a beaker and add 100mL of reagent water. Stir for 30 minutes and then allow it to settle before filtering the method blank through a 0.45um filter. Place a 25mL aliquot of filtrate into a labeled disposable vial.

9.3.3.3 Prepare a Laboratory Control Sample (LCS): in a labeled disposable vial, dilute 0.50mL of the Stock Sulfate ICV Standard (1000mg/L) to 25mL with the Method Blank filtrate from Section 9.3.3.2 for a final concentration of 200mg/kg.

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9.3.3.4 Prepare a Matrix Spike (MS): in a labeled disposable vial, dilute 0.50mL of the Stock Sulfate ICV Standard (1000mg/L) to 25mL with sample filtrate from Section 9.3.3.1 for a final spike concentration of 200mg/kg.

9.3.4 Sulfate Determination

9.3.4.1 Add the contents of one Hach Sulfaver 4 reagent packet to each 25mL aliquot of sample, blank, or standard. Cap the vial and shake.

9.3.4.2 Wait 5 minutes after shaking for turbidity to develop. Shake the vial again and then determine the absorbance using the spectrophotometer.

9.3.4.3 A typical run sequence may be as follows. A CCV/CCB must be analyzed after every fourth sample.

Initial calibration standards
ICV
ICB
(If ICAL not run, CCV/CCB would replace the ICAL, ICV and ICB in the sequence)
Method blank
LCS
2 Client samples
CCV
CCB
4 Client samples
CCV
CCB

9.3.4.4 Compare the absorbance readings to the calibration curve to determine sulfate concentrations. Sample concentrations that exceed the upper calibration range must be diluted and reanalyzed, or the result must be qualified as estimated.

9.3.4.5 A background absorbance reading should be taken prior to addition of reagent if sample has apparent color or turbidity. The difference between the Final Absorbance and the Initial Absorbance will be the background-corrected Absorbance used to determine the sample concentration.

9.3.4.5.1 Sample with reagent packet = Final Absorbance
9.3.4.5.2 Sample without reagent packet = Initial Absorbance
9.3.4.5.3 Absorbance = Final Absorbance – Initial Absorbance

10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Calculations

10.1.1 From the background-corrected absorbance, determine the concentration of sulfate present using the following equation:

$$X = \frac{y - b}{a}$$

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Where: X = sample concentration
y = response or absorbance, corrected for background
a = slope
b = y-intercept

10.1.2 Calculate the final concentration in the samples as follows:

$$\text{Aqueous Sample (mg/L)} = \frac{(X_s)(V_f)}{(V_i)} \qquad \text{Solid Sample (mg/kg)} = \frac{(X_s)(V_f)(D)}{(W_s)}$$

Where: X_s = Sulfate concentration, mg/L
V_f = Final sample volume/extract in L
V_i = Initial sample volume in L
D = Dilution factor of prepared solid extract (Final volume / Initial volume)
W_s = Weight of solid sample extracted in kilograms

$$\text{Moisture corrected concentration} = \frac{\text{(Final concentration as received)}}{\text{(100 - \%Moisture)}} \times 100$$

10.1.3 LCS equation:

$$R = (C/S) * 100$$

Where: R = percent recovery
C = observed LCS concentration
S = concentration of analyte added to the clean matrix

10.1.4 MS/MSD equation:

$$R = \frac{(C_s - C)}{S} * 100$$

Where: R = percent recovery
C_s = observed sample + spike concentration
C = sample concentration
S = concentration of analyte added to the sample

10.1.5 RPD equation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} * 100$$

Where: RPD = relative percent difference
D_1 = first sample result
D_2 = second sample result

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Instrument Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration (ICAL)	Applicable target analyte	Every 6 months at minimum	r ≥ 0.995 **Relative error:** Lowest curve point +/- 50% Mid-point of curve +/- 10%	Analyze a new initial calibration curve. If the second curve does not meet the acceptance criteria, the analyst must consult the department manager. Instrument maintenance and/or preparation of new calibration standards must be considered. Samples associated with a failed initial calibration must be reanalyzed.
Initial Calibration Verification Standard (ICV)	Second Source Standard	Immediately following initial calibration	90-110% Recovery	Analyze another aliquot of the ICV. If the second ICV also exceeds the acceptance range, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICV must be reanalyzed. *Exception:* If the ICV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Initial Calibration Blank (ICB)	Reagent water	Immediately following each ICV	Target analyte must be less than reporting limit.	Reanalyze ICB. If target compound is still > RL in blank and associated samples, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICB must be reanalyzed. *Exceptions:* 1) If a contaminant is present only in the blank and not the samples, no action is required.
Continuing Calibration Standard (CCV)	Applicable target analyte	Beginning of run if ICAL not analyzed. Then every 4 samples, and at end of run.	90-110% Recovery	Analyze another aliquot of the CCV. If the response still fails the acceptance criteria, then a new initial calibration must be prepared and analyzed. Samples associated with a failed CCV must be reanalyzed. *Exception:* If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Continuing Calibration Blank (CCB)	Reagent water	Immediately following each CCV.	Target analyte must be less than reporting limit.	Reanalyze CCB. If target compound is still > RL in blank and associated samples, a new initial calibration must be prepared and analyzed. Samples associated with a failed CCB must be reanalyzed. *Exceptions:* 1) If a contaminant is present only in the blank and not the samples, no action is required.

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11.2 Batch Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water or extract of clean soil matrix plus reagents.	One per preparation batch of up to 20 samples, per matrix.	Target analyte must be less than RL.	Reanalyze method blank. If method blank is still >RL, reanalyze associated samples. *Exceptions:* 1) If a contaminant is present only in the method blank and not the samples, no action is required. 2) If the method blank concentration is less than 1/10 of the amount measured in the sample, corrective action is not required, affected data must be qualified.
Laboratory Control Standard (LCS)	Applicable target analyte	One per preparation batch of up to 20 samples, per matrix.	90-110% Recovery	Reanalyze LCS. If LCS is still outside acceptance criteria, analyze a new initial calibration and reanalyze associated samples. *Exceptions:* 1) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported. 2) Batch may be acceptable based on matrix spike passing LCS criteria, with management approval.
Matrix Spike/ Matrix Spike Duplicate (MS/MSD)	Applicable target analyte	One MS/MSD set per batch plus an additional MS if >10 samples in the batch.	90-110% Recovery ≤20% RPD	No corrective action necessary. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.

11.3 Method Performance

11.3.1 Method Validation

Refer to the SOP for Method Validation and Instrument Verification for the procedures used for initial method validation. Method Detection Limits (MDL) must be determined per the procedure in 40CFR Part 136, Appendix B.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must document acceptable accuracy and precision by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

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12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

The analyst must perform primary review of data and calculated results for accuracy. Secondary review of the data and calculated results must be performed by another qualified analyst, the department supervisor, or the Quality Manager prior to release for reporting. Refer to the SOP for Data Review Process for more information.

12.2 Corrective Action

Corrective action is expected any time QC is not within acceptance criteria, when sample results exceed the calibration range, and when carryover is suspected. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Refer to Section 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

14.0 MODIFICATIONS

14.1 Method adapted for analysis of solid samples.

14.2 Hach Sulfaver 4 reagent pillows are used instead of laboratory-prepared reagents.

14.3 The calibration curve is not made hourly as described in Method 9038 Section 8.2. The calibration curve does not include a zero point.

14.4 Samples are not stirred for exactly one minute at constant speed as described in ASTM D516 Section 11.5 and Method 9038 Section 7.1.5.

14.5 Successive sulfate readings each 30 seconds for 4 minutes are not recorded. The absorbance is recorded after a 5-minute development period.

14.6 Stock standards are purchased from commercial suppliers and are not prepared in the lab.

14.7 The spectrophotometer cell path is >1 cm.

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15.0 RESPONSIBILITIES

Pace employees that perform any part of this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

16.0 ATTACHMENTS

Not applicable to this SOP.

17.0 REFERENCES

17.1 ASTM Method D516-07/11, “Standard Test Method for Sulfate Ion in Water”, 2007/2011.

17.2 EPA SW-846 Method 9038.

17.3 Pace Analytical Quality Manual; latest revision.

17.4 NELAC/TNI Standards; Quality Systems section; 2003, 2009, and 2016.

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18.0 REVISION HISTORY

This Version:

Section	Description of Change
All	Converted to new SOP format.
1.2	Referenced modification for analysis of extracts of soil samples.
7.1	Updated equipment information.
7.2	Updated supplies to match practice.
8.1	Updated reagent information.
9.1.3	Added calibration point-dropping policy and requirement to measure relative error.
9.3.1	Added requirement to allow samples to come to room temperature before analysis.
9.3.2	Added requirement to filter batch QC if any samples are filtered.
9.3.3	Updated soil preparation procedure.
9.3.4	Clarified determination of background absorbance.
11.2	Updated Method Blank and LCS corrective action.
14.0	Added modifications for turbidity-development procedure, purchase of stock standards, and cell path length.
17.4	Added reference to 2016 TNI Standard.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0061	Sulfate	01

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Document Information

Document Number: ENV-SOP-IND1-0095 **Revision:** 01

Document Title: Total Organic Carbon (TOC)

Department(s): Wet Chemistry

Date Information

Effective Date: 01 Jun 2020

Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

Document Number: ENV-SOP-IND1-0095 **Revision:** 01
Title: Total Organic Carbon (TOC)

All dates and times are in Central Time Zone.

ENV-SOP-IND1-0095 Total Organic Carbon (TOC)

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	29 May 2020, 08:21:41 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Sarah Potts (007977)	Manager	29 May 2020, 11:39:17 AM	Approved
Steven Sayer (004775)	General Manager 2	01 Jun 2020, 10:51:02 AM	Approved

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STANDARD OPERATING PROCEDURE
TITLE: TOTAL ORGANIC CARBON (TOC) and DISSOLVED ORGANIC CARBON (DOC)
METHOD: SM 5310C-2011
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the laboratory procedure for the determination of Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC) while meeting the requirements specified in Standard Method 5310C.

1.1 This procedure is applicable to aqueous samples.

1.2 The laboratory reporting limit is 1 mg/L. Refer to the LIMS for detection limits.

1.3 Reporting limits, control limits, volumes used, standard concentrations, vendors, instrumentation, equipment and supplies are subject to change.

2.0 SUMMARY OF METHOD

Organic carbon is oxidized to carbon dioxide by persulfate in the presence of heat or ultraviolet light. The carbon dioxide produced may be purged from the sample, dried and transferred with a carrier gas to a nondispersive infrared (NDIR) analyzer or be coulometrically titrated.

DOC is the fraction of TOC that passes through a 0.45 um pore diameter filter.

3.0 INTERFERENCES

3.1 Insufficient acidification of samples may result in incomplete release of carbon dioxide.

3.2 The intensity of the ultraviolet light reaching the sample may be reduced by highly turbid samples or with aging of the ultraviolet light source, resulting in sluggish or incomplete oxidation.

3.3 Large organic particles or very large or complex organic molecules may be oxidized slowly because persulfate oxidation is rate-limited.

3.4 Persulfate oxidation of organic molecules is slowed in samples containing significant concentrations of chloride.

3.5 With any organic carbon measurement, contamination during sample handling and treatment is a likely source of interference.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

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The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous TOC	250 mL amber glass bottle	pH<2 with H_2SO_4 or H_3PO_4	Cool to ≤6°C	Samples must be analyzed within 28 days of collection.
Aqueous DOC	250 mL amber glass bottle	Filtered 0.45um then pH<2 with H_2SO_4 or H_3PO_4	Cool to ≤6°C	Samples must be analyzed within 28 days of collection.

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Description / Comments
TOC Analyzer	Shimadzu TOC-V_{WP} or equivalent system, to include autosampler and data system.

7.2 Supplies

Supplies	Description
Mechanical pipets	Eppendorf or equivalent, various sizes
Volumetric flasks	Class A, various sizes

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Supplies	Description
Graduated cylinders	Class A, various sizes
Vials	40mL glass with screw cap
Filtration equipment	Whatman Puradisc Aqua or equivalent, prewashed cellulose acetate membrane or other material to minimize carbon leaching, 0.45um pore diameter, and filtration apparatus for Dissolved Organic Carbon analysis

8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration / Description
Reagent water	ASTM Type II water
Phosphoric acid	Extra pure, 85% solution in water. Acros Organics 29570, or equivalent
Sulfuric acid	Concentrated, reagent grade or equivalent
Acidified water	Place about 500mL reagent water into a 1L volumetric flask. Add 8mL phosphoric acid and bring to 1L with reagent water. Store in amber glass at ambient temperature. Solution expires one month from date of preparation.
Phosphoric acid solution	Place about 500mL reagent water into a 1L volumetric flask. Slowly add 200mL phosphoric acid while stirring. Allow solution to cool and bring to 1L with reagent water. Store in amber glass at ambient temperature. Solution expires one month from date of preparation.
Sodium Persulfate	Crystalline, reagent grade. Acros Organics 20202, or equivalent.
Sodium Persulfate solution	Place about 500mL reagent water into a 1L volumetric flask. Add 120g Sodium Persulfate and 30mL phosphoric acid and stir to mix well. Bring to 1L with reagent water. It is recommended that this solution be allowed to stand in a cool dark location for 24 hours before use. Store in amber glass at ambient temperature. Solution expires one month from date of preparation.

8.2 Standards

Standard Type	Description	Expiration	Storage
Stock TOC Calibration Standard	ERA: catalog #978; 1000mg/L potassium hydrogen phthalate, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions
Working TOC Calibration Standards	Refer to Section 8.3.1	Expires one month from preparation.	Same as stock standard
Stock TOC ICV Standard	Thermo/AlfaAesar; catalog #42562; 1000mg/L potassium hydrogen phthalate, or equivalent.	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions

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STANDARD OPERATING PROCEDURE
TITLE: TOTAL ORGANIC CARBON (TOC) and DISSOLVED ORGANIC CARBON (DOC)
METHOD: SM 5310C-2011
ISSUER: Pace ENV – Indianapolis – IND1

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Standard Type	Description	Expiration	Storage
Working TOC ICV Standard	Refer to Section 8.3.2	Prepare fresh daily.	Same as stock standard.
Stock Inorganic Carbon Standard	Ricca; catalog #1845-16; 1000mg/L, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions

8.3 Standard Preparation Procedures

8.3.1 Working TOC Calibration Standard Preparation

Working calibration standards must be prepared fresh in reagent water. Prepare standards in 100mL volumetric flasks and add 2-3 drops of 85% Phosphoric acid to each flask prior to mixing. Pour standards into labeled 40mL vials for analysis. Examples of possible calibration standards are as follows but may vary:

Standard	Stock TOC Calibration Standard Volume	Final Volume	TOC Final Concentration
CAL0	0 mL	100mL	0 mg/L
CAL1	0.05 mL	100mL	0.5 mg/L
CAL2	0.1 mL	100mL	1 mg/L
CAL3	0.5 mL	100mL	5 mg/L
CAL4 (CCV)	1.0 mL	100mL	10 mg/L
CAL5	1.5 mL	100mL	15 mg/L
CAL6	2.0 mL	100mL	20 mg/L

8.3.2 Working TOC ICV Standard Preparation

In a 100mL volumetric flask, dilute 1.0 mL of the Stock TOC ICV Standard (1000mg/L) and 2-3 drops of 85% Phosphoric acid to volume with reagent water for a final spike concentration of 10 mg/L.

9.0 PROCEDURE

9.1 Initial Calibration

9.1.1 Configure the instrument according to manufacturer's instructions.

9.1.2 A minimum of five initial calibration standards and a calibration blank are analyzed in increasing order of concentration. The lowest calibration standard must be at or below

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the reporting limit. A new initial calibration curve is analyzed every six months, at a minimum, or as needed.

9.1.3 Initial Calibration Evaluation

9.1.3.1 **Linear Calibration:** Using the instrument software, construct a standard curve by plotting instrument response versus TOC concentration. The regression calculation will generate a correlation coefficient that is the measure of the "goodness of fit" of the regression line to the data. Refer to Section 11.1 for acceptance criteria and corrective action.

9.1.3.2 Evaluate the Relative Error of the lowest calibration point and the mid-point of the curve as follows:

$$\% \text{ Relative Error} = \frac{\text{Calculated concentration} - \text{Theoretical concentration}}{\text{Theoretical concentration}} \times 100$$

9.1.3.3 Refer to Section 11.1 for acceptance criteria and corrective action.

9.1.4 Initial Calibration Verification (ICV)

9.1.4.1 In addition to meeting the linearity requirement, any new calibration curve must be assessed for accuracy in the values generated. To assess the accuracy of the calibration, a single standard from a secondary source must be analyzed and the results obtained must be compared to the known value of the standard. This step is referred to as Initial Calibration Verification. The ICV is analyzed immediately after an initial calibration curve. Refer to Section 11.1 for acceptance criteria and corrective action.

9.1.5 Initial Calibration Blank (ICB)

9.1.5.1 The ICB consists of acidified reagent water. An ICB must be analyzed after each ICV. Refer to Section 11.1 for acceptance criteria and corrective action.

9.2 Continuing Calibration Verification (CCV)

9.2.1 When an ICAL is not analyzed, the calibration must be verified by analyzing a CCV at the beginning of the analytical sequence. In all cases, a CCV must also be analyzed after every 10 samples and at the end of the analytical sequence to verify the system is still calibrated. The CCV should be from the same material as the calibration standards. Refer to Section 11.1 for acceptance criteria and corrective action.

9.2.2 Continuing Calibration Blank (CCB): A CCB consists of acidified reagent water. A CCB must be analyzed after each CCV. Refer to Section 11.1 for acceptance criteria and corrective action.

9.3 Sample Preparation

9.3.1 Allow samples to come to room temperature.

9.3.2 If total organic carbon (TOC) is to be determined and samples were received unpreserved, add 0.1mL concentrated H_2SO_4 to a 40mL sample aliquot prior to analysis.

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9.3.3 If dissolved organic carbon (DOC) is to be determined, samples should have been filtered prior to preservation in the field. If filtration status is unclear, confirm with Project Manager. For samples requiring lab filtration, use 0.45um syringe filters specific for TOC/COD analysis to minimize carbon leaching. Add 0.1mL concentrated H_2SO_4 to a 40mL sample filtrate. The associated Method Blank and LCS must also be filtered and preserved in the same manner as samples.

9.3.4 Pour well-mixed sample into a labeled 40mL vial. Make all measurements using a Class A graduated cylinder.

9.3.5 If the sample is high in solids, invert to mix and allow solids to settle. Decant or pipet the supernatant into a labeled 40mL vial for analysis.

9.3.6 When sample dilution is needed, use acidifed water as the diluent. Dilution should be considered when sample is turbid, high in solids, or has an organic odor.

9.3.7 **Prepare a Method Blank:** fill a labeled 40mL vial with acidified water.

9.3.8 **Prepare an LCS:** dilute 0.4 mL of the Stock TOC ICV Standard (1000mg/L) to 40mL with acidified water for a final spike concentration of 10 mg/L.

9.3.9 **Prepare a Matrix Spike:** dilute 0.4 mL of the Stock TOC ICV Standard (1000mg/L) to 40mL with sample for a final spike concentration of 10 mg/L.

9.3.10 **Prepare an Inorganic Carbon Check:** dilute 0.4 mL of the Stock Inorganic Carbon Standard (1000mg/L) to 40mL with sample for a final spike concentration of 10 mg/L.

9.4 Sample Analysis

9.4.1 Once calibration is established per the requirements of Sections 9.1 and 9.2, place vials into the autosampler in the desired order and analyze samples per instrument manufacturer's instructions. A typical analytical sequence may be as follows:

ICAL Standards
ICV
ICB *(If ICAL not analyzed, CCV/CCB would replace the ICAL/ICV/ICB)*
Method Blank
LCS
Client samples
Inorganic Carbon Check
MS/MSD
CCV
CCB
Client samples
MS
CCV
CCB

9.4.2 Replicate measurements should be reproducible to within ±10% RPD. Repeat analysis if replicate measurements are outside of the ±10% RPD criteria, unless sample result is <RL.

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9.4.3 Samples with concentrations above the calibration range must be diluted and reanalyzed, or the result must be qualified as estimated.

10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Calculations

10.1.1 Use instrument manufacturer's data system for the determination of sample concentrations. Calculate the final concentration in the samples as follows:

TOC or DOC (mg/L) = $(X_s)(D)$

Where: X_s = On-instrument TOC or DOC concentration, mg/L
D = Dilution factor (Final volume / Initial volume)

10.1.2 LCS calculation:

$$R = (C / S) \times 100$$

Where: R = Percent Recovery
C = Observed LCS concentration
S = True LCS concentration

10.1.3 MS calculation:

$$R = \frac{(C_s - C)}{S} \times 100$$

Where: R = Percent Recovery
C_s = Observed MS concentration
C = Sample concentration
S = True spike concentration

10.1.4 RPD calculation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} \times 100$$

Where: RPD = Relative Percent Difference
D_1 = First Sample Result
D_2 = Second Sample Result

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Instrument Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration	Applicable target analyte	Every 6 months, at a minimum, or as needed.	r ≥ 0.995 for Linear Calibration **Relative error:** Lowest point +/- 50% Midpoint +/- 10%	Analyze a new initial calibration curve. If the second curve attempt does not meet the acceptance criteria, the analyst must consult the department manager. Instrument maintenance and/or preparation of new calibration standards must be considered. Samples associated with a failed initial calibration must be reanalyzed.
Initial Calibration Verification Standard (ICV)	Second Source Standard	Immediately following initial calibration	90-110% Recovery	Analyze another ICV. If the response still fails the acceptance criteria, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICV must be reanalyzed. *Exception:* If the ICV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Initial Calibration Blank (ICB)	Acidified reagent water	Immediately following the ICV	Target analyte must be <½ RL.	Reanalyze blank. If target compound is still >½ RL in blank and associated samples, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICB must be reanalyzed. *Exceptions:* 1) If no additional sample remains for reanalysis, or if reanalysis cannot take place within holding time, the sample results must be qualified. 2) If a contaminant is present only in the blank and not the samples, no action is required.
Continuing Calibration Standard (CCV)	Applicable target analyte	Every 10 samples, and at end of run	90-110% Recovery	Analyze another CCV. If the response still fails the acceptance criteria, then a new initial calibration must be analyzed. Samples associated with a failed CCV must be reanalyzed. *Exception:* If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Continuing Calibration Blank (CCB)	Acidified reagent water	Immediately following each CCV	Target analyte must be <½ RL.	Reanalyze blank. If target compound is still >½ RL in blank and associated samples, a new initial calibration must be prepared and analyzed. Samples associated with a failed CCB must be reanalyzed. *Exceptions:* 1) If no additional sample remains for reanalysis, or if reanalysis cannot take place within holding time, the sample results must be qualified. 2) If a contaminant is present only in the blank and not the samples, no action is required.

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11.2 Batch Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Acidified reagent water	One per preparation batch of up to 20 samples.	Target analyte must be <½ RL.	Reanalyze blank. Reanalyze associated samples if target compound is still >½ RL in method blank and associated samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 2) If a contaminant is present only in the method blank and not the samples, no action is required. 3) If the method blank concentration is less than 1/10 of the amount measured in the sample, corrective action is not required, affected data must be qualified.
Laboratory Control Standard (LCS)	Applicable target analyte	One per preparation batch of up to 20 samples.	**TOC:** 90-110% Recovery **DOC:** 90-110% Recovery	Reanalyze LCS. Reanalyze associated samples if LCS is still outside acceptance limits. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, reported data must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified.
Matrix Spike / Matrix Spike Duplicate (MS/MSD)	Applicable target analyte	One MS/MSD set per batch plus an additional MS if >10 samples in the batch.	80-120% Recovery ≤20% RPD	No corrective action necessary. If LCS recovery meets acceptance criteria, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.
Inorganic Carbon Check	Inorganic Carbon spike of a sample	One Inorganic Carbon Check spike per analytical run.	≤20% RPD between spiked result and unspiked result.	Instrument maintenance is required.

11.3 Method Performance

11.3.1 Method Validation

Refer to the SOP for Method Validation and Instrument Verification for the procedures used for initial method validation. Method Detection Limits (MDL) must be determined per the procedure in 40CFR Part 136, Appendix B.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must

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document acceptable accuracy and precision by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

The analyst must perform primary review of data and calculated results for accuracy. Secondary review of the data and calculated results must be performed by another qualified analyst, the department supervisor, or the Quality Manager prior to release for reporting. Refer to the SOP for Data Review Process for more information.

12.2 Corrective Action

Corrective action is expected any time QC is not within acceptance criteria, when sample results exceed the calibration range, and when carryover is suspected. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Refer to Section 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

14.0 MODIFICATIONS

14.1 Stock standards are purchased as certified solutions and are not prepared in the lab from dry chemicals.

14.2 Reagents are prepared per instrument manufacturer's instructions and may differ from those listed in the method.

14.3 Calibration check standard analyzed after every tenth analysis is not made from a source material other than the calibration standards.

15.0 RESPONSIBILITIES

Pace employees that perform any part of this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The

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employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

16.0 ATTACHMENTS

Not applicable to this SOP.

17.0 REFERENCES

17.1 Standard Methods for the Examination of Water and Wastewaters, Method 5310C, 2000, Editorial revisions 2011.

17.2 Shimadzu TOC-V_{WP} User's Manual, 2004.

17.3 Pace Analytical Quality Manual; latest revision.

17.4 NELAC/TNI Standards; Quality Systems section; 2003, 2009, and 2016.

18.0 REVISION HISTORY

This Version:

Section	Description of Change
All	Converted to new SOP format.
7.2	Added detail for specific filtration equipment to be used.
8.1	Added sulfuric acid
8.2	Updated standards to match current practice.
8.3.1	Added 0.5 mg/L standard to example curve.
9.1	Added detail for number of calibration points and added requirement to determine relative error for each calibration.
9.3	Added handling for samples received unpreserved and handling for samples requiring lab filtration for dissolved analysis.
11.1	Updated ICB/CCB criteria to <1/2RL.
11.2	Updated MB criteria to <1/2RL.
17.4	Added reference to 2016 TNI.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0095	Total Organic Carbon	00

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All Dates and Times are listed in: Central Time Zone

Signature Manifest

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ENV-SOP-IND1-0096 Anions by Ion Chromatography

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Elizabeth Schrage (008534)	Manager - Quality	10 Mar 2021, 09:10:38 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
Timothy Pinckert (003677)	Manager	11 Mar 2021, 07:43:20 AM	Approved
Steven Sayer (004775)	General Manager 2	11 Mar 2021, 10:38:24 AM	Approved

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STANDARD OPERATING PROCEDURE
TITLE: ANIONS BY ION CHROMATOGRAPHY
METHOD: EPA 300.0, Revision 2.1 and SW-846 9056A
ISSUER: Pace ENV – Indianapolis – IND1

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the laboratory procedure for determining the concentration of anions in aqueous and solid samples while meeting the requirements specified in EPA Method 300.0, Rev. 2.1 and SW-846 Method 9056A.

1.1 The table below summarizes the anions that are routinely reported by this method and the current default reporting limits. Refer to the LIMS for method detection limits.

Anion	Water Reporting Limits, (mg/L)	Soil Reporting Limits, (mg/kg)
Bromide	0.05	0.5
Chloride	0.25	2.5
Fluoride	0.1	1
Iodide	0.5	5
Nitrate	0.05	0.5
Nitrite	0.05	0.5
Nitrate+Nitrite	0.1	1
Sulfate	0.25	2.5

1.2 This procedure is applicable to most drinking water, groundwater, surface water, wastewater, and extracts of solid samples.

1.3 Reporting limits, control limits, volumes used, standard concentrations, vendors, instrumentation, equipment and supplies are subject to change.

2.0 SUMMARY OF METHOD

Aqueous samples or solid sample extracts are introduced into an ion chromatograph. The anions of interest are separated and measured using a system comprised of a guard column, analytical column, suppressor device, and conductivity detector.

3.0 INTERFERENCES

3.1 Interferences can be caused by substances with retention times that are similar to and that overlap those of the anions of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or fortification can be used to solve most interference problems associated with retention time.

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3.2 The water dip or negative peak that elutes near and can interfere with the fluoride peak can usually be eliminated by the addition of the equivalent of 1 mL of concentrated eluent to 100 mL of each standard and sample.

3.3 Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baseline in ion chromatograms.

3.4 Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns require filtration to prevent damage to instrument columns and flow system.

3.5 The acetate, formate, and other monovalent organic acid anions elute early in the chromatographic run and can interfere with fluoride. The retention times of anions may differ when large amounts of acetate are present. Therefore, this method is not recommended for leachates of solid samples where acetate is used for pH adjustment.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handling these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

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6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory and data quality objectives for the project.

Sample type	Collection per sample	Preservation	Storage	Holding time
Aqueous	One 125mL plastic or glass bottle	No preservation required	Cool to ≤6°C **Note:** Method 300.0 does not require cooling for Bromide, Chloride, or Fluoride.	**Nitrate or Nitrite:** Samples must be analyzed within 48 hours of collection **Other Anions:** Samples must be analyzed within 28 days of collection
Solid	One 4 oz. wide mouth plastic or glass jar	No preservation required	Cool to ≤6°C	Samples must be analyzed within 28 days of collection

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment

Equipment	Description / Comments
Ion Chromatograph	Dionex Aquion system or equivalent system that includes autosampler and data system.
Guard Column	Dionex AG14 IonPac 4x50mm, or equivalent
Analytical Column	Dionex AS14 IonPac 4x250mm, or equivalent
Analytical Balance	Capable of measuring to the nearest 0.1g
Agitation apparatus	Shaker table, ultrasonic bath or equivalent apparatus for preparation of solids

7.2 Supplies

Supplies	Description
Gastight syringes	Various sizes
Mechanical pipets	Calibration-checked, variable volume
Volumetric pipets	Class A, various sizes
Volumetric flasks	Class A, various sizes
Graduated cylinders	Class A, various sizes
Beakers	Glass or plastic disposable
Syringe filters	0.45um for filtering samples when required
Filtration apparatus	With 0.45um filter disks for filtration of eluent

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Supplies	Description
Sample vials	120mL plastic with screw top caps
Autosampler vials	1.5mL with screw top septum caps

8.0 REAGENTS AND STANDARDS

8.1 Reagents

Reagent	Concentration / Description
Reagent water	ASTM Type II water
Sodium Bicarbonate	A.C.S grade powder, Fisher S233 or equivalent
Sodium Carbonate, Anhydrous	A.C.S. grade powder, Fisher S263 or equivalent
Stock Eluent	Place 500mL reagent water into a 1L volumetric flask. Add 8.4g Sodium Bicarbonate and 37.1g Sodium Carbonate. Dissolve and dilute to 1L with reagent water. This solution expires 6 months from the date of preparation.
Working Eluent	Place 1L reagent water into a 2L volumetric flask. Add 20mL of the Stock Eluent and dilute to 2L with reagent water. This solution should be vacuum filtered through a 0.45um filter prior to use. This solution should be prepared fresh daily.
Simulated soil matrix	Teflon chips, glass beads, plastic beads or other suitable simulated soil matrix

8.2 Standards

Standard Type	Description	Expiration	Storage
IC Stock Calibration Standard (Br^-, Cl^-, F^-, NO_3, SO_4)	AccuStandard; catalog #IS-17854-250ML; 100/250/500ug/mL, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions.
IC Nitrite Stock Calibration Standard	AccuStandard, catalog #IC-NO2-N-10X-1; 1000ug/mL or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions.
IC Intermediate Calibration Standard	See Section 8.3.1	Expires 30 days from date of preparation.	Same as stock standard
IC Working Calibration Standards	See Section 8.3.2	Expires one week from date of preparation.	Same as stock standard
IC Stock ICV Standard (Br^-, Cl^-, F^-, NO_2, NO_3, SO_4)	Inorganic Ventures; catalog # HES-8-REV1; 50/125/250ug/mL, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions.

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Standard Type	Description	Expiration	Storage
IC Working ICV Standard	See Section 8.3.3	Expires one week from date of preparation.	Same as stock standard
IC Iodide Stock Calibration Standard	Environmental Express, catalog #IC-II-M; 1000ug/mL or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions.
IC Iodide Intermediate Calibration Standard	See Section 8.3.4	Expires six months from date of preparation.	Same as stock standard
IC Iodide Working Calibration Standards	See Section 8.3.5	Expires six months from date of preparation.	Same as stock standard
IC Iodide Stock ICV Standard	O2Si, catalog #062013-01-01; 1000ug/mL, or equivalent	Manufacturer's recommended expiration date	Manufacturer's recommended storage conditions.
IC Iodide Working ICV Standard	See Section 8.3.6	Expires six months from date of preparation.	Same as stock standard

8.3 Standard Preparation Procedures

8.3.1 IC Intermediate Calibration Standard Preparation

Dilute 50mL of the IC Stock Calibration Standard (100/250/500ug/mL) and 5mL of the IC Nitrite Stock Calibration Standard (1000ug/mL) to 100mL with reagent water. Final concentration of anions:

Anion	Intermediate Calib. Std Concentration, ug/mL
Bromide	50
Chloride	125
Fluoride	50
Nitrate as N	50
Nitrite as N	50
Sulfate	250

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8.3.2 IC Working Calibration Standards Preparation

Working Calibration Standards are prepared in reagent water from the IC Intermediate Calibration Standard (50/125/250ug/mL). Actual calibration concentrations may vary.

Standard	IC Intermediate Calib. Std. volume	Final Volume in reagent water
CAL0	0mL	100mL
CAL1	0.1mL	100mL
CAL2	0.4mL	100mL
CAL3 (CCV)	1.0mL	100mL
CAL4	2.0mL	100mL
CAL5	4.0mL	100mL
CAL6	10mL	100mL

Final concentrations (mg/L) in each working calibration standard as prepared above:

Anion	CAL0	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6
Bromide	0	0.05	0.2	0.5	1.0	2.0	5.0
Chloride	0	0.125	0.5	1.25	2.5	5.0	12.5
Fluoride	0	0.05	0.2	0.5	1.0	2.0	5.0
Nitrate as N	0	0.05	0.2	0.5	1.0	2.0	5.0
Nitrite as N	0	0.05	0.2	0.5	1.0	2.0	5.0
Sulfate	0	0.25	1.0	2.5	5.0	10	25

8.3.3 IC Working ICV Standard Preparation

Dilute 0.1mL of the IC Stock ICV Standard (50/125/250ug/mL) to 10mL with reagent water. Final concentration of anions:

Anion	ICV Standard Conc., mg/L
Bromide	0.5
Chloride	1.25
Fluoride	0.5
Nitrate as N	0.5
Nitrite as N	0.5
Sulfate	2.5

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8.3.4 IC Iodide Intermediate Calibration Standard Preparation

Dilute 1.0mL of the IC Iodide Stock Calibration Standard (1000ug/mL) to 10mL with reagent water for a final concentration of 100ug/mL.

8.3.5 IC Iodide Working Calibration Standards Preparation

Working Iodide Calibration Standards are prepared in reagent water from the IC Iodide Intermediate Calibration Standard (100ug/mL). Actual calibration concentrations may vary.

Standard	Iodide Intermediate Calib. Std. volume	Final Volume in reagent water	Final Iodide Conc., mg/L
CAL0	0mL	100mL	0
CAL1	0.5mL	100mL	0.5
CAL2 (CCV)	1.0mL	100mL	1
CAL3	5.0mL	100mL	5
CAL4	10mL	100mL	10
CAL5	25mL	100mL	25

8.3.6 IC Iodide Working ICV Standard

Dilute 0.05mL of the IC Iodide Stock ICV Standard (1000ug/mL) to 10mL with reagent water for a final concentration of 5mg/L.

9.0 PROCEDURE

9.1 Sample Preparation and Handling

9.1.1 Aqueous Samples

9.1.1.1 Prepare a Method Blank: Place reagent water in a labeled autosampler vial.

9.1.1.2 Prepare an LCS: Dilute 0.1mL of the IC Stock ICV Standard (50/125/250ug/mL) to 10mL with reagent water. Spike concentrations are the same as the IC Working ICV. **Iodide only:** Dilute 0.05mL of the IC Iodide Stock ICV Standard (1000ug/mL) to 10mL with reagent water for a final concentration of 5mg/L.

9.1.1.3 Prepare an MS/MSD: Dilute 0.1mL of the IC Stock ICV Standard (50/125/250ug/mL) to 10mL with sample. Spike concentrations are the same as IC Working ICV. **Iodide only:** Dilute 0.05mL of the IC Iodide Stock ICV Standard (1000ug/mL) to 10mL with sample for a final concentration of 5mg/L.

9.1.1.4 Filter any samples that contain particles larger than 0.45um using a syringe filter. If filtration is necessary, the associated Method Blank and LCS must also be filtered.

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9.1.1.5 Fill a labeled autosampler vial with a minimum of 1mL of sample. An initial rinse of the vial with sample is recommended. Screw on the septum cap and the sample is ready for analysis.

NOTE: Samples that are received acid preserved for NO3+NO2 must be diluted prior to analysis due to the sulfate interference presented by the sulfuric acid preservative.

9.1.2 Soil Samples

9.1.2.1 Prepare a Method Blank: place 10 +/-0.5g of simulated soil matrix and 100mL reagent water into a labeled 120mL sample vial.

9.1.2.2 Prepare an LCS: place 10 +/-0.5g of simulated soil matrix, 1.0mL of the IC Stock ICV Standard (50/125/250ug/mL) and dilute to100mL with reagent water in a labeled 120mL sample vial. Spike concentration is 5-25 mg/kg. **Iodide only**: place 10 +/-0.5g of simulated soil matrix, 0.5mL of the IC Iodide Stock ICV Standard (1000ug/mL) and dilute to100mL with reagent water in a labeled 120mL sample vial. Spike concentration is 50mg/kg.

9.1.2.3 Prepare samples: Weigh 10 +/-0.5g of sample into a labeled 120mL sample vial and add 100mL of reagent water.

9.1.2.4 Prepare an MS/MSD: place 10 +/-0.5g of sample, 1.0mL of the IC Stock ICV Standard (50/125/250ug/mL) and dilute to 100mL with reagent water in a labeled 120mL sample vial. Spike concentration is 5-25 mg/kg. **Iodide only**: place 10 +/-0.5g of sample, 0.5mL of the IC Iodide Stock ICV Standard (1000ug/mL) and dilute to100mL with reagent water in a labeled 120mL sample vial. Spike concentration is 50mg/kg.

9.1.2.5 Secure caps on all vials. Agitate all samples, Method Blank, LCS, and MS/MSD for 10 minutes then allow the slurry to settle.

9.1.2.6 Filter all samples, the associated Method Blank, LCS and MS/MSD using syringe filters.

9.1.2.7 Fill a labeled autosampler vial with a minimum of 1mL of the filtrate. An initial rinse of the autosampler vial with the filtrate is recommended. Screw on the septum cap and the sample is ready for analysis.

9.2 Initial Calibration (ICAL)

9.2.1 Set up the ion chromatograph per manufacturer's instructions and allow the instrument to warm up to establish a stable baseline.

9.2.2 Analyze a blank and a minimum of five concentrations of calibration standard for each analyte of interest. The lowest calibration standard must be at or below the required reporting limit. Analyze calibration standards in order of increasing concentration. Document the peak area response and retention time for each analyte. A new initial calibration must be performed every six months, at a minimum.

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9.2.3 Initial Calibration Evaluation

9.2.3.1 Each day that analysis is performed, the calibration standard(s) should be evaluated to determine if the chromatographic system is operating properly. Questions that should be asked are: Do the peaks look normal? Is the response obtained comparable to the response from previous calibrations? Are the retention times consistent over the range of calibration for each compound? Careful examination of the standard chromatogram can indicate whether the column is still performing acceptably

9.2.3.2 Using the manufacturer's data system software, establish the individual analyte calibration curves by plotting the peak area response against the corresponding concentrations. Use a least squares linear regression to calculate the calibration curve formula. A weighted least squares regression may also be performed using 1/x or $1/x^2$ as the weighting factor.

9.2.3.3 Using the instrument software, prepare a standard curve by plotting concentration vs response for each anion. A regression equation that does not pass through the origin may be used.

9.2.3.4 The regression calculation will generate a correlation coefficient (r) that is the measure of the "goodness of fit" of the regression line to the data. Refer to Section 11.1 for acceptance criteria and corrective action.

9.2.3.5 Individual analyte calibration levels may be removed from the lowest and/or highest levels of the calibration curve provided the number of remaining calibration points meet the minimum requirements and the quantitation range is adjusted as necessary.

9.2.3.6 Removal of interior calibration levels is not permitted unless a standard introduction error or preparation error can be documented.

9.2.3.7 A calibration level may be replaced provided that the replacement calibration standard is analyzed within the same calibration event.

9.2.3.8 Evaluate the Relative Error of the calibration by one of the following options:

Option 1: Relative Error (%RE)

$$\%\,Relative\ Error = \frac{x_i' - x_i}{x_i}\ x\ 100$$

Where: x_i = True value of the calibration standard
x'_i = Measured concentration of the calibration standard

Calculate %RE for two (2) initial calibration levels, the standard at the mid-point and the standard at the lowest point.

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Option 2: Relative Standard Error (%RSE)

$$\%\text{RSE} = 100\,x\sqrt{\sum_{i=1}^{n}\frac{\left[\frac{x_i' - x_i}{x_i}\right]^2}{(n-p)}}$$

Where: x_i = True value of the calibration level i
x'_i = Measured concentration of calibration level i
p = Number of terms in the fitting equation (avg.=1, linear=2)
n = Number of calibration points

9.2.3.9 Both correlation coefficient and percent error requirements in Section 11.1 must be met for the initial calibration to be valid. Follow corrective action steps in Section 11.1 if requirements are not met.

9.2.4 Initial Calibration Verification (ICV)

The initial calibration must be verified through the analysis of an Initial Calibration Verification (ICV) standard. The ICV is prepared from an independent source at or near the mid-range of the calibration curve and analyzed immediately following the initial calibration curve. Refer to Section 11 for acceptance criteria and corrective action.

9.2.5 Initial Calibration Blank (ICB)

The ICB consists of reagent water. An ICB must be analyzed after each ICV. Refer to Section 11 for acceptance criteria and corrective action.

9.3 Continuing Calibration Verification (CCV)

9.3.1 The initial calibration must be verified daily with the analysis of a Continuing Calibration Verification Standard (CCV) at or near mid-range concentration at the beginning of the analytical sequence, after every 10 samples, and at the end of the analytical sequence, as a minimum requirement. Refer to Section 11 for acceptance criteria and corrective action.

9.3.2 Continuing Calibration Blank (CCB): The CCB consists of reagent water. A CCB must be analyzed after each CCV. Refer to Section 11 for acceptance criteria and corrective action.

9.4 Sample Analysis

9.4.1 Set up the ion chromatography system per manufacturer's instructions and equivalent to the conditions used for initial calibration. Allow the instrument to warm up and establish a stable baseline. The system must be calibrated and free of contamination before samples are analyzed.

9.4.2 All samples must be analyzed at room temperature.

9.4.3 Inject a suitable volume of sample or QC standard into the IC instrument per manufacturer's instructions. The volume of sample injected must be consistent with the

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volume used for initial calibration standards. Record the resulting analyte peak areas as well as the peak retention times. A typical run sequence may be as follows:

Instrument Blank
ICAL Standards
ICV (If an ICAL is not analyzed, a CCV would replace the ICAL and ICV in the sequence)
ICB (CCB if no ICAL)
Method blank
LCS
Client samples
CCV
CCB
Client samples
CCV
CCB

9.4.4 If sample response exceeds the limits of the initial calibration range, dilute the sample with reagent water and reanalyze; otherwise, the over range result must be qualified as estimated.

10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Calculations

Sample concentrations are calculated by comparing response data with the initial calibration. The width of the retention time window used to identify analytes in samples should be based upon measurements of actual retention time variations of standards over the course of a day. Three times the standard deviation of a retention time can be used to calculate a suggested window for each analyte. The experience of the analyst should weigh heavily in the interpretation of chromatograms.

Refer to the Manual Integrations SOP for guidance on performing and documenting manual integrations.

10.1.1 Calculate the final concentration in the samples as follows:

Aqueous Sample (mg/L) = $(X_s)(D)$ Solid Sample (mg/kg) = $\frac{(X_s)(V_f)(D)}{(W_s)}$

Where: X_s = Concentration of the analyte in the sample from the curve in mg/L
D = Dilution factor of aqueous sample or solid extract (Final volume/Initial volume)
V_f = Final volume of solid extract in Liters
W_s = Weight of solid sample purged or extracted in kilograms

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10.1.2 LCS calculation:

$$R = (C / S) \times 100$$

Where: R = Percent Recovery
C = Observed LCS concentration
S = True LCS concentration

10.1.3 MS calculation:

$$R = \frac{(C_s - C)}{S} \times 100$$

Where: R = Percent Recovery
C_s = Observed MS concentration
C = Sample concentration
S = True spike concentration

10.1.4 RPD calculation:

$$RPD = \frac{|D_1 - D_2|}{[(D_1 + D_2)/2]} \times 100$$

Where: RPD = Relative Percent Difference
D_1 = First Sample Result
D_2 = Second Sample Result

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STANDARD OPERATING PROCEDURE
TITLE: ANIONS BY ION CHROMATOGRAPHY
METHOD: EPA 300.0, Revision 2.1 and SW-846 9056A
ISSUER: Pace ENV – Indianapolis – IND1

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11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Instrument Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration	Applicable target analytes	As needed	$r^2 \geq 0.995$ **RE:** mid-point 80-120%; low point 50-150% OR **RSE:** ≤20%	Analyze a new initial calibration curve. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed initial calibration must be reanalyzed.
Initial Calibration Verification Standard (ICV)	Second Source Standard	Immediately following initial calibration of the instrument	90-110% Recovery	Analyze another aliquot of the ICV. If the second ICV also exceeds the acceptance range, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICV must be reanalyzed. *Exception:* If the ICV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Initial Calibration Blank (ICB)	Reagent water	Immediately following each ICV	Target analytes must be less than reporting limit.	Reanalyze ICB. If target compound is still >RL in blank and associated samples, a new initial calibration must be analyzed. Instrument maintenance and/or preparation of new calibration standards should also be considered. Samples associated with a failed ICB must be reanalyzed. *Exceptions:* 1) If no additional sample remains for reanalysis, or if reanalysis cannot take place within holding time, the sample results must be qualified. 2) If a contaminant is present only in the blank and not the samples, no action is required.
Continuing Calibration Standard (CCV)	Applicable target analytes	Beginning of sequence, after every 10 samples, and at end of sequence	90-110% Recovery Retention time: ±10% from expected RT.	Check instrument operating conditions, and if necessary, restore them to the original settings. Analyze another aliquot of the CCV. If the response still fails the acceptance criteria, then a new initial calibration must be prepared and analyzed. Samples associated with a failed CCV must be reanalyzed. *Exception:* If the CCV is outside of the upper control limit, indicating high bias, associated samples determined to be <RL may be reported.
Continuing Calibration Blank (CCB)	Reagent water	Immediately following each CCV	Target analytes must be less than reporting limit.	Reanalyze CCB. If target compound is still >RL in blank and associated samples, a new initial calibration must be prepared and analyzed. Samples associated with a failed CCB must be reanalyzed. *Exceptions:* 1) If no additional sample remains for reanalysis, or if reanalysis cannot take place within holding time, the sample results must be qualified. 2) If a contaminant is present only in the blank and not the samples, no action is required.

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11.2 Batch Quality Control

QA Sample	Component	Frequency	Acceptance Criteria	Corrective Action
Method Blank (MB)	Reagent water	One per preparation batch of up to 20 samples, per matrix.	**300.0:** Target analytes should be less than the MDL. **9056A:** Target analytes should be <10% of the reporting limit or <10% of the lowest sample conc., whichever is greater.	Reanalyze blank. If method blank still does not meet criteria, reanalyze all associated samples. *Exceptions:* 1) If no additional sample remains for reanalysis or if reanalysis cannot take place within holding time, the reported method blank and samples must be qualified. 2) If a contaminant is present only in the method blank and not the samples, no action is required.
Laboratory Control Standard (LCS)	Applicable target analytes	One per preparation batch of up to 20 samples, per matrix.	**300.0:** 90-110% recovery **9056A:** 80-120% recovery	Reanalyze LCS. If LCS is still does not meet criteria, reanalyze all associated samples. *Exceptions:* 1) If no additional sample remains for re-analysis or if re-extraction/re-analysis cannot take place within holding time, reported data must be qualified. 2) If LCS recovery is >QC limits and sample results are non-detect, the sample data may be reported without qualifiers. The LCS data must be qualified.
Matrix Spike/Matrix Spike Duplicate (MS/MSD)	Applicable target analytes	**300.0:** One MS per a minimum of 10% of samples. **9056A:** One MS/MSD set per batch of up to 20 samples, per matrix.	80-120% Recovery ≤15% RPD	No corrective action necessary. If LCS recovery is in range, the system is considered in-control and the out-of-control MS/MSD must be qualified appropriately.
Sample Duplicate (DUP)	Sample	One sample duplicate per batch if an MSD was not performed.	≤15% RPD	No corrective action necessary. Qualify data as appropriate. *Exception:* Duplicate sample values <5x RL are not evaluated because values at or near the RL provide statistically insignificant RPD results.

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11.3 Method Performance

11.3.1 Method Validation

Refer to the SOP for Method Validation and Instrument Verification for the procedures used for initial method validation. Method Detection Limits (MDL) must be determined per the procedure in 40CFR Part 136, Appendix B.

11.4 Analyst Qualifications and Training

Employees that perform this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must document acceptable accuracy and precision by completing an initial demonstration of capability (DOC). Analysts must document on-going DOCs on an annual basis.

12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

The analyst must perform primary review of data and calculated results for accuracy. Secondary review of the data and calculated results must be performed by another qualified analyst, the department supervisor, or the Quality Manager prior to release for reporting. Refer to the SOP for Data Review Process for more information.

12.2 Corrective Action

Corrective action is expected any time QC is not within acceptance criteria, when sample results exceed the calibration range, and when carryover is suspected. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Refer to Section 11 for a complete summary of QC, acceptance criteria, and recommended corrective actions.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Procedures for handling waste generated during this analysis are addressed in Waste Handling and Management, or other applicable SOP. All wastes are accumulated, managed, and disposed of in accordance with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

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14.0 MODIFICATIONS

14.1 Method modified for the determination of Iodide.

14.2 Columns and chromatographic conditions may differ from those recommended and are based on instrument manufacturer's specifications.

14.3 Eluent is filtered through 0.45um filter disks instead of 0.2um filter disks.

14.4 Soil extraction procedure found in Method 300.0, revision 2.1, Section 11.7 is also used for Method 9056A. Shaker table or ultrasonic bath is used for agitation of soils instead of magnetic stir bars.

15.0 RESPONSIBILITIES

Pace employees that perform any part of this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP. If an employee is unable to follow the procedures in this SOP, they must consult with their supervisor for guidance.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and monitoring the implementation of this SOP in their work area.

16.0 ATTACHMENTS

Not applicable to this SOP.

17.0 REFERENCES

17.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Methods 9056A and 8000D.

17.2 Environmental Protection Agency, USEPA Method 300.0, Revision 2.1, August 1993.

17.3 Pace Analytical Quality Manual; latest revision.

17.4 NELAC/TNI Standards; Quality Systems section; 2003, 2009, and 2016.

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18.0 REVISION HISTORY

This Version:

Section	Description of Change
1.2	Clarified extracts of solid samples.
6.0	Removed option for preserved NO3+NO2.
8.2	Updated storage of all standards to manufacturer's recommendation.
9.2.3	Added ICAL point-dropping rules and relative error requirements.
11.1	Added relative error requirements
17.4	Added reference to 2016 TNI Standard.

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-IND1-0096	Anions by Ion Chromatography	02

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Document Information

Document Number: ENV-SOP-MIN4-0005 **Revision:** 05

Document Title: Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS EPA TO15/TO14

Department(s): Air

Date Information

Effective Date: 24 Sep 2020

Notes

Document Notes:

All Dates and Times are listed in: Central Time Zone

Signature Manifest

Document Number: ENV-SOP-MIN4-0005 **Revision:** 05

Title: Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS EPA TO15/TO14

All dates and times are in Central Time Zone.

ENV-SOP-MIN4-0005

QM Approval

Name/Signature	Title	Date	Meaning/Reason
Janielle Ward (007319)	Manager - Quality	24 Sep 2020, 09:56:51 AM	Approved

Management Approval

Name/Signature	Title	Date	Meaning/Reason
David Randall (008925)	Manager	23 Sep 2020, 10:37:13 AM	Approved
Krista Carlson (004514)	Project Manager 1	23 Sep 2020, 05:38:25 PM	Approved
Adam Haugerud (005828)	General Manager 2	24 Sep 2020, 11:33:29 AM	Approved

TEST METHOD STANDARD OPERATING PROCEDURE
TITLE: Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS
TEST METHOD EPA TO15/TO14
ISSUER: Pace ENV – Minneapolis – MIN4

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1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) describes the laboratory procedure for the determination of some of the volatile organic compounds (VOCs), or hazardous air pollutants (HAPs), found in Title III of the Clean Air Act of 1990 by analysis of whole air samples collected in electropolished steel canisters, silicon-ceramic coated canisters or sampling bags (or equivalent). This SOP is related to only those VOCs that have been found to be stable when collected in electropolished steel canisters, silicon-ceramic coated steel canisters or sampling bags (or equivalent). VOCs are defined as any organic compound having an initial boiling point less than or equal to 250˚C measured at 1 atm. Attachment I lists target VOCs applicable to this method.

This SOP is based on the EPA Compendium Method TO15 which can also be applied to TO14. As such, this SOP serves to cover both analyses. See EPA Compendium Method TO15 Section 3 and Attachment I for compound list.

For Ohio VAP, if requirements specific in this SOP are not able to be met, Pace Analytical will narrate any potential bias or justification for reporting in the project narrative on the final report. Additional narratives are provided as needed on a case by case basis in the event of the following occurrences: instrument failure, limited sample volume, report revisions or matrix interferences.

All references contained in this SOP with regards to spiking volumes, standard concentrations and instrument configuration are based on recommended parameters and may be subject to change based on instrument technology, target concentrations and application.

1.1 Target Analyte List and Limits of Quantitation (LOQ)

The target analytes and the normal LOQ that can be achieved with this procedure are provided in Table 1, Appendix A.

LOQ are established in accordance with Pace policy and SOPs for method validation and for the determination of detection limits (DL) and quantitation limits (LOQ). DL and LOQ are routinely verified and updated when needed. The current LOQ for each target analyte that can be determined by this SOP as of the effective date of this SOP is provided in Table 1, Appendix A.

The reporting limit (RL) is the value to which analytes are reported as detected or not detected in the final report. When the RL is less than the lower limit of quantitation (LLOQ), all detects and non-detects at the RL are qualitative. The LLOQ is the lowest point of the calibration curve used for each target analyte.

DL, LOQ, and RL are always adjusted to account for actual amounts used and for dilution.

2.0 SUMMARY OF METHOD

2.1 Samples are received in electropolished steel canisters, silicon-ceramic coated canisters. The gauge pressure upon arrival is measured and recorded. The canister is then pressurized to positive PSI gauge pressure using an inert gas. The canister is connected to an autosampler tree and preconcentrator system, which concentrates the sample prior to injection onto a GC/MS. The data is then analyzed for the desired VOCs.

2.2 This method addresses an extensive set of VOCs by incorporating a cold trap dehydration technique for water management.

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2.3 An aliquot of the whole air sample is concentrated prior to gas chromatographic (GC) separation and mass spectrometry (MS) full scan detection or select ion monitoring (SIM) detection. Samples expected to contain VOCs in a range of 0.005 parts per billion by volume (ppbv) to 500 ppbv can be analyzed by this technique.

2.4 If samples are received in sampling bags, see Section 6.0 for appropriate holding times and actions to transfer the samples to canisters to complete analysis as described in this SOP.

3.0 INTERFERENCES

3.1 Carrier gas potentially contains small amounts of contaminants and is filtered prior to use in instrumentation. Other interferences are sample specific and are dealt with as they occur.

3.2 Interferences in samples can result from contamination of canisters. To minimize this problem, processes must be implemented to ensure that the canisters are contamination free. See SOP ENV-SOP-MIN4-002 *Procedure for Cleaning, Certification, Leak Checking, and Preparation for Shipment of SUMMA Passivated Canisters* (current version or equivalent replacement).

3.3 Contamination of analytical equipment can also occur when samples containing high concentrations of VOCs are analyzed. The resulting "carryover" contamination varies from system to system. The analyst needs to use best judgement when evaluating sample data following samples with large detection levels.

4.0 DEFINITIONS

Refer to the Laboratory Quality Manual for a glossary of common lab terms and definitions.

Absolute Canister Pressure – Pg + Pa, where Pg = gauge pressure in the canister (kPa, psig) and Pa = barometric pressure.

Absolute Pressure – Pressure measured with reference to absolute zero as opposed to atmospheric pressure, usually expressed as kPa, mm Hq or psia.

Cryogen – A refrigerant used to obtain very low temperatures for sample concentration. A typical cryogen is liquid nitrogen (bp -195.8˚C).

Dynamic Calibration – Calibration of an analytical system using calibration gas standard concentrations in a form identical or very similar to the samples to be analyzed and by introducing such standards into the inlet of the sampling or analytical system in a manner very similar to the normal sampling or analytical process.

Gauge Pressure – Pressure measured above ambient atmospheric pressure as opposed to absolute pressure. Zero-gauge pressure is equal to ambient atmospheric (barometric)

MS-SCAN – The GC is coupled to a MS programmed in the SCAN mode to scan all ions repeatedly during the GC run. As used in the current context, this procedure serves as a qualitative identification and characterization of the sample.

MS-SIM – The GC is coupled to a MS that is programmed to scan a selected number of ions repeatedly.

Qualitative Accuracy – The ability of an analytical system to correctly identify compounds.

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Quantitative Accuracy – The ability of an analytical system to correctly measure the concentration of an identified compound.

5.0 HEALTH AND SAFETY

The toxicity or carcinogenicity of each chemical material used in the laboratory has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be as low as reasonably achievable.

The laboratory maintains documentation of hazard assessments and OSHA regulations regarding the safe handling of the chemicals specified in each method. Safety data sheets for all hazardous chemicals are available to all personnel. Employees must abide by the health, safety and environmental (HSE) policies and procedures specified in this SOP and in the Pace Chemical Hygiene / Safety Manual.

Personal protective equipment (PPE) such as safety glasses, gloves, and a laboratory coat must be worn in designated areas and while handling samples and chemical materials to protect against physical contact with samples that contain potentially hazardous chemicals and exposure to chemical materials used in the procedure.

Concentrated corrosives present additional hazards and are damaging to skin and mucus membranes. Use these acids in a fume hood whenever possible with additional PPE designed for handing these materials. If eye or skin contact occurs, flush with large volumes of water. When working with acids, always add acid to water to prevent violent reactions. Any processes that emit large volumes of solvents (evaporation/concentration processes) must be in a hood or apparatus that prevents employee exposure.

Contact your supervisor or local HSE coordinator with questions or concerns regarding safety protocol or safe handling procedures for this procedure.

6.0 SAMPLE COLLECTION, PRESERVATION, HOLDING TIME, AND STORAGE

Samples should be collected in accordance with a sampling plan and procedures appropriate to achieve the regulatory, scientific, and data quality objectives for the project.

The laboratory does not perform sample collection or field measurements for this test method. To assure sample collection and field checks and treatment are performed in accordance with applicable regulations Pace project managers will inform the client of these requirements at the time of request for analytical services when the request for testing is received prior to sample collection. If samples were already collected, the laboratory will record any nonconformance to these requirements in the laboratory's sample receipt record when sufficient information about sample collection is provided with the samples.

The laboratory will provide canisters or sampling bags for the collection of samples upon client request for analytical services. Canisters are prepared in accordance with laboratory SOP ENV-SOP-MIN4-0002 *Cleaning, Certification, Leak Checking, and Preparation for Shipment of SUMMA Passivated Canisters* (current version or equivalent replacement).

General Requirements

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Matrix	Routine Container	Preservation	Holding Time
Air	Sampling Canister	None	Samples collected in sampling canisters must be analyzed within 30 days of collection. Certain samples originating from the state of Minnesota require analysis within 14 days of collection. These samples are those to be reported to certain governing bodies as well as those under specific contract.
Air	Sampling Bag	None	If samples have been collected in bags, the samples need to be transferred to a sampling canister withing two days to maintain a 30 day holding time. The holding time for sampling bags is extended to 72 hours under certain client QAPPs. Collection in a bag may result in higher reporting limits. See Attachment VII for instructions and documentation for the transfer procedure. Ohio VAP samples must be transferred to a sampling canister within two days from collection to extend the holding time of collection to analysis to 30 days.

After receipt, samples are stored at ambient temperature prior to analysis.

After analysis, sample data is submitted for secondary review. Following secondary review, the canisters are returned to the cleaning process as outlined in SOP ENV-SOP-MIN4-0002 *Cleaning, Certification, Leak Checking, and Preparation for Shipment of SUMMA Passivated Canisters* (current version or equivalent replacement).

7.0 EQUIPMENT AND SUPPLIES

7.1 Equipment and Supplies Table

Supply	Description	Vendor/ Item # / Description
Gas Tight Syringes	0.010, 0.025, 0.05, 0.1, 0.25, 0.5, 1, 5, and 10 mL	Fisher, or equivalent
Oven	capable of maintaining a temperature of 65°C	Fisher, or equivalent
Summa ® passivated canisters or Silco® lined canisters (or equivalent)	6 L or 1 L capacity	Restek, Entech
Dual pressure/vacuum gauge	high accuracy	Omega Engineering, or equivalent
Nitrogen		Praxair
Organic free water	DI Water	n/a
Gas Chromatograph	Equipped with a split/splitless injection port and electronic pressure control (EPC) or equivalent. See 9.1.1 and 9.1.2 for operating parameters.	Agilent Technologies 6890N or equivalent
Mass Selective Detector	With Chemstation operating software and WinTarget data processing software or equivalent. See 9.1.3 for operating parameters.	Hewlett Packard 5973 or equivalent
Pre-concentrator	With 7016 canister manifold autosampler. See 9.1.4 for operating parameters.	Entech 7200 or equivalent
Dynamic Diluter	6 channel precision diluter	Entech 4600A or equivalent

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TEST METHOD STANDARD OPERATING PROCEDURE
TITLE: Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS
TEST METHOD EPA TO15/TO14
ISSUER: Pace ENV – Minneapolis – MIN4

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Supply	Description	Vendor/ Item # / Description
Capillary Column	DB-5 60 m x 0.32 mm capillary column or DB-624 60 m x 0.32 mm with a 1.0 μm film thickness or equivalent.	J & W Scientific, or equivalent
Helium Cylinder	High purity grade high-pressure helium cylinder for column carrier gas equipped with a dual stage pressure regulator.	Praxair, or equivalent
Chemstation, Masshunter	Data Acquisition Software	See master list for current version
Target	Data Processing Software	See master list for current version
EPIC Horizon	Data Reporting Software (LIMS)	See master list for current version
Gandalph	Data Packaging Software	See master list for current version

8.0 REAGENTS AND STANDARDS

8.1 Reagents and Standards

8.1.1 Target analyte standards are obtained from various vendors and verified for accuracy.

8.1.2 Calibration Standards is used for Initial Calibration (ICAL), Continuing Calibration (CCV) and Laboratory Control Sample (LCS). Second Source is used for initial calibration verification. Surrogate, Tuning and Internal Standard solutions are obtained from vendors in pressurized cylinders. Standards received in pressurized cylinders follow the manufacturer's expiration dates.

8.1.3 Reagent and Standard Table

Reagent/Standard	Concentration/ Description	Requirements/ Vendor/ Item #
Calibration Standard	This is a custom mix that includes all compounds of interest at 150-750ppbv. Concentrations are listed in nominal concentration. Actual certified concentrations may vary and are applied in calibration tables.	The calibration standard is purchased in the form of a pressurized cylinder from a source independent of the second source verification mix (Spectra Gas, Linde, Custom Gas Solutions, or equivalent).
Initial Calibration Verification (second source standard)	This is a custom mix that includes all compounds of interest at 150ppbv. Concentrations are listed in nominal concentration. Actual certified concentrations may vary and are applied in calibration tables.	The ICV is purchased in the form of a pressurized cylinder from a source independent of the calibration mix.
Internal Standard/ Surrogate/ BFB Standard	This is a custom mix that includes all internal standards, surrogate, and tuning standard at 10ppmv. Concentrations are listed in nominal concentration. Actual certified concentrations may vary and are applied in calibration tables.	The internal, surrogate, and BFB standards are purchased in the form of a pressurized cylinder (Restek or equivalent).

9.0 PROCEDURE

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9.1 Equipment Preparation

9.1.1 Instrument

9.1.1.1 Gas Chromatograph Suggested Operating Parameters

9.1.1.1.1 Initial Temperature: 40°C

9.1.1.1.2 Ramp A: 10°C/min to 150°C

9.1.1.1.3 Ramp B: 35°C/min to 240°C

9.1.1.1.4 Hold: 1 min

9.1.1.1.5 Post-run temperature: 40°C

9.1.1.1.6 Initial Column Flow: 1mL/min

9.1.1.1.7 Hold: 0.1 min

9.1.1.1.8 Ramp 0.5 mL/min/min

9.1.1.1.9 Final Column flow: 2mL/min

9.1.1.2 Inlet Parameters

9.1.1.2.1 Inlet Temperature: 125°C

9.1.1.2.2 Mode: Splitless

9.1.1.2.3 Septum Purge flow: 3 mL/min

9.1.1.2.4 Total flow: 54 mL/min

9.1.1.2.5 Purge flow to split vent: 50 mL/min at 0.5 min

9.1.1.3 Suggested Mass Spectrometer parameters

9.1.1.3.1 Electron Volts: 70 nominal

9.1.1.3.2 Scan Range: 35 to 300 amu

9.1.1.3.3 Scan time: At least 2 scans/peak, not to exceed 1 sec/scan

9.1.1.3.4 Interface temp: 280°C

9.1.1.3.5 The GC/MS system must be setup to meet manufacturer specification. The mass calibration and resolution of the GC/MS are verified by the analysis of a tune standard, p-bromofluorobenzene (BFB). For more information, refer to the Chemstation User's Guide and the GC/MS User's Guide.

9.1.1.4 Entech Pre-Concentrator suggested settings:

9.1.1.4.1 Suggested temperature settings (°C)

Zones	Pre-concentration steps							
	Trap temp	M1 Pre-heat	M1 to M2	M3 Precool	M2 Pre-heat	M2 to M3	Inject	Bakeout
Module 1	-40	10	10					150

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TEST METHOD STANDARD OPERATING PROCEDURE
TITLE: Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS
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Module 1 bulkhead	40		60					150
Module 2	-50		-50		-50	230		220
Module 2 bulkhead	40				60			150
Module 3				-180		-160	80	
Rotary Valve Plate	80							80

9.1.1.4.2 Volumes and flow rates

Volumes	
Trap Flush	75 cc
M1 to M2	60 cc

Flow Rates	
Internal Standard trapping	60 cc/min
Cal standard trapping	60 cc/min
Sample trapping	150 cc/min
Flush	100 cc/min
M1 to M2 transfer	15 cc/min

9.1.1.4.3 Event Times

M3 Focus	2.5 min
Inject	1 min
Bake	7 min
Post-injection Delay	14.5 min (set equal to RT of last VOC)
M3 bake (step 3)	3 min
M3 cool delay	0.3 min

9.1.1.4.4 Zone Temperatures

GC Transfer Line	100°C
Sample Transfer Line	80°C
16-Position Select Valve	80°C
Sample Container	Ambient

9.1.1.4.5 Suggested sample volumes

Internal standard	20 cc
Sample	10-1000 cc

9.2 Initial Calibration

9.2.1 Calibration Design

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9.2.1.1 Working Standard Dilutions and Concentrations – Syringe Method

9.2.1.1.1 All standards prepared into canisters in the air laboratory will be assigned a 30 day holding time. Upon expiration, the expired standard is removed from use and a new standard must be prepared.

Standard	Standard(s) Amount	Concentration of Std	Solvent	Solvent Volume	Final Total Volume	Final Concentration
30 ppbv Calibration Standard	9000cc*	150-750 ppbv+	Nitrogen	15 L Can	30 psig	30-150 ppbv
1 ppbv Calibration Standard	1500cc*	30 ppbv+	Nitrogen	15 L Can	30 psig	1-5 ppbv
Initial Calibration Verification Standard (ICV) (Second Source)	9000cc*	150 ppbv+	Nitrogen	15L Can	30 psig	30 ppbv
Internal Standards/Surrogate/BFB Standard	675cc*	10 ppmv+	Nitrogen	15L Can	30 psig	150 ppbv
Method Blank	value less than RL	N/A	Nitrogen	300cc	300 cc	less than RL
LCS	100cc	30 ppbv+	N/A	N/A	100cc	10 ppbv
ICV	100cc	30 ppbv+	N/A	N/A	100cc	10 ppbv

*Equivalent standards can be prepared into 6 L canisters by dividing these standard volume by 2.5
+Concentrations are listed in requested nominal concentrations. Actual concentrations may vary based on the certified concentration of the standard.

9.2.1.1.2 Calibration standard 30-150 ppbv: Using a 1000 cc gas tight syringe, pull 9 separate 1000 cc aliquots from TO15 Stock Standard Cylinder into a clean, evacuated 15 L canister that has been humidified with 50 µl H_2O. Pressurize the canister to 30 psig with clean nitrogen. This yields a final concentration of 30-150 ppbv. Record the standard ID, date created, analyst initial, canister number, canister volume, stock standard ID, volume used, water volume added, final pressure (psig), final concentration and expiration date in the Air Standards Prep Logbook.

9.2.1.1.3 Calibrations standard 1-5 ppbv: Using the 1000cc gas tight syringe, pull 750cc from the 30-150 ppbv Calibration Standard into a clean, evacuated 15L canister that has been humidified with 50 µL H_2O. A second pull of 750cc is pulled from the 30-150 ppbv Calibration Standard and transferred to the evacuated 15 L canister. Pressurize the canister to 30 psig with clean nitrogen. This yields a final concentration of 1-5 ppbv. Record the standard ID, date created, analyst initial, canister number, canister volume, stock standard ID, stock expiration date, volume used, syringe ID, water volume added, final pressure (psig), final concentration, and expiration date in the Air Standards Prep Logbook.

9.2.1.1.4 ICV 30 ppbv: Using the 1000 cc gas tight syringe, pull 9 separate 1000 cc aliquots from TO15 Second Source Stock Standard Cylinder into a clean, evacuated 15 L canister, that has been humidified with 50 µL H_2O. Pressurize the canister to 30 psig with clean nitrogen. This yields a final concentration of

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30 ppbv. Record the standard ID, date created, analyst initial, canister number, canister volume, stock standard ID, stock expiration date, volume used, syringe ID, water volume added, final pressure (psig), final concentration, and expiration date in the Air Standards Prep Logbook.

9.2.1.1.5 Internal Standard/Surrogate/BFB: Using the 1000 cc gas tight syringe, pull 675 cc from the 10 ppmv TO15 Internal Standard/Surrogate Stock Cylinder into a clean, evacuated 15 L canister, that has been humidified with 50 µL H_2O. Pressurize the canister to 30 psig with clean nitrogen. This yields a final concentration of 150 ppbv. Record the standard ID, date created, analyst initial, canister number, canister volume, stock standard ID, stock expiration date, volume used, syringe ID, water volume added, final pressure (psig), final concentration, and expiration date in the Air Standards Prep Logbook.

9.2.1.1.6 The tune standard, p-bromofluorobenzene, must be 50 ng of less on column.

9.2.1.1.6.1 The tune standard can be evaluated from the continuing calibration verification (CCV) standard so long as all criteria can be evaluated and met, since BFB is present in all injections.

9.2.1.1.7 Internal standard compounds and surrogate standard compounds are used in the analysis.

9.2.1.1.7.1 Internal standards: 1,4-Difluorobenzene and Chlorobenzene-d5

9.2.1.1.7.2 Surrogate: p-bromofluorobenzene (BFB)

Note(s): Surrogate standard is not a method requirement and therefore only reported at specific request of client. Surrogates are not evaluated for Ohio VAP samples.

9.2.1.2 Working Standard Dilutions and Concentrations – Dynamic Diluter method

9.2.1.2.1 The dynamic diluter is used to prepare a 30-150 ppbv calibration standard from the 150-170 ppbv TO15 stock standard. It can also be used to prepare a 30 ppbv ICV standard from the 150 ppbv second source stock standard.

9.2.1.2.1.1 The dynamic diluter mixes stock standards and nitrogen diluent at the desired ratio while humidifying the standard. The analyst stops the diluter program once the working standard canister has the desired final pressure.

9.2.1.2.2 Before and after the preparation of a standard, the dynamic diluter must be flushed clean with nitrogen. This is performed by turning on the source of nitrogen and ensuring the source of standard is disconnected or shut off. In this configuration, the dynamic diluter method can be run for 15 minutes, which allows for the mixing chamber and delivery line to be flushed clean.

9.2.1.2.3 Calibration Standard 30-150 ppbv or ICV 30 ppbv: Connect a clean, evacuated canister to the 'Calibration Gas Out' port. Click 'Go' on the 4600A control software and open the 'Isolation Valve' and the working standard canister valve. Example method parameters below. Once the working standard canister pressure reaches the desired value, click 'Stop' on the control software, and close the 'Isolation Valve' and the working standard canister

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valve. It is recommended that a standard is prepped to a minimum of 25 psia, to provide sufficient volume for analysis. Record the standard ID, date created, analyst initial, canister number, canister volume, stock standard ID, stock expiration date, stock standard flow rate, diluent flow rate, final pressure (psia), final concentration, and expiration date in the Air Standards Dynamic Diluter Prep Logbook.

Example parameters to perform a 5x dilution			
	Concentration	**Flow rates**	**Final concentration**
Nitrogen	Diluent	200 sccm	30-150 ppbv
Stock standard	150-750 ppbv	50 sccm	

9.2.1.2.4 Calibration Standard 1-5 ppbv: This standard can be prepared from the 30-150 ppbv working standard according to section 9.2.1.1.3.

9.2.2 Calibration Sequence

9.2.2.1 BFB Tune

9.2.2.2 Initial Calibration

9.2.2.3 Initial Calibration Verification

Ical Level	Concentration	Calibration Standard Used	Volume of Cal Standard Used
Level 1	0.100-0.500 ppbv	1-5 ppbv std	25 cc*
Level 2	0.200-1.00 ppbv	1-5 ppbv std	50 cc*
Level 3	0.500-2.50 ppbv	1-5 ppbv std	125 cc*
Level 4	1.00-5.00 ppbv	1-5 ppbv std	250 cc*
Level 5	10.0-50.0 ppbv	30-150 ppbv std	100 cc*
Level 6	20.0-100. ppbv	30-150 ppbv std	200 cc*
Level 7	30.0-150. ppbv	30-150 ppbv std	330 cc*
ICV	10 ppbv	30 ppbv std	100 cc*

*All volumes are based on a 300 cc nominal volume. These volumes may occasionally vary if certified concentrations of a standard exceed the target spike level. For example, the volume of the 0.1-0.5 ppbv calibration level may be injected at 20cc in order to ensure all compounds are at or below 0.1 ppbv.

9.2.3 ICAL Evaluation

9.2.3.1 BFB Tune

9.2.3.1.1 Before any standard, method blank, or sample analysis can occur using the GC/MS system, it must be demonstrated that the GC/MS is capable of producing compliant spectra when p-bromofluorobenzene (BFB) is analyzed. Attachment II lists the required spectral criteria.

9.2.3.1.2 The instrument performance check must be analyzed initially and once every 24-hour period. The tune period begins at the time of injection of the BFB.+

9.2.3.1.3 The GC/MS is set up according to the manufacturer's specifications. The MS

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source and mass filter are adjusted by monitoring the mass spectra of Perfluorotributylamine (PFTBA).

9.2.3.1.4 Prepare a standard solution of BFB at a concentration that allows the collection of 50 ng or less under the optimized concentration parameters. This is met by injecting 20 cc during the trapping. The BFB is introduced into the system through microscale purge and trap.

9.2.3.1.5 The spectrum of BFB must be acquired by averaging three scans; the apex and the scans that immediately proceed and follow the apex.

9.2.3.1.6 Background subtraction is accomplished using a single scan taken before the BFB peak.

9.2.3.2 Initial Calibration is performed as a result of extensive instrument maintenance, CCV outliers for analytes of interest, Internal Standard Non Compliance, and at the discretion of the analyst.

9.2.3.2.1 All standards, method blanks, laboratory control spikes (LCS), and samples must be analyzed using the same conditions. A calibration curve must consist of a minimum of 5 standards (6 for quadratic) and spans the expected monitoring range established for each compound of interest to determine instrument response and linearity. The lowest level of the curve must be at or below the reporting limit for each analyte. A typical calibration curve can cover a range from 0.1 to 30 ppbv.

9.2.3.2.2 Calibration points may be dropped on the lower or upper end so long as the criteria listed above is met. If lower calibration points are dropped, the reporting limit of the compound must be raised to the lowest remaining calibration point if it exceeds the current compound reporting limit. If upper calibration points are dropped, samples must be interpreted with the new upper calibration point representing the new upper range for the compound. At no point is it acceptable to drop a mid-point calibration from an initial calibration.

9.2.3.3 Curve Fit

9.2.3.3.1 The %RSD for all calibrated target compounds must be ±30%. Alternately for all target compounds, linear regression is used with an r^2 value of 0.995 or greater. A quadratic curve is utilized if the r^2 (equals COD in Equation 12) value is 0.990 or greater and six calibration points are included in the curve. Curves must not be forced through zero. For Ohio VAP: quadratic curve fit is only to be used for analytes that have historically exhibited nonlinear response.

9.2.3.3.2 The area response for each internal standard in each calibration level must be within 40% of the area response of the mid-point of the initial calibration. The relative retention time (RRT) of each compound must agree within ±0.06 RRT units of the RRT from the mid-point of the initial calibration curve.

9.2.3.4 Curve Refitting

9.2.3.4.1 Every ICAL at the low standard and the mid-point.

9.2.3.4.1.1 The level corresponding to the reporting limit must be quantitated back after processing the curve and be ± 40% of the expected true value.

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9.2.3.4.1.2 The level corresponding to the midpoint must be quantitated back after processing the curve and be ± 30% of the expected true value.

9.2.3.5 Initial Calibration Verification

9.2.3.5.1 A second source standard must be analyzed following an initial calibration curve which contains all the analytes of interest.

9.2.3.5.2 The spike level of the ICV must be near the midpoint level of the calibration curve. The ICV is considered acceptable if the recoveries of the analytes fall within 60-140%.

9.2.3.5.3 Corrective Action for Initial Calibration Verification

9.2.3.5.3.1 If ICV fails criteria, the analyst must consult with his or her supervisor or manager before moving forward. Possible corrective actions include:

9.2.3.5.3.1.1 The system and standards must be evaluated for potential problems. If a problem is isolated and corrected, attempt to run a second ICV. If the second attempt also does not meet criteria, perform further necessary troubleshooting and maintenance.

9.2.3.5.3.1.2 Check pressure on the standard canister.

9.2.3.5.3.1.3 Check system for leaks.

9.2.3.5.3.1.4 Check to see that standards were made correctly.

9.2.3.5.3.2 If the ICV was injected during a period in which it could not be evaluated immediately and was followed by a SDG, data impact is evaluated and reported with necessary footnotes pending supervisor or manager approval.

9.2.3.5.3.3 If the technical acceptance criteria fail for the initial calibration curve, inspect the system for any possible leaks. A high baseline and reduced response potentially indicates a leak.

9.2.3.5.3.4 Examine the response factors of each calibration level. If the response factors of all the compounds for one level appear to be significantly different, analyze that same level calibration standard again

9.2.3.5.3.5 If the same results occur after reanalysis, a new standard canister must be made and analyzed.

9.2.3.5.3.6 If a leak or other system problem cannot be found, try to clean the ion source or perform column maintenance.

9.2.3.5.3.7 Samples to be injected for analysis following the initial calibration should not be scheduled, where possible, until an acceptable initial calibration and ICV have been analyzed. In the event the calibration curve or ICV cannot be evaluated prior to sample scheduling, such as the case with the initial calibration being injected after normal hours of operation, the initial calibration and ICV must be reviewed for failures prior to data workup of scheduled samples. In the event of failures in the initial calibration or ICV, client samples are reviewed for potential impact and reanalyzed or reported with adequate technical justification. Technical justification would

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be if there are samples available that require only a short list of analytes that exclude the failures, analysis may continue for those analytes or if a high bias is identified and the samples are non-detect for target analytes. Clearly document which elements are not acceptable on the analytical checklist for secondary review by a data validator. For samples being evaluated under the Ohio VAP program, all compounds must meet specifications. Those samples not meeting these criteria must be reanalyzed under compliant conditions.

9.2.3.5.3.8 Recalibration must be performed if any major change has been made to the GC/MS system such as replacing the GC column, cleaning the MS source or repair.

9.2.3.6 Continuing Calibration Verification

9.2.3.6.1 After an acceptable tune has been evaluated, the initial calibration curve for each compound of interest must be checked and verified before sample analysis can occur each day. This is accomplished by analyzing continuing calibration verification (CCV) standard at 10-50 ppbv (see section 10.3 Ical Level 5). The CCV is the same source as the ICAL standard.

9.2.3.6.2 The CCV is analyzed after a compliant tune once every 24-hour period during sample analysis unless an initial calibration is analyzed. If there is an initial calibration performed, it will take the place of the CCV and no CCV will be analyzed until after the next tune period.

9.2.3.6.2.1 The %D for each target compound in the continuing calibration verification (CCV) standard must be less than or equal to 30 percent.

9.2.3.6.2.2 The RRT of each compound must agree within ± 0.06 RRT units of the average RRT from the initial calibration curve.

9.2.3.6.1 Corrective action for Continuing Calibration Verification

9.2.3.6.1.1 If the CCV does not meet criteria, the system and standards mist be evaluated for potential problems. If a problem is isolated and corrected, attempt to run a second CCV.

9.2.3.6.1.1.1 Check pressure of the standard canister

9.2.3.6.1.1.2 Check systems for leaks.

9.2.3.6.1.1.3 Check to see that standards were made correctly.

9.2.3.6.1.1.4 Document all maintenance and corrective action measures taken in the maintenance logbook, run logbook or checklist accordingly based on the actions taken.

9.2.3.6.1.2 If, following correction action attempts, the second CCV does not meet criteria, then a new calibration curve must be analyzed.

9.2.3.6.1.3 Samples are not to be scheduled for analysis until CCV criteria has been met or technical justification has been given for the analysis to continue. Technical justification includes the scheduling of samples that meet CCV criteria for a shorter list of volatile compounds. If analytes fail high in a

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CCV, then supervisor approval may be given for analysis of samples that require these analytes.

9.2.3.6.1.4 In the event the CCV cannot be evaluated prior to the scheduling of samples for analysis, as in the case where the CCV is scheduled for injection after standard business hours, the subsequently scheduled samples will be evaluated for impact based on the results for the associated CCV, and either reanalyzed or narrated to indicate impact if reanalysis is not possible. For samples being evaluated under the Ohio VAP program, all compounds must meet specifications. Those samples not meeting these criteria must be reanalyzed under compliant conditions.

9.2.3.6.1.5 Additional calibration procedures (where applicable) can be found in ENV-POL-CORQ-0005 *Acceptable Calibration Practices for Instrument Testing* (current version or equivalent replacement).

9.3 Analysis

9.3.1 Example Analytical Sequence

9.3.1.1 The following is the GC/MS analytical sequence for samples each 24-hour period:

9.3.1.1.1 BFB Instrument tune, which serves to ensure the instrument is in proper running order, must be performed prior to, or in conjunction with the first quality control sample on each run day.

9.3.1.1.2 CCV, which also serves as the Laboratory Control Sample for the batch of twenty samples. Two CCVs are permitted to be analyzed on each system before an Initial Calibration is needed.

9.3.1.1.2.1 In the event the CCV is not compliant for analytes of interest in the samples, and Initial Calibration is required before sample analysis. An ICAL is followed then by the ICV. The ICV may be used as the Laboratory Control Standard or LCS.

9.3.1.1.3 Laboratory Method Blank: 300 cc or greater of nitrogen from a clean 6 L canister.

9.3.1.1.3.1 A clean canister filled with humidified nitrogen is analyzed on the GC/MS system to demonstrate that the system is free of interferences.

9.3.1.1.3.2 The Method Blank is prepared in the same manner as any standard or sample and analyzed in the same manner.

9.3.1.1.4 20 field samples

9.3.1.1.5 Sample duplicate, minimum of one in 20 samples

9.3.1.1.6 Any necessary dilutions from previously analyzed samples (see the dilution preparation section of ENV-FRM-MIN4-0005 *Canister Dilution Factor Benchsheet* (current version or equivalent replacement).

9.3.1.1.7 In the event that time remains in the 24-hour tune period, an additional method blank and LCS must be analyzed in order to analyze additional reportable samples.

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9.3.1.2 Additional calibration procedures (where applicable) can be found in ENV-POL-CORQ-0005 *Acceptable Calibration Practices for Instrument Testing* (current version or equivalent replacement).

9.3.2 Sample Analysis

9.3.2.1 Upon receipt, the canister pressure of each sample is measured and recorded on the canister sample tag.

9.3.2.1.1 If the canister pressure is less than 5 psig, the canister pressure must be increased before analysis can occur.

9.3.2.1.1.1 Add clean nitrogen or helium gas to the sample canister. For a six-liter canister, 5 psig is the desired final pressure. A one-liter canister requires a final pressure of 10 psig for adequate sample volume for analysis.

9.3.2.1.1.2 Record the final canister pressure on the canister sample tag noting which gas was added. Also, note the information in the final analytical results report.

9.3.2.1.1.3 Calculate the resultant dilution factor using Equation 12 in section 10.3.13.

9.3.2.1.1.4 This dilution factor is applied to Equation 13 in section 10.3.14.

9.3.2.1.2 Once the GC/MS system is demonstrated to be in control, an aliquot of the air sample is removed from the canister and pre-concentrated using the Entech 7200 pre-concentrator and 7016 autosampler manifold.

9.3.2.1.3 Analyze the samples under the same operating conditions as the instrument calibration and quality control samples.

9.3.2.1.4 Analyze a duplicate sample for every 20 samples analyzed.

9.3.2.1.5 If time remains in the 24-hour tune period in which an initial calibration was performed, it is possible to continue to analyze samples without the analysis of a CCV standard.

9.3.2.1.6 If the tune period has expired, an instrument tune, CCV standard, and method blank must be analyzed before samples can be analyzed.

9.3.2.1.7 If time remains in the tune period after a batch of no more than 20 samples and its re-runs have been analyzed, it is possible to analyze additional samples after a new LCS and method blank have been analyzed.

9.3.2.2 Procedures for the determination of Air Phase Petroleum Hydrocarbons (APH) can be found on Attachment IX. Reporting of APH can only be conducted per each state or client acceptance of the data (ex: Ohio VAP only allows the analysis of the TO15 analytes listed in Table 1 of EPA Compendium Method TO15 and as specified the Pace scope of accreditation). See the most current certificates for the approved analyte lists, any analytes not approved must be clearly indicated on the report and affidavits as being compounds not certified by the VAP program.

10.0 DATA ANALYSIS AND CALCULATIONS

10.1 Qualitative Identification

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10.1.1 The compounds listed in Attachment I are identified by an analyst competent in the interpretation of mass spectra. Sample mass spectrum is compared to the mass spectrum of a standard of the suspected compound. Two criteria must be satisfied to verify the target compound identifications: (1) elution of the sample component at the same GC retention time as the standard component, and (2) correspondence of the sample component and standard component mass spectra.

10.1.1.1 The relative retention time (RRT) of the sample component must agree within ± 0.06 RRT units of the RRT of the standard component using the CCV standard as reference.

10.1.1.2 Standard and sample mass spectra are compared using reference spectra obtained on the GC/MS system being used. The mass spectra used for comparison are from the same standard as that being used for RRT comparison. Mass spectral requirements are as follows:

10.1.1.2.1 All ions present in the standard mass spectra at a relative intensity greater than 10% (most abundant ion in the spectrum equals 100%) must be present in the sample spectrum.

10.1.1.2.2 The relative intensities of ions specified above must agree within ± 20% between the standard and sample spectra.

10.1.1.2.3 Ions greater than 10% in the sample spectrum but not present in the standard spectrum must be considered and accounted for by the analyst making the comparison. The verification process favors false positive.

10.1.2 Tentatively Identified Compounds (TICS)

10.1.2.1 Non-target sample components are library searched using the latest NIST library for the purpose of tentative identification. These components are referred to as TICs - Tentatively Identified Compounds) and are noted as such in any final report with a qualifier of "J" unless the client specifies differently. The "J" qualifier indicates an estimated value. Guidelines for identification are as follows:

10.1.2.1.1 Characteristic ions in the reference spectrum (ions greater than 10% of the most abundant ion) must be present in the sample.

10.1.2.1.2 The relative intensities of the major ions must agree within ± 20%.

10.1.2.1.3 Ions present in the sample spectrum but not in the reference spectrum must be reviewed for background contamination or presence of co-eluting peaks.

10.1.2.1.4 If in the technical judgment of the analyst, no valid identification can be made, the compound is to be reported as an unknown with possible classification, such as hydrocarbon.

10.1.2.1.5 Estimated concentration of a tentatively identified compound must exceed 5 ppbv.

10.1.2.1.6 TIC searches are reported only upon client request. These results are considered estimated and do not fall under any scope of accreditation held by Pace.

10.1.3 Manual Integration

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10.1.3.1 Manual changes to automated integration is called manual integration. Manual integration is sometimes necessary to correct inaccurate automated integrations but must never be used to meet QC criteria or to substitute for proper instrument maintenance and/or method set-up. To assure that all manual integrations are performed consistently and are ethically justified, all manual integrations must be performed, reviewed, and recorded in accordance with corporate SOP ENV-SOP-CORQ-0006, *Manual Integration.*

10.2 Quantitative Identification

10.2.1 Identified target analytes are quantitated using the internal standard method using the extracted ion current profile (EICP) area of the characteristic ions of analytes listed in Attachment II. This ion is referred to as the quantitation ion.

10.2.2 The RRF from the initial calibration curve analysis is used to quantitate samples and method blanks. Calculate the concentration of the sample component using Equation 13 in section 10.3.14.

10.2.2.1 Additional curve fit equations are in section 14.

10.2.3 The internal standard method of quantitation is also used to determine an estimated concentration for Tentatively Identified Compounds (TIC). The nearest internal standard to the TIC is used as a reference to estimate the concentration of the TIC. If the nearest internal standard exhibits interferences, the next closest internal is used. The estimated concentration is obtained using Equation 13 with the following exceptions:

Ax	=	Total ion chromatogram area of the TIC
Ai	=	Total ion chromatogram area of the specific internal standard
Rf	=	1.0

Estimated TIC concentrations are flagged with a qualifier of "J" which indicates that the quantitated amount is an estimate. TICs are not considered certified analytes under any scope of accreditation. If TICs are reported, they must be clearly indicated as not being certified analytes under the program that the work is related to.

10.2.4 General Technical Acceptance Criteria

10.2.4.1 For data to be reported without qualification, the following criteria must be met for all samples, CCVs, method blanks, and laboratory control sample (LCS).

10.2.4.1.1 The EICP area response for each internal standard must be within ± 40% of the EICP area response in the midpoint of the most recent Initial Calibration. See Attachment I for a list of analytes and assigned internal standards.

10.2.4.1.2 The retention time for each of the internal standards must be ± 0.33 minutes of each of the internal standard (IS) retention times in the most recent ICAL 10.0 Standard.

10.2.4.1.3 Recoveries for surrogate standard compounds (where required) must fall within ± 30% of the true value.

10.2.4.2 If the technical acceptance criteria are not met, samples must be reanalyzed with

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appropriate batch QC to confirm results under compliant operating conditions. This confirmation is performed by reanalyzing the corresponding QC that was out of range with the samples and if found to be not in range, narrative for bias will be noted, as applicable. See Section 11.2 and 11.3 for corrective action for calibration failures and Section 13.1 for all other samples (including QC). If, in the determination of the analyst, reanalysis of a sample could negatively impact results, possibly due to a need to pressurize a canister, data may be qualified and reported with the approval of a supervisor or manager. All reports with nonconformance to the technical criteria must be fully narrated to the client. For work performed under the Ohio VAP program, narration of nonconformance must include an indication of bias in the data.

10.2.4.3 There will be times in which analytical results are obtained outside the linear range due to highly contaminated sites. Pace makes every attempt to dilute the samples within the linear range of the instrument. If sufficient dilutions cannot be made to achieve results within the linear range because of sample size or concentration, the data will be reported qualified as estimated. If the bias can be noted, it will be qualified accordingly in the final report, i.e. biased high or biased low.

10.3 Calculations

10.3.1 See the laboratory SOP ENV-SOP-MIN4-0171 *Laboratory Calculations*, or equivalent replacement, for equations for common calculations.

10.3.2 Relative Response Factor (RRF). Tabulate the area response of the primary ion (Attachment I) for each compound and the associated internal standard. Use the internal standard, which has a retention time nearest to the compound of interest. Calculate the relative response factors (RRF) for each compound using Equation 1:

Equation 1

$$Relative\ Response\ Factor\ (RRF) = \frac{(A_x)(C_i)}{(A_i)(C_x)}$$

Where: A_x = Area of the primary ion for compound *x* to be measured
A_i = Area of the primary ion for the internal standard associated with compound *x*
C_i = Concentration of the internal standard in ppbv
C_y = Concentration of compound *x* to be measured in ppbv

10.3.3 Mean Relative Response Factor. Calculate the mean RRF for each compound using the RRF from the five (or six, where n=6)-point calibration using Equation 2:

Equation 2

$$\overline{R_f} = \frac{\sum_{n=5} R_f}{n}$$

Where: $\overline{R_f}$ = Average relative response factor

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R_f = Relative response factor from calibration curve
N = Number of data points

10.3.4 Standard Deviation ($\sigma_{(n-1)}$).

Equation 3

$$\sigma_{(n-1)} = \sqrt{\sum_{i-1}^{n} \frac{(x_i - \bar{x})^2}{(n-1)}}$$

10.3.5 %Relative Standard Deviation (%RSD). Using the average RRF from Equation 6 and the standard deviation from Equation 7, calculate the %RSD using Equation 4:

Equation 4

$$\%RSD = \frac{s_{(n-1)}}{\bar{R}_f} \times 100$$

10.3.6 Mean area response for Internal Standard:

Equation 5

$$\bar{y} = \sum_{i=1}^{n} \frac{y_i}{n}$$

Where: $\bar{y}$ = Mean area response
y = Area response for the internal standard for each initial calibration standard

10.3.7 If a linear regression is used, the regression produces the slope and intercept terms for a linear equation according to Equation 6:

Equation 6

$$y = ax + b$$

Where: y = instrument response (peak area or height)
a = Slope of the line (also called the coefficient of x)
X = Concentration of the calibration standard
b = The intercept, do not include the origin (0) as a calibration point

10.3.8 To calculate the sample concentration by the internal standard method using the linear regression equation, use Equation 7:

Equation 7

$$C_s = \frac{\left(\frac{A_s \times C_{is}}{A_{is}}\right) - b}{a}$$

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Where: A_s = Area of the peak for the target analyte in the sample
A_{is} = Area of the peak of the internal standard
C_s = Concentration of the target analyte in the calibration standard
C_{is} = Concentration of the internal standard
a = Slope of the line (also called the coefficient of C_s)
b = The intercept

10.3.9 To calculate the coefficient of determination (or r2) for a quadratic curve fit, use Equation 8:

Equation 8

$$COD = \frac{\sum_{i=1}^{n}(y_{obs} - \bar{y})^2 - \left(\frac{n-1}{n-p}\right)\sum_{i=1}^{n}(y_{obs} - Y_i)^2}{\sum_{i=1}^{n}(y_{obs} - \bar{y})^2}$$

Where: Y_{obs} = Observed response for each concentration from each initial calibration standard
y = Mean observed response from the initial calibration (See equation 6)
Y_i = Calculated response at each concentration from the initial calibration (See Equation 5)
n = Total number of calibration points in the equation, 6 points for quadratic
p = Number of adjustable parameters in the polynomial equation

10.3.10 Regression equation (quadratic). Calculate the sample concentration by the internal standard method using the quadratic regression by comparing peak heights to the calibration curve.

Equation 9

$$y = ax^2 + bx + c$$

10.3.11 Percent Difference (%D). The %D in the RRF of the daily RRF of an individual compound compared to the mean RRF for that compound in the most recent calibration curve is determined as follows:

Equation 10

$$\%D = \frac{|R_i - R_c|}{R_i} \times 100$$

Where: R_i = The average RRF from the initial calibration curve for compound *x*
R_c = for compound *x* from the CCV standard.

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10.3.12 Calculate the percent recovery of the LCS using Equation 11:

Equation 11

$$Percent\ Recovery = \frac{C_q}{C_a} \times 100$$

Where: C_q = Quantitated concentration of compound *x* in ppbv
C_a = Actual concentration of compound *x* in ppbv

10.3.13 Calculate the resultant dilution factor using Equation 12:

Equation 12

$$DF = \frac{P_f + 14.7}{P_i + 14.7}$$

Where: P_i = Pressure reading of canister prior to pressurization (psig)
P_f = Pressure reading of canister after pressurization (psig)
DF = Dilution factor

To convert Hg to psig:

Multiply by 0.491559 or divide by 2.036

PSIG reading is converted to One Atmosphere:

One Atmosphere = 14.7 psig = 29.21 inches of Hg

See ENV-FRM-MIN4-0005 *Canister Dilution Factor Benchsheet* (current version or equivalent replacement) for the application of dilution factors for filling canisters.

10.3.14 Calculate the concentration of the sample component using Equation 13:

Equation 13

$$C_x = \frac{(A_x)(C_i)(D_f)}{(A_i)(R_f)}$$

Where: C_x = Concentration of compound *x* in ppbv
A_x = EICP area of the quantitation ion for compound *x*
C_i = Concentration of the internal standard associated with compound *x* in ppbv
D_f = Dilution factor from Equation 12 (if no dilution was performed, D_f equals 1)
A_i = EICP area of the quantitation ion for the internal standard associated with compound *x*
R_f = Average RRF for compound *x* from the most recent calibration curve

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10.3.15 The RPD between the sample and the sample duplicate can be calculated using Equation 14:

Equation 14

$$RPD = \frac{|A - B|}{(A + B)/2} \times 100$$

Where: *A* = Sample value
B = Duplicate value

10.3.16 Convert ppbv to µg/m^3 using Equation 15:

Equation 15

$$\frac{(x\ ppbv \times MW\ \frac{g}{mol})}{24.055\ \frac{L}{mol}} = y\ \frac{\mu g}{m^3}$$

Where: *MW* = Molecular weight

24.055 L/mol = Molar Volume of an ideal Gas

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

Where: *V* = Volume in liters
N = Mols of ideal gas (1 mol)
R = Ideal gas constant
T = Temperature in Kelvin

$$V = \frac{(1mol) \times (0.082\ \frac{(L \times atm)}{(mol \times K)} \times 293.15K}{1\ atm}$$

$$V = 24.055 \frac{L}{mol}$$

10.3.17 Preparation of Working TO15 Standard can be calculated using equation 16:

Equation 16

$$\frac{X}{Y} \times C = Z$$

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Where: X = Volume (L) spiked from stock
Y = Volume (L) of container
C = Concentration (ppbv) of Stock
Z = Concentration (ppbv) of working standard

11.0 QUALITY CONTROL AND METHOD PERFORMANCE

11.1 Quality Control

The following QC samples are prepared and analyzed with each batch of samples. Refer to Appendix B for acceptance criteria and required corrective action.

QC Item	Frequency
Method Blank (MB)	1 per batch of 20 or fewer samples.
Laboratory Control Sample (LCS)	1 per batch of 20 or fewer samples.
Sample Duplicate	1 per batch of 20 or fewer samples. 1 per 10 required for specific QAPPs or clients.
Surrogate	NA unless specifically requested by client
Internal Standard	Internal standard is added to every injection at a concentration of 10ppbv.

11.2 Instrument QC

The following Instrument QC checks are performed. Refer to Appendix B for acceptance criteria and required corrective action.

QC Item	Frequency
Tune	Prior to, or in conjunction with the first QC injection of each analysis day.
Initial Calibration	Result of extensive instrument maintenance, CCV outliers for analytes of interest, Internal Standard Non Compliance, and at the discretion of the analyst.
Initial Calibration Verification	Following the initial calibration and prior to blank and sample analysis.
Continuing Calibration Verification	Following a BFB tune and prior to a method blank when a compliant initial calibration has been established.
Method Blank	Following a compliant initial calibration or continuing calibration and prior to sample analysis.

11.3 Method Performance

11.3.1 Method Validation

11.3.1.1 Detection Limits

Detection limits (DL) and limits of quantitation (LOQ) are established at initial method setup and verified on an on-going basis thereafter. Refer to Pace ENV corporate SOP ENV-SOP-CORQ-0011 *Method Validation and Instrument Verification* and to the laboratory's SOP ENV-SOP-NW-0018 *Determination of LOD and LOQ* (current version or equivalent replacement) for these procedures.

11.4 Analyst Qualifications and Training

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Employees that perform any step of this procedure must have a completed Read and Acknowledgment Statement for this version of the SOP in their training record. In addition, prior to unsupervised (independent) work on any client sample, analysts that prepare or analyze samples must have successful initial demonstration of capability (IDOC) and must successfully demonstrate on-going proficiency on an annual basis. Successful means the initial and on-going DOC met criteria, documentation of the DOC is complete, and the DOC record is in the employee's training file. Refer to laboratory SOP ENV-SOP-NW-0025 *Orientation and Training Procedures* (current version or equivalent replacement) for more information.

12.0 DATA REVIEW AND CORRECTIVE ACTION

12.1 Data Review

Pace's data review process includes a series of checks performed at different stages of the analytical process by different people to ensure that SOPs were followed, the analytical record is complete and properly documented, proper corrective actions were taken for QC failure and other nonconformance(s), and that test results are reported with proper qualification.

The review steps and checks that occur as employee's complete tasks and review their own work is called primary review.

All data and results are also reviewed by an experienced peer or supervisor. Secondary review is performed to verify SOPs were followed, that calibration, instrument performance, and QC criteria were met and/or proper corrective actions were taken, qualitative ID and quantitative measurement is accurate, all manual integrations are justified and documented in accordance with the Pace ENV's SOP for manual integration, calculations are correct, the analytical record is complete and traceable, and that results are properly qualified.

A third-level review, called a completeness check, is performed by reporting or project management staff to verify the data report is not missing information and project specifications were met.

Refer to laboratory SOP ENV-SOP-MIN4-0092 *Data Review Process* (current version or equivalent replacement) for specific instructions and requirements for each step of the data review process.

12.2 Corrective Action

Corrective action is expected any time QC or sample results are not within acceptance criteria. If corrective action is not taken or was not successful, the decision/outcome must be documented in the analytical record. The primary analyst has primary responsibility for taking corrective action when QA/QC criteria are not met. Secondary data reviewers must verify that appropriate action was taken and/or that results reported with QC failure are properly qualified.

Corrective action is also required when carryover is suspected and when results are over range.

Samples analyzed after a high concentration sample must be checked for carryover and reanalyzed if carryover is suspected. Carryover is usually indicated by low concentration detects of the analyte in successive samples analyzed after the high concentration sample.

Sample results at concentrations above the upper limit of quantitation must be diluted and

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reanalyzed. The result in the diluted samples should be within the upper half of the calibration range. Results less than the mid-range of the calibration indicate the sample was over diluted and analysis should be repeated with a lower level of dilution. If dilution is not performed, any result reported above the upper range is considered a qualitative measurement and must be qualified as an estimated value.

Refer to Appendix B for a complete summary of QC, acceptance criteria, and recommended corrective actions for QC associated with this test method.

13.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Pace proactively seeks ways to minimize waste generated during our work processes. Some examples of pollution prevention include but are not limited to: reduced solvent extraction, solvent capture, use of reusable cycletainers for solvent management, and real-time purchasing.

The EPA requires that laboratory waste management practice to be conducted consistent with all applicable federal and state laws and regulations. Excess reagents, samples and method process wastes must be characterized and disposed of in an acceptable manner in accordance with Pace's Chemical Hygiene Plan / Safety Manual.

14.0 MODIFICATIONS

A modification is a change to a reference test method made by the laboratory. For example, changes in stoichiometry, technology, quantitation ions, reagent or solvent volumes, reducing digestion or extraction times, instrument runtimes, etc. are all examples of modifications. Refer to Pace ENV corporate SOP ENV-SOP-CORQ-0011 *Method Validation and Instrument Verification* for the conditions under which the procedures in test method SOPs may be modified and for the procedure and document requirements.

14.1 Pace utilizes 1,4-Difluorobenzene and Chlorobenzene-d5 as internal standards. This is a modification from the three recommended internal standards in the method. Pace has demonstrated with MDLs, ICAL/ICV and PTs that this does not impact the data results.

14.2 Pace utilizes clean nitrogen for cleaning and filling canisters used for samples and standards. This is a modification from the method use of zero air.

14.3 Pace initial calibrations are accepted with average response models, as well as linear and quadratic regression models. Pace utilizes percent drift when analyzing continuing calibrations with regression models. Acceptance criteria utilized is the same as percent difference (± 30% of the midpoint of the most recent ICAL). This process has been adapted from EPA method 8260B. Refer to section 25.8.

15.0 RESPONSIBILITIES

Pace ENV employees that perform any part this procedure in their work activities must have a signed Read and Acknowledgement Statement in their training file for this version of the SOP. The employee is responsible for following the procedures in this SOP and handling temporary departures from this SOP in accordance with Pace's policy for temporary departure.

Pace supervisors/managers are responsible for training employees on the procedures in this SOP and

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monitoring the implementation of this SOP in their work area.

16.0 ATTACHMENTS

Appendix A – Target Analyte List and Routine LOQ

Appendix B – QC Summary

ATTACHMENT I: Target Compound List and Characteristic Ions

ATTACHMENT II: Required BFB Key Ions and Ion Abundance Criteria

ATTACHMENT III: Calibration of THC as Gas

ATTACHMENT IV: Performing Dilutions on Air Canisters

ATTACHMENT V: Air Laboratory Standard Preparation Procedures – Syringe Method

ATTACHMENT VI: Procedures for Analyzing MPCA Samples

ATTACHMENT VII: Procedure for Transfer of Tedlar Bags to SUMMA Canisters

ATTACHMENT VIII: Common Logbook Abbreviations

ATTACHMENT IX: Determination of Air Phase Petroleum Hydrocarbons (APH)

ATTACHMENT X: Preparation of TO15 SIM standards and ICAL

ATTACHMENT XI: Analyte List for Ohio VAP Certification

17.0 REFERENCES

Pace Quality Assurance Manual- most current version.

TNI Standard, Management and Technical Requirements for Laboratories Performing Environmental Analyses, EL-V1-2009.

TNI Standard, Management and Technical Requirements for Laboratories Performing Environmental Analyses, EL-VI-2016-Rev.2.1.

Department of Defense (DoD) Quality Systems Manual- most current version.

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition; USEPA, January 1999; EPA/625/R-96/010b. Compendium Method TO15.

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition; USEPA, January 1999; EPA/625/R-96/010b. Compendium Method TO14A MA DEP Air Phase Petroleum Hydrocarbon (APH) method, 12/2009.

Method 8260B: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS). Section 7.4.5.

40 CFR Appendix B to Part 136, Definition and Procedure for the Determination of the Method Detection Limit - Rev 2, August 28, 2017.

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Ohio Administrative Code 3745-300-04, "Certified Laboratories", October 17, 2019.

Ohio Administrative Code 3745-300-08, "Appendix A to Rule 3745-300-08 of the Administrative Code (Table V-VII)", October 17, 2019.

Ohio Voluntary Action Program – Laboratory Guidance and Templates, "Information to include in Laboratory Standard Operating Procedures for the Voluntary Action Program", Rev.0, September 5, 2013.

18.0 REVISION HISTORY

This Version:

Section	Description of Change
All	Converted to new template.
Table 7.1	Deleted rows – neat liquid standards & glass static dilution flask. Added Entech to Summa canisters Vendor column.
16.0	Deleted Tedlar Bag Transfer Log as attachment, added reference to other attachment. Updated Attachment I notes below table. Updated Attachment VII, step 8. Updated Attachment VIII table headers.
17.0	Added Ohio VAP specific references.
Attachment XI	Updated headers and analyte lists for the "groups".

This document supersedes the following document(s):

Document Number	Title	Version
ENV-SOP-MIN4-0005	Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS EPA TO15/TO14	04

TEST METHOD STANDARD OPERATING PROCEDURE
TITLE: Analysis of Whole Air Sample for Volatile Organic Compound by GC/MS
TEST METHOD EPA TO15/TO14
ISSUER: Pace ENV – Minneapolis – MIN4

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Appendix A: Target Analyte List and Routine LOQ

Table 1: Routine Analyte List and Limits of Quantitation (LOQ)[1]

Analyte	CAS #	Scan PRL (ppbv)	Scan PRL (ug/m3)	SIM PRL (ppbv)	SIM PRL (ug/m3)
1,1,1-Trichloroethane	71-55-6	0.2	1.11	0.02	0.111
1,1,2,2-Tetrachloroethane	79-34-5	0.1	0.698	0.02	0.140
1,1,2-Trichloroethane	79-00-5	0.1	0.555	0.01	0.0555
1,1,2-Trichlorotrifluoroethane	76-13-1	0.2	1.56	0.2	1.56
1,1-Dichloroethane	75-34-3	0.2	0.823	0.02	0.0823
1,1-Dichloroethene	75-35-4	0.2	0.806	0.02	0.0806
1,2,4-Trichlorobenzene	120-82-1	1	7.54	1	7.54
1,2,4-Trimethylbenzene	95-63-6	0.2	0.999	0.2	1.00
1,2-Dibromoethane	106-93-4	0.1	0.781	0.01	0.0781
1,2-Dichlorobenzene	95-50-1	0.2	1.22	0.2	1.22
1,2-Dichloroethane	107-06-2	0.1	0.411	0.02	0.0823
1,2-Dichloropropane	78-87-5	0.2	0.939	0.01	0.0470
1,3,5-Trimethylbenzene	108-67-8	0.2	0.999	0.2	1.00
1,3-Butadiene	106-99-0	0.2	0.450	0.02	0.0450
1,3-Dichlorobenzene	541-73-1	0.2	1.22	0.2	1.22
1,4-Dichlorobenzene	106-46-7	0.5	3.06	0.5	3.06
2-Butanone (MEK)	78-93-3	1	3.00	1	3.00
2-Hexanone	591-78-6	1	4.16	1	4.16
2-Propanol	67-63-0	1	2.50	1	2.50
4-Ethyltoluene	622-96-8	0.5	2.50	0.5	2.50
4-Methyl-2-pentanone (MIBK)	108-10-1	1	4.16	1	4.16
Acetone	67-64-1	2.5	6.04	2.5	6.04
Benzene	71-43-2	0.1	0.325	0.01	0.0325
Benzyl Chloride	100-44-7	0.5	2.63	0.5	2.63
Bromodichloromethane	75-27-4	0.2	1.36	0.01	0.0681
Bromoform	75-25-2	0.5	5.25	0.5	5.25
Bromomethane	74-83-9	0.2	0.789	0.2	0.789
Carbon Disulfide	75-15-0	0.2	0.633	0.2	0.633
Carbon tetrachloride	56-23-5	0.2	1.28	0.02	0.128
Chlorobenzene	108-90-7	0.2	0.936	0.2	0.936
Chloroethane	75-00-3	0.2	0.536	0.2	0.536
Chloroform	67-66-3	0.1	0.496	0.02	0.0993
Chloromethane	74-87-3	0.2	0.420	0.2	0.420

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Analyte	CAS #	Scan PRL (ppbv)	Scan PRL (ug/m3)	SIM PRL (ppbv)	SIM PRL (ug/m3)
cis-1,2-Dichloroethene	156-59-2	0.2	0.806	0.02	0.0806
cis-1,3-Dichloropropene	10061-01-5	0.2	0.923	0.02	0.0923
Cyclohexane	110-82-7	0.5	1.75	0.5	1.75
Dibromochloromethane	124-48-1	0.2	1.73	0.2	1.73
Dichlorodifluoromethane	75-71-8	0.2	1.01	0.2	1.01
Dichlorotetrafluoroethane	76-14-2	0.2	1.42	0.2	1.42
Ethanol	64-17-5	1	1.92	1	1.92
Ethyl Acetate	141-78-6	0.2	0.733	0.2	0.733
Ethyl Benzene	100-41-4	0.2	0.883	0.2	0.883
Hexachlorobutadiene	87-68-3	0.5	5.42	0.5	5.42
m&p-Xylene	106-42-3	0.4	1.77	0.4	1.77
Methyl Tert Butyl Ether	1634-04-4	1	3.66	1	3.66
Methylene chloride	75-09-2	1	3.53	1	3.53
Naphthalene	91-20-3	0.5	2.66	0.5	2.66
n-Heptane	142-82-5	0.2	0.833	0.2	0.833
n-Hexane	110-54-3	0.2	0.716	0.2	0.716
o-Xylene	95-47-6	0.2	0.883	0.2	0.883
Propylene	115-07-1	0.2	0.350	0.2	0.350
Styrene	100-42-5	0.2	0.866	0.2	0.866
Tetrachloroethene	127-18-4	0.1	0.689	0.01	0.0689
Tetrahydrofuran	109-99-9	0.2	0.600	0.2	0.600
Toluene	108-88-3	0.2	0.766	0.2	0.766
trans-1,2-dichloroethene	156-60-5	0.2	0.806	0.02	0.0806
trans-1,3-Dichloropropene	10061-02-6	0.2	0.923	0.02	0.0923
Trichloroethene	79-01-6	0.1	0.546	0.01	0.0546
Trichlorofluoromethane	75-69-4	0.2	1.14	0.2	1.14
Vinyl Acetate	108-05-4	0.2	0.716	0.2	0.716
Vinyl chloride	75-01-4	0.1	0.260	0.01	0.0260
1,2-Dichloroethene (Total)	540-59-0	0.4	1.61		
1,2,3-Trimethylbenzene	526-73-8	0.2	0.999	0.2	1.00
1,4-Dioxane	123-91-1	1	3.66	1	3.66
2,2,4-Trimethylpentane	540-84-1	0.5	2.37	0.5	2.37
Acrolein	107-02-8	0.5	1.17	0.5	1.17
Acrylonitrile	107-13-1	0.5	1.10	0.5	1.10
Allyl Chloride	107-05-1	0.5	1.59	0.5	1.59
Chlorodifluoromethane	75-45-6	0.5	1.80	0.5	1.80

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Analyte	CAS #	Scan PRL (ppbv)	Scan PRL (ug/m3)	SIM PRL (ppbv)	SIM PRL (ug/m3)
Di-isopropyl Ether	108-20-3	1	4.25	1	4.25
Ethyl Tert-Butyl Ether	637-92-3	1	4.25	1	4.25
Isopentane	78-78-4	0.5	1.50	0.5	1.50
Isopropylbenzene	98-82-8	0.5	2.50	0.5	2.50
Methyl Methacrylate	80-62-6	0.2	0.832	0.2	0.832
Methylcyclohexane	108-87-2	0.5	2.04	0.5	2.04
N-Butylbenzene	104-51-8	0.5	2.79	0.5	2.79
N-Propylbenzene	103-65-1	0.5	2.50	0.5	2.50
p-Isopropyltoluene	99-87-6	0.5	2.79	0.5	2.79
Sec- Butylbenzene	135-98-8	0.5	2.79	0.5	2.79
Tert Amyl Methyl Ether	994-05-8	1	4.25	1	4.25
Tert Butyl Alcohol (TBA)	75-65-0	1	3.08	1	3.08
Tert-Butyl Benzene	98-06-6	0.2	1.12	0.2	1.12
Vinyl Bromide	593-60-2	0.2	0.889	0.2	0.889
THC as Gas (C4-C12)		48.6	211	48.6	211
Xylene (Total)	1330-20-7	0.6	2.65	0.6	2.65

[1] *Values in place as of effective date of this SOP. LOQ are subject to change. For the most up to date LOQ, refer to the LIMS or contact the laboratory.*

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Appendix B: QC Summary

QC Item	Frequency	Acceptance Criteria	Corrective Action	Qualification
ICAL	Initial Calibration is performed as a result of extensive instrument maintenance, CCV outliers for analytes of interest, Internal Standard Non Compliance, and at the discretion of the analyst. All standards, method blanks, laboratory control spikes (LCS), and samples must be analyzed using the same conditions. A calibration curve must consist of a minimum of 5 standards (6 for quadratic) and spans the expected monitoring range established for each compound of interest to determine instrument response and linearity. The lowest level of the curve must be at or below the reporting limit for each analyte. A typical calibration curve can cover a range from 0.1 to 30 ppbv. Section 10.3 contains standard preparation information. Calibration points may be dropped on the lower or upper end so long as the criteria listed above is met. If lower calibration points are dropped, the reporting limit of the compound must be raised to the lowest remaining calibration point if it exceeds the current compound reporting limit. If upper calibration points are dropped, samples must be interpreted with the new upper calibration point representing the new upper range for the compound. At no point is it acceptable to drop a mid-point calibration from an initial calibration.	The %RSD for all calibrated target compounds must be ± 30%. Alternately for all target compounds, linear regression is used with an r2 value of 0.995 or greater. A quadratic curve is utilized if the r2 (equals COD in Equation 12) value is 0.990 or greater and six calibration points are included in the curve. Curves must not be forced through zero. For Ohio VAP: quadratic curve fit is only to be used for analytes that have historically exhibited nonlinear response. The area response for each internal standard in each calibration level must be within 40% of the area response of the mid-point of the initial calibration. The relative retention time (RRT) of each compound must agree within ±0.06 RRT units of the RRT from the mid-point of the initial calibration curve.	Initial calibrations are not meant to be a replacement of necessary instrument maintenance. Calibration curve fits are possible indicators of instrument performance or deterioration. Analytes that traditionally are average or linear responders that suddenly display quadratic curve fits could be a sign of a system that is deteriorating. Quadratic cannot be used to extend the calibration range for compounds that normally exhibit a linear response, perform necessary maintenance to return the system to good working order. This is not to eliminate the use of quadratic curve fits, some analytes always present a quadratic response and that is acceptable. If an analyte fails to meet ICAL criteria, the analyst should report sub list of compounds and/or re-analyze samples under compliant conditions. For initial calibrations not meeting criteria, evaluate the system for potential issues. Perform instrument maintenance if necessary. Prepare new standards and rerun the initial calibration. Calibration is performed using the internal standard technique. See Attachment I for internal standard groups. The data is evaluated using Target. See section 11.2 for acceptance criteria.	None. Do not proceed with analysis
ICV	A second source standard must be analyzed following an initial calibration curve which contains all the analytes of interest.	The spike level of the ICV must be near the midpoint level of the calibration curve. The ICV is considered acceptable if the recoveries of the	See Section 9.2.3.5 for required corrective actions based on circumstance.	Qualify analytes with ICV out of criteria.

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QC Item	Frequency	Acceptance Criteria	Corrective Action	Qualification
		analytes fall within 60-140%.		
Curve Refitting	Every ICAL at the low standard and the mid-point.	The level corresponding to the reporting limit must be quantitated back after processing the curve and be ± 40% of the expected true value. The level corresponding to the midpoint must be quantitated back after processing the curve and be ± 30% of the expected true value.	If the reporting limit does not meet these requirements, then the reporting limit should be raised to the next calibration level that meets ± 40% of the expected true value for a given analyte. If the midpoint does not meet these requirements, then the affected analyte(s) should not be reported from the Ical. Analysts should evaluate the system for potential issues. Perform instrument maintenance if necessary. Prepare new standards and rerun the initial calibration.	Qualify analytes with adjusted reporting limits.
CCV	After an acceptable tune has been evaluated, the initial calibration curve for each compound of interest must be checked and verified before sample analysis can occur each day. This is accomplished by analyzing continuing calibration verification (CCV) standard at 10-50 ppbv (see section 10.3 Ical Level 5). The CCV is the same source as the ICAL standard. The CCV is analyzed after a compliant tune once every 24-hour period during sample analysis unless an initial calibration is analyzed. If there is an initial calibration performed, it will take the place of the CCV and no CCV will be analyzed until after the next tune period.	The %D/%Drift for each target compound in the continuing calibration verification (CCV) standard must be less than or equal to 30 percent. The RRT of each compound must agree within ± 0.06 RRT units of the average RRT from the initial calibration curve.	See Section 9.2.3.6 for required corrective actions based on circumstance.	Qualify analytes with CCV out of of criteria.
Internal Standards	Every field sample, standard and QC sample	Must meet criteria specified in Section 9.0.	Troubleshoot instrument performance. Reanalyze samples.	Qualify outages and explain in case narrative.
Method Blank	Analyzed once every 24-hour period or every 20 samples, whichever comes first. The Method Blank is analyzed before samples can be analyzed, and after daily ICAL	An instrument blank analysis is allowed after any sample that has known VOCs present that exceed the upper calibration limit of the method to	Re-analyze associated samples. Exceptions: If sample ND, report sample without qualification;	Qualify outages and explain in case narrative.

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QC Item	Frequency	Acceptance Criteria	Corrective Action	Qualification
	or CCV.	demonstrate that the system is free of possible carryover effects. When possible, historical data can be used to determine if there are high levels of contaminants present, possibly causing carry over in the system. The method blank must not contain any target analyte at a concentration equal to or greater than its reporting limit and must not contain additional compounds with elution characteristics and mass spectral features that interfere with identification and measurement of a method analyte. The internal standard must be within ± 40% of the mean area response of the IS in the most recent calibration. The retention time of each of the internal standards must be within ± 0.33 minutes between the method blank and the most recent calibration standard.	If sample result >10x MB detects, report the data as it is not impacted by the blank detections; If sample result <10x MB detects and cannot be reprepared/reanalyzed, report sample with appropriate qualifier to indicate an estimated value. Client must be alerted and authorize this condition. **NOTE:** For Ohio VAP samples, if the detection is above the reporting limit and corrective actions as listed in this table do not result in acceptable data, the samples must be re-analyzed. If re-analysis is not possible due to depleted sample volume, then contact the client for further instructions. The client can choose to re-submit the sample or have the lab qualify the data and narrate as appropriate. The narrative for any report that includes qualified data must also include a discussion of any bias in the results. NOTE: Specific clients may require method blanks be analyzed from canisters that were previously certified as clean and that have not left the laboratory.	
LCS	A LCS must be analyzed once every 24-hour period or every 20 samples, whichever is more frequent.	The percent recovery for each analyte in the LCS must be within the internally generated recovery limits and can be found in the LIMS system.	Samples are not to be scheduled for analysis until LCS criteria has been met or technical justification has been given for the analysis to continue. Technical justification includes the scheduling of samples that meet LCS criteria for a shorter list of volatile compounds. If analytes fail high in a LCS, then supervisor approval may be given for analysis of samples that require these analytes.	Qualify outages and explain in case narrative.

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QC Item	Frequency	Acceptance Criteria	Corrective Action	Qualification
			In the event the LCS cannot be evaluated prior to the scheduling of samples for analysis, as in the case where the LCS is scheduled for injection after standard business hours, the subsequently scheduled samples will be evaluated for impact based on the results for the associated LCS, and either reanalyzed or narrated to indicate impact if reanalysis is not possible. **NOTE:** If an LCS fails biased high and the associated samples are non-detect, the samples may be reported as the high bias has no impact on the non-detect results. For Ohio VAP samples, if the outlier is an analyte of interest and corrective actions as listed in this table do not result in acceptable data, the QC and samples must be re-analyzed. If re-analysis is not possible due to depleted sample volume, then contact the client for further instructions. The client can choose to re-submit the sample or have the lab qualify the data and narrate as appropriate. The narrative for any report that includes qualified data must also include a discussion of any bias in the results. Failures that produce a high bias with samples that show results as non-detect may be reported for Ohio VAP.	
Sample Duplicate	Client provided samples. Duplicate sample analysis is performed once per 20 samples.	The RPD between the sample and the sample duplicate must be < 25%.	If RPD fails, report data with qualification unless client specific requirements dictate otherwise.	Qualify outages and explain in case narrative.
Tune Standard	Before any standard, method blank, or sample analysis can occur using the GC/MS system, it must be demonstrated that the GC/MS is capable of producing compliant spectra when p-bromofluorobenzene (BFB) is	If the BFB spectrum meets the criteria listed in Attachment II, proceed with standard and sample analysis.	If the BFB spectrum fails to meet the criteria listed in Attachment II, the MS must be re-tuned. Repeated failures potentially indicate the need for MS maintenance such as cleaning the ion source.	None. Do not proceed with analysis.

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QC Item	Frequency	Acceptance Criteria	Corrective Action	Qualification
	analyzed. Attachment II lists the required spectral criteria. The instrument performance check must be analyzed initially and once every 24-hour period. The tune period begins at the time of injection of the BFB.			

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ATTACHMENT I - Target Compound List and Characteristic Ions

Compound	CAS #	Primary Ion	Secondary Ion(s)	Internal Standard Group	TO14 Compound
Propylene	115-07-1	41	39	1	
Dichlorodifluoromethane	75-71-8	85	87	1	X
Chloromethane	74-87-3	50	52	1	X
Dichlorotetrafluoroethane	76-14-2	85	135,87	1	X
Vinyl Chloride	75-01-4	62	64	1	X
1,3-Butadiene	106-99-0	54	39	1	
Bromomethane	74-83-9	94	96	1	X
Chloroethane	75-00-3	64	66	1	X
Ethanol	64-17-5	31	45	1	
Trichlorofluoromethane	75-69-4	101	103,105	1	X
Acetone	67-64-1	43	58	1	
Isopropyl Alcohol	67-63-0	45	43	1	
1,1-Dichloroethene	75-35-4	61	96	1	X
Freon 113	76-13-1	101	103,151	1	X
Methylene Chloride	75-0902	49	84,86	1	X
Carbon Disulfide	75-15-0	76	44,78	1	
Trans-1,2-Dichloroethene	156-60-5	96	61,98	1	
Methyl tert-butyl ether	1634-04-4	73	41	1	
Vinyl Acetate	108-05-4	43	86	1	
1,1-Dichloroethane	75-34-3	63	65	1	X
Methyl Ethyl Ketone	78-93-3	72	43	1	
Hexane	110-54-3	57	41,43	1	
Cis-1,2-Dichloroethene	156-59-2	96	61,98	1	X
Ethyl Acetate	141-78-6	43	61,70	1	
Chloroform	67-66-3	83	85,47	1	X
Tetrahydrofuran	109-99-9	42	41,72	1	
1,1,1-Trichloroethane	71-55-6	97	99,61	1	X
1,2-Dichloroethane	107-06-2	62	64	1	X
Benzene	71-43-2	78	77,50	1	X
Carbon Tetrachloride	56-23-5	117	119	1	X
Cyclohexane	110-82-7	56	84,41	1	
Heptane	142-82-5	43	41	1	
1,2-Dichloropropane	78-87-5	63	41,62	1	X
Trichloroethene	79-01-6	130	132,95	1	X

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Compound	CAS #	Primary Ion	Secondary Ion(s)	Internal Standard Group	TO14 Compound
Acrolein	107-02-8	56	55	1	
Acrylonitrile	107-13-1	53	52	1	
Bromodichloromethane	75-27-4	83	85	1	
Naphthalene	91-20-3	128	127	1	
Methyl Isobutyl Ketone	108-10-1	43	58,100	1	
Cis-1,3-Dichloropropene	10061-01-5	75	39,77	1	X
Trans-1,3-Dichloropropene	10061-02-6	75	39,77	1	X
Toluene	108-88-3	91	92	1	X
1,1,2-trichloroethane	79-00-5	97	83,61	1	
2,2,4-Trimethylpentane	540-84-1	57	41,56	1	
Allyl chloride	107-05-1	76	41,78	1	
Chlorodifluoroethane	75-45-6	67	51,69	1	X
Di-isopropyl ether	108-20-3	45	87,59	1	X
Ethyl tert-butyl ether	637-92-3	59	87	1	X
Methyl methacrylate	80-62-6	69	41	1	X
Methylcyclohexane	108-87-2	98	83,55	1	X
tert-amyl methyl ether	994-05-8	73	87,55	1	X
tert-butyl alcohol	75-65-0	59	41	1	
Dibromochloromethane	124-48-1	129	127	2	
1,2-Dibromoethane	106-93-4	107	109	2	X
Methyl Butyl Ketone	591-78-6	43	58	2	
Tetrachloroethene	127-18-4	166	164,131	2	X
Chlorobenzene	108-90-7	112	77,114	2	X
Ethylbenzene	100-41-4	91	106	2	X
M&p-xylene	106-42-3	91	106	2	X
O-xylene	95-47-6	91	106	2	X
Bromoform	75-25-2	173	171	2	
Styrene	100-42-5	104	78,103	2	X
1,1,2,2-Tetrachloroethane	79-34-5	83	85	2	X
4-Ethyltoluene	622-96-8	105	120,79	2	
1,3,5-Trimethylbenzene	108-67-8	105	120	2	X
1,2,4-Trimethylbenzene	95-63-6	105	120	2	X
1,3-Dichlorobenzene	541-73-1	146	111,148	2	X
Benzyl chloride	100-44-7	91	126	2	
1,4-Dichlorobenzene	106-46-7	146	148,111	2	X
1,2-Dichlorobenzene	95-50-1	146	111,148	2	X

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Compound	CAS #	Primary Ion	Secondary Ion(s)	Internal Standard Group	TO14 Compound
1,2,4-Trichlorobenzene	95-63-6	180	182,184	2	X
Hexachloro-1,3-butadiene	87-68-3	225	227,223	2	X
n-butylbenzene	104-51-8	91	92	2	
n-propylbenzene	103-65-1	91	120	2	
sec-butylbenzene	135-98-8	105	134	2	
tert-butylbenzene	98-06-6	119	91,134	2	X
1,4-Difluorobenzene	540-36-3	114	88	IS #1	
Chlorobenzene-d5	3114-55-4	117	82	IS #2	
p-bromofluorobenzene (surr)	460-00-4	95	174,176	2	

Note(s):

- Current reporting limits can be found in LIMS and in the QA Office.
- Analytes not covered on Ohio VAP certification must be clearly identified on the report and called out as such on affidavits issued. See Attachment XI for complete list of certified analytes per the OH VAP certification.

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ATTACHMENT II - Required BFB Key Ions and Ion Abundance Criteria

Mass	Ion Abundance Criteria
50	8.0 - 40.0 percent of mass 95
75	30.0 - 66.0 percent of mass 95
95	base peak, 100 percent relative abundance
96	5.0 - 9.0 percent of mass 95 (See note)
173	less than 2.0 percent of mass 174
174	50.0 - 120.0 percent of mass 95
175	4.0 - 9.0 percent of mass 174
176	93.0 - 101.0 percent of mass 174
177	5.0 - 9.0 percent of mass 176

Note(s):

- All ion abundances must be normalized to m/z 95, the nominal base peak, even though the ion abundance of m/z 174 may be up to 120 percent that of m/z 95.

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ATTACHMENT III – Calibration of THC as Gas

III-1 THC as gas is calibrated by using the same calibration runs that are used for all other compounds, as well as using the same acceptance criteria.

III-2 The original calibration files are copied to a target batch. This does not change the raw data in any way, it merely allows the same data to be processed against two different methods.

III-3 The area response is obtained by summing the area in the total ion chromatogram from the first eluting compound of interest till the end of the run. The internal standard is included as part of this value, the response factor is not calculated using the internal standard method. It is solely based on area response and calibration concentration.

III-4 The calibration concentration at each level is obtained by summing the values of the individual compounds present in the calibration standard.

III-5 A response factor is obtained as detailed earlier in this SOP. Calibration criteria are the same as stated earlier in this SOP.

III-6 Custom THC values may be obtained and are noted as such on final reports. These custom values can be based on calibrating using a select list of compounds or a select time frame for example. Requests for these custom values are to be evaluated on an individual basis for analytical feasibility.

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ATTACHMENT IV – Performing Dilutions on Air Canisters

When a sample is over the linear range of calibration for a compound of interest, several compounds of interest, or the matrix of the sample interferes with internal standard detections, a dilution is performed.

SYSTEM DILUTION

The pre-concentrator uses a digital mass flow controller to pull volume of the air sample onto the system.

1x	=	300cc
2x	=	150cc
5x	=	60cc
10x	=	30cc
20x	=	15cc
30x	=	10cc

SERIAL DILUTION

For samples that may require a dilution greater than 30x, the lab performs serial dilutions by emptying the pressurized air in the sample back to ambient conditions (0psig) and refilling the can to 15psig.

This doubles the volume once inside the can and is a 2x

As you multiply this process, the resultant dilution factor is multiplied out.

1. Flush to 0psig fill to 15 = **2x**
2. Flush to 0 and fill again to 15 = **4x**
3. **8x**
4. **16x**
5. **32x**
6. **64x**
7. **128x**
8. **256x**

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ATTACHMENT V – Air Laboratory Standard Preparation Procedures (Syringe Method)

Calibration Standard

The calibration stock standard is purchased in the form of a pressurized cylinder from SPECTRA GASES, Inc, or equivalent. This is a custom mix that includes all compounds of interest at 1ppmv.

TO15 Standard Preparation

Standards are prepared in a 6L or 15L summa canister that has been evacuated to less than 200 mTorr. The canister is humidified with 50 µl of deionized water. A 1000cc gas tight syringe is filled with a desired volume of TO15 stock standard. The summa canister is then pressurized to 30 psig (3 atm) with clean nitrogen from Praxair, resulting in a 30.0 ppbv standard. An aliquot of the 30.0 ppbv standard is withdrawn with a 1000cc gas tight syringe and transferred to a second 6L or 15L summa canister that has been evacuated to less than 200 mTorr and humidified with 50 µl of deionized water. This second canister is then pressurized to 30 psig (3 atm) with clean nitrogen, resulting in a 1.00 ppbv standard.

The standard ID, date created, analyst initials, canister number, canister volume, stock standard ID, volume used, water volume added, final pressure in psig, final concentration in ppbv and expiration date are recorded in the standard preparation logbook.

Second Source Verification

The second source stock standard is purchased in the form of a pressurized cylinder from a source independent of the calibration mix (Custom Gas, or equivalent). This includes all compounds of interest at 1ppmv.

The second source standard is prepared in a 6L or 15L summa canister following the same method as the TO15 30.0 ppbv standard.

Canister Volume (L)	Canister Final Pressure (psig)	Canister Final Pressure (atm)	Canister Pressurized Volume (L)	Initial standard concentration (ppmv)	Standard Volume (cc)	Standard Volume (L)	Final Standard Concentration (ppmv)	Final Standard Concentration (ppbv)
6	30	3.04	18.24	1.00	540	0.540	0.030	30.0
15	30	3.04	45.6	1.00	1350	1.35	0.030	30.0
6	30	3.04	18.24	0.030	600	0.600	0.001	1.00
15	30	3.04	45.6	0.030	1500	1.50	0.001	1.00

*The Pressurized canister volume can be obtained from Boyle's Law, stating $P_1V_1=P_2V_2$. At 3.04 atm, a 15 L cylinder occupies the same volume as a 45.6L cylinder at 1.00 atm. 1350 cc of a standard is put into the pressurized canister creating a 1.35L/45.6 L dilution factor to result in the standard to determine the final concentration in ppbv.

Internal Standard/ Surrogate/ BFB Standard 150ppbv:

Standards are prepared in a15 L summa canister that has been evacuated to less than 200 mTorr. The canister is humidified with 50 µL of deionized water. A 1000 cc gas tight syringe is filled with a desired volume of Internal Standard/Surrogate/BFB standard. The summa canister is then pressurized to 30 psig (3 atm) with clean nitrogen from Praxair, resulting in a 150. ppbv standard.

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ATTACHMENT V – Air Laboratory Standard Preparation Procedures (Syringe Method) (Continued)

The standard ID, date created, analyst initials, canister number, canister volume, stock standard ID, volume used, water volume added, final pressure in psig, final concentration in ppbv and expiration date are recorded in the ENV-LBK-MIN4-0001 *Standard Preparation Logbook* (current version or equivalent replacement).

Canister Volume (L)	Canister Final Pressure (psig)	Canister Final Pressure (atm)	Canister Pressurized Volume (L)	Initial standard concentration (ppmv)	Standard Volume (cc)	Standard Volume (L)	Final Standard Concentration (ppmv)	Final Standard Concentration (ppbv)
15	30	3.04	45.6	10.0	675	0.675	0.150	150.

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ATTACHMENT VI – Procedures for Analyzing MPCA Samples

VI-1 Samples must be carefully monitored for carryover from previous samples with large detections. Analysts and data reviewers need to verify that each analysis has been evaluated for potential carryover.

a. If a compound of interest has an on-column concentration that is greater than 10% of the previous sample, it is assumed that this value is not due to carryover.

b. If the compound of interest has an on-column concentration between 2-10% of the previous sample, then the analyst carefully examines other factors relating to sample analysis (i.e. the concentration of related components, the overall concentration of constituents in each sample, etc.). When in doubt, the analyst must re-analyze the sample to confirm that the results are not due to carryover.

c. When the compound of interest has an on-column concentration which is less than 2% of the previous sample's concentration, but greater than the method reporting limit, the sample must be analyzed to confirm or eliminate possible carryover.

VI-2 Sample duplicate analysis must be performed at a minimum of 1 in 10 samples analyzed.

VI-3 The relative detection limit for MPCA samples is 0.200 ppbv for all analytes except m&p xylene which has a relative detection limit of 0.400 ppbv.

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ATTACHMENT VII – Procedure for Transfer of Tedlar Bags to SUMMA Canisters

In the event that a sample is collected into a tedlar bag, the client has two days to get the bag to the facility for analytical testing. Pace Analytical Services recognizes a two day holding time for all samples collected in tedlar bags. Upon receipt at the laboratory, the sample in the tedlar bag is transferred into a batch certified, evacuated SUMMA canister for analysis. The sample is subsequently analyzed by the appropriate method within 30 days of initial sample collection.

Procedure for transfer:

VII-1 Tedlar bag is received and logged for analysis by Pace Analytical Services.

VII-2 The sample is delivered to the Air Lab, and the laboratory numbers assigned to the sample is recorded in a logbook (as delivered; see ENV-LBK-MIN4-0016 *Tedlar Bag Transfer Log*, or equivalent replacement).

VII-3 The bag is connected to a clean, evacuated canister (200 mTorr).

a. The tip of the bag valve is placed into tubing, connected by a ¼" nut to the sample valve of the canister, secured with a wrench to ensure all sample is pulled into the can.

VII-4 The bag is opened first. Second, the can is opened.

a. By opening the canister second, the sample is transferred into the can through vacuum (since the can is evacuated to 200 mTorr, and the bag is at ambient room pressure).

VII-5 After the sample is transferred the sample data and canister number, time and date, is recorded into the transfer logbook (ENV-LBK-MIN4-0016 *Tedlar Bag Transfer Log*, or equivalent replacement).

VII-6 Sample is submitted to the laboratory for analysis.

VII-7 A data qualifier is added to the report, notifying the client of the transfer.

VII-8 All tedlar bag transfers must be recorded using logbook ENV-LBK-MIN4-0016 *Tedlar Bag Transfer Log* (current version or equivalent replacement). The required information to record are:

a. Sample ID

b. Can ID

c. Date Collected

d. Date when the tedlar bag was evacuated to the SUMMA canister

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ATTACHMENT VIII – Common Logbook Abbreviations

Abbreviation	Word or Phrase Equivalent
RR	Reanalysis for previously analyzed sample
DIL	Dilution for over-range compounds from a previously reported sample
CONF	Confirms results from a previously analyzed sample
C/O	Possible carryover from a prior sample
OK	Analysis is acceptable and sample is reported

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ATTACHMENT IX – Determination of Air Phase Petroleum Hydrocarbons (APH)

This method is designed, based on the Massachusetts APH method, to measure the gaseous-phase concentrations of volatile aliphatic and aromatic petroleum hydrocarbons in air and soil gas. Volatile aliphatic hydrocarbons are collectively quantitated within two carbon number ranges: C_5 through C_8, and C_9 through C_{12}. Volatile aromatic hydrocarbons are collectively quantitated within the C_9 to C_{10} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 28°C and 245°C. This is a performance-based method. Modifications to this method are permissible, provided that adequate documentation exists, or has been developed, to demonstrate an equivalent or superior level of performance.

Collective Aliphatic/Aromatic ranges: Relative Response Factors are calculated for C_5-C_8 Aliphatic Hydrocarbons and C_9-C_{12} Aliphatic Hydrocarbons based upon a correlation between the TOTAL mass of aliphatic APH Component Standards eluting within the range of interest and the total ion area count. A Relative Response Factor is calculated for C_9-C_{10} Aromatic Hydrocarbons based upon a correlation between the TOTAL mass of aromatic APH Component Standards eluting within this range and the total area count of extracted ions 120 and 134. Specified APH Component Standards are designated "marker" compounds to define the beginning and end of the hydrocarbon ranges.

- **C_5 through C_8 Aliphatic Hydrocarbon**s are defined as all aliphatic hydrocarbon compounds which elute from isopentane to just before n-nonane (C_9).
- **C_9 through C_{12} Aliphatic Hydrocarbons** are defined as all aliphatic hydrocarbon compounds which elute from n-nonane to just after 1-methylnaphthalene.
- **C_9 through C_{10} Aromatic Hydrocarbons** are defined as all aromatic hydrocarbon compounds which elute from just after o-xylene to just after 1-methylnaphthalene, excluding naphthalene and 2-methylnaphthalene, which are quantitated and evaluated separately as Target APH Analytes.

Hydrocarbon Range	Beginning Marker	Ending Marker
C_5-C_8 Aliphatic Hydrocarbons	0.1 min. before isopentane	0.01 min. before n-Nonane
C_9-C_{12} Aliphatic Hydrocarbons	0.01 min. before n-Nonane	0.1 min. after 1-Methylnaphthalene
C_9-C_{10} Aromatic Hydrocarbons	0.1 min. after o-xylene	0.1 min. after 1-Methylnaphthalene

Standard Information: All APH standards are purchased as 30 component mixtures from a known vendor, such as SPEX CertiPrep or O2Si, in methanol.

Initial Calibration (*Suggested Parameters*)

- Standard Concentration: Components range from 90-260 mg/L
- Prepare a **12 ppbv** working standard by adding 5.4 µL to a clean, evacuated 6L canister which has been humidified with 50 µL of water. Fill to 30 psig with nitrogen.

Initial Calibration Verification

- Standard Concentration: Components range from 90-260 mg/L
- Prepare working standard by adding 5.4 µL to a clean, evacuated 6L canister which has been humidified with 50 µL of water. Fill to 30 psig with nitrogen.

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ATTACHMENT IX – Determination of Air Phase Petroleum Hydrocarbons (APH) (Continued)

Initial Calibration and ICV Table:

	Volume (cc)	C5-C8	C9-C12	C9-C10
ICAL-1	10	5.2	6.4	2.4
ICAL-2	25	13	16	6
ICAL-3	50	26	32	12
ICAL-4	125	65	80	30
ICAL-5	250	130	160	60
ICAL-6	500	260	320	120
ICV	125	65	80	30
Note(s): All values are expressed in ppbv.				

Component Mixture		Ions	
Compound	**CAS NO**	**Quant**	**Qual.**
1,3-Butadiene	106990	54	39
Isopentane	78784	43	42
MTBE	1634044	73	41
n-Hexane	110543	57	41/43
Benzene	71432	78	77/50
Cyclohexane	110827	56	84/41
2,3-Dimethylpentane	565593	56	43
n-Heptane	142825	43	41
Toluene	108883	91	92
n-Octane	111659	43	85/57
Ethylbenzene	100414	91	106
2,3-Dimethylheptane	3074713	43	84/85
m-Xylene	108383	91	106
p-Xylene	106423	91	106
o-Xylene	95476	91	106
n-Nonane	111842	43	57
Isopropylbenzene	98828	105	120
1-Methyl-3-ethylbenzene	620144	105	120
1,3,5-Trimethylbenzene	108678	105	120
n-Decane	124185	57	85
1,2,3-Trimethylbenzene	526738	105	120
p-Isopropyltoluene	99876	119	105
Indene	95136	115	116
Butylcyclohexane	1678939	83	55
n-Undecane	1120214	57	42
Naphthalene	91203	128	127
n-Dodecane	112403	57	43
Hexylcyclohexane	4292755	83	82
2-Methylnaphthalene	91576	142	141
1-Methylnaphthtalene	90120	142	141

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ATTACHMENT X – Preparation of TO15 SIM standards and ICAL

CALIBRATION STANDARD

The calibration stock standard is purchased in the form of a pressurized cylinder from SPECTRA GASES, Inc, or equivalent. This is a custom mix that includes all compounds of interest at 1ppmv.

TO15 Standard Preparation - SIM

TO15 Scan standards are prepared in a 6 L or 15 L summa canister that has been evacuated to less than 200 mTorr. The canister is humidified with 50 µL of deionized water. A 1000 cc gas tight syringe is filled with a desired volume of TO15 stock standard. The summa canister is then pressurized to 30 psig (3 atm) with clean nitrogen from Praxair, resulting in a 30.0 ppbv standard.

A 45 cc aliquot of the 30.0 ppbv standard is withdrawn with a 60 cc gas tight syringe and transferred to a second 6 L summa canister that has been evacuated to less than 200 mTorr and humidified with 50 µL of deionized water. A second 45 cc aliquot of the 30.0 ppbv standard is transferred for a total of 90cc. This second canister is then pressurized to 30 psig (3 atm) with clean nitrogen, resulting in a 0.15 ppbv standard. This 0.15 ppbv standard is the SIM primary standard.

The standard ID, date created, analyst initials, canister number, canister volume, stock standard ID, volume used, water volume added, final pressure in psig, final concentration in ppbv and expiration date are recorded in the standard preparation logbook.

Initial Calibration Verification (ICV) - SIM

The second source stock standard is purchased in the form of a pressurized cylinder from a source independent of the calibration mix (Custom Gas, or equivalent). This includes all compounds of interest at 1 ppmv.

The TO15 Scan second source standard is prepared in a 6 L or 15 L summa canister following the same method as the TO15 30.0 ppbv standard.

Next, a SIM secondary standard is prepared into a second 6 L summa canister in the same manner as the SIM primary standard. The resulting 0.15 ppbv standard is the SIM secondary source standard.

Initial Calibration and ICV Table:

	Volume (cc)	Calibration Standard Used	Concentration
ICAL-1	10	0.15	0.005
ICAL-2	20	0.15	0.01
ICAL-3	40	0.15	0.02
ICAL-4	100	0.15	0.05
ICAL-5	200	0.15	0.1
ICAL-6	400	0.15	0.2
ICAL-7	600	0.15	0.3
ICV	200	0.15	0.1

all expressed in ppbv

Continuing Calibration Verification (CCV) – SIM

A CCV standard is analyzed at 0.100 ppbv (ICal level 5). The CCV is the same source as the ICAL standard.

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ATTACHMENT X – Preparation of TO15 SIM standards and ICAL (Continued)

Acceptance Criteria

The analysis of analytes for TO15 SIM has the same acceptance criteria for TUNE, ICAL, ICV, and CCV as specified for TO15 Scan in section 11, Calibration and Standardization. TO15 SIM has the same acceptance criteria for MB, LCS, DUP, IS, and Surrogates as specified for TO15 Scan in section 9 and Appendix B.

TO-15 SIM Analytes		
Compound	**Quant ion**	**Qualifier ion**
Vinyl chloride	62	64
1,3-butadiene	54	39,43
1,1-dichloroethene	61	96
Trans-1,2-dichloroethene	96	61
1,1-dichloroethane	63	65
Cis-1,2-dichloroethene	96	61
chloroform	83	85,47
1,1,1-trichloroethane	97	99
1,2-dichloroethane	62	64
benzene	78	77
Carbon tetrachloride	117	119
1,2-dichloropropane	63	41,62
trichloroethene	130	132
bromodichloromethane	83	85
Cis-1,3-dichloropropene	75	39,77
Trans-1,3-dichloropropene	75	39,77
1,1,2-trichloroethane	83	97
toluene	91	92
1,2-dibromoethane	107	109
tetrachloroethene	166	164
ethylbenzene	91	106
m&p-xylene	91	106
o-xylene	91	106
1,1,2,2-tetrachloroethane	83	85
naphthalene	128	127

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ATTACHMENT XI – Analyte List for Ohio VAP Certification **(Current as of Issue Date)**

"Volatile Organic Compounds" Group				
Analyte	**CAS #**		**Analyte**	**CAS #**
1,1,1-Trichloroethane	71-55-6		Carbon disulfide	75-15-0
1,1,2,2-Tetrachloroethane	79-34-5		Carbon tetrachloride	56-23-5
1,1,2-Trichloroethane	79-00-5		Chlorobenzene	108-90-7
1,1-Dichloroethane	75-34-3		Chloroethane	75-00-3
1,1-Dichloroethene	75-35-4		Chloroform	67-66-3
1,2,3-Trimethylbenzene	526-73-8		Chloromethane	74-87-3
1,2,4-Trichlorobenzene	120-82-1		cis-1,3-Dichloropropene	10061-01-5
1,2,4-Trimethylbenzene	95-63-6		Cyclohexane	110-82-7
1,2-Dibromoethane	106-93-4		Ethyl acetate	141-78-6
1,2-Dichlorobenzene	95-50-1		Ethylbenzene	100-41-4
1,2-Dichloroethane	107-06-2		Hexachlorobutadiene	87-68-3
1,2-Dichloropropane	78-87-5		Isopropylbenzene	98-82-8
1,3,5-Trimethylbenzene	108-67-8		m&p-Xylene	106-42-3
1,3-Butadiene	106-99-0		Methyl methacrylate	80-62-6
1,4-Dichlorobenzene	106-46-7		Methyl tert-butyl ether (MTBE)	1634-04-4
1,4-Dioxane	123-91-1		Methylene chloride (Dichloromethane)	75-09-2
2,2,4-Trimethylpentane	540-84-1		Naphthalene	91-20-3
2-Butanone (MEK)	78-93-3		n-Hexane	110-54-3
4-Methyl-2-pentanone (MIBK)	108-10-1		o-Xylene	95-47-6
Acetone	67-64-1		Styrene	100-42-5
Acrolein	107-02-8		Tetrachloroethene	127-18-4
Acrylonitrile	107-13-1		Tetrahydrofuran	109-99-9
Allyl chloride	107-05-1		Toluene	108-88-3
Benzene	71-43-2		Trichloroethene	79-01-6
Benzyl chloride	100-44-7		Vinyl acetate	108-05-4
Bromodichloromethane	75-27-4		Vinyl bromide (Bromoethane)	593-60-2
Bromoform	75-25-2		Vinyl chloride	75-01-4
Bromomethane	74-83-9		Xylene (Total)	1330-20-7

"Additional" Analytes (Individually Certified)	
Analyte	**CAS #**
1,3-Dichlorobenzene	541-73-1
cis-1,2-Dichloroethene	156-59-2
Dibromochloromethane	124-48-1
Dichlorodifluoromethane	75-71-8
trans-1,2-Dichloroethene	156-60-5
trans-1,3-Dichloropropene	10061-02-6
Trichlorofluoromethane	75-69-4

Non-Regulated VAP Analytes	
Analyte	**CAS #**
1,1,2-Trichlorotrifluoroethane	76-13-1
2-Hexanone	591-78-6
2-Propanol	67-63-0
4-Ethyltoluene	622-96-8
Chlorodifluoromethane	75-45-6
Dichlorotetrafluoroethane	76-14-2
Di-isopropyl ether (DIPE)	108-20-3
Ethanol	64-17-5
Ethyl-t-butylether (ETBE)	637-92-3
Isopentane	78-78-4
Methylcyclohexane	108-87-2
N-Butylbenzene	104-51-8
n-Heptane	142-82-5
N-Propylbenzene	103-65-1
p-Isopropyltoluene	99-87-6
Propylene	115-07-1
Sec- Butylbenzene	135-98-8
tert-amyl methyl ether (TAME)	994-05-8
tert-Butyl alcohol (TBA, 2-Propanol))	75-65-0
tert-Butyl benzene	98-06-6
THC as Gas (C4-C12)	-----

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