SAMPLING AND ANALYSIS PLAN

SHEBOYGAN RIVER AND HARBOR SUPERFUND SITE
TECUMSEH SITE, SHEBOYGAN FALLS, WISCONSIN

SME Project Number: 069638.00.051
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1. INTRODUCTION

We prepared this Sampling and Analysis Plan (SAP) in response to a request for additional sampling by the United States Environmental Protection Agency (USEPA) in a letter dated March 25, 2020. This SAP was prepared to describe additional environmental assessment activities of the former Tecumseh Products Company facility and Sheboygan Falls dewatering site located south of Cleveland Street and west of Hickory Street in Sheboygan Falls, Wisconsin; hereinto referred to as “the Site”.

The objective of this assessment is to obtain information required by the USEPA to fill in gaps in available data on the Site and off-site on the east-adjoining site, as identified in the April 23, 2020 Data Gap Analysis, and to determine the limits of impacted soil for remedial actions on the Site. Descriptions of the Site history and known current environmental conditions; strategies and procedures for collection and chemical analyses of soil samples, data evaluation, and reporting; and the estimated project schedule are presented in the following sections.

2. SITE HISTORY, CURRENT CONDITIONS, AND PLANNED SITE ASSESSMENT

Summaries of the Site history, current Site conditions, and environmental conditions identified during previous investigations of the Property are presented in the following subsections. The SME Assessment Team’s planned subsurface assessment activities to further evaluate the Site are also summarized below.

2.1 SITE HISTORY

The Site was developed with a manufacturing facility by the Diecast Corporation in 1957. In 1960, hydraulic oil in equipment on the Site was replaced with polychlorinated biphenyl (PCB)-containing, fire-retardant hydraulic oil. Diecast Corporation owned and operated the manufacturing facility until 1966, when the Tecumseh Products Company, a manufacturer of refrigeration and air conditioning compressors and gasoline engines, acquired the facility and continued die casting operations. Early in the facility operations, spent oil absorbent materials were reportedly incinerated in a burn pit on the Site and later disposed on the Site. Absorbent materials stored in on-site pits were also removed and disposed at the Sheboygan Falls demolition fill landfill (located in the area of the east-adjoining Rochester Park). During plant expansion, some contaminated soil was moved to fill low spots on the Site and used for flood control along the Sheboygan River. Portions of the plant expansion were also reportedly constructed on areas of contaminated soil. In 1972, hydraulic oil in equipment on the Site was replaced with non-PCB-containing, water-based hydraulic oil. PCBs were found in soil across the southern portion of the Site and in sewer lines that lead to the Sheboygan River from the Tecumseh facility. Prior to remediation, contamination levels in the Sheboygan River were highest in the sediments immediately surrounding the Tecumseh Falls Site, but decreased in concentration downstream. The Tecumseh Products Company closed the facility in 2003 and the buildings on the Site were removed by 2005. The Site was used as a dewatering facility associated with the remedial river sediment dredging activities for the Sheboygan River from 2005 to 2007.

The USEPA Record of Decision (ROD) listed the risks at the Sheboygan River and Harbor Superfund site to be from the potential chemicals of concern (PCOC) consisting of, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), and select metals. The metals listed as the target of concern for the Remedial Investigations were cadmium, chromium, copper, lead, mercury, nickel, and zinc. Pesticides, dioxins, and dibenzofurans were not present in the sediment and as such, were not listed as PCOCs.

2.2 CURRENT CONDITIONS

The Site has remained vacant since the completion of remedial river sediment dewatering operations in the Upper River in 2007. SME completed Phase II Environmental Site Assessments on the Site in 2016 and 2018 to determine if the river sediment dewatering operations on the Site caused PCB impacts to the Site. SME completed soil borings on the Site in 2016 and 2018. The soil borings were completed in the following areas:

- the area of the former confined treatment facility (CFT);
- the area of the former sediment management facility (SMF);
- the area along the west side of the former building (area of a former preferential pathway and known dewatering release);
- along the northern side of the former dewatering pad where a dewatering release had occurred;
- along the eastern side of the former dewatering pad where a dewatering release had occurred;
- and along the southeastern side of the former dewatering pad where a dewatering release had occurred.

The 2016 and 2018 soil borings on the west side of the former building, and on the eastern and northern portions of the Site identified previously unknown PCB- and PAH-impacted soil. The previously unknown PCB-impacted soil was determined to be from historical releases from to historical manufacturing operations on the Site prior to the dewatering operations. Volatile organic compounds (VOCs) were not detected above the laboratory reporting limits in the analyzed samples. Selected metals were detected above the laboratory reporting limits but less than the RSLs.

PAH-impacted soil was identified on the west side of the former building/dewatering pad and was limited in extent and was vertically and horizontally delineated. PCB-impacted soil was identified in a limited area on the west side of the former dewatering pad and in a limited area on the north side of the former dewatering pad. PCB-impacted soil identified on the north and west sides of the former dewatering pad was limited in extent and was vertically and horizontally delineated. PCB-impacted soil was identified in an area covering portion of the east side of Site and extending to borings along the eastern property boundary. The areas of PCB-impacted soil identified in 2016 and 2018 are shown on Figure 2.

In addition to the soil borings on the Site, soil borings were completed on the east-adjoining Rochester Park to the east to determine if PCB impacts extended onto the park property. Ten soil borings were completed on the eastern portion of Rochester Park and near the Site. PCBs were measured in each of the samples at concentrations less than 7 ppm.

In April 2020, SME completed a data gap analysis to assess the adequacy and coverage of past investigations and remedial activities. The data gap analysis included compiling the locations and results of all historical sampling activities and historical remedial excavations. Based on SME's review of the available information, the following gaps in available data were identified:

- Data Gap #1 –The area of the former and current parking lot located on the western portion of the Site
- Data Gap #2 – The current condition and integrity of the former building slab and dewatering pad pavements
- Data Gap #3 – The area of PCB-impacted soil above the USEPA Principal Threat Waste (PTW) criteria on the eastern portion of the Site was partially delineated; however, additional data is necessary in this area of the Site to fully delineate soil above the PTW criteria and to optimally remediate the Site.

- Data Gap #4 – The potential for PCBs to extend off-site and into the Cleveland Street right of way (ROW) located north and/or the Hickory Street ROW located to the east.
- Data Gaps #5 and #6 - The potential for additional unidentified PCB-impacts on the east-adjoining Rochester Park. Rochester Park was divided into two units; the northern portion of the park where the landfill was historically located, which was identified as Data Gap #5 and the southern portion of the park, which was identified as Data Gap #6.

2.3 PLANNED SITE ASSESSMENT

We designed the proposed assessment activities to address the identified data gaps. The assessment activities include environmental sampling of soil on the Site and the east-adjoining Rochester Park; environmental sampling of the asphalt pavement on the former dewatering pad on the Site for disposal planning; and a pavement evaluation of the former building slab and dewatering pad on the Site.

3. SAMPLING PLAN

The sampling plan for the assessment activities is presented in this section. The sampling plan includes a summary of the planned soil sampling locations, rationales for those locations, and descriptions of procedures and methods for field sampling.

3.1 ENVIRONMENTAL SAMPLING PLAN

SME utilized industry-established statistical software to assist in the creation of a soil sampling plan to address the data gaps identified in the April 23, 2020, Serial Letter #62 (Data Gap Analysis). The software tool employed for systematic sampling was Visual Sampling Plan (VSP), which was authored by the United States Department of Energy, Pacific Northwest National Laboratory. Some of the methods VSP employs involves the comparison of the standard deviation of the data to a standard. To use VSP, we evaluated the standards previously used on the Site and adjoining sites. A commercial/industrial cleanup standard of 8.66 ppm was previous developed for the Site and the USEPA indicated the USEPA Principal Threshold Waste (PTW) threshold of 100 parts per million (ppm) was deemed appropriate as a minimum cleanup standard for the Site.

A recreational standard was not historically developed for the adjoining property to the east and the 100 ppm PTW threshold is not appropriate as a standard that would be protective of park receptors. As such, SME developed a recreational standard to use with VSP; however, we are not proposing this as a cleanup standard but as an initial screening level for comparison purposes within VSP.

Several risk assessments were historically performed in relation to the Superfund efforts on the Sheboygan River and Harbor (BB&L, 1990, USEPA, 1993, Environ, 1995). These risk assessments evaluated the direct contact risk to floodplain soils in the various parks along the river. These risk assessments concluded that the direct contact risk to receptors in the parks were of “marginal concern.” The risk at Rochester Park was 9×10^{-8} based on a mean PCB concentration of 19.7 ppm PCBs with a range of 0.17 ppm to 172 ppm. The PCBs samples collected from Rochester Park by BB&L (1999) and by SME (2016/2018) ranged from non-detect (0.062) ppm to 83 ppm with a mean of 5.85 ppm. While these concentrations are within the range of concentrations that led to the previous conclusions regarding the direct contact risk at the park, they do not provide a standard for use in VSP.

SME developed a recreational standard based on USEPA risk calculations and the exposure factors used in the previous risk assessments based on the 90^{th} percentile exposure. The following was used in the calculations:

Receptor	Exposure Duration (ED) in years	Exposure Frequency (ET) in days/year	Exposure Time (ET) in hours/day[1]
Adult	26	36.5	2
Child (0-2)	2	95.9	2
Child (4-6)[2]	3.9	95.9	2
Child (6-16)	10	95.9	2

Notes:

[1] Best Professional Judgement, the previous risk assessments did not provide this time.

[2] Only age group provided.

The remaining variables used in the calculations were obtained from the Regional Screening Level calculator or Risk Assessment Guidance Superfund. The calculated recreational standard for Total PCBs is 18 ppm based on a 10^{-5} carcinogenic risk (Appendix A). This value is consistent with the previous risk calculation for Rochester Park that was based on a mean PCB concentration of 19.7 ppm. SME used 18 ppm as the standard in VSP for Rochester Park.

Sampling rationales and locations for each distinct assessment area are described below in Sections 3.1.1 to 3.1.5 and sampling procedures and methods are described below in Sections 3.2.

3.1.1 SAMPLING RATIONALE FOR THE WESTERN PARKING LOT ON THE SITE (DATA GAP #1)

We used VSP to evaluate the number of samples needed to investigate the western parking lot area of the Site. The objective was to use VSP to calculate the appropriate number and possibly distribution of potential sampling locations over the investigation area to ensure the sampling plan achieves acceptable confidence levels. We used VSP to evaluate different sampling scenarios as discussed below.

3.1.1.1 VSP HOT SPOT ANALYSIS

We first used VSP to the western parking lot of the Site with the primary the objective to design a sampling plan that would be capable of detecting a hypothetical ‘hot spot’ of soil contamination (in this instance, PCBs) with a circular geometry having a radius of 15 feet. The hot spot size was determined based on the extent of impact around sample GT4, which was collected west of the dewatering at the edge of the sampling area. The western parking lot area is approximately 97,735 ft^2 (9,080 m^2) and is comprised of the paved parking area west of the former dewatering containment area and north of the former sediment management facility (SMF). VSP generated the number of samples, a triangular grid spacing for sample locations, and a total sampling cost based on a probability of detection level input by the user and unit sampling costs.

Several sampling designs were generated based on individual scenarios where the probability of hotspot detection was specified at confidence levels of 75%, 85%, and 95%. The size and shape of the hypothetical target ‘hot spot’ was not varied. A statistical report for each confidence level scenario is included in Appendix A. In summary, a 75% detection probability confidence level resulted in a grid spacing of 33 feet (942 ft^2) and 105 sampling locations. An 85% detection probability confidence level resulted in a grid spacing of 31 feet (832 ft^2) and 117 sampling locations. The most conservative scenario utilized a 95% detection probability confidence level and resulted in a grid spacing of 29 feet (727 ft^2) with 135 sampling locations.

The number of sample locations, which varied from 105 to 135 locations appeared unreasonable based on the following reasons:

- We did not find evidence that this area, with the exception of the SMF, which has already been sampled, was ever used for any purpose except parking of vehicles.
- Sample GT4, which was impacted with PCBs, was collected in the area along a former preferential pathway and a dewatering pad water release. The area of impact was limited to immediately along the former preferential pathway and PCBs were not identified above the screening levels in the other samples in the area.
- The USEPA has not considered this area one of concern in the past.

3.1.1.2 VSP FIXED THRESHOLD ANALYSIS

We then evaluated the VSP scenario of comparing the data to a standard (fixed threshold). We assumed the soil in the western parking lot meets the PCB standards as the null hypothesis. Consistent with what was performed in the *Post Remedial Monitoring Plan* (PRS 2010) using VSP, 5% was chosen as the alpha (α) error or the acceptable probability we accept that the soil in the western parking lot meets the standards when in fact, they does not. The beta (β) error, the acceptable probability the western parking lot will be remediated when it does not need to be, was set at 50%. The delta (Δ) or gray area is the average amount the end user of the data will allow the standard to be exceeded and still assume the soil in the western parking lot meets the standards. We used 1 ppm as the allowable VSP gray area based on the commercial/industrial cleanup standard of 8.66 ppm (1/8.66 or 11.55% of the standard). We used the 1 ppm VSP standard and the standard deviation of the PCB data collected from west of the dewatering pad with and without the outlier (59.6ppm) as determined by ProUCL to calculate the number of samples needed.

Including the outlier for the standard deviation calculation, VSP estimated that 32 samples would be needed to representatively characterize the western parking lot data gap. Excluding the outlier, 25 samples would be needed. The difference is not significant and we selected the greater of the two options. The VSP and ProUCL statistical reports are included in Appendix A.

We will advance thirty-two (32) soil borings in the western parking lot area as shown on Figure 3. These 32 soil borings are in addition to any other samples historically collected in this area. The 32 soil boring locations will be divided between 8 judgmental locations along the western edge of the parking lot/flood control berm and 24 systematic locations spaced across the western parking lot area.

Surficial runoff from the parking area would flow to the west, toward the flood control berm on the western side of the parking lot; therefore, we will complete eight (8) soil borings (PL1 through PL8) along the western edge of the parking lot and the flood control berm to evaluate the potential for transport of PCB-impacted soil migrating with stormwater runoff.

We will complete the remaining twenty-four (24) soil borings (PL9 through PL32) in a systematic, triangular sampling grid across the parking lot. The triangular sampling grid was determined based on the USEPA *Guidance on Choosing a Sampling Design for Environmental Data Collection*. Based on triangular grid methodology, the western parking lot area of approximately 97,735 ft^2 and 24 samples to be collected on the grid pattern, the grid nodes on each row of samples would be spaced approximately 68 feet apart. The subsequent row would be offset approximately 58 feet below to the center of the distance between the grid nodes on the previous row. Sample locations on the western parking lot of the Site are shown on Figure 3.

Based on historical information on the Site, PCB-impacted soil is predominantly present in near surface soil. Soil borings will be driven to 4 feet below ground surface (bgs) and samples will be collected will be collected from each sampling locations from the ground surface or immediately below the pavement (0 – 6 inches) and from the depths shown in Table 1.

3.1.2 SAMPLING RATIONALE FOR THE FORMER DEWATERING CONTAINMENT AREA ON THE SITE (DATA GAP #2)

Site restoration activities include repair and removal of portions of the asphalt pavement present on the former dewatering pad on the Site. To facilitate proper characterization and disposal of the pavement waste materials, we will to collect representative asphalt samples for laboratory analysis. Pavement and building slab cores will be collected as part of the pavement and geotechnical evaluation of the former dewatering pad (See Section 3.3). We will to divide a portion of the asphalt pavement for environmental purposes and collect 6 samples of the asphalt for laboratory analysis. The asphalt pavement is anticipated to be approximately 3 inches in thickness and the environmental sample will include a composite of the thickness of the asphalt pavement layer. The asphalt pavement samples will be analyzed for PCBs. See section 3.3.1.1 for further information regarding the geotechnical and pavement evaluation for this area. Pavement sampling locations in this area will be determined based upon the field review program discussed in Section 3.3.1.1; however, general anticipated locations of the pavement samples are shown on Figure 3.

3.1.3 SAMPLING RATIONALE FOR THE EASTERN PORTION OF THE SITE (DATA GAP #3)

Nine (9) soil borings will be completed in the eastern portion of the Site. These soil boring locations were determined to adequately delineate the extent of PCB–impacted soil exceeding the PTW criteria that is planned to be removed during future remedial activities.

Soil borings will be driven to depths from 4 feet to 6 feet bgs and samples will be collected from each sampling locations from the ground surface or immediately below the concrete (0 – 6 inches) and from the depths shown in Table 1. SME will submit all of the samples for laboratory analysis but will request the laboratory to hold the samples as noted in Table 1. Sample locations on the eastern portion of the Site are shown on Figure 3.

3.1.4 SAMPLING RATIONALE FOR OFFSITE STREET ROW SAMPLING (DATA GAP #4)

3.1.4.1 CLEVELAND STREET ROW

Fourteen (14) soil borings will be completed along the Cleveland Street ROW to evaluate the potential for impacted soil to extend from the Property into the ROW. The soil borings will be located in the Cleveland Street ROW with a spacing of 45 feet between borings. The samples will be collected using a hand auger and/or direct push rig. Soil borings will be driven to depths up to 8 feet bgs and samples will be collected from each sampling locations from the ground surface or immediately below the pavement (0 – 6 inches) and from the depths shown in Table 1. Soil boring locations in the Cleveland Street ROW are shown on Figure 3.

3.1.4.2 HICKORY STREET ROW

Five (5) soil borings (including one soil boring associated with the delineation borings associated with the sampling on the eastern portion of the Site) will be completed along the Hickory Street ROW to evaluate the potential for impacted soil to extend from the Property into the ROW. The soil borings will be located in the Hickory Street ROW with a spacing of 40 feet between borings. The samples will be collected using a hand auger and/or direct push rig. Soil borings will be driven to depths up to 8 feet bgs and samples will be collected from each sampling locations from the ground surface or immediately below the pavement (0 – 6 inches) and from the depths shown in Table 1. Soil boring locations in the Hickory Street ROW are shown on Figure 3. Sample locations on the eastern portion of the Site are shown on Figure 3.

3.1.5 SAMPLING RATIONALE FOR OFFSITE PARK SAMPLING (DATA GAPS #5 AND #6)

For the Rochester Park, we used the VSP scenario of comparing the data to a standard or fixed threshold. We assumed the soil in Rochester Park meets the PCB standards as the null hypothesis. Consistent with the previous analysis using VSP, 5% was chosen as the alpha (α) error, 50% was chosen as the beta (β) error, and the delta (∆) for the park was chosen as 1.91 ppm (based on the risk-based soil concentration or fixed threshold of 18 ppm). We used the standard deviation of the park data with and without the outlier (83 ppm) as determined by ProUCL to calculate the number of samples needed.

Using the data set that included the outlier, the standard deviation is 16.59 and VSP indicates 206 samples are needed. If we eliminate the outlier, the standard deviation is 3.337 and VSP calculates that 10 samples are needed. We do not believe 10 samples would be sufficient to evaluate potential exposures at Rochester Park; therefore, we re-evaluated with a beta (β) error of 10% and VSP calculated that 28 samples would be sufficient. We will collect 28 additional samples to supplement the 24 previously collected samples (Appendix A). The sample locations are discussed further in Section 3.1.4.1 and 3.1.4.2.

3.1.5.1 NORTHERN PORTION OF ROCHESTER PARK - FORMER LANDFILL (DATA GAP #5)

Eight (8) soil borings will be completed on the northern portion of Rochester Park, which was historically used as a landfill (OPAL1 to OPAL8). Soil boring locations on the northern portion of the park will be based on the landfill areas identified on the historical aerial photography and are shown on Figure 4. The samples will be collected using a hand auger and/or direct push rig. Soil borings in the northern portion of the park will be driven to depths up to 8 feet bgs and samples will be collected from each sampling locations from the ground surface or immediately below the pavement (0 – 6 inches) and from the depths shown in Table 1. If fill materials are encountered in the northern portion of the park, the soil borings will be advanced to the terminal depth of fill materials or depth of encountered groundwater, whichever is first encountered first. Soil boring locations in the northern portion of the park are shown on Figure 4.

3.1.5.2 SOUTHERN PORTION OF ROCHESTER PARK (DATA GAP #6)

Sixteen (16) soil borings will be completed in the southern portion of Rochester Park. A drainage ditch, which extended from the former Tecumseh Plant to the southeast to the Sheboygan River, was historically present in the southern portion of the Park. Four (4) judgmental sample locations (OPA1 to OPA4) will targeted along the former alignment of this drainage ditch to evaluate if historical runoff from the Site transported PCB-impacted soil along the ditch. The judgmental sample locations will be selected for optimal coverage of the drainage ditch in conjunction with the below noted gridded pattern.

Twelve (12) soil boring locations (OPA5 through OPA16) will be completed in a systematic, triangular grid pattern across the southern portion of the park. Based on triangular grid methodology, the southern park area of approximately 351,060 ft^2 and 12 samples to be collected on the grid pattern, the grid nodes on each row of samples would be spaced approximately 180 feet apart. The subsequent row would be offset approximately 160 feet below to the center of the distance between the grid nodes on the previous row.

Soil borings in the southern portion of the park will be driven to 4 feet bgs and samples will be collected will be collected from each sampling locations from the ground surface or immediately below the pavements (0 – 6 inches) and from the depths shown in Table 1. Soil boring on the southern portion of the park are shown on Figure 4.

3.2 ENVIRONMENTAL SAMPLING PROCEDURES AND METHODS

Soil sampling, quality control (QC) sampling, and waste management procedures and methods are summarized in this subsection. Sampling activities will be conducted in accordance with the Quality Assurance Project Plan (QAPP)[1]. Sampling locations will be documented in the field with a sub-meter accurate GPS unit.

3.2.1 SOIL SAMPLING PROCEDURES

We will collect soil samples according to the methods described in the following standard operating procedures that are included in the project QAPP:

- SOP 1 - Soil and Groundwater Sampling Using Direct-Push Methods.
- SOP 2 - Soil Sampling with a Hand Auger.
- SOP 4 - Methanol Preservation.
- SOP 7 - Field Measurements Using a Photoionization Detector (PID)
- SOP 9, Decontamination of Field Equipment

We will advance a soil boring at each location using hydraulically driven, direct-push coring equipment or a hand auger for collection of soil samples as described in Section 3.1. The details of our sampling activities are provided below:

- We will collect continuous soil samples from each boring, visually classify them in the field, and note physical indicators of man-made materials and environmental contamination. Sampling intervals will begin at the ground surface for areas with topsoil or below the base of the surface layer for gravel covered areas or concrete or asphalt pavement areas.
- We will field-screen the soil samples using a portable 11.2 eV PID to identify the potential presence of volatile organic compounds (VOCs). Samples with elevated VOC field screening results (>5 ppm) will be submitted to the laboratory for analysis of VOCs[2]. If there are no soil samples with elevated field screening results, we will randomly select 10% of the soil samples for VOC analysis.
- We will collect soil samples for chemical analyses in accordance with the plan described in Table 1, and summarized as follows.
    - Western parking lot on the Site (PL1 through PL8) - We will advance borings to a depth of 4 feet bgs and will collect soil samples from three intervals: 0' – 0.5', 0.5 – 2' and 2 – 4'.
        - Soil samples from the 0' – 0.5' interval will be analyzed for PCBs, PAHs and metals. Known PAH-impacted soil on the Site was limited to the 0 – 0.5' interval; therefore, PAH and metals analysis will be completed on this interval.
        - Soil samples from the 0.5' – 2' interval will be analyzed for PCBs.
        - Soil samples from the 2' – 4' interval will be archived for potential analysis.

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[1] Revision 2, Pollution Risk Services, LLC and URS Corp., May 2004 and updated in 2015 by SME and provided in Serial Letter #21

[2] It is SME's experience that soil samples that have PID reading less than 5 ppm typically do not contain VOCs or VOCs at levels posing risks to receptors.

    - If unnatural coloration or man-made debris are observed, soil samples from the 0.5' – 2' and 2' – 4' intervals may also be analyzed for PAHs and metals.

- Eastern portion of the Site (SBP11 through SBP15, SBP6(1N,1E,1S,1W) and BP3(1N,1E,1S,1W)) - We will advance borings to depth from 4 feet to 6 feet bgs and will collect soil samples from intervals consistent with the previously identified impact in the nearby borings.
    - Soil samples will be analyzed for PCBs from the set intervals noted in Table 1.

- Off-site Roadway ROWs (CS1 through CS14 and HS1 through HS4) - We will advance borings to a depth of 8 feet bgs and will collect soil samples from five intervals: 0' – 0.5', 0.5 – 2', 2 – 4', 4' – 6' and 6' – 8'.
    - Soil samples from the 0' – 0.5' interval will be analyzed for PCBs, PAHs and Metals. Know PAH-impacted soil on the Site was limited to the 0 – 0.5' interval; therefore, PAH and metals analysis will be completed on this interval.
    - Soil samples from the 0.5' – 2' and 4' – 6' intervals will be analyzed for PCBs.
    - Soil samples from the 2' – 4' and 6' – 8' intervals will be archived for potential analysis.
    - If unnatural coloration or man-made debris are observed, soil samples from the 2' – 4' and 6' – 8' intervals may also be analyzed for PAHs and metals.

- Off-site Park Area – Historical Grassy Ditch in the Southern Portion (OPA1 through OPA4) - We will advance borings to a depth of 4 feet bgs and will collect soil samples from three intervals: 0' – 0.5', 0.5 – 2', and 2 – 4'.
    - Soil samples from the 0' – 0.5' interval will be analyzed for PCBs, PAHs and Metals. Potential impacts from runoff or surficial deposition of PAHs or metals would be limited to the 0 – 0.5' interval; therefore, PAH and metals analysis will be completed on this interval.
    - Soil samples from the 0.5' – 2' interval will be analyzed for PCBs.
    - Soil samples from the 2' – 4' intervals will be archived for potential analysis.
    - If unnatural coloration or man-made debris are observed, soil samples from the 2' – 4' interval may also be analyzed for PAHs and metals.
    - If evidence of fill materials is found during boring activities, boring will be extended to the depth of fill or depth of encountered groundwater.

- Off-site Park Area –Southern Portion (OPA5 through OPA16) - We will advance borings to a depth of 4 feet bgs and will collect soil samples from three intervals: 0' – 0.5', 0.5 – 2', and 2 – 4'.
    - Soil samples from the 0' – 0.5' interval will be analyzed for PCBs, PAHs and Metals. Potential impacts from runoff or surficial deposition of PAHs or metals would be limited to the 0 – 0.5' interval; therefore, PAH and metals analysis will be completed on this interval.
    - Soil samples from the 0.5' – 2' interval will be analyzed for PCBs.
    - Soil samples from the 2' – 4' intervals will be archived for potential analysis of PCBs, PAHs or metals.
    - If unnatural coloration or man-made debris are observed, soil samples from the 2' – 4' interval may also be analyzed for PAHs and metals.
    - If evidence of fill materials is found during boring activities, boring will be extended to the depth of fill or depth of encountered groundwater

- Off-site Park Area –Northern Portion (OPAL1 through OPAL8) - We will advance borings to a depth of 8 feet bgs and will collect soil samples from five intervals: 0' – 0.5', 0.5 – 2', 2 – 4', 4' – 6' and 6' – 8'.
    - Soil samples from the 0' – 0.5', 0.5' – 2' and 4 – 6' intervals will be analyzed for PCBs, PAHs and Metals.
    - Soil samples from the 2' – 4' and 6' – 8' intervals will be archived for potential analysis of PCBs, PAHs or metals.
    - If oily materials are observed in the 2' – 4' and 6' – 8' intervals, the samples will also be analyzed for PAHs.
    - If oily materials, unnatural coloration or man-made debris are observed, soil samples from the 2' – 4' and 6' – 8' interval may also be analyzed for PAHs and/or metals.
    - If evidence of fill materials is found during boring activities, boring will be extended to the depth of fill.

We will submit all of the samples for laboratory analysis but will request the laboratory to hold the samples as noted in Table 1. In the event the concentrations of the analyzed soil samples above the evaluation criteria noted in Section 5.1, SME will direct the laboratory to analyze the other samples from that boring for the parameters that were exceeded in the analyzed samples. Depending on the results, additional "step-out" samples may be needed. Please see Section 5.1 for a discussion of these samples.

After completion of soil sampling at each boring location, we will place soil cuttings back into their respective boreholes, fill the remaining space with hydrated bentonite, and restore the ground surface to match surrounding conditions. Excess soil cuttings will be managed as investigation-derived waste (Section 3.1.6.3).

3.2.2 ASPHALT SAMPLING PROCEDURES

As described in Section 3.3, 6 pavement cores will be completed in the former dewatering containment pad. The pavement cores will be performed with a diamond tipped drill core barrel and will extend through the thickness of the asphalt cap and former building floor slab. We will divide a portion of the asphalt pavement portion of the core for environmental analysis. The asphalt pavement portion of each core will be pulverized to a sufficient size for laboratory analysis and placed in the laboratory-supplied sample containers. The asphalt pavement samples will be analyzed for PCBs.

3.2.3 QUALITY ASSURANCE AND QUALITY CONTROL

We will minimize the potential for cross-contamination by using new, disposable, nitrile sampling gloves for collection of each soil sample; using new, disposable, plastic bowls for homogenization of each soil sample; decontaminating non-disposable soil sampling equipment before each use; and calibrating field instruments in accordance with manufacturer's instructions.

We will collect quality control (QC) samples as described in SOP 6, *Field Quality Control Samples*, included in Appendix B and as summarized in Table 1. The sample handling (SOP 10) and custody requirements, laboratory analytical methods, analysis reporting limits, and reporting protocols will be consistent with SOP 10, *Sample Labeling, Handling and Chain of Custody*, included in Appendix B and in the project QAPP.

3.2.4 WASTE MANAGEMENT

We will manage investigation-derived wastes as described in SOP 12, *Investigative Derived Wastes*, included in Appendix B and in the project QAPP.

3.3 GEOTECHNICAL AND PAVEMENT SAMPLING PLAN

3.3.1 GEOTECHNICAL AND PAVEMENT SAMPLING RATIONAL FOR SITE AND FORMER DEWATERING PAD (DATA GAP #2 AND #3)

3.3.1.1 FORMER DEWATERING CONTAINMENT AREA (DATA GAP #2)

Site restoration activities include repair and removal of portions of the asphalt pavement present on the former dewatering pad on the Site that is acting as an engineering control to prevent direct contact with the impacted soil beneath the slab. The limits of repair are scoped to include sections with large and/or wide cracks that extend the full depth of the asphalt pavement. Additional repair of the former building floor slab is also anticipated.

To address the continuity of the asphalt pavement in the dewatering containment, we will conduct a detailed visual evaluation to map out the cracks or deteriorated containment area surface (within the limits of the existing asphalt berm). Key indicators of deterioration will be wide cracks in the surface, vegetation propagation, low spots or fatigue cracked locations, or significant ponding water locations. To evaluate the extent of the repairs and cap maintenance required, we anticipate performing six (6) pavement cores (PS1 to PS6); however, additional sampling locations may be required based upon the observed extent and types of surface deterioration. Pavement cores will be performed with a diamond tipped drill core barrel and will extend through the thickness of the asphalt cap and the former building floor slab. Sampling locations are generally located on Figure 3; however, specific locations will be determined based upon the field review program.

Environmental samples of the asphalt cap will be obtained from the pavement cores for characterization and disposal of the pavement waste materials (Section 3.1.2). It is anticipated that asphalt repairs will be necessary based on deterioration; however, full depth pavement removals (asphalt + building floor) are not anticipated to be necessary at this time.

Pavement core locations will be documented in the field with a sub-meter GPS unit.

3.3.1.2 EASTERN PORTION OF THE SITE (DATA GAP #3)

Up to ten (10) soil borings (GS1 to GS10) will be completed on the eastern portion of the site for the geotechnical and pavement evaluation. Soil boring locations were determined to evaluate the existing infrastructure cap material thicknesses, currently consisting of asphalt, concrete, gravel or topsoil. The extent of each material and representative thickness data will be identified and utilized in the development of the site restoration plan. Performance of this work will be completed during the environmental evaluation portions of the program, utilizing similar sampling protocols, equipment and on-site field investigation team. Samples locations for the geotechnical and pavement evaluation are shown on Figure 3.

Pavement coring will be performed with a nominal 4-inch diameter diamond tipped core barrel to obtain an intact sample of the pavement material. Following coring, US Army Corp of Engineers, Dynamic Cone Penetrometer testing (USACE DCP) will be performed to depths between 3 feet to 4 feet bgs.

Soil borings will be driven to depths from 4 feet to 6 feet bgs, depending on the encountered subsurface materials at each boring location. After completion of soil sampling at each boring location, we will place soil cuttings back into their respective boreholes, fill the remaining space with hydrated bentonite, and restore the ground surface to match surrounding conditions. Excess soil cuttings will be managed as investigation-derived waste (Section 3.1.6.3).

Soil sampling, quality control (QC) sampling, and waste management procedures and methods will be completed in accordance with Section 3.1.5 Soil Sampling Procedures and Methods. Sampling locations will be documented in the field with a sub-meter accurate GPS unit.

4. ANALYSIS PLAN

4.1 ENVIRONMENTAL ANALYSIS PLAN

The designated laboratory will analyze soil samples for PCOC to screen for the potential presence of impact associated with the issues identified in Section 2.2 (see Table 1 for specific analytes for each sample). In addition to PCBs, PAHs, and metals, SME will to collect soil samples for analysis of VOCs if field screening indicates the presence of ionizable organic vapors.

Laboratory analyses and field screening will be performed as described in the project QAPP. Pace Analytical in Green Bay, Wisconsin will analyze the soil samples. The following USEPA methods will be used:

- PCBs – Method 8082 (Soil) and Method 8082A (Asphalt);
- Metals – Method 6010 or 6020 for cadmium, chromium, copper, lead, nickel, and zinc;
- Mercury – Method 7470 or 7471 for mercury;
- PAHs – Method 8270; and
- VOCs – Method 8260.

Laboratory testing, the analysis method reporting limits (MRLs), QA/QC procedures, and reporting protocols performed by Pace Analytical will be consistent with those described in the project QAPP.

4.2 GEOTECHNICAL ANALYSIS PLAN

The SME laboratory will review the pavement cores for existing composition, thickness and deterioration factors. Core measurements will be completed in accordance with ASTM requirements and core data logs will be prepared. Representative photographs of each core will be obtained for record. Cores will be stored in SME laboratory facilities for a period of 60 days. At which time they shall be disposed in accordance with project protocols.

5. DATA EVALUATION AND REPORTING

5.1 ENVIRONMENTAL DATA EVALUATION AND REPORTING

We will evaluate the environmental data collected during this site assessment as described in Section 4.0 - Data Verification/Validation and Usability of the project QAPP. Following data review, verification, and validation, we will prepare a summary report. The report will include details of the activities performed, procedures followed, and results. The report also will include a sampling location diagram, tabulated analytical results, soil boring logs, a copy of the laboratory analytical report for all samples collected, and a copy of the chain-of-custody (COC) records.

5.1.1 EVALUATION CRITERIA AND DECISION MAKING MATRICES FOR SITE SAMPLES

Soil cleanup criteria for the Site should be developed that is protective of human health and the environment. Planned remedial actions on the area of soil boring G4, located west of the former dewatering containment pad and east of the western parking lot, currently includes removal of the known PCB-impacted soil above the WDNR industrial/commercial cleanup criteria of 8.66 ppm. As such, the known PCB-impacted soil in the area of G4 will not require additional assessment activities or an engineering control to limit exposure. Planned remedial actions on the northern and eastern portions of the Site includes targeted removal of the known PCB-impacted soil above the PTW criteria of 100 ppm and construction of an engineered control (cap) to limit exposure.

The following sections will describe the evaluation criteria for each distinct sampling area and decision matrices for determining supplemental assessment activities that may be necessary following the sampling planned in the SAP.

5.1.1.1 WESTERN PARKING LOT SAMPLES EVALUATION CRITERIA

Evaluation for the Site depends on anticipated remedial activities on the Site; engineering controls anticipated to be used at the Site; and the final use of the Site. At this time, no remedial actions are planned for the western parking lot; however, if impacted soil is found in this area, additional remedial actions will be evaluated depending on the results of this assessment.

In the USEPA-approved 2016 SAP (SME, 2016), the WDNR industrial/commercial clean-up level for PCBs on the Site was determined to be 8.66 ppm. To evaluate if the western parking lot was impacted by historical operations on the site, we will use the soil PCB cleanup criteria of 8.66 ppm since it also matches State of Wisconsin requirements. If PCB sample results are greater than 8.66 ppm, the western parking lot would be considered to be impacted and evaluation of remedial activities and engineering controls would be necessary. To determine if PCB-impacted soil is present at concentrations that would require removal, we will use the 100 ppm USEPA PTW criteria. If PCB sample results are greater than 8.66 ppm and less than 100 ppm, the PCB-impacted soil may be suitable to remain in place with an associated engineering control. If PCB sample results are greater than 100 ppm, the PCB-impacted soil will be removed as part of the remedial activities on the Site.

To determine if PCB-impacted soil in areas of planned remedial activities will require special disposal we will use the 50 ppm TSCA criteria. The PCB criteria for disposal of soil should follow TSCA guidance where: soil with PCBs concentrations greater than 8.66 ppm and less than 50 ppm will be removed and transported to in-state landfill for disposal. Any material with PCB concentrations greater than 50 ppm would be disposed at an out-of-state, TSCA permitted, landfill for disposal.

The soil cleanup criteria for the remaining PCOC are the RSLs based on a 10^{-5} carcinogenic risk and Hazard Quotient of 1.0. If PCOC sample results are greater than the RSLs, the western parking lot would be considered to be impacted and evaluation of remedial activities and engineering controls would be necessary.

5.1.1.2 WESTERN PARKING LOT SAMPLES DECISION MAKING MATRIX

Depending on the soil results from soil samples collected in the western parking lot of the Site, additional sampling may be needed that is not specifically discussed in this plan. We will use the following decision making matrix for selecting additional sample locations in the western parking lot of the Site:

PCOC	Soil Concentration	Sample Objective / Result	Additional Evaluation
PCBs	<8.66 ppm	Clean results or delineation location for other impacted borings	No additional evaluation
	>8.66 ppm	PCB-impacted area but less than PTW. Remedial actions will consist of either remove or cap, depending on size.	Step out 15 feet in all 4 cardinal directions possible and complete borings to a depth of 4 feet bgs or below the encountered impact per Table 1 and collect samples at intervals shown in Table 1.
	>50 ppm	PCB-impacted area TSCA criteria requiring special disposal. Remedial actions will consist of either remove or cap, depending on size.	
	>100 ppm	PCB-impacted area above PTW. Remedial actions will include removal of the impacted area.	Step out 15 and 30 feet in all 4 cardinal directions necessary and collect samples to a depth of 4 feet to 8 feet bgs feet per Table 1 and collect samples at intervals shown in Table 1.
PAHs, metals, VOCs	<RSLs (10^{-5})	Clean results or delineation location for other impacted borings	No additional evaluation
	>RSLs (10^{-5})	PCOC-impacted area. Additional evaluation of the data will be made that could include a property-specific Risk assessment or a comparison to area background levels	Step out 15 feet in all 4 cardinal directions possible and complete borings to a depth of 4 feet bgs or below the encountered impact per Table 1 and collect samples at intervals shown in Table 1.

5.1.1.3 EASTERN PORTION OF THE SITE EVALUATION CRITERIA

Evaluation for the Site depends on anticipated remedial activities on the Site; the final use of the Site; and engineering controls anticipated to be used at the Site. Planned remedial actions on the northern and eastern portions of the Site include removal of the known PCB-impacted soil above the 100-ppm PTW criteria and construction of an engineering control (cap) to limit exposure. If sample results are less than 100 ppm, the impacted soil may be suitable to remain in place with an associated engineering control. If sample results are greater than 100 ppm, the impacted soil will be removed as part of the remedial activities on the Site.

The soil cleanup criteria for the remaining PCOC are the RSLs based on a 10^{-5} carcinogenic risk and Hazard Quotient of 1.0. If PCOC sample results are greater than the RSLs, the eastern portion of the Site would be considered to be impacted and evaluation of remedial activities and engineering controls would be necessary.

5.1.1.4 EASTERN PORTION OF THE SITE DECISION MAKING MATRIX

Depending on the soil results from soil samples collected in the eastern portion of the Site, additional sampling may be needed that is not specifically discussed in this plan. We will use the following decision making matrix for selecting additional sample locations in the eastern portion of the Site:

PCOC	Soil Concentration	Sample Objective / Result	Additional Evaluation
PCBs	<100 mg/kg	PCB-impacted area below PTW criteria. Delineation location for limit of soil impacted above PTW criteria.	No additional evaluation
	>100 mg/kg	PCB-impacted area above PTW. Remedial actions will include removal of the impacted area.	Step out 15 feet in all 4 cardinal directions necessary and collect samples to a depth of 4 to 6 feet bgs feet per Table 1 and collect samples at intervals shown in Table 1.
PAHs, metals, VOCs	<RSLs (10^{-5})	Clean results or delineation location for other impacted borings	No additional evaluation
	>RSLs (10^{-5})	PCOC-impacted area. Additional evaluation of the data will be made that could include a property-specific Risk assessment or a comparison to area background levels	Step out 15 feet in all 4 cardinal directions possible and complete borings to a depth of 4 feet bgs or below the encountered impact per Table 1 and collect samples at intervals shown in Table 1.

5.1.2 EVALUATION CRITERIA AND DECISION MAKING MATRICES FOR OFFSITE SAMPLES

Soil cleanup criteria for samples collected from the Cleveland Street and Hickory Street ROWs and Rochester Park should be developed that is protective of human health and the environment. At this time, no remedial actions are planned for the Street ROWs or Rochester Park; however, if impacted soil is found in these areas, additional remedial actions will be evaluated depending on the results of this assessment.

The following sections will describe the evaluation criteria for each distinct sampling area and decision matrices for determining supplemental assessment activities that may be necessary following the sampling planned in the SAP.

5.1.2.1 CLEVELAND STREET AND HICKORY STREET ROW EVALUATION CRITERIA

Evaluation for the Cleveland Street and Hickory Street ROW depends on the surface materials at the sampling location. At this time, no remedial actions are planned for along Cleveland Street and Hickory Street. To evaluate if the Cleveland Street and Hickory Street ROWs were impacted by historical operations on the Site, we will use the soil PCB cleanup criteria of 8.66 ppm. The soil cleanup criteria for the remaining PCOC are the RSLs based on a 10^{-5} carcinogenic risk and Hazard Quotient of 1.0.

If PCB-impacted or PCOC-impacted soil greater is found in near surface and exposed soil along the street pavement, additional remedial actions will be evaluated depending on the results of this assessment. If PCB-impacted or PCOC-impacted soil is found below the existing street pavements, remedial actions will not be necessary due to the street pavements acting as an engineering control; however, the City of Sheboygan Falls will be notified of the impacted soil to address exposure during future construction or maintenance activities associated with the roadway and municipal or private utilities.

5.1.2.2 CLEVELAND STREET AND HICKORY STREET ROW DECISION MAKING MATRIX

Depending on the soil results from soil samples collected in the Cleveland Street and Hickory Street ROW, additional sampling may be needed that is not specifically discussed in this plan. We will use the following decision making matrix for selecting additional sample locations in the Cleveland Street and Hickory Street ROW:

PCOC	Soil Concentration	Sample Objective / Result	Additional Evaluation
PCBs	<8.66 mg/kg	Clean results or delineation location for other impacted borings	No additional evaluation
	>8.66 mg/kg	PCB-impacted area above WDNR criteria. Notify the City of Sheboygan Falls of impacted soil. If impacted soil is present in near surface and exposed soil, evaluate engineering control of area.	Step out 15 feet in all 4 cardinal directions necessary and collect samples to a depth of 4 to 8 feet per Table 1 and collect samples at intervals shown in Table 1.
PAHs, metals, VOCs	<RSLs (10^{-5})	Clean results or delineation location for other impacted borings	No additional evaluation
	>RSLs (10^{-5})	PCOC-impacted area. Additional evaluation of the data will be made that could include a property-specific Risk assessment or a comparison to area background levels	Step out 15 feet in all 4 cardinal directions possible and complete borings to a depth of 4 feet bgs or below the encountered impact per Table 1 and collect samples at intervals shown in Table 1.

5.1.2.3 ROCHESTER PARK EVALUATION CRITERIA

Evaluation for Rochester Park depends on the surface materials at the sampling location. At this time, no remedial actions are planned for Rochester Park. To evaluate if the Rochester Park was impacted by historical operations on the Site, we will use the recreational standard accepted by USEPA.

If impacted soil is found in near surface and exposed soil in Rochester Park, additional remedial actions will be evaluated depending on the results of this assessment. If impacted soil is found in soil below the existing pavements, remedial actions will not be necessary due to the pavements acting as an engineering control; however, the City of Sheboygan Falls will be notified to address future construction or maintenance activities.

5.1.2.4 ROCHESTER PARK DECISION MAKING MATRIX

Depending on the soil results from soil samples collected from Rochester Park, additional sampling may be needed that is not specifically discussed in this plan. We will use the following decision making matrix for selecting additional sample locations from Rochester Park:

PCOC	Soil Concentration	Sample Objective / Result	Additional Evaluation
PCBs	<8.66 mg/kg	Clean results or delineation location for other impacted borings	No additional evaluation
	<50 mg/kg	PCB-impacted area above WDNR criteria.	Step out 15 feet in all 4 cardinal directions necessary and collect samples to a depth of 4 to 8 feet per Table 1 and collect samples at intervals shown in Table 1.
	>100 mg/kg	PCB-impacted area above PTW. Remedial actions will include removal of the impacted area.	Step out 15 and 30 feet in all 4 cardinal directions necessary and collect samples to a depth of 4 to 8 feet bgs feet per Table 1 and collect samples at intervals shown in Table 1.
PAHs, metals, VOCs	<RSLs (10^{-5})	Clean results or delineation location for other impacted borings	No additional evaluation
	>RSLs (10^{-5})	PCOC-impacted area. Additional evaluation of the data will be made that could include a property-specific Risk assessment or a comparison to area background levels	Step out 15 feet in all 4 cardinal directions possible and complete borings to a depth of 4 feet bgs or below the encountered impact per Table 1 and collect samples at intervals shown in Table 1.

5.2 GEOTECHNICAL DATA EVALUATION AND REPORTING

Data from the evaluations will be tabulated for design engineer's use in development of the Site Plan. A data report of existing conditions, and preliminary limits of site pavement and the containment area will be prepared. The pavement limits plan will be preliminary and based on the developed site data.

6. ESTIMATED SCHEDULE

The environmental activities described in this SAP are to be implemented according to the schedule presented below. This schedule is in weeks relative to EPA approval of the SAP.

- Field Sampling ....Within weeks 1 - 6
- Laboratory Analyses .... Within 4 weeks of sample receipt
- Data Evaluation and Reporting .... Within 12 weeks of sample receipt

7. REFERENCES

1990, Remedial Investigation and/Enhanced Screening Report, Sheboygan River and Harbor, BB&L.

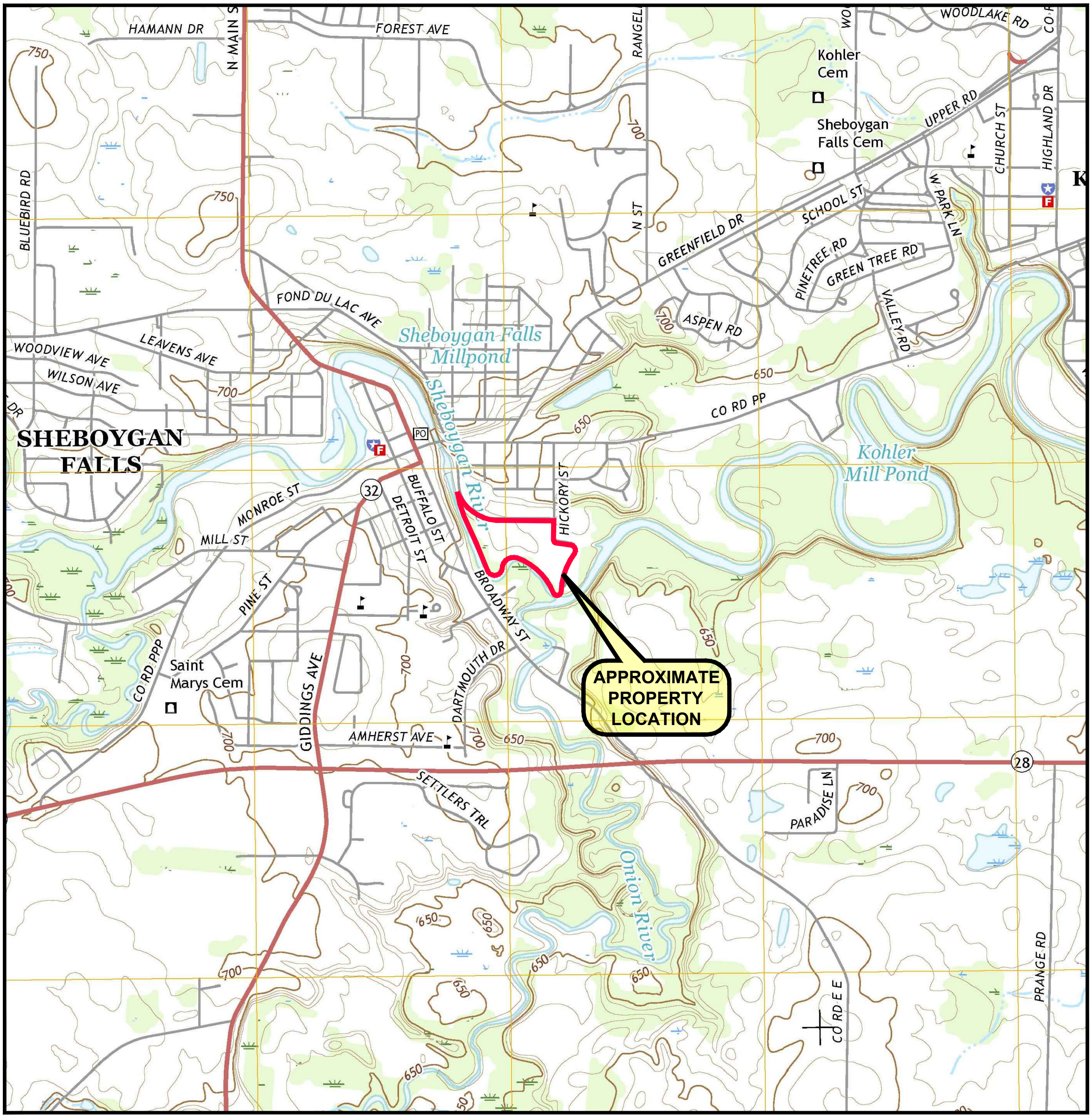
1993, Baseline Human Health Risk Assessment, USEPA.

1995, Risk Assessment for the Sheboygan River, Environ Corporation.

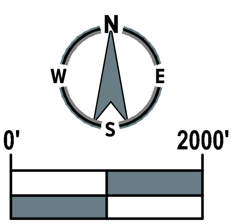
2016, Sampling and Analysis Plan, Tecumseh Dewatering Site, SME

2020, Serial Letter #62, SME

FIGURES



Base map obtained from USGS Store website



SCALE: 1" = 2000'

USGS QUADRANGLE(s) REFERENCED

SHEBOYGAN FALLS (WI) 2016

No.	Revision Date	Date	5-5-2020
		Drawn By	JAB
		Designed By	AJL
		Scale	1" = 2000'
		Project	069638.00.051

SITE LOCATION MAP
SHEBOYGAN RIVER SUPERFUND SITE
FORMER TECUMSEH SITE
SHEBOYGAN FALLS, WISCONSIN

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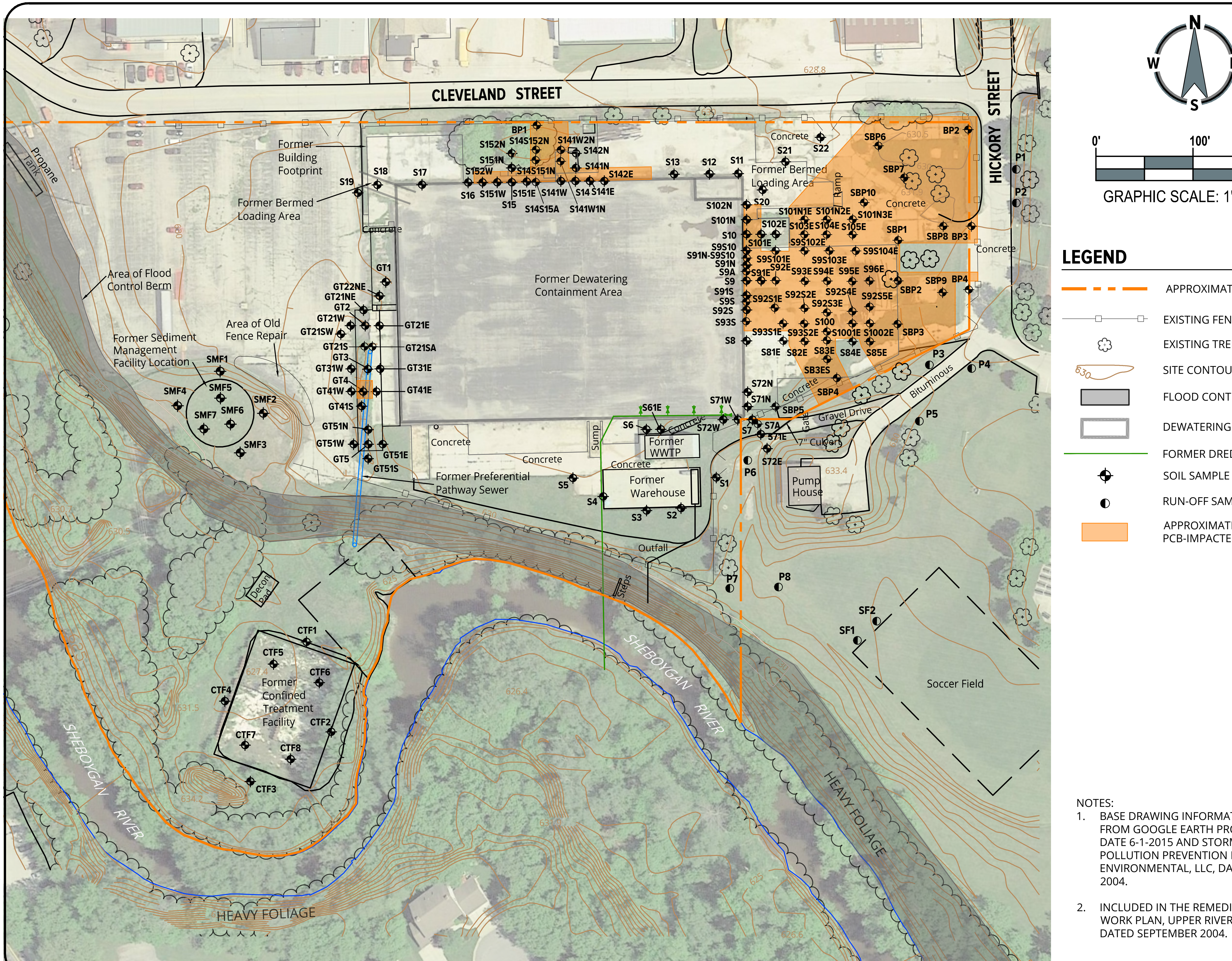
Figure No. 1

May 04, 2020 - 2:39pm - jblake \\sme-inc\pz\WIP\069638.00\CAD\069638.00.051\rev2\069638.00-TopoMap.dwg



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GRAPHIC SCALE: 1" = 100'

LEGEND

- APPROXIMATE SITE BOUNDARY
- EXISTING FENCE
- EXISTING TREE AND/OR BRUSH
- SITE CONTOURS
- FLOOD CONTROL BERM
- DEWATERING PAD
- FORMER DREDGE SLURRY PIPE
- SOIL SAMPLE LOCATION
- RUN-OFF SAMPLE LOCATION
- APPROXIMATE AREA OF PCB-IMPACTED SOIL

NOTES:

1. BASE DRAWING INFORMATION TAKEN FROM GOOGLE EARTH PRO WITH IMAGE DATE 6-1-2015 AND STORMWATER POLLUTION PREVENTION PLAN, BY PETRO ENVIRONMENTAL, LLC, DATED SEPTEMBER 2004.
2. INCLUDED IN THE REMEDIAL ACTION WORK PLAN, UPPER RIVER - PHASE 1, DATED SEPTEMBER 2004.

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Project
SHEBOYGAN RIVER SUPERFUND SITE

Project Location
FORMER TECUMSEH SITE SHEBOYGAN FALLS, WISCONSIN

Sheet Name
2016 / 2018 PCB-IMPACTED SOIL DIAGRAM

No.	Revision Date

Date: 5-5-2020

CADD: JAB

Designer: KE/AJL

Scale: AS NOTED

Project: 069638.00.051

Figure No.: 2

DRAWING NOTE: SCALE DEPICTED IS MEANT FOR 11" X 17" AND WILL SCALE INCORRECTLY IF PRINTED ON ANY OTHER SIZE MEDIA

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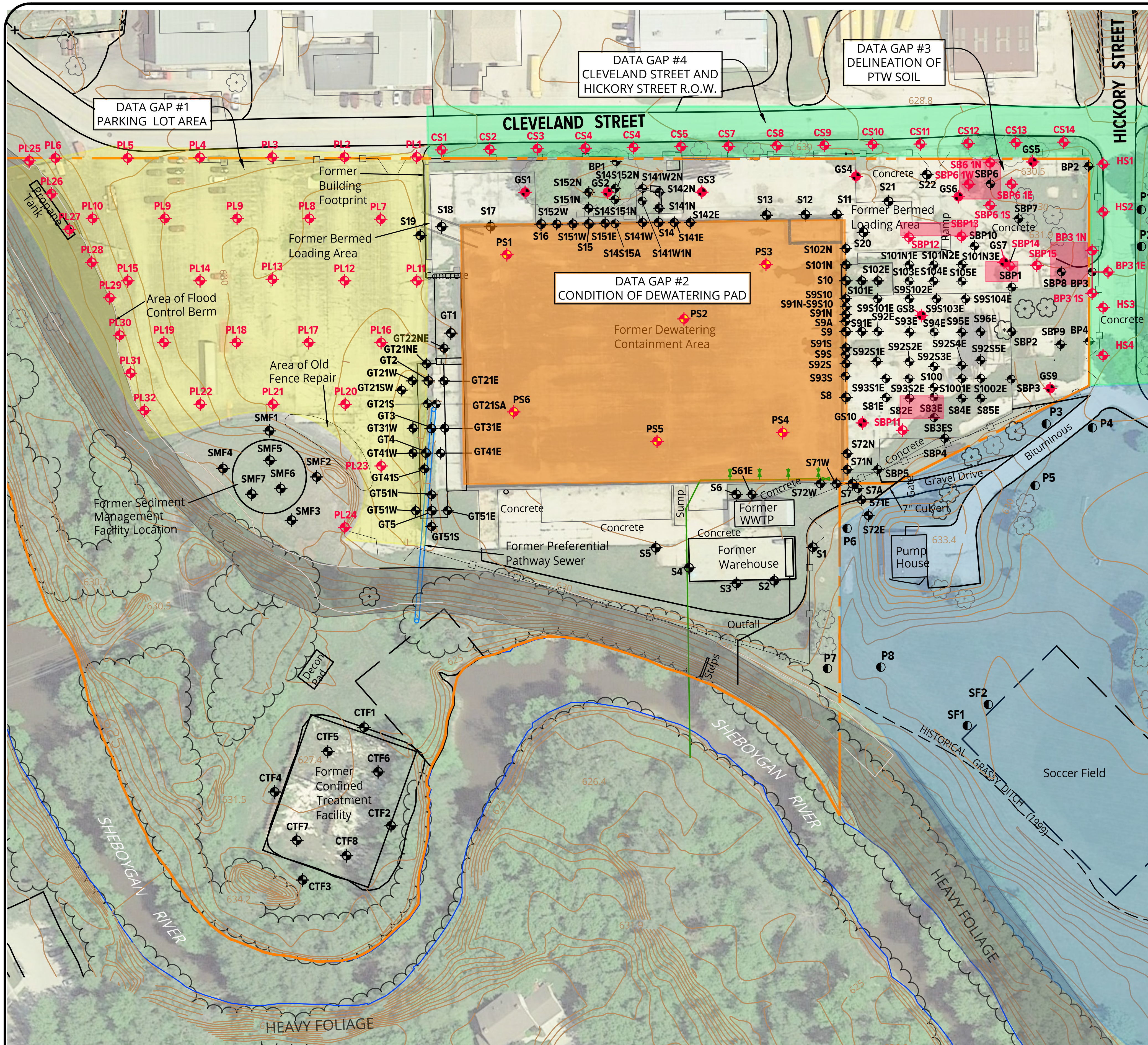

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0' 100' 200'

GRAPHIC SCALE: 1" = 100'

LEGEND

- APPROXIMATE SITE BOUNDARY
- EXISTING FENCE
- EXISTING TREE AND/OR BRUSH
- SITE CONTOURS
- FLOOD CONTROL BERM
- DEWATERING PAD
- FORMER DREDGE SLURRY PIPE
- SOIL SAMPLE LOCATION
- RUN-OFF SAMPLE LOCATION
- PROPOSED BORING LOCATION
- PAVEMENT BORING LOCATION
- GEOTECHNICAL BORING LOCATION

NOTES:

1. BASE DRAWING INFORMATION TAKEN FROM GOOGLE EARTH PRO WITH IMAGE DATE 6-1-2015 AND STORMWATER POLLUTION PREVENTION PLAN, BY PETRO ENVIRONMENTAL, LLC, DATED SEPTEMBER 2004.
2. INCLUDED IN THE REMEDIAL ACTION WORK PLAN, UPPER RIVER - PHASE 1, DATED SEPTEMBER 2004.

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Project
SHEBOYGAN RIVER SUPERFUND SITE

Project Location
FORMER TECUMSEH SITE
SHEBOYGAN FALLS, WISCONSIN

Sheet Name
PROPOSED SITE AND STREET R.O.W. SAMPLE LOCATIONS

No.	Revision Date

Date: 4-16-2020
CADD: JAB
Designer: KE/AJL
Scale: AS NOTED
Project: 069638.00.051
Figure No.: 3

DRAWING NOTE: SCALE DEPICTED IS MEANT FOR 11" X 17" AND WILL SCALE INCORRECTLY IF PRINTED ON ANY OTHER SIZE MEDIA

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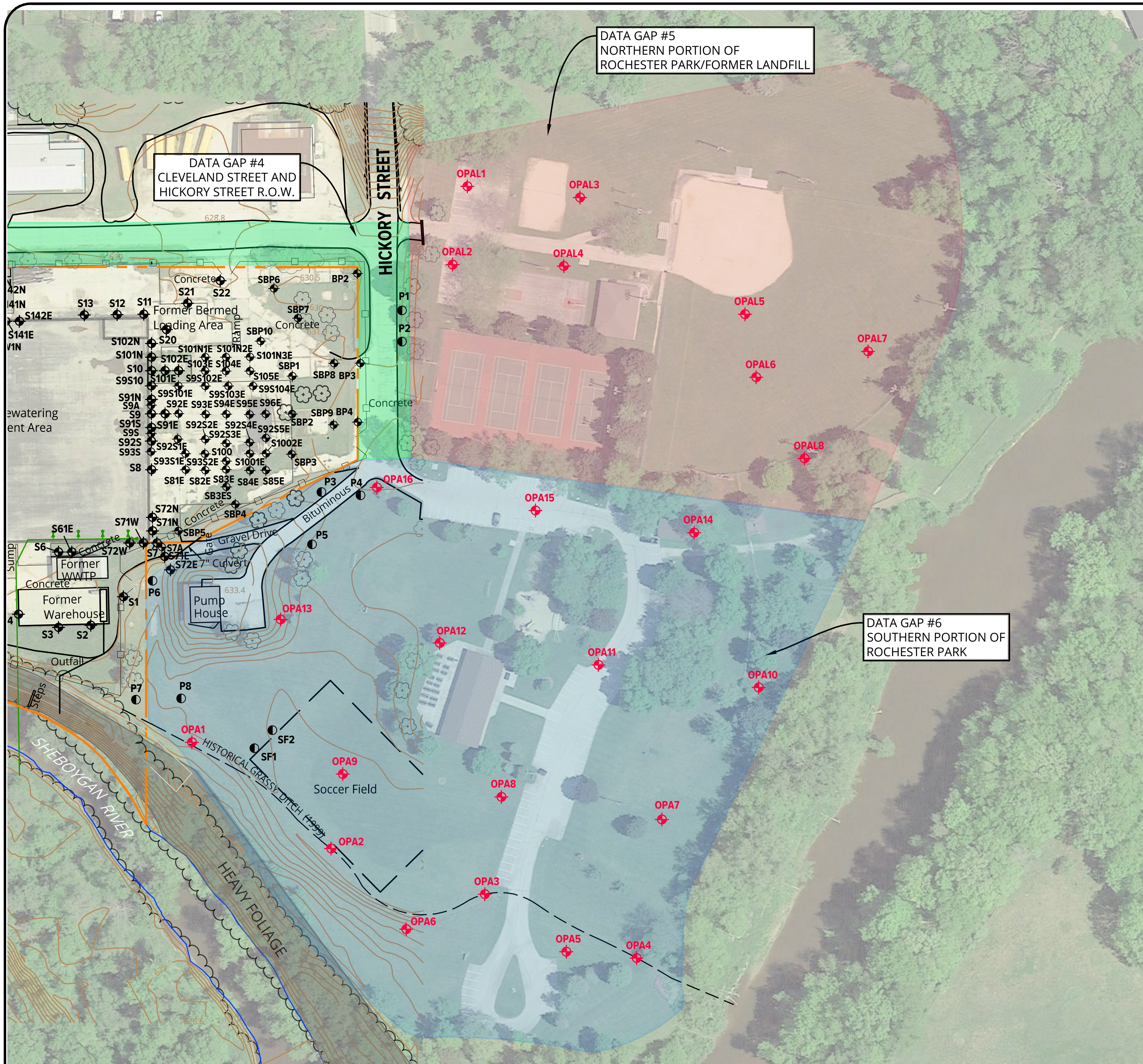

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0' 120' 240'

GRAPHIC SCALE: 1" = 120'

LEGEND

- APPROXIMATE SITE BOUNDARY
- EXISTING FENCE
- EXISTING TREE AND/OR BRUSH
- SITE CONTOURS
- FLOOD CONTROL BERM
- DEWATERING PAD
- FORMER DREDGE SLURRY PIPE
- SOIL SAMPLE LOCATION
- RUN-OFF SAMPLE LOCATION
- PROPOSED BORING LOCATION

NOTES:

1. BASE DRAWING INFORMATION TAKEN FROM GOOGLE EARTH PRO WITH IMAGE DATE 6-1-2015 AND STORMWATER POLLUTION PREVENTION PLAN, BY PETRO ENVIRONMENTAL, LLC, DATED SEPTEMBER 2004.
2. INCLUDED IN THE REMEDIAL ACTION WORK PLAN, UPPER RIVER - PHASE 1, DATED SEPTEMBER 2004.

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Project
SHEBOYGAN RIVER SUPERFUND SITE

Project Location
FORMER TECUMSEH SITE SHEBOYGAN FALLS, WISCONSIN

Sheet Name
PROPOSED OFF-SITE SAMPLE LOCATIONS

No.	Revision Date

Date	4-16-2020
CADD	JAB
Designer	KE/AJL
Scale	AS NOTED
Project	069638.00.051
Figure No.	4

DRAWING NOTE: SCALE DEPICTED IS MEANT FOR 11" X 17" AND WILL SCALE INCORRECTLY IF PRINTED ON ANY OTHER SIZE MEDIA

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PLOT DATE: May 08, 2020 - 9:52am - jblake

TABLES

TABLE 1: PROPOSED SAMPLE COLLECTION AND ANALYSIS

TABLE 1

PROPOSED SAMPLE COLLECTION AND ANALYSES
SHEBOYGAN SUPERFUND SITE
TECUMSEH SITE
SHEBOYGAN FALLS, WISCONSIN
SME Project No. 069638.00.051

Sample Target	Sample ID	Number of Locations	Maximum Boring Depth (feet bgs)	Target Sample		Media	ANALYTES							
				Sample Depth (feet bgs)	Rationale		PCBs[1]		PAHs[1]		Metals[1]		VOCs[1]	
							ANALYZED	ARCHIVED	ANALYZED	ARCHIVED	ANALYZED	ARCHIVED	ANALYZED	ARCHIVED
On-Site Western Portion of Site Parking Lot Data Gap Area Along Western Berm	PL1 though PL8	8	4	**0 - 0.5[2]** **0.5 - 2** *2 - 4*	Surficial runoff and potential transport of PCB-impacted soil would flow toward the flood control berm on the western portion of the Site. PCB concentrations generally highest in near surface soil across the Site. Collection of deeper sample for potential analysis.	Soil	16	8	8	16	8	16	Soil samples with PID > 5ppm. Minimum of 10% of total analyzed soil samples	
On-Site Western Portion of Site Parking Lot Data Gap Area Gridded Area	PL9 though PL32	24	4	**0 - 0.5[2]** **0.5 - 2** *2 - 4*	PCB concentrations generally highest in near surface soil across the Site. Collection of deeper sample for potential analysis.	Soil	48	24	24	48	24	48		
On-Site - Eastern Portion of Site Delineation of PTW soils	SBP11 through SBP12	2	4	**0 - 0.5[2]** **0.5 - 2** *2 - 4*	Horizontal delineation of identified PCB-impacted soil in the area of S101N1E and S82E on the eastern portion of the Site.	Soil	4	2	0	0	0	0		
	SBP13 through SBP15	3	6	**0 - 0.5[2]** **0.5 - 2** **2 - 4** **4 - 6**	Horizontal delineation of identified PCB-impacted soil in the area of S101N3E on the eastern portion of the Site.	Soil	12	0	0	0	0	0		
	SBP6 1N	1	4	**0 - 0.5** **0.5 - 2** *2 - 4*	Horizontal delineation of identified PCB-impacted soil around SBP6 on the eastern portion of the Site.	Soil	2	1	0	0	0	0		
	SBP6 1E	1	4			Soil	2	1	0	0	0	0		
	SBP6 1S	1	4			Soil	2	1	0	0	0	0		
	SBP6 1W	1	4			Soil	2	1	0	0	0	0		
	BP3 1N	1	6	**0 - 0.5[2]** **0.5 - 2** **2 - 4**	Horizontal delineation of identified PCB-impacted soil in the area of BP3 on the eastern portion of the Site.	Soil	3	0	0	0	0	0		
	BP3 1E	1	6			Soil	3	0	0	0	0	0		
	BP3 1S	1	6			Soil	3	0	0	0	0	0		
Onsite Former Dewatering Containment Pad Asphalt Pavement Samples	PS1 to PS6	6	0.25	**0 - 0.25**	PCB information for asphalt disposal during remedial actions.	Asphalt	6	0	0	0	0	0	NA	
Offsite Roadways Along Cleveland Street ROW	CS1 though CS14	14	8	**0 - 0.5[2]** **0.5 - 2** *2 - 4* **4 - 6** *6 - 8*	PCB concentrations generally highest in near surface soil across the Site. Collection of deeper sample for potential analysis.	Soil	42	28	14	56	14	28	Soil samples with PID > 5ppm. Minimum of 10% of total analyzed soil samples	
Offsite Roadways Along Hickory Street ROW	HS1 though HS4 (BP3 1E above)	4	8	**0 - 0.5[2]** **0.5 - 2** *2 - 4* **4 - 6** *6 - 8*	PCB concentrations generally highest in near surface soil across the Site. Collection of deeper sample for potential analysis.	Soil	12	8	4	16	4	8		

TABLE 1

PROPOSED SAMPLE COLLECTION AND ANALYSES
SHEBOYGAN SUPERFUND SITE
TECUMSEH SITE
SHEBOYGAN FALLS, WISCONSIN
SME Project No. 069638.00.051

Sample Target	Sample ID	Number of Locations	Maximum Boring Depth (feet bgs)	Target Sample: Sample Depth (feet bgs)	Target Sample: Rationale	Media	ANALYTES: PCBs[1] ANALYZED	PCBs[1] ARCHIVED	PAHs[1] ANALYZED	PAHs[1] ARCHIVED	Metals[1] ANALYZED	Metals[1] ARCHIVED	VOCs[1] ANALYZED	VOCs[1] ARCHIVED
Offsite Park Area Southern Portion Historical Grassy Ditch	OPA1 through OPA4	4	4	**0 - 0.5**[2] **0.5 - 2** *2 - 4*	PCB concentrations generally highest in near surface soil. PCBs in the Park area would be from surficial runoff or deposition from flood events. Historical re-grading of the park may have changed the grade of the area up to 2 feet. Collection of deeper sample for potential analysis.	Soil	8	4	4	8	4	8	Soil samples with PID > 5ppm. Minimum of 10% of total analyzed soil samples	
Offsite Park Area Southern Portion Overall Coverage	OPA5 through OPA16	12	4	**0 - 0.5**[2] **0.5 - 2** *2 - 4*	PCB concentrations generally highest in near surface soil. PCBs in the Park area would be from surficial runoff or deposition from flood events. Historical re-grading of the park may have changed the grade of the area up to 2 feet. Collection of deeper sample for potential analysis.	Soil	24	12	12	24	12	24		
Offsite Park Area of Former Landfill	OPAL1 through OPAL8	8	8[3]	**0 - 0.5**[2] **0.5 - 2** *2 - 4*[3] **4 - 6** *6 - 8*[3]	PCB concentrations generally highest in near surface soil. PCBs in the Park area of former landfill contamination would be from historical disposal of materials from the Site. Collection of deeper sample for potential analysis.	Soil	24	16	24	16	24	16		

		PCBs ANALYZED	PCBs ARCHIVED	PAHs ANALYZED	PAHs ARCHIVED	Metals ANALYZED	Metals ARCHIVED	VOCs ANALYZED	VOCs ARCHIVED
SUBTOTALS	Soil Samples Collected	207	217	90	184	90	148	21	0
	Asphalt Samples Collected	6	0	0	0	0	0	0	0
	Subtotal Samples	**430**		**274**		**238**		**21**	

		Media	PCBs ANALYZED	PCBs ARCHIVED	PAHs ANALYZED	PAHs ARCHIVED	Metals ANALYZED	Metals ARCHIVED	VOCs ANALYZED	VOCs ARCHIVED
QC SAMPLES	Methanol Blank	Soil	0	0	0	0	0	0	2	0
	Field Blank	Soil	11	0	5	0	5	0	2	0
	Equipment Blank	Soil	11	0	5	0	5	0	2	0
	Field Duplicate	Soil	11	0	5	0	5	0	2	0
	Subtotal Soil QC Samples	Soil	33	0	15	0	15	0	8	0
	Equipment Blank	Asphalt	1	0	0	0	0	0	0	0
	Field Duplicate	Asphalt	1	0	0	0	0	0	0	0
	Subtotal Asphalt QC Samples	Asphalt	2	0	0	0	0	0	0	0
	Subtotal QC Samples	**All**	**35**	**0**	**15**	**0**	**15**	**0**	**8**	**0**

		PCBs ANALYZED	PCBs ARCHIVED	PAHs ANALYZED	PAHs ARCHIVED	Metals ANALYZED	Metals ARCHIVED	VOCs ANALYZED	VOCs ARCHIVED
TOTAL SAMPLES	**All**	**248**	**217**	**105**	**184**	**105**	**148**	**29**	**0**
	All	**465**		**289**		**253**		**29**	

NOTES:
1. VOCs **-** Volatile Organic Compounds; PAHs **-** Polycyclic Aromatic Hydrocarbons; PCBs - polychlorinated biphenyls; Metals - cadmium, total chromium, copper, lead, mercury, silver, nickel, and zinc.
2. Sample intervals will begin at the ground surface for areas with topsoil or below the base of the surface layer for gravel covered areas or concrete or asphalt pavement areas. Known PAH-impacted soil on the Site was located in the 0 - 0.5 interval; therefore, samples from this interval will be analyzed for PAH or metals.
3. If evidence of fill materials is found during boring activities, boring will be extended to the depth of fill. Additional sample intervals will be analyzed if visible oily materials, or other evidence of are encountered .
4. Sample intervals in **BOLD** will be initially analyzed. Sample intervals in *italics* will be archived for potential analyses.

APPENDICES

APPENDIX A – VSP DOCUMENTATION

Area West of the Former Dewatering Containment Pad PCB Results

GT1	0 - 0.5'	9/28/2016	0.6
GT2	0 - 0.5'	9/28/2016	1.28
GT2	0.5' - 1.5'	9/28/2016	NA
GT2	1.5' - 3.5'	9/28/2016	NA
GT2-1N	0 - 0.5'	11/10/2016	NA
GT2-1NE	0 - 0.5'	11/10/2016	NA
GT2-1E	0 - 0.5'	11/10/2016	NA
GT2-1E	0.5' - 1.5'	11/10/2016	NA
GT2-1E	1.5' - 3.5'	11/10/2016	NA
GT2-1S	0 - 0.5'	11/10/2016	NA
GT2-1S	0.5' - 1.5'	11/10/2016	NA
GT2-1S	1.5' - 3.5'	11/10/2016	NA
GT2-1SW	0 - 0.5'	11/10/2016	NA
GT2-1W	0 - 0.5'	11/10/2016	NA
GT3	0 - 0.5'	9/28/2016	3.2
GT3	0.5' - 1.5'	9/28/2016	NA
GT3	1.5' - 3.5'	9/28/2016	NA
GT3-1E	0 - 0.5'	11/10/2016	NA
GT3-1E	0.5' - 1.5'	11/10/2016	NA
GT3-1E	1.5' - 3.5'	11/10/2016	NA
GT3-1W	0 - 0.5'	11/10/2016	NA
GT4	0 - 0.5'	9/28/2016	9.33
GT4	0.5' - 1.5'	9/28/2016	59.6
GT4	1.5' - 3.5'	9/28/2016	1.44
GT4-1E	0 - 0.5'	11/10/2016	0.758
GT4-1S	0 - 0.5'	11/10/2016	3.12
GT4-1S	0.5' - 1.5'	11/10/2016	NA
GT4-1S	1.5' - 3.5'	11/10/2016	NA
GT4-1W	0 - 0.5'	11/10/2016	3.2
GT5	0 - 0.5'	9/28/2016	0.531
GT5	0.5' - 1.5'	9/28/2016	NA
GT5	1.5' - 3.5'	9/28/2016	NA
GT5-1N	0 - 0.5'	11/10/2016	NA
GT5-1E	0 - 0.5'	11/10/2016	NA
GT5-1S	0 - 0.5'	11/10/2016	NA
GT5-1W	0 - 0.5'	11/10/2016	NA

Outlier Analysis, Western Parking Area

	A–L
1	Outlier Tests for Selected Uncensored Variables
2	User Selected Options
3	Date/Time of Computation: ProUCL 5.14/4/2020 2:09:46 PM
4	From File: WorkSheet.xls
5	Full Precision: OFF
6	
7	
8	Dixon's Outlier Test for West PCBs
9	
10	Number of Observations = 9
11	10% critical value: 0.441
12	5% critical value: 0.512
13	1% critical value: 0.635
14	
15	1. Observation Value 59.6 is a Potential Outlier (Upper Tail)'
16	
17	Test Statistic: 0.852
18	
19	For 10% significance level, 59.6 is an outlier.
20	For 5% significance level, 59.6 is an outlier.
21	For 1% significance level, 59.6 is an outlier.
22	
23	2. Observation Value 0.531 is a Potential Outlier (Lower Tail)
24	
25	Test Statistic: 0.008
26	
27	For 10% significance level, 0.531 is not an outlier.
28	For 5% significance level, 0.531 is not an outlier.
29	For 1% significance level, 0.531 is not an outlier.

Random sampling locations for comparing a mean with a fixed threshold (parametric)

Summary

This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The mean value at the site is less than the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	32
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2
Total cost of sampling [d]	$9,960.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the mean value at the site is less than the threshold. The alternative hypothesis is that the mean value is equal to or exceeds the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the

same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently larger than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability (1-β) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z_{1-\alpha}^2$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
β	is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

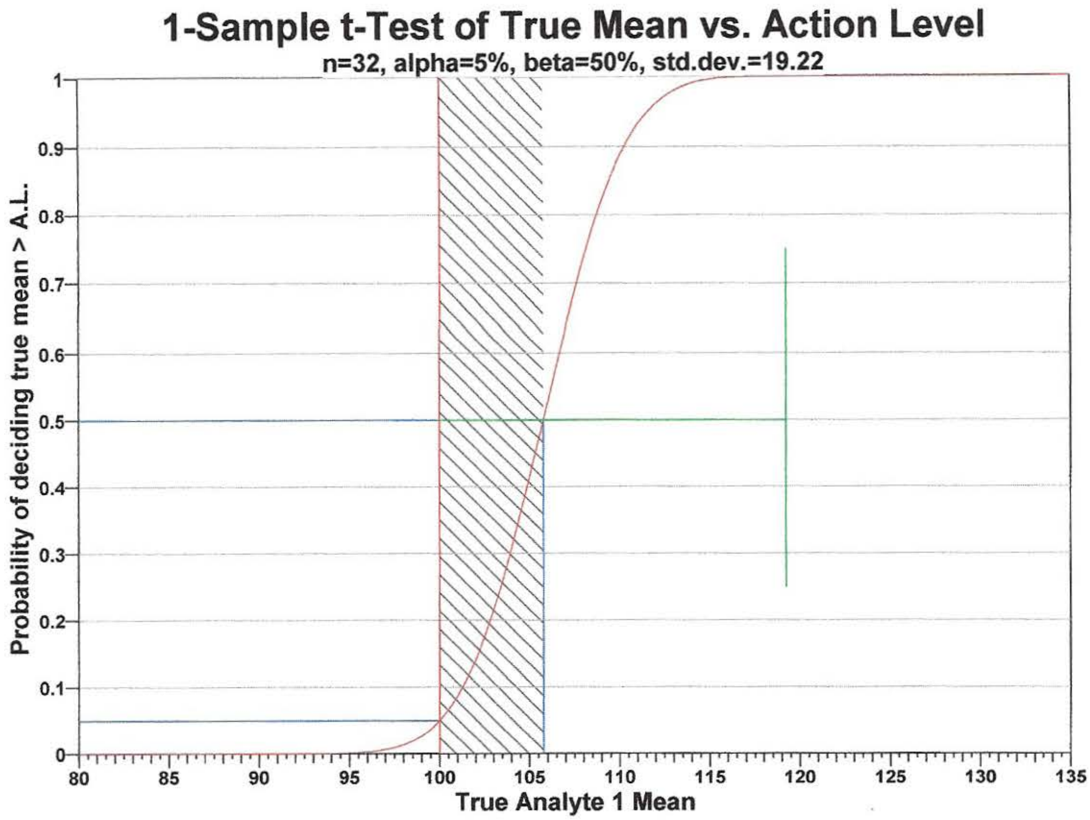
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Analyte 1	32	19.22	5.775	0.05	0.5	1.64485	-0

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the lower horizontal dashed blue line is positioned at α on the vertical axis; the upper horizontal dashed blue line is positioned at 1-β on the vertical axis. The vertical green line is positioned at one standard deviation above the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at α and the upper bound of Δ at 1-β. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, upper bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ < action level and alpha (%), probability of mistakenly concluding that μ > action level. The following table shows the results of this analysis.

Number of Samples							
AL=100		α=5		α=10		α=15	
		s=38.44	s=19.22	s=38.44	s=19.22	s=38.44	s=19.22
UBGR=110	β=45	48	13	31	9	21	6
	β=50	42	12	26	7	17	5
	β=55	36	10	21	6	13	4
UBGR=120	β=45	13	5	9	3	6	2
	β=50	12	4	7	3	5	2
	β=55	10	4	6	3	4	2
UBGR=130	β=45	7	3	5	2	3	2

	β=50	6	3	4	2	3	1
	β=55	6	3	4	2	2	1

s = Standard Deviation
UBGR = Upper Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ < action level
α = Alpha (%), Probability of mistakenly concluding that μ > action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $9,960.00, which averages out to a per sample cost of $311.25. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**32 Samples**
Field collection costs		$25.00	$800.00
Analytical costs	$130.00	$130.00	$4,160.00
Sum of Field & Analytical costs		**$155.00**	**$4,960.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$9,960.00**

Further Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

West Parking Area, outlier not included

Random sampling locations for comparing a mean with a fixed threshold (parametric)

Summary

This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The mean value at the site is less than the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	25
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2
Total cost of sampling [d]	$8,875.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the mean value at the site is less than the threshold. The alternative hypothesis is that the mean value is equal to or exceeds the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the

same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently larger than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability (1-β) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z^2_{1-\alpha}$$

where

- n is the number of samples,
- S is the estimated standard deviation of the measured values including analytical error,
- Δ is the width of the gray region,
- α is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
- β is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
- $Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
- $Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

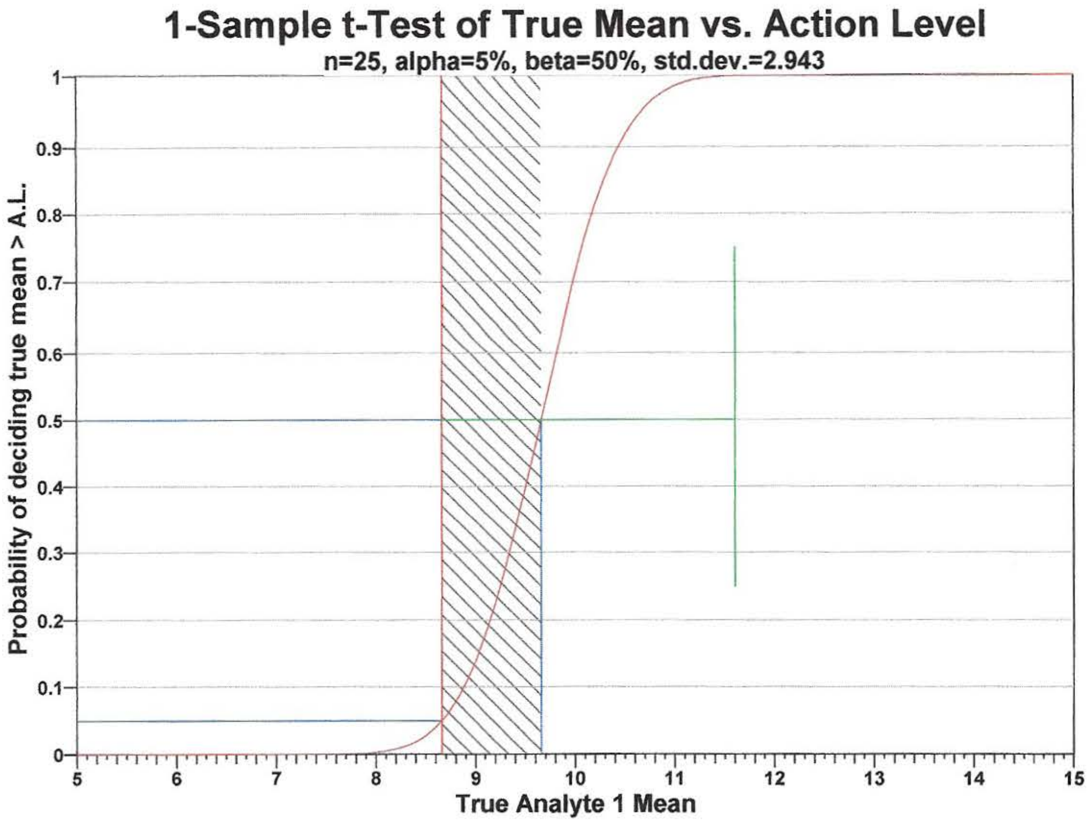
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Analyte 1	25	2.943	1	0.05	0.5	1.64485	-0

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the lower horizontal dashed blue line is positioned at α on the vertical axis; the upper horizontal dashed blue line is positioned at 1-β on the vertical axis. The vertical green line is positioned at one standard deviation above the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at α and the upper bound of Δ at 1-β. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, upper bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ < action level and alpha (%), probability of mistakenly concluding that μ > action level. The following table shows the results of this analysis.

Number of Samples							
AL=8.66		α=5		α=10		α=15	
		s=5.886	s=2.943	s=5.886	s=2.943	s=5.886	s=2.943
UBGR=110	β=45	147	38	93	24	63	17
	β=50	127	33	77	20	51	13
	β=55	108	29	63	17	39	11
UBGR=120	β=45	38	11	24	7	17	5
	β=50	33	10	20	6	13	4
	β=55	29	9	17	5	11	3
UBGR=130	β=45	18	6	11	4	8	3

	β=50	16	5	10	3	7	2
	β=55	14	5	8	3	5	2

s = Standard Deviation
UBGR = Upper Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ < action level
α = Alpha (%), Probability of mistakenly concluding that μ > action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $8,875.00, which averages out to a per sample cost of $355.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**25 Samples**
Field collection costs		$25.00	$625.00
Analytical costs	$130.00	$130.00	$3,250.00
Sum of Field & Analytical costs		**$155.00**	**$3,875.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$8,875.00**

Further Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

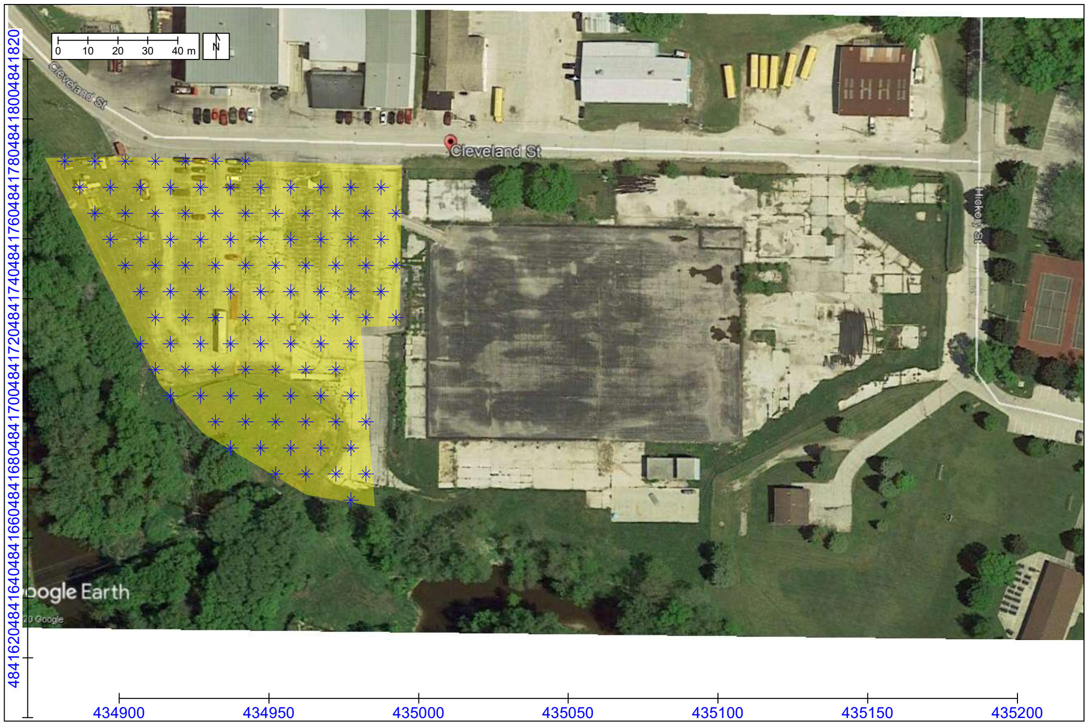
Systematic sampling locations for detecting an area of elevated values (hot spot)

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (e.g., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Detect the presence of a hot spot that has a specified size and shape
Type of Sampling Design	Hot spot
Sample Placement (Location) in the Field	Systematic (Hot Spot) with a random start location
Formula for calculating number of sampling locations	Algorithm developed by Singer and Wickman (1969)
Calculated total number of samples	104
Type of samples	Point Samples
Number of samples on map [a]	105
Number of selected sample areas [b]	1
Specified sampling area [c]	9081.96 m^2
Grid pattern	Triangular
Size of grid / Area of grid [d]	32.9891 feet / 942.479 ft^2
Total cost of sampling [e]	$21,800.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Size of grid / Area of grid gives the linear and square dimensions of the grid spacing used to systematically place samples.
[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Primary Sampling Objective
The primary purpose of sampling at this site is to detect "hot spots" (local areas of elevated concentration) of a given size and shape with a specified probability, 1-β.

Selected Sampling Approach
This sampling approach requires systematic grid sampling with a random start. If a systematic grid is not used, the probability of detecting a hot spot of a given size and shape will be different than desired or calculated.

Number of Total Samples: Calculation Equation and Inputs
The algorithm used to calculate the probability of a hit (which makes possible the calculation of the hot spot size or the number of samples) was developed by Singer and Wickman (1969) and Singer (1972) with refinements by Davidson (1995). Gilbert (1987) also discussed hotspot sampling designs. Inputs to the algorithm include the size, shape, and orientation of a hot spot of interest, an acceptable probability of finding a hot spot, the desired type of sampling grid, and the sampling budget. For this design, the grid size was calculated based on the given hot spot size and other parameters.

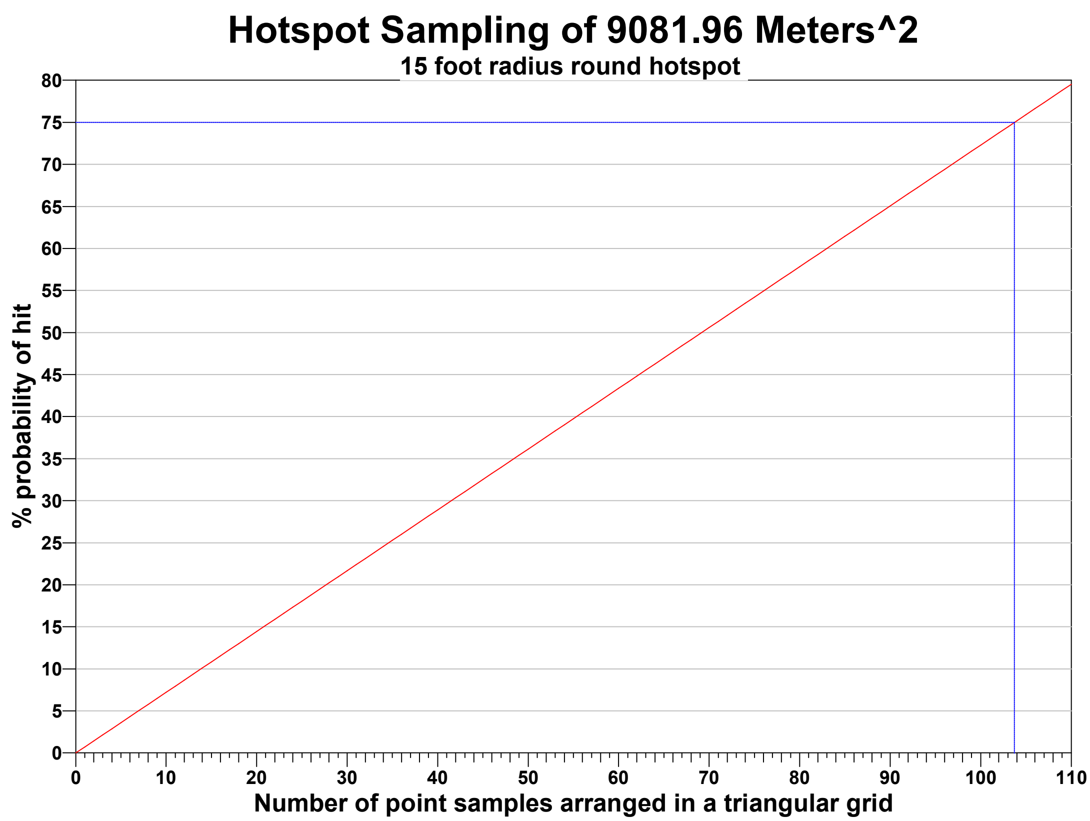
The inputs to the algorithm that result in the grid size are:

Parameter	**Description**	**Value**
Inputs		
1-β	Probability of detection	75%
Grid Type	Grid pattern (Square, Triangular or Rectangular)	Triangular
Sample Type	Point samples or square cells	Points
Hot Spot Shape	Hot spot height to width ratio	1
Hot Spot Size	Length of hot spot semi-major axis	15 feet
Hot Spot Area [a]	Area of hot spot ($Length^2$ * Shape * π)	706.858 ft^2
Angle	Angle of orientation between hot spot and grid	Random
Sampling Area	Total area to sample	9081.96 m^2
Outputs		
Grid Size	Spacing between samples	32.9891 feet

Grid Area	Area represented by one grid	942.479 ft^2
Samples [b]	Optimum number of samples	103.724

[a] Length of semi-major axis is used by Singer-Wickman algorithm. Hot spot area is provided for informational purposes.
[b] The optimum number of samples is calculated by dividing the sampling area by the grid area.

The following graph shows the relationship between the number of samples and the probability of finding the hot spot. The dashed blue line shows the actual number of samples for this design (which may differ from the optimum number of samples because of edge effects).



Assumptions that Underlie the VSP Locating a Hot Spot Design Method

1. In the decision area there is at least one hotspot of the designated size, which is circular or elliptical in shape.
2. The level of contamination that defines a hotspot is well defined.
3. The location of the hotspot is unknown, and if a hotspot is present, all locations within the sampling area are equally likely to contain the hotspot.
4. With a randomly determined starting location, samples are taken on a square, rectangular or triangular (equilateral) grid pattern that covers the decision area.
5. Each sample is collected, handled, measured or inspected using approved methods that yield sufficiently precise measurements.
6. A very small proportion of the surface of the decision area will be sampled. The area sampled by a single sample is much smaller than the hotspot of interest.
7. The sample methodology and sample analysis process is the same for all sample locations.
8. There are no classification errors. If a hotspot is sampled, then contamination is detected (i.e., no false negatives). If an uncontaminated area is sampled, it is not mistakenly identified as a hotspot (i.e., no false positives).

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the probability of hit (%), hot spot shape (height to width ratio) and hot spot size (length of semi-major axis). The following table shows the results of this analysis.

Number of Samples

		Size=7.5	Size=15	Size=22.5
1-β=70	**Shp=0.8**	485	122	54
	Shp=0.9	431	108	48
	Shp=1	388	97	44
1-β=75	**Shp=0.8**	520	130	58
	Shp=0.9	461	116	52
	Shp=1	415	104	47
1-β=80	**Shp=0.8**	558	140	62
	Shp=0.9	492	123	55
	Shp=1	443	111	50

1-β = Probability of Hit (%)
Shp = Hot Spot Shape (Height to Width Ratio)
Size = Hot Spot Size (Length of Semi-major Axis)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $21,800.00, which averages out to a per sample cost of $207.62. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**105 Samples**
Field collection costs		$25.00	$2,625.00
Analytical costs (Analyte 1)	$135.00	$135.00	$14,175.00
Sum of Field & Analytical costs		**$160.00**	**$16,800.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$21,800.00**

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2006). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

A map of the actual sample locations will be generated so that the sampling plan and the field implementation may be compared. Deviations from planned sample locations due to topographic, vegetative, or other features will be noted. Their impacts will be qualitatively assessed. If a hot spot is discovered, additional sampling may be performed to determine its size and shape, in which case, the initial assumptions of the sampling design may then be assessed and/or reconsidered.

References
EPA 2006. *Data Quality Assessment: Statistical Methods for Practitioners EPA QA/G-9S*, EPA/240/B-06/003, U.S. Environmental Protection Agency, Office of Environmental Information, Washington DC.

Davidson, J.R. 1995. *ELIPGRID-PC: Upgraded Version.* ORNL/TM-13103. Oak Ridge National Laboratory, Oak Ridge, TN.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Wiley & Sons, Inc., New York, NY.

Singer, D.A. and J.E. Wickman. 1969. *Probability Tables for Locating Elliptical Targets with Square, Rectangular, and Hexagonal Point Nets*. Pennsylvania State University, University Park, Pennsylvania. Special Publication 1-69.

Singer, D.A. 1972. "ELIPGRID: A Fortran IV program for calculating the probability of success in locating elliptical targets with square, rectangular and hexagonal grids." *Geocom Bulletin/Programs* 4:1-16.

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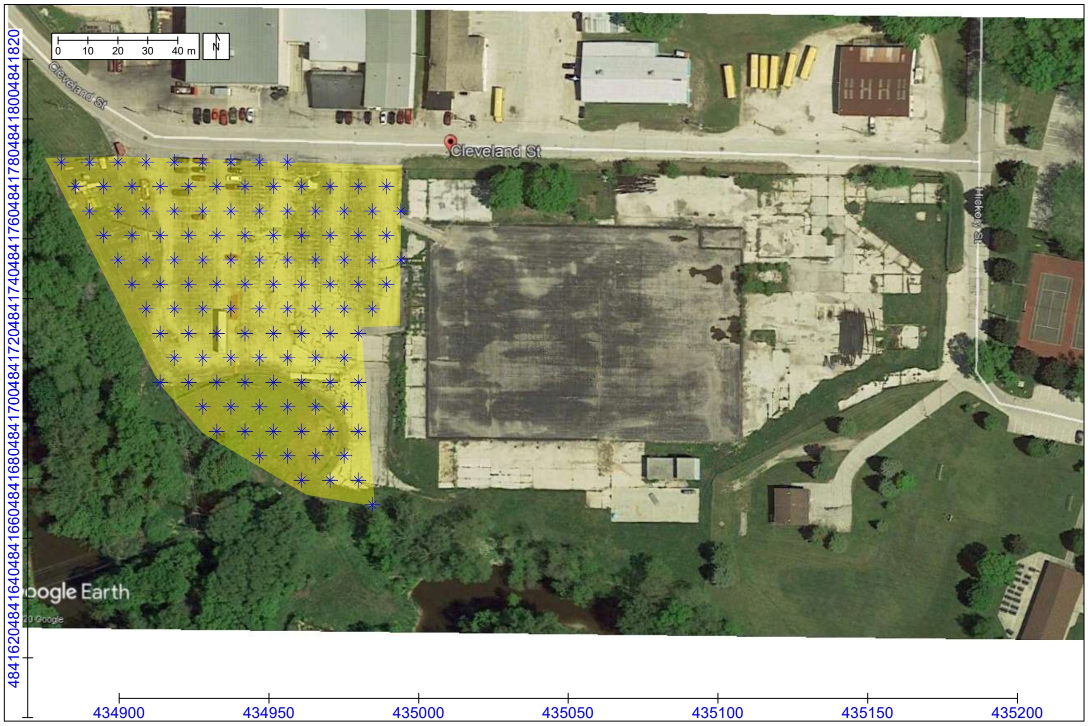
Systematic sampling locations for detecting an area of elevated values (hot spot)

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (e.g., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Detect the presence of a hot spot that has a specified size and shape
Type of Sampling Design	Hot spot
Sample Placement (Location) in the Field	Systematic (Hot Spot) with a random start location
Formula for calculating number of sampling locations	Algorithm developed by Singer and Wickman (1969)
Calculated total number of samples	118
Type of samples	Point Samples
Number of samples on map [a]	117
Number of selected sample areas [b]	1
Specified sampling area [c]	9081.96 m^2
Grid pattern	Triangular
Size of grid / Area of grid [d]	30.9879 feet / 831.6 ft^2
Total cost of sampling [e]	$23,720.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Size of grid / Area of grid gives the linear and square dimensions of the grid spacing used to systematically place samples.
[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Primary Sampling Objective
The primary purpose of sampling at this site is to detect "hot spots" (local areas of elevated concentration) of a given size and shape with a specified probability, 1-β.

Selected Sampling Approach
This sampling approach requires systematic grid sampling with a random start. If a systematic grid is not used, the probability of detecting a hot spot of a given size and shape will be different than desired or calculated.

Number of Total Samples: Calculation Equation and Inputs
The algorithm used to calculate the probability of a hit (which makes possible the calculation of the hot spot size or the number of samples) was developed by Singer and Wickman (1969) and Singer (1972) with refinements by Davidson (1995). Gilbert (1987) also discussed hotspot sampling designs. Inputs to the algorithm include the size, shape, and orientation of a hot spot of interest, an acceptable probability of finding a hot spot, the desired type of sampling grid, and the sampling budget. For this design, the grid size was calculated based on the given hot spot size and other parameters.

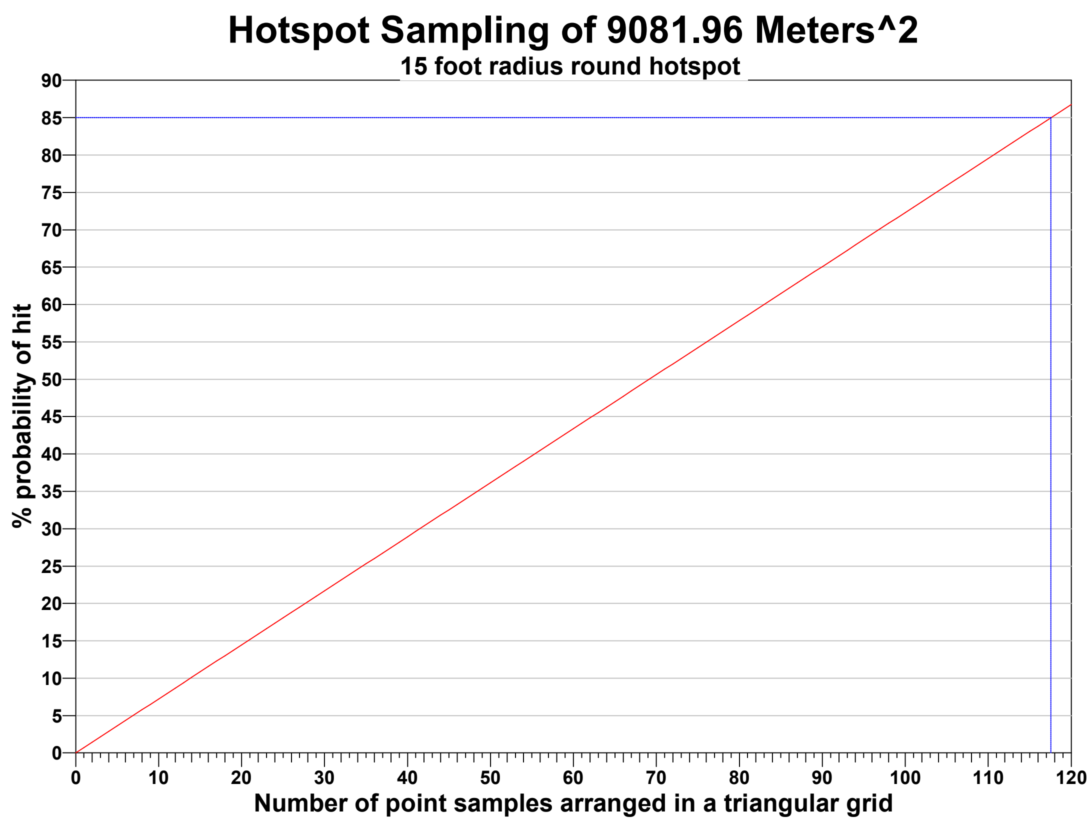
The inputs to the algorithm that result in the grid size are:

Parameter	Description	Value
Inputs		
1-β	Probability of detection	85%
Grid Type	Grid pattern (Square, Triangular or Rectangular)	Triangular
Sample Type	Point samples or square cells	Points
Hot Spot Shape	Hot spot height to width ratio	1
Hot Spot Size	Length of hot spot semi-major axis	15 feet
Hot Spot Area [a]	Area of hot spot (Length^2 * Shape * π)	706.858 ft^2
Angle	Angle of orientation between hot spot and grid	Random
Sampling Area	Total area to sample	9081.96 m^2
Outputs		
Grid Size	Spacing between samples	30.9879 feet

Grid Area	Area represented by one grid	831.6 ft^2
Samples [b]	Optimum number of samples	117.553

[a] Length of semi-major axis is used by Singer-Wickman algorithm. Hot spot area is provided for informational purposes.
[b] The optimum number of samples is calculated by dividing the sampling area by the grid area.

The following graph shows the relationship between the number of samples and the probability of finding the hot spot. The dashed blue line shows the actual number of samples for this design (which may differ from the optimum number of samples because of edge effects).



Assumptions that Underlie the VSP Locating a Hot Spot Design Method

1. In the decision area there is at least one hotspot of the designated size, which is circular or elliptical in shape.
2. The level of contamination that defines a hotspot is well defined.
3. The location of the hotspot is unknown, and if a hotspot is present, all locations within the sampling area are equally likely to contain the hotspot.
4. With a randomly determined starting location, samples are taken on a square, rectangular or triangular (equilateral) grid pattern that covers the decision area.
5. Each sample is collected, handled, measured or inspected using approved methods that yield sufficiently precise measurements.
6. A very small proportion of the surface of the decision area will be sampled. The area sampled by a single sample is much smaller than the hotspot of interest.
7. The sample methodology and sample analysis process is the same for all sample locations.
8. There are no classification errors. If a hotspot is sampled, then contamination is detected (i.e., no false negatives). If an uncontaminated area is sampled, it is not mistakenly identified as a hotspot (i.e., no false positives).

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the probability of hit (%), hot spot shape (height to width ratio) and hot spot size (length of semi-major axis). The following table shows the results of this analysis.

Number of Samples

		Size=7.5	Size=15	Size=22.5
1-β=80	Shp=0.8	558	140	62
	Shp=0.9	492	123	55
	Shp=1	443	111	50
1-β=85	Shp=0.8	600	150	67
	Shp=0.9	526	132	59
	Shp=1	471	118	53
1-β=90	Shp=0.8	650	163	73
	Shp=0.9	563	141	63
	Shp=1	498	125	56

1-β = Probability of Hit (%)
Shp = Hot Spot Shape (Height to Width Ratio)
Size = Hot Spot Size (Length of Semi-major Axis)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $23,720.00, which averages out to a per sample cost of $202.74. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**117 Samples**
Field collection costs		$25.00	$2,925.00
Analytical costs (Analyte 1)	$135.00	$135.00	$15,795.00
Sum of Field & Analytical costs		**$160.00**	**$18,720.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$23,720.00**

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2006). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

A map of the actual sample locations will be generated so that the sampling plan and the field implementation may be compared. Deviations from planned sample locations due to topographic, vegetative, or other features will be noted. Their impacts will be qualitatively assessed. If a hot spot is discovered, additional sampling may be performed to determine its size and shape, in which case, the initial assumptions of the sampling design may then be assessed and/or reconsidered.

References
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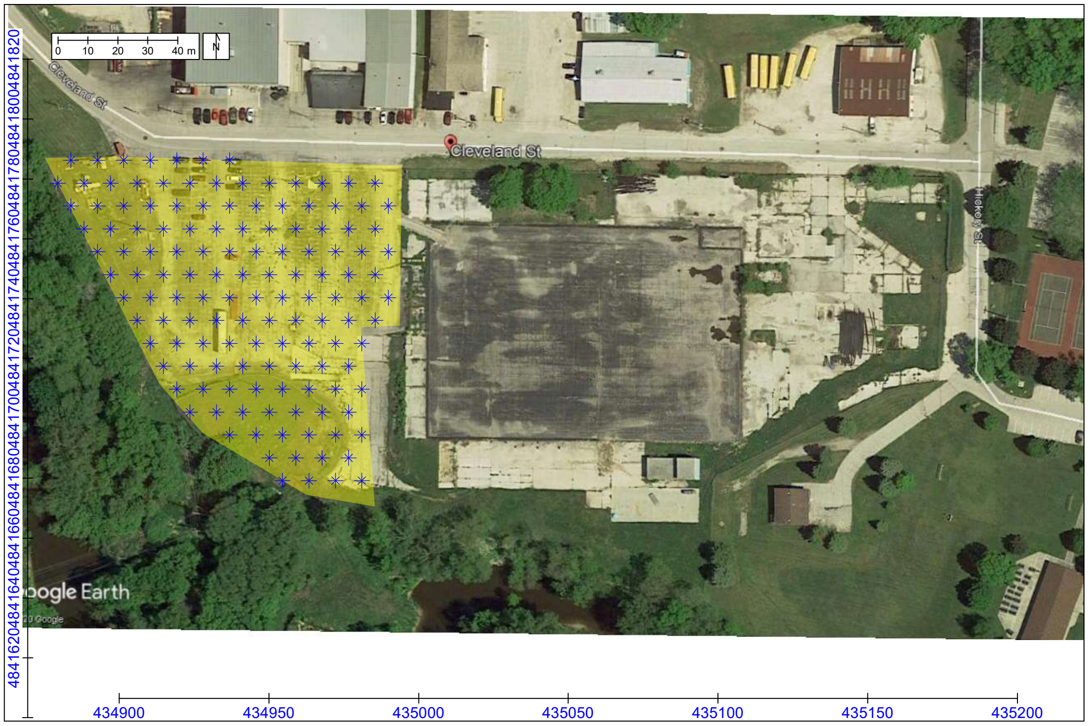
Systematic sampling locations for detecting an area of elevated values (hot spot)

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (e.g., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Detect the presence of a hot spot that has a specified size and shape
Type of Sampling Design	Hot spot
Sample Placement (Location) in the Field	Systematic (Hot Spot) with a random start location
Formula for calculating number of sampling locations	Algorithm developed by Singer and Wickman (1969)
Calculated total number of samples	135
Type of samples	Point Samples
Number of samples on map [a]	135
Number of selected sample areas [b]	1
Specified sampling area [c]	9081.96 m^2
Grid pattern	Triangular
Size of grid / Area of grid [d]	28.9807 feet / 727.359 ft^2
Total cost of sampling [e]	$26,600.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Size of grid / Area of grid gives the linear and square dimensions of the grid spacing used to systematically place samples.
[e] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Primary Sampling Objective
The primary purpose of sampling at this site is to detect "hot spots" (local areas of elevated concentration) of a given size and shape with a specified probability, 1-β.

Selected Sampling Approach
This sampling approach requires systematic grid sampling with a random start. If a systematic grid is not used, the probability of detecting a hot spot of a given size and shape will be different than desired or calculated.

Number of Total Samples: Calculation Equation and Inputs
The algorithm used to calculate the probability of a hit (which makes possible the calculation of the hot spot size or the number of samples) was developed by Singer and Wickman (1969) and Singer (1972) with refinements by Davidson (1995). Gilbert (1987) also discussed hotspot sampling designs. Inputs to the algorithm include the size, shape, and orientation of a hot spot of interest, an acceptable probability of finding a hot spot, the desired type of sampling grid, and the sampling budget. For this design, the grid size was calculated based on the given hot spot size and other parameters.

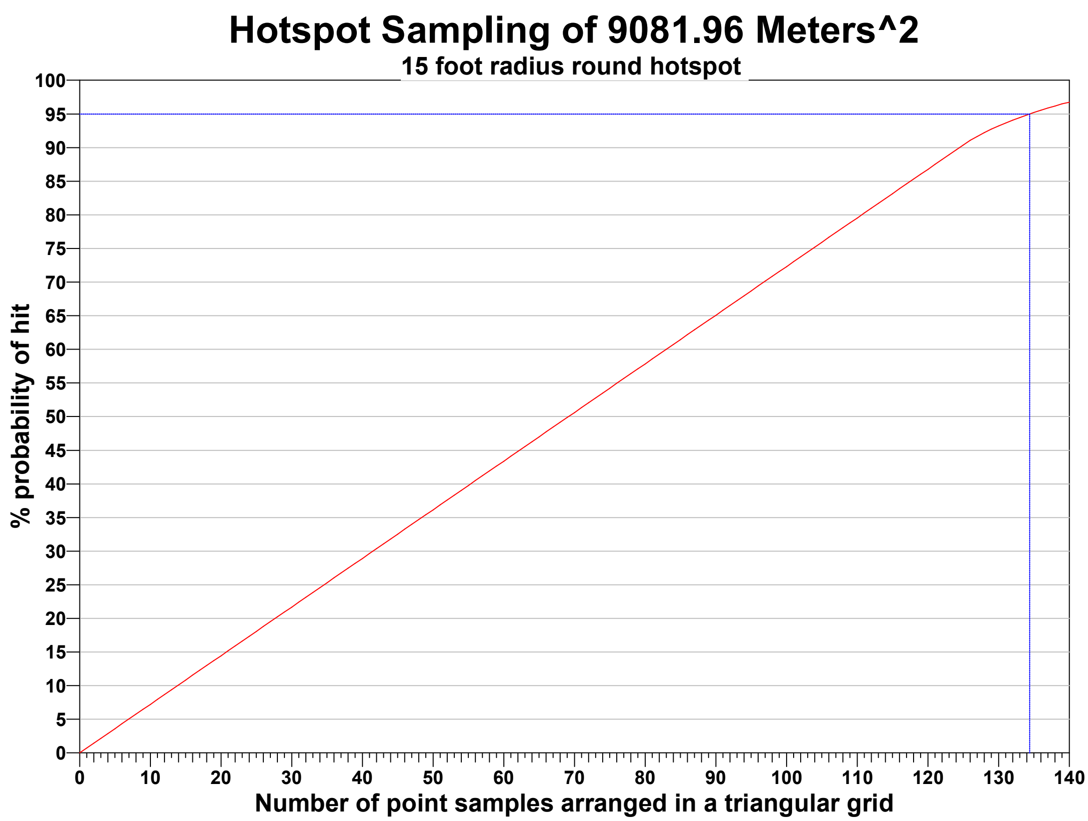
The inputs to the algorithm that result in the grid size are:

Parameter	**Description**	**Value**
Inputs		
1-β	Probability of detection	95%
Grid Type	Grid pattern (Square, Triangular or Rectangular)	Triangular
Sample Type	Point samples or square cells	Points
Hot Spot Shape	Hot spot height to width ratio	1
Hot Spot Size	Length of hot spot semi-major axis	15 feet
Hot Spot Area [a]	Area of hot spot (Length^2 * Shape * π)	706.858 ft^2
Angle	Angle of orientation between hot spot and grid	Random
Sampling Area	Total area to sample	9081.96 m^2
Outputs		
Grid Size	Spacing between samples	28.9807 feet

Grid Area	Area represented by one grid	727.359 ft^2
Samples [b]	Optimum number of samples	134.4

[a] Length of semi-major axis is used by Singer-Wickman algorithm. Hot spot area is provided for informational purposes.
[b] The optimum number of samples is calculated by dividing the sampling area by the grid area.

The following graph shows the relationship between the number of samples and the probability of finding the hot spot. The dashed blue line shows the actual number of samples for this design (which may differ from the optimum number of samples because of edge effects).



Assumptions that Underlie the VSP Locating a Hot Spot Design Method

1. In the decision area there is at least one hotspot of the designated size, which is circular or elliptical in shape.
2. The level of contamination that defines a hotspot is well defined.
3. The location of the hotspot is unknown, and if a hotspot is present, all locations within the sampling area are equally likely to contain the hotspot.
4. With a randomly determined starting location, samples are taken on a square, rectangular or triangular (equilateral) grid pattern that covers the decision area.
5. Each sample is collected, handled, measured or inspected using approved methods that yield sufficiently precise measurements.
6. A very small proportion of the surface of the decision area will be sampled. The area sampled by a single sample is much smaller than the hotspot of interest.
7. The sample methodology and sample analysis process is the same for all sample locations.
8. There are no classification errors. If a hotspot is sampled, then contamination is detected (i.e., no false negatives). If an uncontaminated area is sampled, it is not mistakenly identified as a hotspot (i.e., no false positives).

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the probability of hit (%), hot spot shape (height to width ratio) and hot spot size (length of semi-major axis). The following table shows the results of this analysis.

Number of Samples

		Size=7.5	Size=15	Size=22.5
1-β=90	**Shp=0.8**	650	163	73
	Shp=0.9	563	141	63
	Shp=1	498	125	56
1-β=95	**Shp=0.8**	713	179	80
	Shp=0.9	612	153	68
	Shp=1	538	135	60
1-β=100	**Shp=0.8**	866	217	97
	Shp=0.9	748	187	84
	Shp=1	667	167	75

1-β = Probability of Hit (%)
Shp = Hot Spot Shape (Height to Width Ratio)
Size = Hot Spot Size (Length of Semi-major Axis)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $26,600.00, which averages out to a per sample cost of $197.04. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**135 Samples**
Field collection costs		$25.00	$3,375.00
Analytical costs (Analyte 1)	$135.00	$135.00	$18,225.00
Sum of Field & Analytical costs		**$160.00**	**$21,600.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$26,600.00**

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2006). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

A map of the actual sample locations will be generated so that the sampling plan and the field implementation may be compared. Deviations from planned sample locations due to topographic, vegetative, or other features will be noted. Their impacts will be qualitatively assessed. If a hot spot is discovered, additional sampling may be performed to determine its size and shape, in which case, the initial assumptions of the sampling design may then be assessed and/or reconsidered.

References
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Singer, D.A. 1972. "ELIPGRID: A Fortran IV program for calculating the probability of success in locating elliptical targets with square, rectangular and hexagonal grids." *Geocom Bulletin/Programs* 4:1-16.

Rochester Park PCB Data

Sample	Event	Results (mg/kg)	Comments
NB-COMP-6	BB&L 1999	2.6	
NB-COMP-7	BB&L 1999	2.8	
NB-COMP-8	BB&L 1999	3.5	
NB-COMP-9	BB&L 1999	1.6	
NB-COMP-10	BB&L 1999	1.9	
NB-SS-48	BB&L 1999	3.3	
NB-SS-49	BB&L 1999	6.25	
NB-SS-50	BB&L 1999	83	
G-1	1978	4	No lab reports or maps provided.
G-2	1978	8	
Unnamed	1978	2.29	Not presented in report table, only narrative. Data is rejected.
Unnamed	1978	228	
SF-1	SME	0.385	
SF-2	SME	6.11	
P-1	SME	2.87	
P-2	SME	6.89	
P-3	SME	0.246	
P-4	SME	0.372	
P-5	SME	0.407	
P-6	SME	0.834	
P-7	SME	0.856	
P-7	SME	1.68	
P-8	SME	1.84	
NRB-7	BB&L 1999	0.062	Not detected at listed detection limit
NRB-8	BB&L 1999	NA	Not collected or reported.
NRB-9	BB&L 1999	0.73	
NRB-10	BB&L 1999	0.12	
Count		24	Does not include rejected data.
Min		0.062	
Max		83	
Mean		5.85	

Outlier Analysis - Park Data

	A	B	C	D	E	F	G	H	I	J	K	L
1					Outlier Tests for Selected Variables replacing nondetects with 1/2 the Detection Limit							
2			User Selected Options									
3		Date/Time of Computation		ProUCL 5.14/4/2020 10:35:04 AM								
4				From File	WorkSheet.xls							
5				Full Precision	OFF							
6												
7												
8			Dixon's Outlier Test for Park PCBs									
9												
10	Total N = 24											
11	Number NDs = 1											
12	Number Detects = 23											
13	Number Data (n) = 24											
14	10% critical value: 0.367											
15	5% critical value: 0.413											
16	1% critical value: 0.497											
17	Note: NDs replaced by DL/2 in Outlier Test											
18												
19	1. Data Value 83 is a Potential Outlier (Upper Tail)?											
20												
21	Test Statistic: 0.920											
22												
23	For 10% significance level, 83 is an outlier.											
24	For 5% significance level, 83 is an outlier.											
25	For 1% significance level, 83 is an outlier.											
26												
27	2. Data Value 0.031 is a Potential Outlier (Lower Tail)?											
28												
29	Test Statistic: 0.031											
30												
31	For 10% significance level, 0.031 is not an outlier.											
32	For 5% significance level, 0.031 is not an outlier.											
33	For 1% significance level, 0.031 is not an outlier.											

Recreational - Calculation of Generic Direct-Contact Soil Standards

SOIL DIRECT CONTACT EXPOSURE FACTORS	UNITS	DEFAULT VALUE	REFERENCE
Residential Exposure Duration	years	26	Environ Risk Assessment
Adult Exposure Duration	years	26	Environ Risk Assessment
Child Exposure Duration	years	6	RSL Online Calculator Default Value
Exposure Duration Age Segment 0-2	years	2	RSL Online Calculator Default Value
Exposure Duration Age Segment 2-6	years	4	RSL Online Calculator Default Value
Exposure Duration Age Segment 6-16	years	10	RSL Online Calculator Default Value
Exposure Duration Age Segment 16-30	years	16	Environ Risk Assessment adjusted for 0-16
Exposure Frequency	days/year	95.9	Environ Risk Assessment
Air Exposure Time	hours/day	2	Best Judgement
Child Non-Cancer Averaging Time	days	2,190	ED x 365 days/year
Cancer Averaging Time	days	25,550	70 yr (lifetime) x 365 days/year
Adult Body Weight	kg	80	U.S. EPA 1991 RSL
Child Body Weight	kg	15	U.S. EPA 1991 (pg. 15)
Adult Soil Ingestion Rate	mg/day	100	U.S. EPA 1991 (pg. 15)
Child Soil Ingestion Rate	mg/day	200	U.S. EPA 1991 (pg. 15)
Adult Skin Surface Area Exposed To Soil	cm^2	6,032	RSL
Child Skin Surface Area Exposed To Soil	cm^2	2,373	RSL
Adult Soil Skin Adherence Factor	mg/cm^2	0.07	U.S. EPA 2002 (Exhibit 1-2)
Child Soil Skin Adherence Factor	mg/cm^2	0.2	U.S. EPA 2002 (Exhibit 1-2)
Conversion Factor	kg/mg	1.00E-06	RSL User's Guide
Fraction Contaminated	unitless	0.5	Estimated based on exposed soil
Target Hazard Quotient	unitless	1	U.S. EPA RAGS
Target Cancer Risk	unitless	1.00E-05	U.S. EPA RAGs

Notes:

(a) U.S. EPA 1991. Human health evaluation manual, supplemental guidance: "Standard default exposure factors". OSWER Directive 9285.6-03

(b) U.S. EPA Regional Screening Level (RSL) User's Guide. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

(c) U.S. EPA 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. December 2002.

CALCULATION OF GENERIC NUMERICAL STANDARDS - SOIL DIRECT CONTACT (Ingestion, dermal contact, and inhalation of volatiles and particulates)

A. INGESTION PATHWAY

$$\text{Non} - \text{Cancer TCS}_{oral} = \frac{THQ \times ATN_c \times BW_c}{EF \times ED_c \times \left(1/_{RfD}\right) \times IRS_c \times CF \times FC}$$

Where:
- THQ = Target Hazard Quotient
- ATN_c = Child Averaging Time Non-Cancer (days)
- BW_c = Child Body Weight (kg)
- EF = Child Exposure Frequency (days/year)
- ED_c = Child Exposure Duration (years)
- RfD = Reference Dose (mg/kg-day)
- IRS_c = Child Soil Ingestion Rate (mg/day)
- CF = Conversion Factor (kg/mg)
- FC = Fraction Contaminated (unitless)

$$\text{Cancer TCS}_{oral} = \frac{TCR \times ATC}{SF \times EF \times IFS_{adj} \times CF \times FC}$$

Where:
- TCR = Target Cancer Risk
- ATC = Averaging Time Cancer (days)
- SF = Slope Factor $(mg/kg\text{-}day)^{-1}$
- EF = Exposure Frequency (days/year)
- IFS_{adj} = Age-Adjusted Soil Ingestion Factor (mg-year/kg-day)
- CF = Conversion Factor (kg/mg)
- FC = Fraction Contaminated (unitless)

$$\text{Mutagen TCS}_{oral} = \frac{TCR \times ATC}{SF \times EF \times IFSM_{adj} \times CF \times FC}$$

Where:
- TCR = Target Cancer Risk
- ATC = Averaging Time Cancer (days)
- SF = Slope Factor $(mg/kg\text{-}day)^{-1}$
- EF = Exposure Frequency (days/year)
- $IFSM_{adj}$ = Mutagen Age-Adjusted Soil Ingestion Factor (mg-year/kg-day)
- CF = Conversion Factor (kg/mg)
- FC = Fraction Contaminated (unitless)

B. DERMAL PATHWAY

$$\text{Non} - \text{Cancer TCS}_{dermal} = \frac{THQ \times ATN_c \times BW_c}{EF \times ED_c \times \left(1/_{RfD} \times GIABS\right) \times AF_c \times SAS_c \times ABS \times CF \times FC}$$

Where:
- THQ = Target Hazard Quotient
- ATN_c = Child Averaging Time Non-Cancer (days)
- BW_c = Child Body Weight (kg)
- EF = Child Exposure Frequency (days/year)
- ED_c = Child Exposure Duration (years)
- RfD = Reference Dose (mg/kg-day)
- GIABS = Gastrointestinal Absorption Factor (unitless)
- AF_c = Child Adherence Factor (unitless)
- SAS_c = Child Skin Suraface Area Exposed To Soil (cm^2)
- ABS = Dermal Absorption (unitless)
- CF = Conversion Factor (kg/mg)
- FC = Fraction Contaminated (unitless)

$$\text{Cancer TCS}_{dermal} = \frac{TCR \times ATC}{SF/_{GIABS} \times EF \times DFS_{adj} \times ABS \times CF \times FC}$$

Where:
- TCR = Target Cancer Risk
- ATC = Averaging Time Cancer (days)
- SF = Slope Factor $(mg/kg\text{-}day)^{-1}$
- GIABS = Gastrointestinal Absorption Factor (unitless)
- EF = Exposure Frequency (days/year)
- DFS_{adj} = Age-Adjusted Soil Dermal Contact Factor (mg-year/kg-day)
- ABS = Dermal Absorption (unitless)
- CF = Conversion Factor (kg/mg)
- FC = Fraction Contaminated (unitless)

$$\text{Mutagen TCS}_{dermal} = \frac{TCR \times ATC}{SF/_{GIABS} \times EF \times DFSM_{adj} \times ABS \times CF \times FC}$$

Where:
- TCR = Target Cancer Risk
- ATC = Averaging Time Cancer (days)
- SF = Slope Factor $(mg/kg\text{-}day)^{-1}$
- GIABS = Gastrointestinal Absorption Factor (unitless)
- EF = Exposure Frequency (days/year)
- $DFSM_{adj}$ = Mutagen Age-Adjusted Soil Dermal Contact Factor (mg-year/kg-day)
- ABS = Dermal Absorption (unitless)
- CF = Conversion Factor (kg/mg)
- FC = Fraction Contaminated (unitless)

C. INHALATION PATHWAY

$$\text{Non}-\text{Cancer TCS}_{\text{inhalation}} = \frac{\text{THQ} \times \text{ATN}_c}{\text{EF} \times \text{ED}_c \times \text{ETA} \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\frac{1}{\text{RfC}}\right) \times \left(\frac{1}{\text{VF}} + \frac{1}{\text{PEF}}\right) \times \text{FC}}$$

Where:
THQ = Target Hazard Quotient
ATN_c = Child Averaging Time Non-Cancer (days)
EF = Child Exposure Frequency (days/year)
ED_c = Child Exposure Duration (years)
ETA = Air Exposure Time (hours/day)
RfC = Reference Concentration (mg/m^3)
VF = Volatilization Factor (m^3/kg)
PEF = Particulate Emission Factor (m^3/kg)
FC = Fraction Contaminated (unitless)

$$\text{Cancer TCS}_{\text{imhalation}} = \frac{\text{TCR} \times \text{ATC}}{\text{IUR} \times \left(\frac{1000\ \mu g}{mg}\right) \times \text{EF} \times \text{ED}_r \times \text{ETA} \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\frac{1}{\text{VF}} + \frac{1}{\text{PEF}}\right) \times \text{FC}}$$

Where:
TCR = Target Cancer Risk
ATC = Averaging Time Cancer (days)
IUR = Inhalation Unit Risk (µg/m3)-1
EF = Exposure Frequency (days/year)
ED_r = Residential Exposure Duration (years)
ETA = Air Exposure Time (hours/day)
VF = Volatilization Factor (m3/kg)
PEF = Particulate Emission Factor (m3/kg)
FC = Fraction Contaminated (unitless)

$$\text{Mutagen TCS}_{\text{inhalation}} = \frac{\text{TCR} \times \text{ATC}}{\text{EF} \times \text{ETA} \times \left(\frac{1\ \text{day}}{24\ \text{hours}}\right) \times \left(\frac{1000\ \mu g}{mg}\right) \times \text{IURM}_{\text{adj}} \times \left(\frac{1}{\text{VF}} + \frac{1}{\text{PEF}}\right) \times \text{FC}}$$

Where:
TCR = Target Cancer Risk
ATC = Averaging Time Cancer (days)
EF = Exposure Frequency (days/year)
ETA = Air Exposure Time (hours/day)
$IURM_{adj}$ = Mutagen Age-Adjusted Inhalation Unit Risk Factor ($(\mu g/m^3\text{-year})^{-1}$)
VF = Volatilization Factor (m^3/kg)
PEF = Particulate Emission Factor (m^3/kg)
FC = Fraction Contaminated (unitless)

D. ALL SOIL DIRECT CONTACT PATHWAYS

$$\text{TCS}_{\text{total}} = \frac{1}{\frac{1}{\text{TCS}_{\text{oral}}} + \frac{1}{\text{TCS}_{\text{dermal}}} + \frac{1}{\text{TCS}_{\text{inhalation}}}}$$

Rochester Park Recreational PCB Risk Criteria

Chemical	CAS Number	Recreational Soil Std Non-Cancer (mg/kg)	Recreational Soil Std Cancer (mg/kg)	Rec. Single Chem GDCSS (mg/kg)	Soil Saturation Standard (mg/kg)
Polychlorinated Biphenyls, Total	1336-36-3	NA	18	18	NA

All Rochester Park Data

Random sampling locations for comparing a mean with a fixed threshold (parametric)

Summary

This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The mean value at the site is less than the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	206
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2
Total cost of sampling [d]	$36,930.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the mean value at the site is less than the threshold. The alternative hypothesis is that the mean value is equal to or exceeds the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the

same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently larger than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability (1-β) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z_{1-\alpha}^2$$

where
n is the number of samples,
S is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
β is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

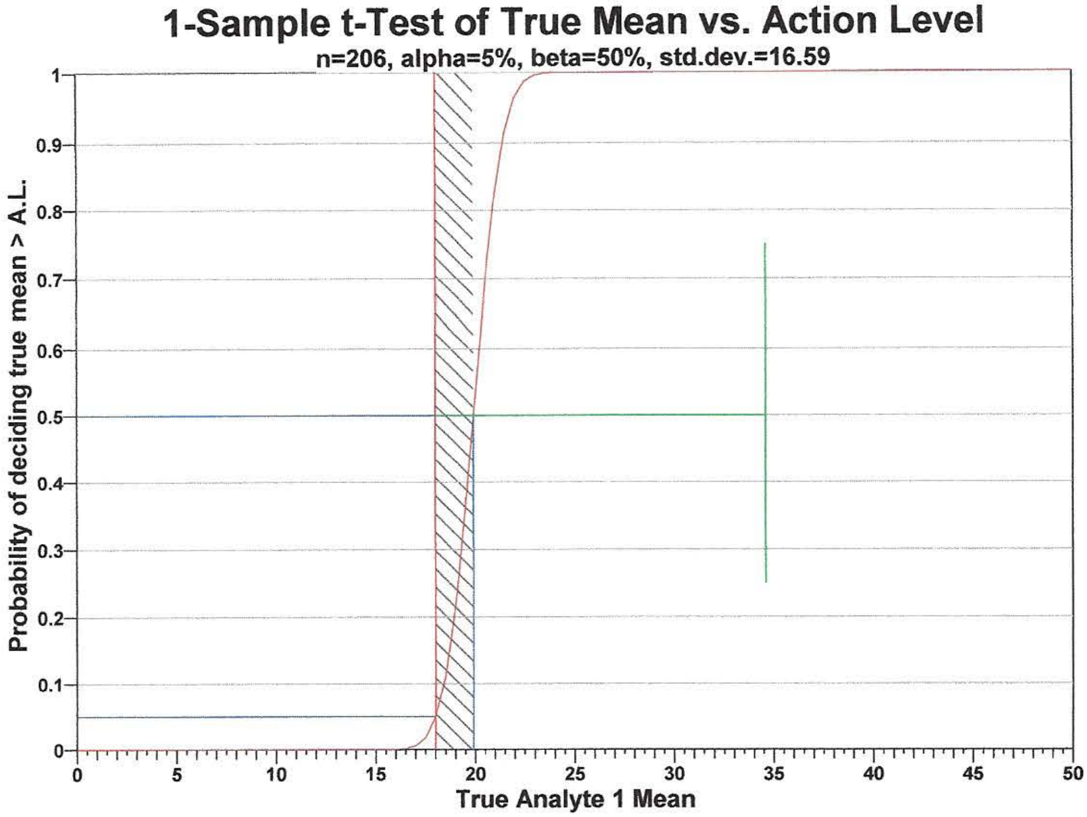
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Analyte 1	206	16.59	1.91	0.05	0.5	1.64485	-0

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the lower horizontal dashed blue line is positioned at α on the vertical axis; the upper horizontal dashed blue line is positioned at 1-β on the vertical axis. The vertical green line is positioned at one standard deviation above the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at α and the upper bound of Δ at 1-β. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, upper bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ < action level and alpha (%), probability of mistakenly concluding that μ > action level. The following table shows the results of this analysis.

Number of Samples							
AL=18		α=5		α=10		α=15	
		s=33.18	s=16.59	s=33.18	s=16.59	s=33.18	s=16.59
UBGR=110	β=45	1067	268	674	170	460	116
	β=50	921	232	559	141	366	92
	β=55	786	198	455	115	283	72
UBGR=120	β=45	268	68	170	43	116	30
	β=50	232	59	141	36	92	24
	β=55	198	51	115	30	72	19
UBGR=130	β=45	120	31	76	20	52	14

	β=50	104	27	63	17	42	11
	β=55	89	24	52	14	32	9

s = Standard Deviation
UBGR = Upper Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ < action level
α = Alpha (%), Probability of mistakenly concluding that μ > action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $36,930.00, which averages out to a per sample cost of $179.27. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**206 Samples**
Field collection costs		$25.00	$5,150.00
Analytical costs	$130.00	$130.00	$26,780.00
Sum of Field & Analytical costs		**$155.00**	**$31,930.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$36,930.00**

Further Recommended Data Analysis Activities

Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

Rochester Park Data, outlier removed.

Random sampling locations for comparing a mean with a fixed threshold (parametric)

Summary
This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The mean value at the site is less than the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	10
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2
Total cost of sampling [d]	$6,550.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the mean value at the site is less than the threshold. The alternative hypothesis is that the mean value is equal to or exceeds the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the

same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently larger than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability (1-β) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z_{1-\alpha}^2$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
β	is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

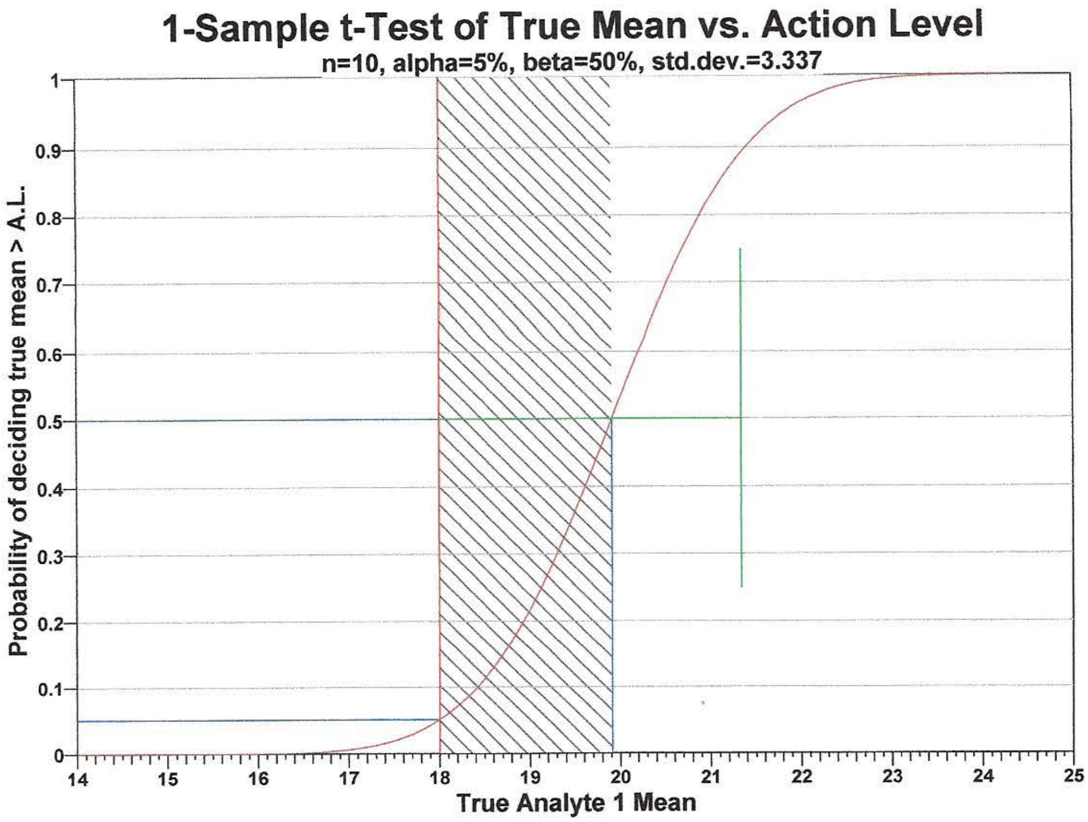
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Analyte 1	10	3.337	1.91	0.05	0.5	1.64485	-0

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the lower horizontal dashed blue line is positioned at α on the vertical axis; the upper horizontal dashed blue line is positioned at 1-β on the vertical axis. The vertical green line is positioned at one standard deviation above the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at α and the upper bound of Δ at 1-β. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, upper bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ < action level and alpha (%), probability of mistakenly concluding that μ > action level. The following table shows the results of this analysis.

<table>
<tr><th colspan="8">Number of Samples</th></tr>
<tr><th colspan="2" rowspan="2">AL=18</th><th colspan="2">α=5</th><th colspan="2">α=10</th><th colspan="2">α=15</th></tr>
<tr><th>s=6.674</th><th>s=3.337</th><th>s=6.674</th><th>s=3.337</th><th>s=6.674</th><th>s=3.337</th></tr>
<tr><td rowspan="3">UBGR=110</td><td>β=45</td><td>45</td><td>13</td><td>29</td><td>8</td><td>20</td><td>6</td></tr>
<tr><td>β=50</td><td>39</td><td>11</td><td>24</td><td>7</td><td>16</td><td>5</td></tr>
<tr><td>β=55</td><td>34</td><td>10</td><td>20</td><td>6</td><td>12</td><td>4</td></tr>
<tr><td rowspan="3">UBGR=120</td><td>β=45</td><td>13</td><td>5</td><td>8</td><td>3</td><td>6</td><td>2</td></tr>
<tr><td>β=50</td><td>11</td><td>4</td><td>7</td><td>3</td><td>5</td><td>2</td></tr>
<tr><td>β=55</td><td>10</td><td>4</td><td>6</td><td>2</td><td>4</td><td>2</td></tr>
<tr><td>UBGR=130</td><td>β=45</td><td>7</td><td>3</td><td>4</td><td>2</td><td>3</td><td>2</td></tr>
</table>

	β=50	6	3	4	2	3	1
	β=55	5	3	3	2	2	1

s = Standard Deviation
UBGR = Upper Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ < action level
α = Alpha (%), Probability of mistakenly concluding that μ > action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $6,550.00, which averages out to a per sample cost of $655.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**10 Samples**
Field collection costs		$25.00	$250.00
Analytical costs	$130.00	$130.00	$1,300.00
Sum of Field & Analytical costs		**$155.00**	**$1,550.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$6,550.00**

Further Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

Park data, no outlier using 10% Beta Error

Random sampling locations for comparing a mean with a fixed threshold (parametric)

Summary

This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The mean value at the site is less than the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	28
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2
Total cost of sampling [d]	$9,340.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective

The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the mean value at the site is less than the threshold. The alternative hypothesis is that the mean value is equal to or exceeds the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the

same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently larger than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability (1-β) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z_{1-\alpha}^2$$

where

n	is the number of samples,
S	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
β	is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is 1-α,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is 1-β.

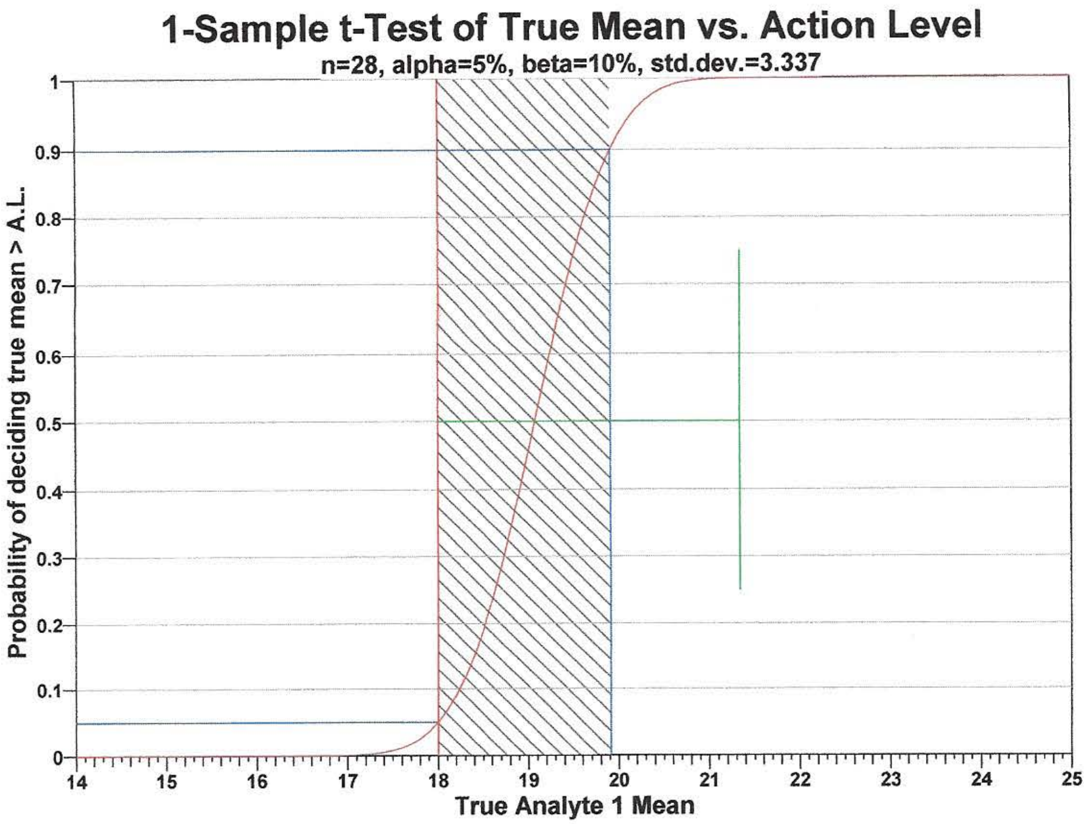
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Analyte 1	28	3.337	1.91	0.05	0.1	1.64485	1.28155

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the lower horizontal dashed blue line is positioned at α on the vertical axis; the upper horizontal dashed blue line is positioned at 1-β on the vertical axis. The vertical green line is positioned at one standard deviation above the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at α and the upper bound of Δ at 1-β. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, upper bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ < action level and alpha (%), probability of mistakenly concluding that μ > action level. The following table shows the results of this analysis.

Number of Samples							
AL=18		α=5		α=10		α=15	
		s=6.674	s=3.337	s=6.674	s=3.337	s=6.674	s=3.337
UBGR=110	β=5	151	39	119	31	100	26
	β=10	120	31	92	24	75	20
	β=15	101	27	75	20	60	16
UBGR=120	β=5	39	11	31	9	26	7
	β=10	31	9	24	7	20	6
	β=15	27	8	20	6	16	5
UBGR=130	β=5	18	6	14	5	12	4

	β=10	15	5	11	4	9	3
	β=15	13	5	10	3	8	3

s = Standard Deviation
UBGR = Upper Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ < action level
α = Alpha (%), Probability of mistakenly concluding that μ > action level
AL = Action Level (Threshold)

Cost of Sampling

The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $9,340.00, which averages out to a per sample cost of $333.57. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**28 Samples**
Field collection costs		$25.00	$700.00
Analytical costs	$130.00	$130.00	$3,640.00
Sum of Field & Analytical costs		**$155.00**	**$4,340.00**
Fixed planning and validation costs			$5,000.00
Total cost			**$9,340.00**

Further Recommended Data Analysis Activities

Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

APPENDIX B – SOPs

SOP 01 - DIRECT PUSH
SOP 02 - HAND AUGER
SOP 04 – METHANOL PRESERVATION
SOP 06 - QC SAMPLES
SOP 07 - PID
SOP 09 - DECON
SOP 10 - SAMPLE LABELING, HANDLING, AND COC
SOP 12 – INVESTIGATIVE DERIVED WASTES

SME SOP 1
STANDARD OPERATING PROCEDURE
SOIL AND GROUNDWATER SAMPLING
USING DIRECT-PUSH METHODS

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) provides guidance for the collection of soil and groundwater samples using direct-push sampling methods. Direct-push sampling methods use a hydraulically-powered percussion hammer to drive samplers to the desired depth for collection of soil and groundwater samples. The term soil probe is intended to be synonymous with the direct-push sampling systems that are mounted on pickup trucks, all-terrain vehicles, skids, etc.

This SOP occasionally uses the nomenclature of Geoprobe® brand direct-push sampling equipment. Specific sampling tools will vary depending on the brand of the direct-push system, such as Geoprobe ®, Simco ®, etc, however, sampling tools used by competing direct-push systems are generally similar.

Contact the appropriate utility locator service to locate subsurface utilities at the site before beginning subsurface activity. Take note of the lead time required by utility locator services to provide utility clearance. Contact the utility locator at least 3 working days but no more than 10 working days prior to drilling or other subsurface activity. In addition, ask the owner for all known utility locations. Consider the need to hire a private locator in areas where dangerous utilities are expected. Refer to SME's Safety Manual for additional information regarding utility clearance.

OBJECTIVE

The objective of using direct-push sampling methods is to obtain soil and/or groundwater samples representative of in-situ conditions for visual classification and/or laboratory analyses.

EQUIPMENT LIST

1. Project instructions, health and safety plan.
2. Appropriate field forms and logs.
3. Laboratory analytical sample containers and labels.
4. Tool box with:
    - Sharpies, water proof pens, pencils
    - Liner cutter or utility knife with hook blades
    - Side cutters
    - 1 ½-Inch putty knife or spatula
    - Pliers
    - Measuring tapes and/or measuring wheel.
5. Field photoionization detector (PID), calibration gas, and an appropriate regulator, as required by project instructions.
6. Cooler with cold packs or ice.
7. Small diameter electronic water level meter.
8. Peristaltic pump and tubing (for water sampling). The peristaltic pump and tubing are usually supplied by the direct-push contractor. If using a contractor other than SME, contact the contractor to verify.

9. Decontamination equipment as specified in SME SOP 9, *Decontamination of Field Equipment*.
10. Glass geotech jars or one-gallon resealable baggies for visually classified samples and field screening.
11. Other supplies/equipment
    - plastic sheeting
    - large garbage bags
    - towel or paper towel
    - sturdy work gloves.

PROCEDURES

The environmental field representative will be responsible for the collection of the soil and groundwater samples, as well as for related sample handling and field documentation. Procedures for soil and groundwater sample collection, using direct-push methods are presented below.

A. DECONTAMINATION

The direct-push operator will be responsible for decontamination of soil probe equipment. As such, the direct-push operator should clean soil probe rods, macro-cores, stainless steel screen point samplers or other non-disposable temporary well screens and riser pipe, and other direct-push equipment with a high pressure, high temperature steam cleaner prior to each use. The environmental field representative will be responsible for decontamination of sampling equipment following the guidance provided in the SME SOP 9, *Decontamination of Field Equipment*. Management of investigation residuals including soil cuttings, unused soil samples, purge water, development water, decontamination water, and disposable sampling and personal protection equipment, should follow SME SOP 12, *Investigative Derived Wastes*. In addition, the project instructions should be consulted for site specific requirements related to decontamination and investigative derived wastes.

B. SOIL SAMPLING

Two types of soil samplers can be employed for the collection of soil samples; continuous and discrete samplers. In continuous sampling, the soil above the desired depth of interest is continuously removed, generally in 4- to 5-foot lengths, until the desired sampling depth is reached. Discrete samplers, generally 2 and 4 feet in length, allow the direct-push operator to drive the sampler through overlying soils to a desired depth, before collection of the desired sample. The direct-push operator will operate the direct-push sampling system. For soil samples, the operator will generally bring the soil sample, which is collected in an acetate liner, to the field representative.

Soil Samples Collected for Field Screening and Classification

1. Receive the liner from the operator. Confirm sample interval and the up/down orientation of the liner with operator. Note up/down orientation on liner.
2. Cut the liner along the entire length using a specialized liner cutter or a utility knife with a hooked blade. If using a utility knife, make two parallel cuts, approximately two inches apart, along the length of the liner. Remove the 2-inch length, leaving the soil sample cradled in the remaining liner section.
3. Measure and record the length of recovery.

4. Collect representative soil samples of each encountered soil type, lithology, and/or analytical sample interval, for classification and field screening with a PID into an 8-ounce glass geotechnical sample jar or resealable plastic baggie, as specified in project instructions.
5. Conduct PID field screening following SME SOP 7, *Field Measurements Using a Photoionization Detector (PID)*.
6. Classify the soil in accordance with SME's General Notes for Soil Classification and the Unified Soil Classification System, then record the classification on the field log (see attached).
7. Record additional pertinent information, as appropriate, on the field logs. Field logs should be filled out completely prior to leaving the site.
8. Manage soil samples in 8-ounce glass geotechnical sample jars or resealable plastic baggies as specified in project instructions or SME SOP 12, *Investigative Derived Waste*.

Analytical Soil Sample Collection

1. Select the desired sampling depth or interval based on the project instructions. Notify the project manager or person in responsible charge of observed field or subsurface conditions which may require variation of the project instructions provided.
2. Collect soil samples from the desired depth interval in an appropriate laboratory supplied container(s). Soil samples for VOCs analysis should be collected with minimal disturbance following the procedures outlined in SME SOP 4, *Methanol Preservation of Soil Samples* or SME SOP 4A, *Soil Sampling with EnCore® Samplers*. For other parameters, the remainder of the sample from the desired depth interval should be placed into a stainless steel, plastic, or other container made of acceptable material and mixed thoroughly to obtain a homogeneous sample representative of the sampling interval unless directed otherwise by the project instructions or person-in-responsible charge.
3. To minimize the potential for cross contamination, a clean pair of nitrile gloves, or other type if required for the suspected contaminants, should be worn prior to collection of each analytical soil sample.
4. Label sample jars with the project number, date and time of collection, sample ID, generally consisting of the soil probe location and sample interval (Example: SB1-LS2 (2-4')), the requested analysis, the type of preservative, if applicable, and the sampler's initials, as specified in SME SOP 10, *Sample Labeling, Sample Handling, and Chain of Custody*.
5. Record the sample depth, time of collection, and observations which contributed to the selection of that particular sample interval, i.e. particular odors, staining, elevated PID readings, etc., on the soil probe field log.
6. Place the analytical samples in a cooler with cold packs or ice as soon as practical after obtaining the sample to maintain sample integrity. Ice or refrigerate samples until delivery to the analytical laboratory. During winter months care should be taken to prevent samples from freezing.
7. Clean sampling tools, i.e. liner cutter, utility knife, putty knife, if used, with non-phosphate laboratory grade detergent and rinse with distilled water

between each sample location following SOP 9, *Decontamination of Field Equipment*.

8. Follow the project instructions and SME SOP 6, *Field Quality Control Samples*, for collection of Quality Assurance/Quality Control (QA/QC) samples.
9. Record the sample information on the Chain of Custody as specified in SME SOP 10, *Sample Labeling, Sample Handling, and Chain of Custody*.
10. Manage residual soil cuttings according to SME SOP 12, *Investigative Derived Wastes*, and the project instructions.

C. GROUNDWATER SAMPLING

Groundwater sampling from soil probes may be conducted with a Screen Point Sampler or by using a slotted well point (temporary well). A screen point sampler uses a 19-inch long stainless steel screen, with 0.0057-inch mesh encased in a perforated stainless steel sleeve. The screen section is enclosed in a sheath until it is pushed to the desired depth. At the desired depth the sleeve is pulled back to collect the groundwater sample. Temporary wells use a slotted PVC screen and riser. The PVC well may be pushed to depth for short distances, in the case of cave-in, but is generally placed in the open probe hole. Temporary wells are typically used at the water table and may be preferred where turbid water is expected from disturbance of the soil.

1. Purge the screen point sampler or temporary well using a peristaltic pump and clean lengths of tubing. Purge the groundwater of approximately 3 well volumes of groundwater, or until the groundwater appears relatively free of suspended sediment. If the screen point sampler or temporary well goes dry, consult the person-in-responsible charge.

   If low-flow sampling is required, pump the groundwater using a low flow rate, generally between 100 and 500 ml/min. For low-flow sampling, monitoring of the drawdown within the screen point sampler or temporary well, may also be required. If the project requires the monitoring of indicator parameters, such as temperature, dissolved oxygen, pH, conductivity, ORP, or turbidity, to determine well stabilization prior to sampling, refer to SME SOP 5, *Low-Flow (Minimal Drawdown) Sampling*, for groundwater sampling guidance.

   If low-flow sampling is not required, purge groundwater until three consecutive measurements meet the following criteria:

   - pH: +/- 0.1 pH units
   - Conductivity: +/- 3%
   - Temperature: +/- 0.2 ^{o}C

   Refer to SME SOP 14, *Calibration and Use of Oakton Instruments PC 300 waterproof handheld pH, Conductivity, temperature, and TDS meter*.

2. Collect groundwater samples in pre-cleaned laboratory supplied containers with the proper preservative. To minimize the potential for cross contamination, a clean pair of nitrile gloves, or other type if required for the suspected contaminants, should be worn prior to collection of each analytical groundwater sample.
3. Samples collected for metals analysis will generally be collected as unfiltered. Consult the project instructions for direction as to the specific project requirements.

4. Unless indicated otherwise in the project instructions, collect the samples in the following order:
   a. Volatile organic compounds
   b. Semi-volatile organic compounds, including PCBs and pesticides
   c. Metals
   d. Cyanide
   e. Anions and Cations (nitrate/nitrite/sulfate)
   f. Alkalinity
5. Groundwater samples collected for VOC analysis should be observed for bubbles. If the sample contains air bubbles, collect a new sample into a new container appropriately preserved. If air bubbles persist, collect an unpreserved sample. Note the use of unpreserved sample containers in the field log on the Chain of Custody.
6. Label the analytical groundwater sample jars with the project number; date of collection; sample ID, generally consisting of the soil boring location, sample type, and screened interval [example: SB2-GW(6-10')]; the requested analysis; the type of preservative, if applicable; and the samplers initials following SME SOP 10, *Sample Labeling, Sample Handling, and Chain of Custody*.
7. Place the analytical samples in a cooler with cold packs or ice as soon as practicable after obtaining the sample to maintain sample integrity. Ice or refrigerate samples until delivery to the analytical laboratory. During winter months care should be taken to prevent samples from freezing.
8. Record the sample ID, the time of collection, and the screened interval, if not included as part of the sample ID, on the soil boring field log.
9. Follow the project instructions and SME SOP 6, *Field Quality Control Samples*, for collection of QA/QC samples.
10. Record the sample information on the Chain of Custody as specified in SME SOP 10, *Sample Labeling, Sample Handling, and Chain of Custody*.
11. Manage purged groundwater according to SME SOP 12, *Investigative Derived Wastes*, and the project instructions.

<u>Prior to Leaving the site</u>

1. Review collected analytical and quality control sample labels for consistency and accuracy. Double check that requested analytical and QA/QC samples have been collected.
2. Complete the chain-of-custody. Verify that each analytical sample and QA/QC sample is documented on the chain-of-custody, and that the dates and times documented are consistent with those on the sample containers.
3. Document/verify soil probe locations on a scaled site map, preferably relative to some fixed, reproducible point. Identify deviations from the project instructions.
4. Borehole sealing and surface repair should be performed by the probe operator according to SME SOP 12A, *Investigative Derived Waste* and the project instructions.

5. Clean sampling equipment and buckets used for decontamination of sampling equipment. Dispose of decontamination water according to SME SOP 12, *Investigative Derived Waste* and the project instructions.
6. Review the site to verify debris such as soil liners, used gloves, etc., have been cleaned up and managed according to SME SOP 12, *Investigative Derived Waste* and the project instructions.
7. If required, notify designated contact, site supervisor, contractor, client, etc. that SME, and any subcontractors retained by SME, are leaving the site.

ATTACHMENTS

Soil Boring Log
General Notes for Soil Classification
Unified Soil Classification System Guide

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

ASTM D 6282-98 (Reapproved 2005), Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations

ASTM D 6001-96 (Reapproved 2002), Standard Guide for Direct-Push Water Sampling for Geoenvironmental Investigations

ASTM D6640-01 (2005), Standard Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations

Geoprobe Technical Bulletin No. 95-1500, Screen Point 15 and Screen Point 16 Groundwater Samplers, Standard Operating Procedure

Geoprobe Technical Bulletin No. 95-8500, Geoprobe Macro-Core Soil Sampler, Standard Operating Procedure

EPA/600/R-92/128, July 1992, Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies, Benjamin J. Mason, Ph.D., CR 814701

US EPA Environmental Response Team, Standard Operating Procedures, SOP #2012, February 18, 2000

HEALTH AND SAFETY

THE HEALTH AND SAFETY PLAN (HASP) FOR THE PROJECT SHOULD BE REVIEWED PRIOR TO PERFORMING FIELD ACTIVITIES. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND FIRST AID SUPPLIES SHOULD BE TAKEN INTO THE FIELD, AS SPECIFIED IN THE HASP, AND USED AS APPROPRIATE. IF A HASP HAS NOT BEEN SUPPLIED, CONSULT THE PERSON-IN-RESPONSIBLE CHARGE.

SME SOP 2
STANDARD OPERATING PROCEDURE
SOIL SAMPLING WITH A HAND AUGER

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) describes methods to obtain soil samples utilizing a hand auger for environmental projects.

Contact the appropriate utility locator service to locate subsurface utilities at the site before beginning subsurface activity. Take note of the lead time required by utility locator services to provide utility clearance. In Wisconsin, the Digger's Hotline must be contacted at least 48 hours but no more than 10 working days prior to drilling or other subsurface activity. In addition, ask the owner for all known utility locations. Consider the need to hire a private locator in areas where dangerous utilities are expected. Refer to SME's Safety Manual for additional information regarding utility clearance.

OBJECTIVE

Soil sampling is used to observe and classify subsurface soil conditions and to collect soil samples for laboratory testing. Hand augers are often conducted when a sampling location is inaccessible to a drill rig. The ability to advance a hand auger is dependent on subsurface conditions. Generally, the use of a hand auger is not considered for sampling depths greater than 7 or 8 feet.

EQUIPMENT LIST

To conduct soil sampling utilizing hand auger equipment, the field sampling personnel should bring the following equipment:

1. Project instructions, health and safety plan.
2. Appropriate field forms and logs.
3. Hand Auger consisting of the following items (as appropriate):
    - T-handle
    - Auger extension, total length equal to the proposed boring depth
    - Auger bucket:
        - 3¼-inch diameter, stainless steel bucket auger
        - 2- inch diameter steel split bucket auger
        - 3-inch diameter PVC pipe in length equal to the proposed boring depth
4. A tool box which consists of the following items:
    - utility knife
    - 12 piece ½-inch drive socket set
    - 1-1/2 inch putty knife or spatula
    - flashlight
    - 12-inch channel locks
    - 25-foot weighted fiberglass, plastic or steel measuring tape
    - 100-foot plastic measuring tape
    - duct tape
    - non-phosphate detergent
5. Shovel or pick-ax for potential use at the ground surface
6. Photoionization detector (PID)

7. Cooler with cold packs or ice, depending on project instructions
8. Decontamination equipment as specified in SME SOP 9, *Decontamination of Field Equipment*.
9. Work gloves consisting of latex, nitrile and/or rubber for handling samples. The glove material should be matched to resist the suspected contaminants.
10. A sufficient quantity of geotechnical jars and laboratory jars to accommodate the proposed number of samples to be obtained.
11. Roll of 4 millimeter plastic sheeting for placement beneath sampling equipment.

PROCEDURES

The following describes the procedures and techniques used during soil sampling with a hand auger:

1. Hand auger borings are typically advanced by rotating and applying pressure to the hand auger.
   - For sampling through layers of saturated sand less than 4 feet thick, a 3-inch diameter temporary PVC casing can be used to keep the bore hole open. A 2-inch diameter split bucket hand auger is used to remove soil from inside the PVC casing.
2. Plastic sheeting should be placed adjacent to the borehole to facilitate sample collection. After removing the bucket auger from the borehole, care should be taken to prevent dropping soil on the ground. The soil sample should be extracted from the auger bucket using a pre-cleaned putty knife or spatula. Note that soil samples should generally NOT be collected for analysis of volatile organic compounds (VOCs) from hand augers. However, if the project instructions request sampling for VOCs, the soil sample intended for VOC analysis should be collected with minimal disturbance and preserved with methanol in the field following the procedures outlined in SME SOP 4, *Methanol Preservation of Soil Samples*. For other parameters, the remainder of the sample from the desired depth interval should be placed into a stainless steel, plastic, or other container made of acceptable material and mixed thoroughly to obtain a homogeneous sample representative of the sampling interval unless directed otherwise by the project instructions or person-in-responsible charge. A second portion of the soil sample should be placed into a 6-oz glass jar (geotechnical jar) or resealable plastic bag for visual engineering classification and screening with a PID according to SOP 7, *Field Measurements Using a Photoionization Detector (PID).* Residual soil should be placed in a bucket or on plastic sheeting until the hand auger boring is completed.
3. Field staff should visually classify the encountered soils using SME's General Notes for Soil Classification and the Unified Soil Classification System (USCS) and record this information on field boring logs along with other sampling information.
4. Laboratory samples should be labeled and placed into a cooler with cold packs or ice as provided by SME SOP 10, *Sampling Labeling, Sample Handling, and Chain of Custody.* During winter months geotechnical and environmental samples should be protected from freezing which can result in sample damage and jar breakage.
5. Decontaminate hand augers and sampling equipment as outlined in SME SOP 9, *Decontamination of Field Equipment.*
6. Following completion of the hand auger boring, the borehole should be backfilled with remaining soil cuttings or according to the project instructions. The filled borehole shall be capped according to the project instructions.

7. Wastes shall be managed according to SME SOP 12, *Investigative Derived Wastes* and the project instructions.

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

ASTM D 6907-05, Standard Practice for Sampling Soils and Contaminated Media with Hand-Operated Bucket Augers

US EPA Environmental Response Team, Standard Operating Procedures, SOP #2012, February 18, 2000

HEALTH AND SAFETY

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SME SOP 4

STANDARD OPERATING PROCEDURE
METHANOL PRESERVATION OF SOIL SAMPLES

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) describes methods to conduct field methanol preservation of soil samples intended for laboratory analysis of volatile organic compounds (VOCs). VOCs include benzene, toluene, ethylbenzene and xylenes(s) (BTEX), naphthalene, halogenated volatile organic compounds (HVOCs), ethylene dibromide, MTBE, MEK, etc. Methanol preservation is not required for soil samples intended for laboratory analysis of semi-volatile organic compounds (SVOCs), which include polynuclear aromatic hydrocarbons (PAHs). It should be noted that naphthalene and 2-methylnaphthalene can be analyzed by the laboratory using either a VOC or an SVOC/PAH analysis method. Confirm which type of analysis method is needed for the project if naphthalene and/or 2-methylnaphthalene are constituents of concern.

OBJECTIVE

Methanol preservation of soil samples is intended to limit volatilization of VOCs from the time of sample collection to sample analysis. This method is intended to minimize disturbance of the soil prior to sample collection and to quickly field preserve the soil sample, to assist in obtaining analytical results that are representative of in-situ conditions.

EQUIPMENT LIST

1. Project instructions, health and safety checklist and associated job hazard analysis (JHA)
2. Field activity report, low-flow monitoring well sampling field reports (one for each well to be sampled), and chain-of-custody (COC)
3. Safety glasses and nitrile gloves
4. Sample labels (as needed)
5. Tool Box:
    - Sharpies, water proof pens, pencils
    - Liner cutter or utility knife with hook blades
    - Putty knife, spatula, or stainless steel spoon (or equivalent metal implement)
    - Small brush
    - Clean disposable towels
    - Digital flat scale or spring scale accurate to ±1 gram (gr)
    - US nickel (equal to approximately 5 gr) or a 5 gr to 10 gr weight for scale calibration
    - Non-phosphate detergent
    - Plastic baggies with color changing seal
6. Laboratory analytical sample supplies and containers (i.e., methanol kits)
    - 10 milliliter (mL) polyethylene syringes

- 40 mL volatile organic analysis (VOA) jars with Teflon™ lined septas containing 10 mL of methanol. The VOAs should be labeled with an expiration date and the sample container tracking number and/or tare weight (used by the laboratory to document and track initial VOA weight). Check the VOAs prior to leaving the office to confirm the VOAs are not expired and have a tracking number. If no date is listed on the VOA, check with the selected analytical laboratory to verify the methanol is acceptable for use.
- 4-ounce or 8-ounce glass jars

7. Cooler with ice
8. Decontamination equipment as specified in SME SOP 9, *Decontamination of Field Equipment*
9. Other supplies/equipment

- Plastic sheeting
- Large garbage bags
- Towel or paper towel
- Sturdy work gloves

Notes:

1. The selected analytical laboratory should at a minimum provide the 10-ml polyethylene syringe, 40-ml VOAs with 10 ml of methanol, and the 4-oz. wide mouth jar. Be sure to check with the selected analytical laboratory well before the sampling event to verify what supplies they will be providing.
2. For the purposes of this SOP, it is assumed the selected analytical laboratory is providing 10 ml methanol preservation kits. Methanol preservation requires 1 gr of soil for 1 mL of methanol.

PROCEDURES

The procedure and techniques presented below assume the soil sample has been collected using a hand auger, hollow-stem auger, or direct-push sampling system (e.g., Geoprobe®) and that the split-barrel sampler or direct-push acetate liner has been opened. When collecting samples for VOC analysis, avoid sources that generate VOCs such as petroleum products, vehicle exhaust, etc.

1. Wear your safety glasses and appropriate gloves.
2. Wipe the digital flat or spring scale with a moist, clean towel.
3. Calibrate the scale using the 5-g nickel or known weight. Record the calibration. The calibration should be performed prior to beginning sampling activities at each boring location.
4. Using the scale, weigh the empty syringe, then re-zero the scale.
5. Insert the open end of syringe into a fresh face of undisturbed soil (if possible) within the sample collection device (i.e., split barrel sampler or acetate liner). If collecting samples from a hand auger barrel, it may not be possible to collect a sample directly from the barrel. It may be necessary to collect the sample from soil that has been transferred from the barrel to plastic sheeting. In this event, attempt to minimize disturbance and handling of the soil prior to sample collection.

6. Push the syringe into the soil and fill it to about the 10-mL mark on the syringe. *Note: Depending on the soil type, e.g., stiff clays or gravel, and the moisture content, you may not be able to push the syringe into the soil matrix or the soil matrix may not stay in the syringe. In this case, you may have to manually transfer the appropriate amount of soil from the sample collection device using a stainless steel spoon or equivalent implement and place it into the syringe until you get to the 10-mL mark.*
7. Using the stainless steel spoon or other instrument, push the soil deeper into the syringe to leave an approximately ¼ inch to ½ inch space at the top of the syringe.
8. Weigh the soil-filled syringe on the re-zeroed scale. The weight of the soil must be 10 gr ±1 gr (9 gr to 11 gr). If the weight of the sample is more than the maximum amount (11 gr), use the stainless steel spoon or equivalent implement to extract enough soil to get to 10 gr ± 1 gr of soil. If the weight of the sample is less than the minimum amount (9 gr), re-sample.
9. Insert tip of syringe into a 40-ml VOA containing methanol and depress the plunger **SLOWLY** to release soil into the VOA.
10. Place cap **TIGHTLY** on VOA.
11. Gently swirl the sample and methanol for about 10 seconds to break up the soil. **DO NOT SHAKE.**
12. Complete the laboratory affixed label on the VOA. Do not add additional labels to the VOA because they may cover and/or damage the sample container tracking number and/or tare weight used by the laboratory to record the amount of methanol added to each VOA. Label sample containers as specified in SME SOP 10, *Sample Labeling, Sample Handling, and Chain of Custody*.
13. Place VOA in laboratory supplied re-sealable bags and place in the cooler with ice. If the laboratory did not supply plastic bags for transport, place the VOA in an individual re-sealable plastic bag. Keep the samples cool (ice or refrigerated) until delivery to the analytical laboratory. During summer months on hot days, ice may need to be replaced during sampling and transport. During winter months, care should be taken to prevent samples from freezing.
14. If needed, fill a 4-ounce or 8-ounce jar with soil collected from the same sample interval as the VOC sample. This sample will be submitted to the analytical laboratory for dry weight. You may be able to use samples intended for other analyses (e.g., PAHs or metals) for your dry weight. Check with the selected laboratory to verify this.
15. Clean sampling tools (e.g., liner cutter, utility knife, putty knife, etc.) with non-phosphate, laboratory-grade detergent and rinse with distilled water between each boring location following SOP 9, *Decontamination of Field Equipment*.
16. Follow the project instructions and SME SOP 6, *Field Quality Control Samples*, for collection of Quality Assurance/Quality Control (QA/QC) samples.
17. Record the sample information on the Chain of Custody (COC) as specified in SME SOP 10, *Sample Labeling, Sample Handling, and Chain of Custody*.
18. Manage excess soil cuttings generated during sample collection as described in SME SOP 12, *Investigative Derived Waste*.

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

“Environmental Response Division Guidance Memo New VOC Sediment Sampling Method 5035 ERD Field Sampling Procedure,” Interoffice Communication, Revised March 31, 1998.
“Soil Sampling and Analysis for Volatile Organic Compounds,” EPA Ground-Water Issue, February, 1991.

HEALTH AND SAFETY

THE HEALTH AND SAFETY CHECKLIST AND JHA(S) FOR THE PROJECT SHOULD BE REVIEWED PRIOR TO PERFORMING FIELD ACTIVITIES. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND FIRST AID SUPPLIES SHOULD BE TAKEN INTO THE FIELD, AS SPECIFIED IN THE HEALTH AND SAFETY CHECKLIST, AND USED AS APPROPRIATE. IF A HEALTH AND SAFETY CHECKLIST HAS NOT BEEN SUPPLIED, CONSULT THE PERSON-IN-RESPONSIBLE CHARGE.

SME SOP 6
STANDARD OPERATING PROCEDURE
FIELD QUALITY CONTROL SAMPLES

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) provides guidance for the collection of quality control (QC) samples during a sampling event. QC is the set of activities that are performed for the purposes of monitoring, measuring, and controlling the performance of a measurement process. QC samples provide measurable data quality indicators used to evaluate the difference components of the measurement system, including sampling and analysis. The QC samples discussed in this SOP include blanks (field, equipment rinse, and trip), duplicates (including splits), and matrix spike/matrix spike duplicates.

OBJECTIVE

QC samples provide measurable data quality indicators used to evaluate the difference components of the measurement system, including sampling and analysis. During the systematic planning process, each QC sample's value should be determined based on its contribution to measuring based on its contribution to measuring precision, accuracy/bias, contamination, and sensitivity. QC samples may impose significant costs; therefore, it is important to identify which of those samples are not cost-effective (i.e. which provide little additional information regarding data quality, or which duplication information provided by other QC samples). Project QC needs must be determined based on the decision to be made and the related level of data quality required. Deciding the most appropriate QC samples and setting appropriate acceptance limits are a key part of project planning and frequently require some professional judgment; therefore, the QC samples needed for a specific project should be selected by the project manager or specified person-in-responsible charge.

EQUIPMENT LIST

Equipment needed for collection of field quality control samples includes:

1. Project instructions, health and safety plan.
2. Appropriate field forms and logs.
3. Sample bottles appropriate for each type of QC sample and matrix;
4. Distilled water;
5. Deionized water or prepared trip blank(s);
6. Sample collection device for equipment rinse blanks; and
7. SME SOPs for groundwater sampling activities and/or soil sampling activities as appropriate.

PROCEDURES

The sampling procedure for the collection of field quality control samples is identical to the collection of actual field samples. The exact procedure depends on the contaminants of concern, sampling matrix, and sampling method. Refer to individual SOPs for the matrix and type of sampling. The specific QC samples collected should be as specified by individual SOPs and based on project quality objectives.

A. BLANKS

1. Field Blank

- A field blank is a sample container filled in the field during a sampling event with distilled water and preservatives, as appropriate. Field blanks are analyzed for parameters anticipated to be in the on-site atmosphere, such as volatile organics or particulate metals. A field blank collected near the time of potential greatest atmospheric contamination is typical. Examples of sources of atmospheric contamination include emissions from facility operations or heavy equipment operation, and dust from active excavation.
- It is common for a project to combine the field blank and equipment blank into a single QC sample. However, if the combined blank reveals contaminants of concern, it will be impossible to distinguish between atmospheric contamination and contamination caused by improper decontamination.
- Where method volatile analysis for soils, sediments, sludges, and waste container samples is done, methanol blank samples should be provided by the laboratory for each methanol lot used. These lots should be tracked in the field and reported on the laboratory receipt form so laboratory correlations can be made.
- Collect one per 20 or fewer samples per matrix and analytical group per concentration level, at least one per day.

2. Equipment Rinse Blank

- Equipment rinse blanks are collected from non-dedicated equipment. Examples of non-dedicated equipment include bailers, pumps, split barrel samples, trowels and vacuum filtrations units which are frequently reused, requiring decontamination between each use. Refer to SOP 9, *Decontamination of Field Equipment*, for standard decontamination procedures. After decontamination, the sampling device is rinsed again with distilled water and this final rinse water is sampled as the equipment rinse blank.
- To collect equipment rinse blanks from the vacuum filtration unit used to filter groundwater samples for dissolved metal analysis, the unit should be assembled in the same manner as for sample collection, including a new filter. A sample volume of distilled water is then run through the cleaned filtration unit as the equipment rinse blank. Equipment rinse blanks are analyzed for the same parameters of concern as other samples. Note: Filtering samples for metals should only be performed if indicated in the project instructions or by the person-in-responsible charge.
- If needed, further demonstration of the effectiveness of decontamination can be obtained by collecting a second equipment rinse blank after sampling, prior to decontamination. The results of this sample can be compared to the equipment rinse blank collected on decontaminated equipment.
- The frequency of equipment rinse blanks should be increased when higher sample concentrations are expected or when false positive detections are not acceptable.

- Collect one per 10 or fewer samples per matrix and analytical group per sampling procedure per sampling team.

3. Trip Blank

- A trip blank is a sample of deionized water prepared before any sampling is performed and are supplied by the laboratory upon request. Trip blanks are typically filled and capped in the laboratory, and sent to the field with other sample containers in the cooler or other sample transport receptacle. The trip blank remains unopened in the field, is stored with other site samples, and is returned to the laboratory for analysis. Trip blanks are analyzed primarily for volatile organic samples. To avoid cross-contamination between samples, samples which are indicated in the field to contain higher concentrations of volatile organics should be packaged separately from other samples. A spare cooler is useful for this purpose. However, trip blanks may also be used for phthalates, which can be transferred from plastics in sample containers to sample.
- Collect one per every volatile organic sample shipping container.

B. FIELD DUPLICATE (REPLICATE) SAMPLES, CO-LOCATED SAMPLES AND SUBSAMPLES

The difference between field duplicate (replicate), co-located samples and subsamples on most projects is insignificant. If the sample is not mixed together, then split, the sample is a co-located sample; if the sample is mixed together, then split, the sample is a subsample (commonly referred to as a duplicate).

- When collecting soil samples for volatile organic compounds (VOCs), the field duplicate samples should be co-located; if mixed, the VOCs present in the sample may be released due to aeration, yielding inaccurate results.
- When collecting soil samples for semi-VOCs, polynuclear aromatic hydrocarbons (PAHs) or metals, the field duplicate samples may be subsamples.
- When collecting groundwater samples via low-flow sampling, there is no significant difference between co-located samples and subsamples.
- Collect one per 10 or fewer samples per matrix and analytical group per sampling procedure per sampling team.

Split samples are field duplicate (replicate) samples which are sent to two or more different laboratories to be analyzed for the same parameters as other samples. It is common to split samples between a governmental regulatory body (e.g., MDEQ) and a facility owner or liable party. Consult the person-in-responsible charge to determine if split samples will be collected for a specific project. *Note: When evaluating the results of split samples, the results should be evaluated by taking into consideration the acceptance "windows" of the two or more laboratories, plus sampling error, and allowances for heterogeneous matrices (soils and solids). If the laboratories produce results which differ by more than would be expected from random error sources, the laboratories should be contacted to verify that the correct samples were analyzed and the correct analysis methods were used. In addition you may request that the laboratories re-evaluate their calibration and batch QC information. If there is still no explanation for the differences it may be useful for the laboratories to exchange calibration standards or repeat analysis of another split sample set.*

C. MATRIX SPIKE/MATRIX SPIKE DUPLICATE (MS/MSD)

MS/MSD samples and surrogates are two or more separate samples, from the same source collected at the same times that are spiked in the laboratory. MS/MSD samples for organic and inorganic water analyses require double sample volume. The actual MS/MSD sample is prepared by the laboratory to evaluate accuracy.

MS/MSD samples should be taken at critical locations, but different from the field blank.

Collect one MS/MSD sample per 20 or fewer samples per matrix and analytical group, at least one per day.

D. DATA RECORDS MANAGEMENT

Quality control samples receive the same documentation as actual samples. They should be listed on the chain-of-custody forms and in field notes, including information on collection date and time, and the sample generation process (i.e., "equipment rinse blank from split barrel sample after completion of SB4").

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

US EPA, Guidance for Preparing Standard Operating Procedures (SOP's), EPA QA/G-6, Office of Environmental Information, March 2001.

US EPA, Guidance on Environmental Data Verification and Data Validation, EPA QA/G-8, Office of Environmental Information, November 2002.

US EPA, Uniform Federal Policy for Quality Assurance Project Plans, EPA-505-B-04-900A, Intergovernmental Data Quality Task Force, March 2005.

HEALTH AND SAFETY

THE HEALTH AND SAFETY PLAN (HASP) FOR THE PROJECT SHOULD BE REVIEWED PRIOR TO PERFORMING FIELD ACTIVITIES. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND FIRST AID SUPPLIES SHOULD BE TAKEN INTO THE FIELD, AS SPECIFIED IN THE HASP, AND USED AS APPROPRIATE. IF A HASP HAS NOT BEEN SUPPLIED, CONSULT THE PERSON-IN-RESPONSIBLE CHARGE.

Field Quality Control Sample Summary Table

The following reference table summarizes the field QC sample information contained in this SOP:

Sampling QC	Data Quality Indicator	Purpose	Recommended Frequency
VOA Trip Blank	Contamination (Accuracy/Bias)	To evaluate contamination introduced during storage and transport.	Minimum 1 per shipment cooler
Field Blank	Contamination (Accuracy/Bias)	To evaluate contamination introduced during sampling, storage, and transport.	Minimum 1 per 20 or fewer samples per matrix and analytical group per concentration level, at least 1 per day
Equipment Blank (rinsate blank)	Contamination (Accuracy/Bias)	To evaluate carryover contamination resulting from successive use of sampling equipment.	Minimum 1 per 10 or fewer samples per matrix and analytical group per sampling procedure per sampling team, at least 1 per day
Field Duplicates -Co-located Samples -Subsamples	Precision	To measure overall precision by evaluating cumulative effects of both field and laboratory precision.	Minimum 1 per 10 or fewer samples per matrix and analytical group per sampling procedure per sampling team, at least 1 per day
Split Samples	Interlaboratory Comparability	To evaluate sample handling procedures from field to laboratory and to evaluate interlaboratory comparability and precision.	As specified by method and based on project quality objectives.
Matrix Spike & Matrix Spike Duplicate	Laboratory Bias/Precision	To determine laboratory preparatory and analytical bias and precision for specific compounds in specific sample matrices.	Minimum 1 per 20 or fewer per matrix and analytical group, at least 1 per day

SME SOP 7 (REVISION 1.0)

STANDARD OPERATING PROCEDURE
FIELD MEASUREMENTS
USING A PHOTOIONIZATION DETECTOR (PID)

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) describes methods for field headspace screening of soil samples and health and safety monitoring with a photoionization detector (PID).

OBJECTIVE

The objective of headspace screening with a PID is to measure ionizable compounds within the vapor of a soil sample. Screening the sample headspace with a PID gives a relative estimate of the level of volatile organic compounds (VOCs) in the soil vapor. The objective of monitoring the breathing zone in work areas or other zones with a PID is to reduce the risk of exposure to volatile compounds above predetermined levels.

PREPARATION

Preparation for the use of a PID is necessary prior to mobilization. The battery should be charged, the lamp cleaned and the unit calibration checked, prior to mobilizing to the field. Sufficient calibration gas(es) must be available and the type and nature of contaminants that may be encountered at the site should be considered.

EQUIPMENT LIST

1. Project instructions, health and safety plan
2. Appropriate field forms and logs
3. PID
4. Span Gas container with regulator
5. Tedlar bag (if required by the PID for calibration checks)
6. Tip for the PID (if required)
7. Charged Battery/Spare Battery
8. Sealable plastic bags or geotechnical jars
9. Tool box that includes a small Philips head screwdriver, small soft brushes, and cloths
10. PID instructions, including calibration checks and trouble shooting

PROCEDURES

FIELD MEASUREMENT PROCEDURES FOR HEADSPACE SCREENING OF A SOIL SAMPLE

1. The PID must have a calibration check at the beginning of each day of use.
   - Turn the PID on and allow it to warm up.
   - Complete a calibration check of the PID with zero gas (the atmosphere) and appropriate span gas, normally isobutylene at 100 parts per million (ppm).

Note A: The PID is factory calibrated to Benzene to direct read benzene. Field calibration is only a calibration check and allows setting to direct read other ionizable compounds.

Note B: The PID is not a selective monitor and has little ability to differentiate between chemicals. However, the PID sensitivity can be adjusted to a specific chemical so that it reads in a relative scale. Refer to the manufacturer's manual for additional information.

2. The soil sample to be screened should be removed from the sampler and vertically split in two with a clean steel putty knife.
3. Approximately 100 to 200 grams of soil representative of the anticipated zone of contamination should be placed in a sealable plastic bag. In the absence of sealable plastic bags, geotechnical jars can be used. The soil should be placed in the bags as soon as practicable after the soil is collected. The soil sample should be broken up within the bag and then placed in a warm place (e.g., tailgate in the sun or in a heated truck cab in the winter months), to allow contaminants to volatilize into the headspace. It is very important in the colder months to warm the samples in a heated truck cab.
4. Allow approximately 10 minutes for vapors to volatilize from the soil into the headspace. Stick the tip of the PID into the headspace by piercing the plastic bag or after lifting the jar lid. Record the highest number shown on your PID within the time limit of the PID. Generally the PID will have screened the headspace within 10 seconds of piercing the bag.
5. The tip of the PID should never touch the soil. If the PID tip touches the soil, turn the unit off, remove the PID tip and check for clogging. The lamp may require cleaning if the PID pulls soil particles into the unit. The pump or fan may also be damaged in this case.
6. Manage soil samples in plastic bags or geotechnical jars in accordance with SME SOP 12, *Investigative Derived Wastes,* and the project instructions.

FIELD MEASUREMENT PROCEDURES FOR HEALTH AND SAFETY SCREENING

Health and safety screening with a PID should be conducted at sites where volatile organic compounds may exist at elevated levels. The project instructions and/or Health and Safety Plan should be reviewed to determine if health and safety screening with a PID is applicable for a site. The procedures provided below should be followed at sites as directed by the project instructions and/or Health and Safety Plan.

1. Follow Calibration methods above.
2. Use the PID to measure the atmosphere in the work zone or breathing area.
3. It is recommended that the field representative on site should check the PID every three to five minutes to monitor vapors in the work zone. Monitoring should be conducted in areas of concern at the site as directed by the project instructions and/or Health and Safety Plan.

4. If PID readings are above predetermined standards, the field representative should contact the person-in-responsible charge to evaluate appropriate action.

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

www.raesystems.com

HEALTH AND SAFETY

THE HEALTH AND SAFETY PLAN (HASP) FOR THE PROJECT SHOULD BE REVIEWED PRIOR TO PERFORMING FIELD ACTIVITIES. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND FIRST AID SUPPLIES SHOULD BE TAKEN INTO THE FIELD, AS SPECIFIED IN THE HASP, AND USED AS APPROPRIATE. IF A HASP HAS NOT BEEN SUPPLIED, CONSULT THE PERSON-IN-RESPONSIBLE CHARGE.

SME SOP 9 (REVISION 1.0)

STANDARD OPERATING PROCEDURE
DECONTAMINATION OF FIELD EQUIPMENT

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) describes methods to conduct decontamination of non-disposable and/or non-dedicated field equipment used during environmental sampling activities.

OBJECTIVE

Decontamination is conducted to minimize potential cross contamination between field equipment used for sampling activities and the samples intended to be submitted for laboratory analysis.

EQUIPMENT LIST

1. Project instructions, health and safety plan
2. Appropriate field form and logs
3. Distilled or deionized water in sufficient volume for the project
4. Laboratory grade non-phosphate detergent
5. Clean five gallon buckets. The buckets can be plastic, galvanized or stainless steel depending on analytes. In most cases, plastic is acceptable
6. 40-gallon containers and 10-gallon containers, if decontaminating pumps and tubing
7. Utility brushes and bottle brush and/or cleaners recommended by the equipment manufacturer
8. Paper and/or cloth towels
9. Plastic sheeting
10. Clean lint-free wipes
11. Personal protective equipment required by the project

PROCEDURES

Non-disposable or non-dedicated equipment used for the collection of soil and groundwater samples should be decontaminated prior to use, between each sampling point or well location, and prior to being returned to the office. Equipment subject to decontamination include, but are not limited to, such items as hand augers, shovels, utility knives, down-hole purge pumps, water level probes, free product probes, flow cells, sensors/probes used to collect groundwater parameter data, and groundwater collection buckets, etc., General procedures for the decontamination of non-disposable and non-dedicated sampling equipment are presented below.

GENERAL EQUIPMENT

- Fill one 5-gallon bucket with 2 or more gallons of distilled or deionized water for washing. Add the amount of detergent recommended by the manufacturer. (If using Liquinox, approximately 2 and 1/2 tablespoons per gallon of water.)

- Fill two additional 5-gallon buckets with distilled or deionized water for the first and second rinse.
- Place a utility brush in the wash and first rinse buckets.
- Manually scrub each piece of equipment in the wash bucket using a utility brush, bottle brush or other scrubber if indicated by the manufacturer. Some equipment may require disassembly to decontaminate. Disassemble according to the manufacturer's instructions.
- Transfer the cleaned equipment to the first rinse bucket. Scrub the cleaned equipment with the designated utility brush. Transfer the equipment to the second rinse bucket for the final rinse.
- Repeat the wash and two-rinse cycle after each sample point.
- Following the final cleaning, air dry equipment or dry with a clean towel.
- Dispose of the decontamination waste water and solutions according to SME SOP 12, *Investigative Derived Wastes,* and the project instructions.

WATER LEVEL AND FREE PRODUCT PROBES

- Unwind the probe tape at least the length of the deepest anticipated well plus an additional approximately 20 feet.
- Using a utility brush, scrub the probe tape in the wash bucket. Also wash the surface of the tape still wound around the spool.
- Transfer the cleaned tape to the first rinse bucket. Scrub the cleaned tape, and the surface of the unwound tape with the designated utility brush. Transfer the tape to the second rinse bucket for the final rinse.
- Repeat the wash and two-rinse cycle after each well is gauged.
- Following the final cleaning, wipe the tape and probe with a paper towel or clean lint free wipe while rolling the tape onto the reel.

GROUNDWATER SAMPLING PUMPS WITH NON-DISPOSABLE TUBING LINES

The following are procedures for the decontamination of groundwater sampling pumps with non-disposable tubing lines. The procedures assume that free product will not be encountered.

- Place the pump on plastic sheeting or within an appropriately-sized container if collection of external wash and/or rinse water is required by the project instructions.
- Prepare a wash solution using distilled or deionized water and detergent, as indicated above, but prepare enough solution for approximately five minutes of pumping. A 40-gallon sized container is recommended.
- Pump the distilled or deionized water and detergent solution through the pump and tubing for approximately five minutes.
- Manually scrub the outside of the pump and the portion of line that will enter the well casing. Also scrub additional lines that may have contacted contaminants due to drips or contact with contaminated lines or the ground.
- Pump distilled or deionized water through the pump and tubing for approximately 5 minutes. Pump the first few minutes into the detergent solution to keep the detergent in one container. Pump the remaining volume into an appropriately sized container.

- Rinse the external portions of the pump and lines with distilled or deionized water.
- Pump an additional 5 gallons of clean distilled water through the pump as a final rinse. Collect the rinse in an appropriately sized container.
- Repeat the wash and rinse process between each sampling location.
- After the final cleaning, rewind the tubing onto the reel and allow the pump to air dry.
- Dispose of the decontamination waste water and solutions according to SME SOP 12, *Investigative Derived Wastes,* and the project instructions.

SPECIAL NOTES

A rinse of methanol, isopropanol or other solvent or acid may be required, depending on site conditions and/or sample parameters. Review decontamination requirements with the person-in-responsible charge prior to mobilizing to the field.

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING (QA/QC)

Field blanks may be required in order to evaluate potential cross contamination associated with rinse water. Consult the project instructions to determine if a field blank(s) is required. If a field blank is required, follow the procedures in SME SOP 6, *Field Quality Control Samples,* and the project instructions.

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

U.S. EPA "Sampling Equipment Decontamination," SOP#:2006, dated August 11, 1994.

Michigan Department of Environmental Quality – Remediation and Redevelopment Division Operational Memorandum No. 2 – Attachment 5, dated October 22, 2004, effective date February 1, 2005.

HEALTH AND SAFETY

THE HEALTH AND SAFETY PLAN (HASP) FOR THE PROJECT SHOULD BE REVIEWED PRIOR TO PERFORMING FIELD ACTIVITIES. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND FIRST AID SUPPLIES SHOULD BE TAKEN INTO THE FIELD, AS SPECIFIED IN THE HASP, AND USED AS APPROPRIATE. IF A HASP HAS NOT BEEN SUPPLIED, CONSULT THE PERSON-IN-RESPONSIBLE CHARGE.

SME SOP 10
STANDARD OPERATING PROCEDURE
SAMPLE LABELING, SAMPLE HANDLING, AND CHAIN OF CUSTODY

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) provides guidance to properly handle and label sample containers and complete Chain of Custody records.

OBJECTIVES

Proper labeling and handling of samples are crucial to a sampling program. The integrity of a sampling program depends on the completion of accurate and legible labels and the handling of samples in accordance with accepted practices. Sample handling is documented by a Chain of Custody. Because the Chain of Custody provides the primary record of sample handling and conveys other important information, it needs to be completed with care and in detail. Due the importance of the Chain of Custody in a sampling program, following is a list of the various functions of a Chain of Custody.

1. A Chain of Custody documents the method(s) of analyses to be performed by the laboratory and the due date of the analytical results. Because the sample times are recorded on the Chain of Custody forms, it also assists the laboratory in analyzing samples within acceptable holding times and helps to provide a record that each sample was analyzed within acceptable holding times.
2. A Chain of Custody functions as a permanent record of the identity of each sample collected and analyzed. The final laboratory analytical report is not considered complete without including the Chain of Custody forms.
3. A Chain of Custody creates the permanent legal record of the exchange of custody and transportation of each sample between collection in the field and laboratory analyses. During the path between collection and analyses, the Chain of Custody documents personnel who have handled the samples.
4. A Chain of Custody assists in maintaining sample integrity (i.e., the sample accurately represents site conditions at the sampling point and is not reflective of conditions external to the site) and obtaining defensible data because the Chain of Custody records personnel responsible for maintaining sample integrity, thereby reducing opportunities for cross contamination or sample tampering.

EQUIPMENT LIST

1. Project instructions, health and safety plan.
2. Appropriate field form and logs.
3. Custody seal for each container, if required by the project instructions

PROCEDURE

1. Clearly mark each sample container label using a permanent marker with a fine enough point to write legibly. Methanol preserved sample containers are pre-affixed with labels which indicate the pre-measured amount of methanol in the sample container. Non-methanol preserved sample containers should

be affixed with a label in the field. If possible, fill out each label immediately prior to filling the sample container so that the label does not become wet or dirty before the information is recorded. Caution: Filling out labels far in advance of sample collection can create serious problems if great care is not exercised in verifying that the label matches the sample location and that the time of sample collection is accurate. After filling out the label for the sample container, the label can be covered with clear packing tape as an added precaution against damage to the label. At a minimum, the following information should be recorded on each label:

- Unique sample identification number (e.g., SB1-S1 (0-2'), SB1-GW, FB1, MW1, etc.) generated using sample description information, including method of collection (soil boring = SB, hand auger = HA, monitoring well = MW, soil gas = SG, field blank = FB, trip blank = TB, equipment blank = EB, duplicate = Dup), environmental matrix code (soil = S, soil gas = SG, groundwater = GW, surface water = SW, etc.), sample number and depth.
- Unique Project identification number (site specific project number)
- Name of company that collected the sample
- Name or initials of person who collected the sample
- Date sample was collected
- Approximate time sample was collected
- Preservative, if present
- Analyses requested

2. Collect samples according to procedures indicated in the appropriate SME SOPs, being careful to record pertinent field notes on appropriate field logs. Transfer samples into appropriate containers as directed by the analytical laboratory and according to the appropriate SOPs. If desired, each sample container can be affixed with a Chain of Custody seal placed across the container opening, which is then signed and dated. The Chain of Custody seal is any adhesive label or tape that can be used to seal a sample container such that if it is opened or tampered with will be broken. Then place each sample container in a plastic bag and seal the bag.

3. Immediately following completion of sampling activities, fill out the Chain of Custody forms provided by the laboratory at the time the samples are packed for transfer to the laboratory. Each laboratory's Chain of Custody form differs slightly, but usually includes:

   - Analytical laboratory name, address and phone number
   - A Chain of Custody serial number
   - Sampler's name, phone number and company name
   - Project Name and/or Number
   - Unique sample identification numbers matching the enclosed samples
   - Sample matrix (e.g., water, soil, air, wipe, solid, liquid, etc.)
   - Preservative present in each sample container, if any
   - Date and time each sample was collected
   - Container types and/or number of containers for each sample identification number
   - Analyses requested for each sample identification number
   - Requested turnaround time
   - Signatures of responsible persons, and dates and times of transfer of samples
   - Special instructions or notes to the laboratory

4. Once the Chain of Custody forms are completed, review each sample container to verify that the sample identification number, date, time, etc. on the labels being sent to the laboratory match the information documented on the Chain of Custody forms. In addition, verify that the sample identification numbers on the Chain of Custody forms match the sample identification numbers recorded on the field map and/or field notes. This serves as a check to verify that no duplicate or incorrect sample labels are present and that sample results can be located spatially at the site.
5. Place sample containers in a sample transfer container (e.g., cooler) and transport samples and Chain of Custody forms to the appropriate location for transfer to laboratory personnel. The Chain of Custody forms should be included with or attached to the sample transfer container. At the time of transfer, sign and date the Chain of Custody forms (including the time) in the appropriate space and verify that the person receiving the sample containers also signs and dates the forms. One copy of the Chain of Custody form should be kept by each party relinquishing control of the samples. The copy kept by the sampler should be placed in the project file for future reference.

   To simplify the Chain of Custody record and reduce the potential for problems, as few people as possible should have custody of the samples. Each of the responsible persons must control access to the samples until the responsibility is transferred by signature and date on the forms. Samples should not be left in unrestricted areas. When out of the personal view of the responsible person, the samples should be placed in a restricted area (e.g., locked vehicle, locked motel room, locked storage room, etc.) until transfer to the appropriate person. If possible, the sample containers should remain in the original transfer container (e.g., cooler) and each responsible person should verify that required temperatures are maintained (usually through the use of ice or ice packs).

   If necessary, interim storage (i.e., a refrigerator) can be used to help maintain required temperatures. However, the sampler should document the transfer of custody to the storage location by recording the location name (e.g., "SME cold storage", "SME refrigerator", etc.) and time of transfer in the appropriate signature and time areas on the forms. In addition, the sampler should go through the check off procedure again when the samples are returned to the laboratory transfer container (e.g., cooler) to verify that all samples are present.
6. Submit SME copy of Chain of Custody to person-in-responsible charge for review.

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.

REFERENCES

US EPA Publication SW-846. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Third Edition, November 2004.

US EPA- Office of Superfund Remediation and Technology Innovation. Contract Laboratory Program Guidance for Field Samplers, August 2004.

Georgia Department of Natural Resources- Environmental Protection Division, Water Protection Branch. Water Quality: Quality Assurance Manual, June 1999.

HEALTH AND SAFETY

THE HEALTH AND SAFETY PLAN (HASP) FOR THE PROJECT SHOULD BE REVIEWED PRIOR TO PERFORMING FIELD ACTIVITIES. APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND FIRST AID SUPPLIES SHOULD BE TAKEN INTO THE FIELD, AS SPECIFIED IN THE HASP, AND USED AS APPROPRIATE. IF A HASP HAS NOT BEEN SUPPLIED, CONSULT THE PERSON-IN-RESPONSIBLE CHARGE.

SME SOP 12A
STANDARD OPERATING PROCEDURE
INVESTIGATIVE DERIVED WASTES

ACTIVITY DESCRIPTION

This Standard Operating Procedure (SOP) describes methods for management of potentially contaminated investigative derived wastes generated during environmental sampling activities in Wisconsin. Investigative derived wastes include soil cuttings, unused soil samples, purge water, development water, decontamination water and disposable sampling and personal protection equipment.

OBJECTIVE

The management option selected for investigative derived wastes should: 1) be protective of human health and the environment, 2) be cost effective and consider waste minimization, and 3) comply with applicable regulatory requirements.

EQUIPMENT LIST

1. Project instructions, health and safety plan
2. Appropriate field forms and logs
3. Five-gallon bucket
4. Water-proof pen
5. Adhesive Barrel Labels
6. Wisconsin DOT approved ring or bung top barrels

PROCEDURES

For environmental projects, subsurface sampling methods include collection of soil and groundwater samples using a hand auger, a hydraulically driven soil probe, or a rotary drill rig using hollow-stem augers. Methods for management of investigative derived wastes should be reviewed with the SME person-in-responsible charge prior to mobilizing to the field. In general investigative derived wastes should be handled as follows:

1. Soil cuttings derived from sampling methods. Soil cuttings produced by hand augering should be temporarily stored in a clean 5-gallon bucket or on plastic sheeting until used for backfill. Unused soil in liner samples produced during soil probing should be retained in the liners or transferred into a clean 5-gallon bucket until used for backfill. Soil cuttings produced by hollow-stem auger drilling should be shoveled into a pile until used for backfill. Soil samples which are not submitted for analytical testing should either be returned to the probe or borehole of origin, or transported to an SME laboratory for further evaluation and disposal, as specified by the project instructions.
2. Water purged from temporary or permanent monitoring wells during sampling should be returned to the probe or borehole through the temporary or permanent well casing/screen. Purge water should be temporarily stored in a clean 5-gallon bucket until it is returned to the borehole.
3. Well development and decontamination water can be discharged onto the unpaved, ground surface in the vicinity of the monitoring well or borehole. Care should be taken to avoid discharging development or decontamination water to pavement

that drains into a storm sewer. For wells installed in paved areas, consult the project instructions for management of disposal of well development and decontamination water.

4. Disposable sampling and used personal protection equipment should be disposed of in an on-site sanitary waste dumpster, or if one is not available on the site, brought back to SME for disposal. Disposable sampling and used personal protection equipment should be double-bagged in disposable garbage bags until disposal.

   In some instances, project objectives will require the containerization of investigative derived wastes, either in whole or in part. The person-in-responsible charge should instruct field representatives of project-specific requirements for management of soil cuttings, purge water, development water, decontamination water and used sampling and personal protection equipment.

   Exceptions to the above methodology will need to be considered in the following scenarios:

   - Elevated levels of contamination or free product are expected or encountered during drilling;
   - A confining layer is penetrated during drilling;
   - A monitoring well is installed in the borehole;
   - Project-specific requirements are provided.

CONTAINERIZATION

If containerization is required, the following guidelines apply:

1. Investigative derived wastes comprised of different media should not be combined in a single barrel or barrels.
2. Barrels containing investigative derived wastes should be clearly labeled as to the content, date generated, borehole locations and contact information. Labels should be filled in with an indelible, waterproof pen.
3. Barrels containing soil or water should not be filled more than 2/3 full due to weight and freezing potential.
4. The Owner and SME person-in-responsible charge should be consulted to determine an onsite storage place for barrels until the contents can be characterized and disposal can be arranged.
5. Review the project instructions for barrel sampling responsibilities and required laboratory analyses for waste characterization necessary to evaluate disposal alternatives. If waste characterization sampling by the field representative is required, representative samples of the contents of the various media stored in barrels should be collected using methodologies that satisfy project objectives.
6. Record the number of barrels and contents in the project notes.

SPECIAL NOTE

If the investigative derived wastes are determined to be a RCRA hazardous waste, special management will be required. In this event, consult with the SME person-in-responsible charge.

GENERAL

This SOP has been developed to provide procedures that represent reasonable practices consistent with the standard of care ordinarily exercised by members of the environmental profession currently practicing under similar conditions. Site specific *conditions may exist where this SOP may be modified or an alternative approach may be implemented. Such modifications or alternative approaches should be discussed with the person-in-responsible charge.*

REFERENCE

Guide to Management of Investigation-Derived Wastes, US. EPA, January 1992.

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SME