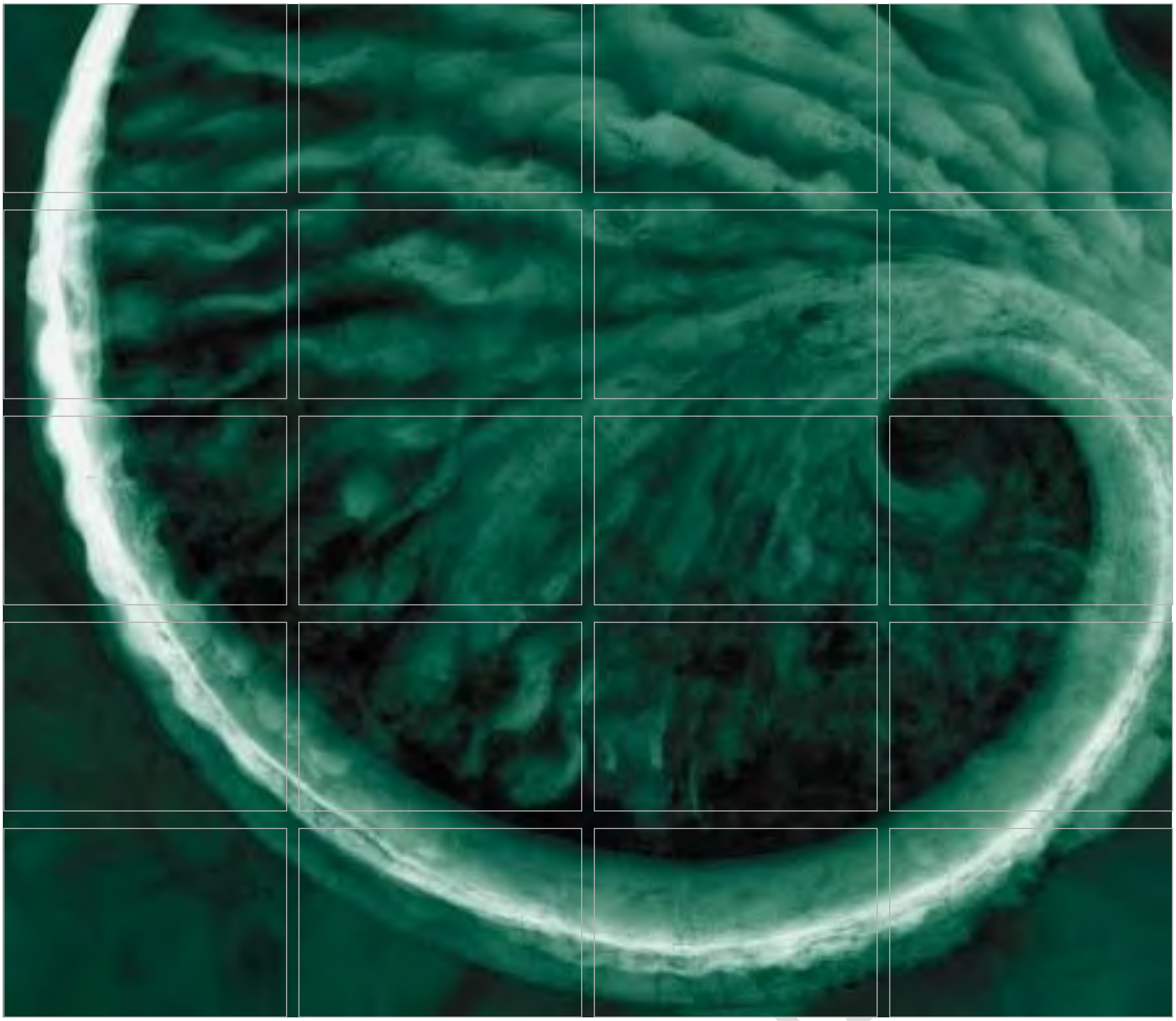

Draft Final Site Characterization Work Plan and Sampling and Analysis Plan

Prepared for:

K2

Former K2 Facility
Vashon, Washington

December 2014

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ERM

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Project # 0266125

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1. INTRODUCTION

ERM-West, Inc. (ERM) prepared this *Site Characterization Work Plan and Sampling and Analysis Plan* in support of planned site investigation activities at the Former K2 manufacturing facility at 19215 Vashon Highway Southwest in Vashon, Washington (the "subject property"). A subject property location and layout map is included as Figure 1. This document has been prepared to address site characterization requirements in Chapter 173-340-350(7)(c) Washington Administrative Code (WAC) and in accordance with sampling and analysis plan elements in Chapter 173-340-820 WAC. Both are sections of the Model Toxics Control Act (MTCA), the Washington state contaminated site cleanup regulation.

The objective of the scope of work described in this document is to evaluate soil and groundwater conditions in the vicinity of known and suspected sources of chemical releases at the subject property toward completing site characterization compliant with the MTCA regulation.

The subject property has been entered into the Washington State Department of Ecology (Ecology) Voluntary Cleanup Program (VCP) as project number NW2894.

1.1. Background

The subject property covers an area of approximately 11.6 acres in the central highland area of Vashon Island. The surrounding area is characterized predominately by rural residential development with some scattered commercial and light industrial development. The unincorporated community of Vashon is approximately one mile north of the subject property.

The subject property is the location of an idled manufacturing plant previously used by K2 to produce skis, snowboards, and bicycles. K2 originally developed the facility in the early 1970s and several additions to the original manufacturing buildings have been made since that time. The subject property is currently developed with a manufacturing and office building and several outbuildings surrounded by paved lots, and landscaped and lawn areas. A storm water retention pond that collects surface water from across the facility is situated in the southeast corner of the subject property. This pond discharges to the adjacent ditch along Vashon Highway.

Prior to development of the subject property as the K2 plant, a greenhouse and florist business operated in the northeast portion of the subject property. The remainder of the site was undeveloped prior to the development of the K2 plant.

1.2. Site Geology and Hydrogeology

The subject property is located on Vashon Island, in the Puget Lowlands. The primary geological units in the island are glacial sediments related to multiple continental glaciation events in the Pleistocene, during which ice flowed southward across the Puget Lowlands, as well as sediments deposited during interglacial periods. Soils at the subject property are expected to include glacial till and outwash deposited during the most recent glaciation approximately 13,000 to 16,000 years ago.

Based on previously-reported conditions and on ERM experience at sites in the vicinity, near-surface soils are expected to be glacial till, consisting of a mixture of silt, sand, and gravel.

Reports of past site investigation efforts indicate that groundwater was not encountered in borings completed to 16 feet below ground surface (bgs) at the subject property; however, available documentation includes reports of seasonal groundwater seepage into basement portions of the facility. Groundwater levels at a nearby site range seasonally from approximately 2 to 8 feet bgs. ERM expects that groundwater will be encountered at a depth between 10 and 20 feet bgs at the subject property. Based on the topography of the subject property vicinity and knowledge of shallow groundwater conditions at a nearby site, groundwater flow direction is expected to be toward the east to southeast.

1.3. Previous Site Investigation and Remediation Efforts

The following reports are available that detail site investigations and remedial actions conducted at the subject property:

- A Phase I Environmental Site Investigation (ESA) by Berg Environmental Services (Berg) dated 16 March 2007;
- A Phase II ESA by White Shield, Inc. (White Shield) dated 11 July 2008; and
- An underground storage tank (UST) removal, site assessment, and soil remediation report by White Shield dated 11 February 2009.

The subject property conditions identified during each of these programs are summarized below. Additionally, Farallon Consulting developed a memorandum dated 13 February 2014 that included a comprehensive evaluation of the work previously completed at the subject property with regard to compliance with site characterization requirements under MTCA. The summary of the Recognized Environmental Conditions (RECs) at the site in the following section was developed based on the summary presented in that document.

1.3.1 Recognized Environmental Conditions

As part of their investigation activities, Berg and White Shield identified and evaluated the presence of RECs at the subject property. RECs are defined as the presence or likely presence of hazardous substances or petroleum products in soil, groundwater and/or surface water on a property under conditions that indicate an existing release, a past release, or a material threat of a release of those substances from current or past operations at or near the property.

The table of RECs developed from the Berg and White Shield subject property data evaluations are summarized as follows:

Recognized Environmental Conditions

REC Location 1	Potential releases of materials from the former chemical handling area on the north side of the main plant building, including in the area of operations and drain field of the former florist ship and greenhouse in this vicinity. This area also includes a steel 300-gallon heating oil UST
REC Location 2	Potential releases of materials in the solvent still area to the west of the main plant building.
REC Location 3	Potential releases from the hazardous waste shed, centrifuge area, and abandoned vehicle area (where possible contaminated soil was removed in the early 2000s), each in the area to the west of the main plant building.
REC Location 4	Potential releases from the former resin tank farm area south of the main plant building.
REC Location 5	Potential releases of intermittently-stored materials on the lawn area south of the main plant building, and potential seepage from the adjacent process area within the building.
REC Location 6	Potential releases of materials from the boiler room area on the southeast corner of the main plant building.
REC Location 7	Potential releases in the machine shop area in the northeast corner of the subject property, which includes a reported open-ended sump, a gel coat

	area, a paint booth, and a 300-gallons steel heating oil UST.
REC Location 8	Potential releases in areas of equipment and materials storage on paved areas west of the main plant building.
REC Location 9	Potential releases from the storm water retention pond into the ditch along Vashon Highway.
REC Location 10	Potential releases from the storm water retention pond to underlying soils and groundwater.
REC Location 11	Potential releases related to a second drain field serving the former greenhouse and florist business.
REC Location 12	Potential solvent releases related to two former vapor degreasers operated inside the main plant building.
Site-wide REC	Groundwater quality related to release

Each of the numbered REC areas is shown on Figure 2. Additional information regarding the USTs at the subject property is included in Section 1.3.3 below.

1.3.2 *White Shield Site Investigation Results*

In 2008, White Shield collected soil samples from 11 direct-push borings completed at scattered locations around the subject property to evaluate conditions in the vicinity of the RECs identified above. Borings were advanced to depths of up to 14 feet below ground surface (bgs) at the locations shown in Figure 2. Soil sample results are summarized in Table 1.

Groundwater was not reported encountered in the borings. At least one soil sample was collected from each boring and the soil sample were analyzed for one or more of the following: petroleum hydrocarbons, pesticides, herbicides, volatile organic compounds (VOCs) and the metals arsenic, cadmium, chromium, lead, and mercury.

Petroleum hydrocarbons were detected in one soil sample collected at a depth of 1 foot bgs adjacent to the UST in REC Location 1. Diesel-range petroleum hydrocarbons (TPH-D) was detected at a concentration of 2,200 milligrams per kilogram (mg/kg), which is greater than the MTCA Method A cleanup standard of 2,000 mg/kg. That sample also contained heavy oil-range petroleum hydrocarbons (TPH-HO) at a concentration of 740 mg/kg, less than the MTCA Method A cleanup standard of 2,000 mg/kg. The report characterized the contaminated soil as being within a band several inches thick that appeared to be related to a surficial release of petroleum product.

The VOC trichloroethene (TCE), a common industrial solvent, was detected in soil samples collected from three borings completed near REC locations 2, 3, and 10 (borings B-6, B-4, and B-10, respectively). The TCE concentration in each of the samples was less than the MTCA Method A Soil Cleanup level for Unrestricted Land Uses of 0.03 mg/kg.

Methylene chloride was also detected in one sample from boring B-9-1, but at a concentration less than the MTCA Method A cleanup level. The methylene chloride detection was attributed to laboratory-related sample contamination.

The metals arsenic, chromium, and lead were detected in one or more of the samples, but at concentration less than the applicable MTCA Method A cleanup levels and at concentrations generally within the ranges of regional background concentrations in soils for the area.

Pesticides and herbicides were not detected in the samples analyzed for those compounds.

1.3.3 Underground Storage Tanks

The Berg Phase I ESA reported that three heating oil underground storage tanks (USTs) were reported closed in place at the subject property in 1988. The White Shield Phase II confirms the location of two of the USTs, but does not mention the third. The two USTs reported by White Shield were 300 gallon steel tanks; one beneath the machine shop building in the northeast corner of the subject property and the other adjacent to the north wall of the main plant building. K2 personnel have confirmed that only two USTs containing petroleum or other hazardous materials are present on the subject property, and that the third UST reported by Berg is in error, or is in reference to a potable water tank (cistern) west of the boiler room area.

The UST under the machine shop remains in place, but the UST adjacent to the north wall of the main plant building was removed by White Shield in August 2008, and diesel-contaminated soil was identified in the vicinity of the UST during decommissioning activities. The accessible petroleum-contaminated soil was removed to the extent practicable, but the soil sample collected from soils adjacent to the plant building foundation contained 6,100 milligrams per kilogram (mg/kg) of diesel-range petroleum hydrocarbons (TPH-D). The applicable regulatory cleanup standard (MTCA Method A soil cleanup level) for TPH-D is 2,000 mg/kg.

A map showing the outline of the UST removal and remedial excavation is shown in Figure 3. A summary of the soil sample analytical results is included in Table 1.

The finished UST removal and soil remedial excavation was a maximum of 9 feet deep, and groundwater was not reported encountered. A total of approximately 115 cubic yards of soil, including the petroleum-contaminated soil, were removed from the UST excavation and disposed at the RABANCO Regional Landfill in Roosevelt, Washington.

2. SITE CHARACTERIZATION PLAN

This section includes an overview of ERM's site characterization approach at the subject property. It includes a summary of the seven areas of concern (AOCs) designated to group adjacent and similar REC areas into single comprehensive investigation areas. An overview of the sampling program and rationale for the planned sample locations in each AOC is also provided.

2.1 Designation of Areas of Concern

Based on the RECs summarized above, and the findings from site investigation and UST decommissioning activities, ERM has developed a set of AOCs for the subject property. Table 2 includes a correlation of the AOCs with the previously-identified REC areas and conditions. The AOCs are shown on Figure 4.

A summary of the past activities and known conditions in each AOC available site investigation results in included in each AOC summary, as is a list of the known and potential constituents of concern identified for each AOC.

2.1.1 AOC 1 – Machine Shop

This area was the original manufacturing facility for the K2 plant on the subject property, and has the longest history of use by K2. The machine shop houses a gel coat pit, a paint booth, and reportedly has a sump with an unknown history of use. A 300-gallon heating oil UST is also reported beneath the building. A drain field serving the former greenhouse and florist ship on the subject property also may be present in whole or in part in AOC 1.

No contamination associated with operations at the machine ship was detected in soil samples collected from two borings completed adjacent to the east side of the machine shop building in 2008. ERM subject property reconnaissance activities in November 2014 confirmed the location of the UST, paint booth, and sump. During the subject property reconnaissance, no gel coat pit was observed in the machine shop and K2 personnel confirmed that no gel coat pit was present, although available information indicates that fiberglass ski components were manufactured in the building in the past.

The sump was observed to consist of an approximately 10-inch-diameter corrugated, galvanized metal pipe secured into the floor slab and extending down approximately 4 feet below grade. Sediments in the sump prevented confirmation of whether the sump had an open or sealed bottom. K2 personnel indicated that the sump previously collected spilled water and was periodically pumped when it was observed to be full. The sediments in the sump appeared to be wood, plastic, and metal shavings uncontaminated by organic fluids.

Potential constituents of concern in soil and groundwater associated with AOC 1 include:

- Petroleum hydrocarbons;
- VOCs (solvents and petroleum-related VOCs);
- Semi-volatile organic compounds (SVOCs) associated with petroleum products and gel coating materials;
- Pesticides associated with the former greenhouse; and
- Metals associated with paint and machining wastes.

2.1.2 AOC 2 – Decommissioned UST and North Lot

A 300-gallon UST was removed from this area in 2008. Approximately 115 cubic yards of soils contaminated with TPH-D were excavated during removal of the UST in 2008, and TPH-D concentrations greater than the cleanup level remain in soils beneath the main plant building adjacent to the former UST location. The north lot area was also previously used as the chemical loading and offloading area for the K2 facility, and transformers containing polychlorinated biphenyls (PCBs) were identified at the subject property during a 1989 audit that have since been replaced. A drain field serving the former greenhouse and florist on the subject property also may be present in whole or in part in AOC 2.

Known constituents of concern in AOC 2 include TPH-D in soil. Potential constituents of concern in soil and groundwater associated with AOC 2 include:

- Petroleum hydrocarbons;
- VOCs (solvents and petroleum-related VOCs);
- SVOCs associated with petroleum products, coatings, and resins;
- Pesticides associated with the former greenhouse;
- PCBs (soil only); and
- Metals associated with pigments, paint, and machining wastes.

2.1.3 AOC 3 – Still, Centrifuge Room, and Chemical, Equipment, and Hazardous Waste Storage Areas

This AOC includes several chemical handling and storage areas, including the solvent still, the hazardous waste shed, and storage areas periodically used for chemicals, equipment, and supplies. This area also includes the former location of an abandoned vehicle, which was reported removed along with 3 to 4 feet of underlying soil around 2000 by Berg (2007). In November 2014, ERM discussed the vehicle issue with K2 personnel, who confirmed that this "abandoned" vehicle was actually a truck periodically used for trash hauling from the facility, and that it was eventually sold and driven from the subject property under its own power. The former vehicle parking spot was identified by the K2 representative and observed by ERM staff, who confirmed that the parking spot was paved with concrete that was part of the broader facility parking lot, and did not appear to have been cut or have any other indication of excavation activity. K2 personnel confirmed that no excavation had been completed in the area.

TCE was detected at concentrations less than applicable regulatory cleanup standards in soil samples from two of three soil samples collected from borings completed within AOC 3 in 2008. No TCE was detected in the third sample.

Known constituents of concern in AOC 3 include TCE in soil. Potential constituents of concern in soil and groundwater associated with AOC 3 include:

- Petroleum hydrocarbons;
- VOCs (solvents and petroleum-related VOCs);
- SVOCs associated with petroleum products, coatings, and resins; and
- Metals associated with pigments, paint, and machining wastes.

2.1.4 AOC 4 – Former Drain Field and Vapor Degreasers

This AOC includes an area inside the main plant building at the subject property where two vapor degreasers were previously operated. A second drain field attributed to the former greenhouse and florist operation at the subject property is also located in this area.

No soil or groundwater sampling has been completed in this area.

Potential constituents of concern in soil and groundwater associated with AOC 4 include:

- Petroleum hydrocarbons;
- VOCs (solvents and petroleum-related VOCs);
- SVOCs associated with petroleum products, coatings, and resins;
- Pesticides associated with the former greenhouse; and
- Metals.

2.1.5 AOC 5 – Former Resin Tank and Grinding Process Area

This AOC includes the aboveground resin storage tanks south of the main plant building, the open lawn area along the south side of the main plant building, and the grinding process area just inside the plant building on the south side. A release of 30 to 50 gallons of resin was reported in the tank area in 1996. The other concerns in this area include potential historical releases of grinding fluids and potential historical releases from storage tanks in the AOC.

No contaminants associated with subject property activities were detected in soil samples from two borings drilled near the resin tanks and in the lawn area in 2008.

Potential constituents of concern in soil and groundwater associated with AOC 5 include:

- Petroleum hydrocarbons;
- VOCs (solvents and petroleum-related VOCs);
- SVOCs associated with petroleum products and resins; and
- Metals.

2.1.6 AOC 6 – Boiler Room

This AOC includes the plant boiler room, where some petroleum-related staining was reported observed on the concrete floor. A transformer that may have contained PCBs was present in this room prior to the 1980s, when it was replaced with a non-PCB transformer.

No soil or groundwater sampling has been completed in this area.

Potential constituents of concern in soil and groundwater associated with AOC 4 include:

- Petroleum hydrocarbons;
- VOCs (petroleum-related VOCs);
- SVOCs associated with petroleum products; and
- PCBs (soil only).

2.1.7 AOC 7 – Storm Water Retention Pond

Surface water from across the subject property is collected and channeled to the storm water retention pond, from which it is discharged into the adjacent ditch along the Vashon Highway. Releases of hazardous materials to the ground surface across the subject property may have made their way to this retention pond through storm runoff. Two releases to the retention pond and adjoining ditch have been reported by K2: approximately 20 gallons of heating oil in 1993 and an unreported volume of grinding fluid in 1997.

TCE was detected at a concentration less than the applicable regulatory cleanup level in a soil sample from a boring completed at AOC 7 in 2008.

The known constituent of concern at AOC 7 is TCE in soil. Potential constituents of concern in soil and groundwater associated with AOC 7 include:

- Petroleum hydrocarbons;
- VOCs (solvents and petroleum-related VOCs);
- SVOCs associated with petroleum products, coatings, and resins;
- PCBs (soil only); and

- Metals associated with pigments, paint, and machining wastes.

2.2 Site Investigation Overview

The objectives of the site investigation are to complete investigation of the AOCs in a manner that evaluates whether significant releases of hazardous materials have occurred to soil or groundwater at the subject property, and to do so in a manner that provides an understanding of the likely extent and distribution of contaminants in on-property soil and groundwater.

ERM proposes to meet the site investigation objectives by completing the following scope of work at the subject property:

- Completion of a geophysical survey at AOCs 1, 2, and 4 to investigate the location of the drain field(s) associated with the former greenhouse and florist operations at the subject property;
- Collection of soil and groundwater samples from 18 soil borings, 9 monitoring wells, and 1 surface soil locations for field screening and laboratory analysis of contaminants of concern for the applicable AOC.

The planned geophysical survey locations are shown on Figure 5. Planned soil borings, monitoring wells, and surface soil sample locations are shown on Figure 6. The specific scope and rationale for the sampling program details are developed in Section 4.

3. PROJECT DELIVERABLES AND SCHEDULE

A Site Characterization Report will be written following the completion of the field site investigation program described in Section 2. The report will summarize and discuss the results of the site characterization effort, including a description of the nature and on-property extent of soil and groundwater contamination identified at the subject property.

The field effort described in this work scope will be initiated within 30 days of receiving Ecology's approval of this *Site Characterization Work Plan and Sampling and Analysis Plan*. The work scope is expected to be completed and the Site Characterization Report submitted to Ecology within 120 days of receiving Ecology's approval of this Site Characterization Work Plan and Sampling and Analysis Plan. If additional site investigation is needed to complete a MTCA-compliant site characterization, Ecology will be notified and the schedule adjusted to adapt to the additional effort required.

4. SAMPLING AND ANALYSIS PLAN

This *Sampling and Analysis Plan* (SAP) defines field sampling rationale, procedures, and data gathering methods to ensure that the data collected over the course of the project are of known quality to meet their intended use, and that all components of data acquisition are thoroughly documented, verifiable, and defensible.

A qualified ERM consultant will be onsite during all field activities. The ERM personnel will maintain a field notebook to document all work activities during the project. The field notebook will be a weather-resistant, bound, survey-type field book.

Standard Operating Procedures (SOPs) for various tasks discussed in this SAP are provided in Appendix A.

This section is organized as follows:

- Section 4.,1 provides a summary of the rationale for each sample collection location;
- Section 4.2 outlines the field program;
- Section 4.3 summarizes equipment decontamination procedures;
- Section 4.4 summarizes the field quality assurance/quality control (QA/QC) sample collection and analysis program;
- Section 4.5 describes the field documentation, sample handling, and sample analysis procedures;
- Section 4.6 outlines the project data QA/QC requirements; and
- Section 4.7 describes the containment, handling, and disposal of investigation-derived wastes.

4.1. Sampling Program Rationale

The soil and groundwater samples planned for collection and laboratory analysis as part of this site investigation are intended to provide information to address the site investigation objectives. Specifically, each planned sample is intended to help evaluate conditions reported in each area of concern.

Table 3 summarizes the planned sample collection and laboratory analysis planned for each sample location shown in Figure 6. Table 4 summarizes the rationale for the soil and/or groundwater samples planned for collection at each sampling location relative to the environmental concerns at each AOC.

4.2. Field Program

The field site characterization effort at the subject property will consist of the following investigative tasks:

- Completion of an underground utility location survey at each planned subsurface exploration location to confirm that no utilities or underground structures will be encountered or damaged during the investigation activities;
- Completion of a geophysical survey at AOCs 1, 2, and 4 to investigate the location of the drain field(s) associated with the former greenhouse and florist operations at the subject property;
- Collection of one surface soil sample from near the outfall of the retention pond at AOC 7;
- Drilling 12 soil borings using a rotary or direct-push drilling rig, with collection of soil samples from each boring and collection of grab groundwater samples at 10 of the borings;
- Drilling six borings using a hand auger, with soil sample collection at each boring;
- Installation of nine monitoring wells and collection of groundwater samples from each well; and
- Completion of a location and elevation survey of each sample point.

A summary of each of these tasks is included in the subsections below.

4.2.1 Underground Utility Location

Prior to initiating ground disturbance activities at the subject property that have the potential for damaging underground utilities or other subsurface infrastructure, ERM will complete underground utility screening to minimize the potential encountering and damaging underground features. The screening will be completed at each planned soil disturbance location and will include the following tasks:

- Review of utility locations on existing facility as-built plans;
- Notification of the public utility “one-call” hotline at least 72 hours prior to digging;
- Completion of a private utility locate at each exploration location, to include standard utility location practices and a sweep of the area using a ground-penetrating radar (GPR) device; and
- For power-drilled borings, complete a pilot boring using hand tools or an air knife to a depth of 5 to 8 feet bgs.

4.2.2 Geophysical Survey

A survey using GPR will be completed to evaluate the areas that have been identified as possible drain fields associated with the former greenhouse and florist business at the subject property. The possible drain field locations have been identified based on information in previous reports (Berg 2007 and White Shield 2008) and from discussions with K2 personnel familiar with the subject property history.

The GPR used will be calibrated to evaluate excavations in the range of 4 to 6 feet below ground surface (bgs), consistent with the expected depth of a septic drain field with some allowance for grade aggradation as part of subsequent facility development. The survey transits are planned to be completed along the transit lines shown in Figure 5. The GPR results will be screened for evidence of multiple linear trenches typical of drain fields. Locations of borings B2-1 and B4-1 will be modified based on the findings of the GPR survey.

4.2.2 Surface Soil Sampling

One surface soil sample (SS7-1) will be collected from directly beneath the outfall from the retention pond in the southeast corner of the subject property (AOC 7) to the adjacent public drainage ditch along Vashon Highway South (Figure 6). The soil sample will be collected using a stainless-steel trowel from within the upper 6 inches of soil at that location.

4.2.3 Soil Borings

Twelve borings will be completed using a powered drill rig, and six borings will be advanced using a hand auger at the locations shown in Figure 6 to collect soil and groundwater samples to evaluate the nature and extent of contaminants at the subject property.

The boreholes will be advanced using hand auger, rotary hollow-stem auger, sonic, or direct-push drilling methods, as described in the Drilling and Soil Boring SOP in Appendix A. Soil samples will be logged throughout the depth of the drilling while advancing each borehole, as described in the Lithologic Logging SOP in Appendix A.

Groundwater is estimated to be approximately 10 to 12 feet bgs at the subject property. Power-drilled borings will be advanced to first groundwater if no grab groundwater sample will be collected at the location. If a groundwater sample is collected, the boring will be advanced 3 to 4 feet below first encountered groundwater. Borings are expected to be advanced to a maximum depth of 15 feet bgs, or may be terminated at any obstructions encountered at shallower depths.

Hand-auger borings will be advanced to a target depth of 3 feet bgs, unless obstructions are encountered that prevent completion of the borehole to that depth.

Soil samples collected from the borings will be field screened for the presence of volatile organic vapors using a photoionization detector (PID). For each sample interval of approximately 2 to 3 feet, a portion of the recovered soil will be sealed in a plastic bag. After at least 10 minutes, the soil in the bag will be gently agitated and the bag will then be pierced by the PID probe. The resulting PID response will be recorded on the boring log. Additional field-level information that may indicate the presence of contaminants, such as color or incidental odor, will also be recorded on the boring logs.

At least one soil sample will be collected from each boring for laboratory analysis for the parameters indicted in Table 3. The soil samples will be selected for analysis using the following criteria:

- If field screening results do not indicate evidence of contamination, the soil sample from immediately above the water table will be analyzed or, for borings not advanced to the water table, the deepest soil sample will be submitted for analysis.
- If field screening indicates that contamination may be present, the soil sample corresponding to the zone of greatest apparent contamination will be submitted for laboratory analysis. In this case, an additional, deeper sample may also be submitted to evaluate the vertical extent of the contamination.

Grab groundwater samples will be collected from groundwater collected within the drill rods or augers. The groundwater sample may be collected directly through the drilling rods or augers using a bailer or pump, or, if conditions require, through a 2-inch slotted PVC well screen temporarily installed in the well rods or auger. Prior to sample collection, a volume of water will be pumped or bailed from the casing, rods, or augers to allow collection of formation water minimally disturbed by the drilling process.

Soil borings will be abandoned by removing all drilling and sample collection materials and backfilling the hole with bentonite chips. The surface will be returned to as close to original grade conditions as is practical.

4.2.4 Monitoring Well Installation and Groundwater Sample Collection

Nine monitoring wells will be installed at the locations shown in Figure 6 to allow for the evaluation of the nature and extent of contaminants in groundwater at the subject property. The monitoring wells locations have been selected based on the expected southeasterly groundwater flow direction at the subject property.

Monitoring wells will be constructed in accordance with the Washington Minimum Standards for Construction and Maintenance of Wells in Chapter 173-160 Washington Administrative Code (WAC). The boreholes for the monitoring wells will be advanced using sonic drilling methods, as described in the Drilling and Soil Boring SOP (Appendix A). Soil samples will be logged continuously while advancing the borehole, as described in the Lithologic Logging SOP (Appendix A). The monitoring wells will be constructed using 2-inch diameter, threaded, Schedule 40 PVC screen and casing. A 10-foot long, 0.010-inch slot screen will be placed such that it straddles the water table with approximately 7 feet of screen below the water table at the time of drilling. A sand pack consisting of 10/20 silica sand or equivalent, will be placed around the screen and extend approximately 2 feet above the top of the screen. A bentonite chip seal will be placed in the three feet above the sand pack and a cement-bentonite grout will be placed on top of the bentonite chips to a depth of approximately 2 to 3 feet bgs. The remainder of the monitoring well borehole annulus will be filled with concrete and finished with a flush-with-grade protective monument. The wells will be equipped with expandable locking caps.

Following construction, the wells will be developed to settle the soil around the screened interval and remove particulates from the sand pack. The procedures for well development are outlined in ERM's Monitoring Well Development SOP (Appendix A).

Groundwater samples will be collected from the monitoring wells at least 24 hours after development activities are completed using the low-flow methods outlined in ERM's SOP Groundwater Monitoring in Appendix A. The low-flow groundwater purging/sampling technique employs the use of a flow-through cell, equipped with a meter for measuring groundwater quality parameters such as pH, temperature, specific conductivity, dissolved oxygen, and oxidation/reduction potential.

4.2.5 Location and Elevation Survey

After completion of the borings and monitoring wells, a Washington State-licensed land surveyor will survey the location and ground surface elevation of each boring and well, and top of casing elevation of each well. The location and elevation of the surface soil sampling point will also be identified. The ground surface elevation and horizontal position of each of the borings and wells, and the elevation of the highest point on the rim of each well casing, will be determined utilizing the local NAVD88 vertical system and horizontal NAV83 system. Horizontal locations will be established to an accuracy of 0.1 foot and elevations will be established to an accuracy of 0.01 inch.

4.3. Decontamination Procedures

Decontamination of non-disposable sampling equipment that comes in contact with samples (such as pumps and trowels) will be performed to prevent the introduction of extraneous material into samples, and to prevent cross contamination between samples. All non-disposable (non-dedicated) sampling equipment will be decontaminated by washing with an aqueous solution of a non-phosphate detergent such as Liquinox™ or equivalent. Drilling equipment, such as drill rods and augers, will be decontaminated by high-pressure steam washing.

Decontamination water will be collected in appropriate 55-gallon drums and will be handled and disposed along with the other investigation-derived wastes as described in Section 4.7.

4.4. Quality Assurance/Quality Control Samples

Field QA/QC samples will be collected and analyzed during the project to assess the consistency and performance of the sampling program. Field QA/QC samples for this project will include trip blanks, field blanks, field duplicates, and equipment rinsate blanks. Additionally, accommodation for laboratory preparation and analysis of matrix spikes/matrix spike duplicate (MS/MSD) sample analyses will be made. The laboratory will also measure the temperature of the samples in each cooler upon delivery to the laboratory.

Field QA/QC samples will be collected from the subject property as indicated in Table 3.

4.4.1. Trip Blanks Samples

Trip blank samples will be provided by the laboratory with each sample container shipment and will consist of two or three 40-milliliter volatile organic analysis (VOA) vials filled with deionized water. The purpose of trip blank samples is to evaluate the potential for *ex situ* volatile organic vapors to affect sample results for gasoline-range petroleum hydrocarbons (TPH-G) and VOCs. One trip blank will be included in each cooler containing samples slated for TPH-G or VOC analysis.

4.4.2. Field Duplicate Samples

Field duplicate samples consist of duplicate samples of the same matrix as the original samples collected at the same time and location, to the extent possible, using the same sampling techniques. The purpose of field duplicate samples is to evaluate the variability of the in the laboratory analytical method results. Field duplicate samples will be analyzed for the same constituents as the associated original samples.

4.4.3. Equipment Rinsate Blank Samples

Equipment rinsate blank samples are used to evaluate the effectiveness of the decontamination procedure and to identify potential cross-contamination during sampling events. Equipment rinsate samples will be collected by pouring deionized water over the decontaminated sampling equipment (e.g., pump or split spoon) and collecting the rinsate directly into the sample containers. The rinsate samples will be analyzed for the same constituents as the associated samples collected with that sampling tool.

4.4.4. Matrix Spike and Matrix Spike Duplicate

The laboratory will analyze a MS/MSD for each sampling event. Sufficient sample volumes will be collected and submitted to the laboratory to allow the laboratory to select an appropriate sample from each batch for MS/MSD evaluation.

4.4.5. Temperature Blanks

The laboratory will measure and record the temperature of the samples in the cooler immediately upon receipt of the samples.

4.5. Field Documentation, Sample Handling, and Sample Analysis

This section describes the procedures for documentation and sample management in the field, including field documentation, sample documentation, sample packaging and shipping procedures, and sample analysis.

The soil and groundwater samples will be analyzed for the parameters as summarized in Table 3, using the analytical methods indicated in the table. Soil and groundwater samples collected from the subject property will be packed in coolers with ice and transported under standard chain-of-custody protocol to an accredited analytical laboratory. The laboratory analysis reports will be returned to ERM on a standard schedule, which is typically 10 to 15 business days, depending on the laboratory selected.

Specific documentation, handling, and analysis procedures related to the samples are described in the subsections below.

4.5.1. Sample Identification, Numbering, and Labeling

Sample labels will be filled out with indelible ink and affixed to each sample container. If non waterproof labels are used, then each sample label will be covered with clear tape to keep it dry. Sample containers will be placed in re-sealable plastic bags to protect the sample from moisture during transportation to the laboratory. Each sample container will be labeled with the following, at a minimum.

- Sample identification;
- Sample collection date;
- Time of collection;
- Project number;
- Sampler's initials;
- Analysis to be performed;
- Preservative used (if any); and
- Project location (i.e., K2 Vashon).

Samples submitted to the analytical laboratory will be uniquely identified based on the name of the location from which it is collected as indicated on Table 3. Additionally, soil samples will include the depth at which the sample was collected. For example, a soil sample collected from 8.5 feet bgs in boring B5-2 would be identified as "B5-2-8.5."

4.5.2. Field Documentation

Data collection activities performed at the subject property will be documented in field notebooks and/or on COC records using waterproof, indelible ink. The pages of the field notebooks will be sequentially numbered, the field notebooks will be bound, have a water-resistant cover, and be assigned to individual field personnel for the duration of field activities. Entries will be as detailed and as descriptive as possible so that a particular situation can be recalled without relying solely on the sampler's memory. Field log entries will be dated and signed. Information entered in the field notebook will include, at a minimum, the following items:

- Project name and number;
- Dates and times of entries;
- Weather conditions;

- Names of personnel performing the activities;
- Subcontractors and vendors on site;
- A description of daily activities;
- A description of sample locations, including sample name and type;
- Depths of samples if relevant;
- Sample descriptions (including odor and staining);
- Sample collection methods;
- Preservatives (if appropriate);
- Parameters for analysis;
- Field instrument calibration information;
- Field instrument readings; and
- Health and safety information.

Field notebooks will be stored in ERM's project file when not in use. In addition, digital photographs will be taken to document field activities.

At the beginning of each daily entry, the date, start time, weather, names of all sampling team members present, and the signature of the person making the entry will be entered. The names of visitors to the subject property, field sampling or investigation team personnel, and the purpose of their visit will also be recorded in the field logbook.

Measurements made and samples collected will be recorded. Whenever a sample is collected, a detailed description of the sample collection location shall be recorded. A description of any photographs taken at the subject property will also be noted.

The equipment used to collect samples will be noted, along with the time of the sampling, sample description, depth at which the sample was collected, volume, and number of containers. Decontamination procedures will also be recorded. Field QC samples collected will also be recorded documenting the location and time of the sample collection.

4.5.3. Chain-of-Custody Procedures

A chain-of-custody (COC) record will be completed for every sample. A copy of an ERM COC form is included in Appendix B. In addition to providing a custody exchange record for the samples, the COC record serves as a formal request for sample analyses. After completion of the COC, one copy will be retained by the sample coordinator for project files and the original will be sent to the analytical laboratory with the sample shipment.

The COC record will be the controlling document to ensure that sample custody is maintained. The COC record will be initiated in the field by sampling personnel upon collecting a sample. Each individual who has the sample(s) in his/her possession will sign the COC. Each time the sample custody is transferred, the former custodian will sign the COC on the "Relinquished by" line, and the new custodian will sign the COC on the "Received by" line. The date, time, and the name of their project or company affiliation will accompany each signature.

After the laboratory receives the samples, the sample custodian will inventory each shipment before signing for it, and note on the original COC record any discrepancy in the number of samples, temperature of the cooler or broken samples. The ERM Project Manager will be notified immediately of any problems identified with shipped samples, and will determine the appropriate course of action.

The waybill number or courier name will be recorded on the COC when a commercial carrier is used. The shipping container will be secured with a custody seal, thereby allowing for custody to be maintained by the shipping personnel until receipt by the laboratory.

The laboratory will initiate an internal COC that will track the sample within the various areas of the laboratory and subcontracted laboratories. The relinquishing signature of the sample custodian and the custody acceptance signature of the laboratory personnel transfer custody of the sample. This procedure is followed each time a sample changes hands.

4.5.4. Sample Preservation, Packaging, and Shipment

After collection, samples will be immediately labeled and stored in a chilled cooler with ice or a frozen ice pack to maintain a temperature of 4°C ±2°C. The appropriate sample containers, preservation techniques, and holding times for samples collected during the investigation are summarized in Table 5.

The shipping of samples to the analytical laboratory, by land delivery services, will be performed according to the DOT regulations. The International Air Transportation Association regulations will be adhered to when shipping samples by air courier services. Transportation methods will be selected to ensure that the samples arrive at the laboratory in time to permit testing according to established holding times and project schedules. No samples will be accepted by the receiving laboratory without a properly prepared COC record and properly labeled and sealed shipping container(s).

Packaging of sample containers will be based on the level of protection a sample will require during handling, shipping, and storage. Protection may vary according to sample type, sample media, suspected amount of hazardous substances, required testing, and handling and storage conditions. Proper packaging will include:

- **Inner packing**: plastic bags, shock-absorbing packing material, and ice for preservation;
- **Over packing**: Metal or plastic coolers;

- **Over pack sealing**: Strapping tape and custody seals; and
- **Marking and labeling of over pack**: Laboratory address, any appropriate DOT Hazard Class Labels, and handling instructions.

Before sample collection, sample labels will be affixed to each sample container. If non-waterproof labels are used, each sample label will be covered with clear tape to keep the label dry. Sample bottles will be placed in a re-sealable plastic bag to keep the container dry. Glass sample containers will be protected with bubble wrap or other protective packaging material. A temperature blank will be placed in every cooler with samples.

The COC will be filled out and a copy of the COC form will be retained for documentation. Samples will be packed in a sample cooler with ice in sufficient quantity to keep the samples cooled to 4 ºC ±2 ºC for the duration of the shipment to the laboratory. Saturday deliveries will be coordinated in advance with the laboratory.

If samples are picked up by a laboratory courier service, the COC form will be completed and signed by the laboratory courier. The cooler will then be released to the courier for transportation to the laboratory.

If a commercial carrier is used, the COC form will include the shipping carrier in the "transfers accepted by" column, and will be sealed in a re-sealable bag. The COC form will then be taped to the inside of the sample cooler lid. Cooler drain spouts will be taped from the inside and outside of the cooler to prevent any leakage. The cooler will be taped shut with strapping tape, and a custody seal will be taped across the cooler lid. Clear tape will be applied to the custody seals to prevent accidental breakage during shipping. The samples will then be shipped to the analytical laboratory. A copy of the courier air bill will be retained for documentation.

4.6. Project Data Quality Assurance and Quality Control Requirements

This section summarizes the protocols put in place to ensure the quality of the field and laboratory data generated as part of this project.

4.6.1. Laboratory Data Validation/Review

ERM will perform a level II data review of the analytical data reports. The data review will be in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Data Review and the QA/QC criteria specified in this document. Data will be reviewed and flagged with the appropriate data qualifiers.

Based on laboratory data validation/review, a qualified ERM scientist will determine if the QA criteria have been met, and will establish and document data usability.

4.6.2. Record Keeping

The project file will include copies of the *Site Characterization Work Plan and Sampling and Analysis Plan* which document the proposed collection and sample analytical approaches. Additionally, records that document any departures from the *Site*

Characterization Work Plan and Sampling and Analysis Plan (such as site logbooks) will be maintained in the project file. The results of all analyses, including laboratory reports and summary tables or interpretive reports, will also be retained.

The contract laboratory will submit analytical data in both hard-copy format and as electronic data deliverables (EDD). The EDD will be in a format recognized by Ecology's current (2014) Environmental Information Management (EIM) system. The validated EDDs as well as other records regarding the physical, chemical, and biological analyses/measurements collected from the site will be uploaded to the EIM. Supplementary information regarding the data (metadata), including information about environmental studies, monitoring locations, and data quality, will also uploaded to and stored on the EIM.

4.7. Investigation-Derived Waste

Investigation-derived waste (i.e., development, purge and decontamination water, and soil cuttings) from the drilling and sampling activities will be collected in 55-gallon drums. The drums will be labelled with the content source and type, date of accumulation, and ERM contact information. ERM will develop disposal recommendation based on the analytical results for the associated samples and will assist K2 in disposal of the waste in accordance with the State and Federal regulations.

5. REFERENCES

Berg Environmental Services. 2007. *Draft Executive Summary, Phase I Site Assessment K2 Sports Vashon Property*. Partial report. 16 March 2007.

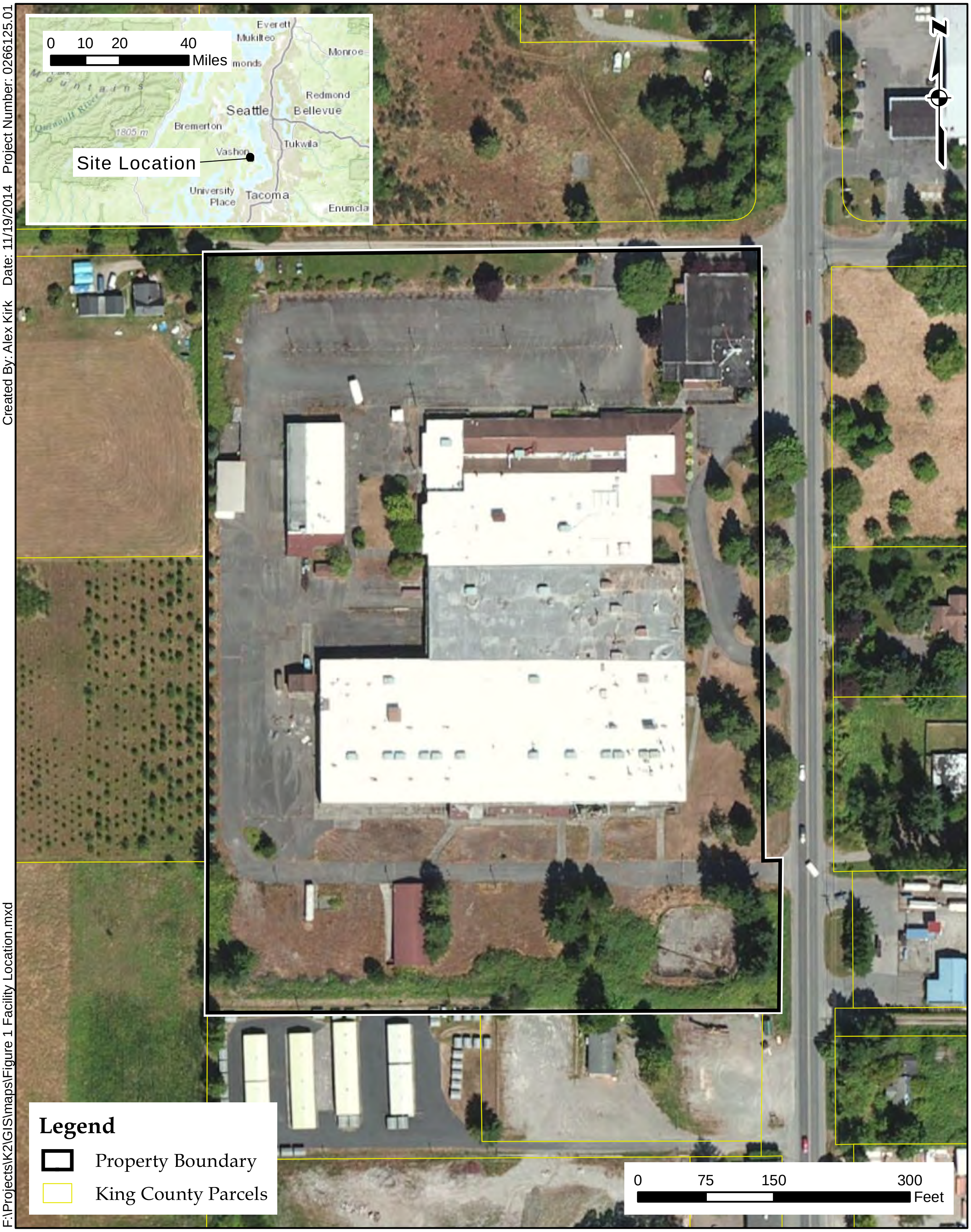
Washington State Department of Ecology (Ecology). 2013. *Model Toxics Control Act Regulation.* Chapter 173-340 Washington Administrative Code. Publication Number 94-06. Revised 2013.

White Shield, Inc. 2008. *Phase II Environmental Site Assessment, K2 Corporation, Vashon, Washington*. 11 July 2008.

White Shield, Inc. 2009. *Underground Heating Oil Storage Tank Decommissioning Report, K2 Sports USA, 19215 Vashon Highway, Vashon, Washington.* Prepared for K2 Sports. 11 February 2009.

FIGURES

F:\Projects\K2\GIS\maps\Figure 1 Facility Location.mxd Created By: Alex Kirk Date: 11/19/2014 Project Number: 0266125.01



Environmental Resources Management
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Portland, Oregon 97204

ERM

Figure 1
Facility Location & Layout
K2 Site Investigation
Vashon, Washington

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Figure 2
Recognized Environmental Condition Locations
K2 Site Investigation
Vashon, Washington

F:\Projects\K2\GIS\maps\Figure 3 UST Decommissioning.mxd Created By: Alex Kirk Date: 11/20/2014 Project Number: 0266125.01

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Figure 3

Underground Storage Tank Decommissioning
K2 Site Investigation
Vashon, Washington

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ERM

Figure 4
Areas of Concern
K2 Site Investigation
Vashon, Washington

F:\Projects\K2\GIS\maps\Figure 5 Geophysical Transits.mxd Created By: Alex Kirk Date: 11/18/2014 Project Number: 0266125.01

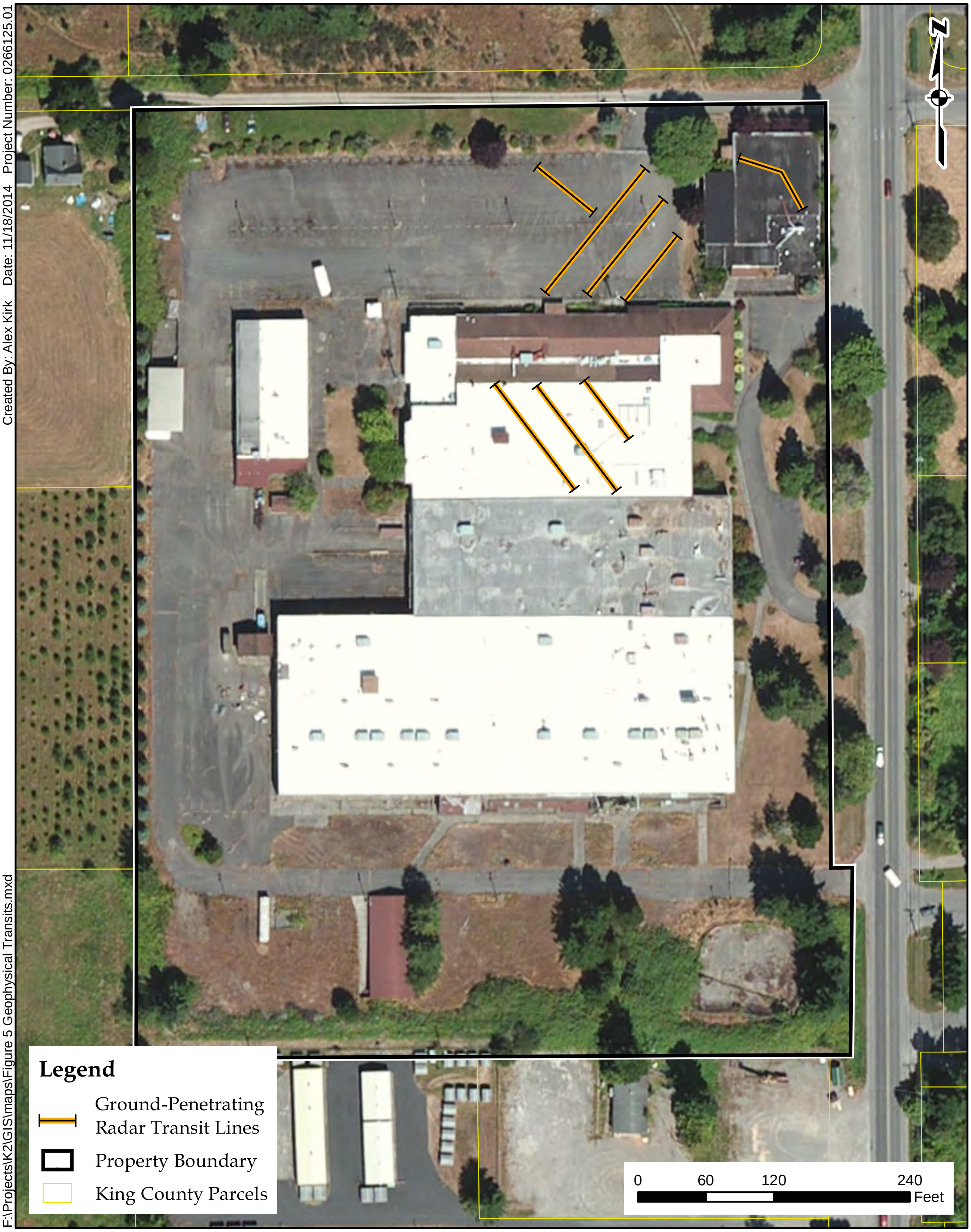

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Figure 5
Geophysical Transit Locations
K2 Site Investigation
Vashon, Washington

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ERM

Figure 6
Proposed Sample Locations
K2 Site Investigation
Vashon, Washington

TABLES

Table 1

Summary of Constituents Detected in Soil Samples

2008 Site Investigation and UST Decommissioning

K2 Facility, Vashon, Washington

Boring/ Sample Location	Sample Identifier	Sample Depth (feet bgs)	TPH-D	TPH-HO	Volatile Organic Compounds		Pesticides/ Herbicides	Metals		
					Methylene Chloride	Trichloroethene		Arsenic	Chromium	Lead
Site Investigation Borings										
B-1	B-1-8	8	ND	ND	ND	ND	NA	ND	28	ND
B-2	B-2-6	6	ND	ND	ND	ND	NA	ND	34	ND
B-3	B-3-1	1	2,200	740	NA	NA	NA	NA	NA	NA
	B-3-10	10	ND	ND	NA	NA	NA	NA	NA	NA
B-4	B-4-4	4	ND	ND[1]	ND	0.0035	NA	ND	35	ND
B-5	B-5-4	4	ND	ND[1]	ND	ND	ND	ND	30	ND
B-6	B-6-4	4	ND	ND	ND	0.0016	NA	ND	29	ND
B-7	B-7-4	4	ND	ND	ND	ND	NA	ND	27	ND
B-8	B-8-6	6	ND	ND	ND	ND	NA	NA	NA	NA
B-9	B-9-2	2	ND	ND	ND	ND	NA	16	47	28
B-10	B-10-14	14	ND	ND	ND	0.009	NA	ND	27	ND
B-11	B-11-6	6	ND	ND	ND	ND	NA	NA	NA	NA
UST Excavation Limits										
North Lot UST	Northwall-5 1/2'	5.5	ND	ND	NA	NA	NA	NA	NA	NA
	Westwall-5'	5	ND	ND	NA	NA	NA	NA	NA	NA
	Southwall-4'	4	6,100	ND	NA	NA	NA	NA	NA	NA
	Eastwall-5'	5	ND	ND	NA	NA	NA	NA	NA	NA
	B-1-9'	9	ND	ND	NA	NA	NA	NA	NA	NA
	B-2-8 1/2'	8.5	ND	ND	NA	NA	NA	NA	NA	NA
MTCA Method A Cleanup Level[2]			2,000	2,000	0.02	0.03	NS	20	2,000[3]	250

Notes:

Concentrations reported in milligrams per kilogram.

Shaded cells indicate concentrations that are greater than the respective MTCA Method A Cleanup Level.

bgs = Below ground surface

MTCA = Model Toxics Control Act

NA = Not analyzed

ND = Not detected

NS = No standard

TPH-D = Diesel-range petroleum hydrocarbons

TPH-HO = Heavy oil-range petroleum hydrocarbons

[1]TPH-HO reported detected using Method NWTPH-HCID, but not detected in follow-up analysis using Method NWTPH-Dx.

[3]MTCA Method A Soil Cleanup Levels for Unrestricted Land Uses (Chapter 173-340-900 Washington Administrative Code, Table 740-1)

[3]Value for Chromium(III). Choromium(VI) value is 19 milligrams per kilogram.

Table 2

Summary of Areas of Concern

K2 Facility, Vashon, Washington

Area of Concern	Recognized Environmental Concern Areas
AOC 1 - Machine Shop	REC 7 - Open-Ended Sump in the Machine Shop
	REC 7 - Possible Former Drain Field
	REC 7 - Area Near the Northwest Corner of the Machine Shop, Former Gel Coat Pit, and Paint Booth
	300-gallon underground storage tank under building
	Groundwater
AOC 2 - Decommissioned UST and North Lot	REC 1 - Former Florist Shop and Greenhouses
	REC 1 - Former Chemical Loading/Unloading Area on North Side of Main Building
	REC 7 - Possible Former Drain Field
	Groundwater
AOC 3 - Still; Centrifuge Room; and Chemical, Equipment, and Hazardous Waste Storage Areas	REC 2 - Still Area
	REC 3 - Hazardous Waste Shed
	REC 3 - Centrifuge Room
	REC 8 - Former Equipment and Materials Storage Areas Near the West Side of the Property
	Rooms on the West Side of Carpenter Shop Building and Nearby Pavement
	Soil Cleanup Area on South Side of Carpenter Building
	Groundwater
AOC 4 - Former Drain Field and Vapor Degreasers	REC 11 - Former Drain Field
	REC 12 - Former Vapor Degreaser Areas
	Groundwater
AOC 5 - Former Resin Tank and Grinding Process Area	REC 4 - Former Resin Tank Farm Area
	REC 5 - Unpaved Areas and Soil on the South End of the Property
	Groundwater
AOC 6 - Boiler Room	REC 6 - Soil and Groundwater Near the Boiler Roon
	Groundwater
AOC 7 - Storm Water Retention Pond	REC 9 - Discharges to Storm Drain Including Ditch
	REC 10 - Soil Underneath Retention Pond
	Groundwater

Notes:

AOC = Area of concern

REC = Recognized environmental condition

Area of Concern	Sample Location	Sample Type	Sample Analyses						
			TPH-G	TPH-D/HO	VOCs	SVOCs	Pesticides	PP Metals	PCBs
		Ecology or USEPA Analytical Method	NWTPH-Gx	NWTPH-Dx	8260	8270 SIM	8080	6010/6020/ 7000 Series	8082
AOC 1 - Machine Shop	B1-1	Soil	1	1	1	1	0	1	0
		Groundwater[1]	1	1	1	1	0	1	0
	HA1-1	Soil	1	1	1	1	0	1	0
	MW1-1	Groundwater	1	1	1	1	0	1	0
	MW1-2	Groundwater	1	1	1	1	0	1	0
	Additional Analyses	Soil	1	1	1	0	0	0	0
	QA/QC Samples	Trip Blank	1	0	1	0	0	0	0
		Rinsate Blank (Groundwater)	1	1	1	1	1	1	0
Subtotal Analyses			8	7	8	6	1	6	0
AOC 2 - Decommissioned UST and North Lot	B2-1	Soil	1	1	1	0	1	1	0
		Groundwater	1	1	1	0	1	1	0
	B2-2	Soil	1	1	1	0	0	1	1
		Groundwater	1	1	1	0	0	0	0
	B2-3	Soil	0	1	1	1	0	0	0
	HA2-1	Soil	0	1	1	1	0	0	0
	MW2-1	Groundwater	1	1	1	1	0	0	0
	Additional Analyses	Soil	0	1	1	1	0	0	0
	QA/QC Samples	Trip Blank	1	0	1	0	0	0	0
		Rinsate Blank (Soil)	1	1	1	1	1	1	1
Subtotal Analyses			7	9	10	5	3	4	2
AOC 3 - Still, Centrifuge Room, and Chemical, Equipment, and Hazardous Waste Storage Area	B3-1	Soil	1	1	1	0	0	1	0
		Groundwater	1	1	1	0	0	1	0
	B3-2	Soil	1	1	1	0	0	1	0
		Groundwater	1	1	1	0	0	1	0
	B3-3	Soil	1	1	1	0	0	1	0
		Groundwater	1	1	1	0	0	1	0
	B3-4	Soil	1	1	1	0	0	1	0
		Groundwater	1	1	1	0	0	1	0
	MW3-1	Groundwater	1	1	1	1	0	1	0
	MW3-2	Groundwater	1	1	1	1	0	1	0
	Additional Analyses	Soil	2	2	2	4	0	2	0
		Groundwater	0	0	0	1	0	0	0
	QA/QC Samples	Trip Blank	2	0	2	0	0	0	0
		Field Blank (Soil)	1	1	1	1	0	1	0
Subtotal Analyses			15	13	15	8	0	13	0
AOC 4 - Former Drain Field and Vapor Degreasers	B4-1	Soil	1	1	1	1	1	1	0
		Groundwater	1	1	1	1	1	1	0
	HA4-1	Soil	0	0	1	0	0	0	0
	HA4-2	Soil	0	0	1	0	0	0	0
	MW4-1	Groundwater	1	1	1	1	1	1	0
	QA/QC Samples	Trip Blank	1	0	1	0	0	0	0
		Field Duplicate (Groundwater)	1	1	1	1	1	1	0
Subtotal Analyses			5	4	7	4	4	4	0
AOC 5 - Former Resin Tank and Grinding Process Area	B5-1	Soil	0	1	1	1	0	0	0
	B5-2	Soil	1	1	1	1	0	1	0
		Groundwater	1	1	1	1	0	1	0
	MW5-1	Groundwater	0	1	1	1	0	0	0
	QA/QC Samples	Trip Blank	0	0	2	0	0	0	0
		Rinsate Blank (Soil)	0	1	1	1	0	1	0
		Field Duplicate (Groundwater)	0	1	1	1	0	1	0

Area of Concern	Sample Location	Sample Type	Sample Analyses						
			TPH-G	TPH-D/HO	VOCs	SVOCs	Pesticides	PP Metals	PCBs
Ecology or USEPA Analytical Method			NWTPH-Gx	NWTPH-Dx	8260	8270 SIM	8080	6010/6020/ 7000 Series	8082
Subtotal Analyses			2	6	8	6	0	4	0
AOC 6 - Boiler Room	HA6-1	Soil	0	1	1	1	0	0	1
	MW6-1	Groundwater	0	1	1	1	0	0	0
	QA/QC Samples	Trip Blank	0	0	1	0	0	0	0
		Field Blank (Groundwater)	0	1	1	1	0	0	0
Subtotal Analyses			0	3	4	3	0	0	1
AOC 7 - Storm Water Retention Pond	B7-1	Soil	1	1	1	1	0	1	0
		Groundwater	1	1	1	1	0	1	0
	HA7-1	Soil	2	2	2	2	0	2	2
	SS-1	Soil	1	1	1	1	0	1	1
	MW7-1	Groundwater	1	1	1	1	0	1	0
	QA/QC Samples	Trip Blank	1	0	1	0	0	0	0
Subtotal Analyses			7	6	7	6	0	6	3
Total Analyses			44	48	59	38	8	37	6

Notes:

[1]Boring may need to be completed with hand auger. If so, groundwater sample may not be encountered/collected.

Ecology = Washington State Department of Ecology

PCBs = Polychlorinated biphenyls

PP Metals = Priority Pollutant metals

SVOCs = Semivolatile organic compounds

TPH-G = Gasoline-range petroleum hydrocarbons

TPH-D/HO = Diesel- and heavy oil-range petroleum hydrocarbons

USEPA = United States Environmental Protection Agency

Sample Location Key:

B = Soil boring, power drill

HA = Soil boring, hand auger

MW = Monitoring well

SS = Surface soil sample

Area of Concern	Recognized Environmental Concern Areas	Planned Sample Locations Related to Each Area	Sample Media
AOC 1 - Machine Shop	REC 7 - Sump in the Machine Shop	HA1-1, MW1-1, MW1-2	Soil and groundwater
	REC 7 - Possible Former Drain Field	B2-1[1]	Soil and groundwater
	REC 7 - Area Near the Northwest Corner of the Machine Shop, Former Gel Coat Pit, and Paint Booth	HA1-1, MW1-1, MW1-2	Soil and groundwater
	300-gallon underground storage tank under building	B1-1	Soil and groundwater
	Groundwater	B1-1, MW1-1, MW1-2	Groundwater
AOC 2 - Decommissioned UST and North Lot	REC 1 - Former Florist Shop and Greenhouses	B2-1	Soil and groundwater
	REC 1 - Former Chemical Loading/Unloading Area on North Side of Main Building	B2-2	Soil and groundwater
	REC 7 - Possible Former Drain Field	B2-1	Soil and groundwater
	UST Removed in 2008	B2-3, HA2-1, MW2-1	Soil and groundwater
	Groundwater	B2-1. B2-2, MW2-1, MW4-1	Groundwater
AOC 3 - Still; Centrifuge Room; and Chemical, Equipment, and Hazardous Waste Storage Areas	REC 2 - Still Area	B3-3, B3-4, MW3-2	Soil and groundwater
	REC 3 - Hazardous Waste Shed	B3-2, B3-4, MW3-2	Soil and groundwater
	REC 3 - Centrifuge Room	B3-3, B3-4, MW3-2	Soil and groundwater
	REC 8 - Former Equipment and Materials Storage Areas Near the West Side of the Property	B3-1	Soil and groundwater
	Rooms on the West Side of Carpenter Shop Building and Nearby Pavement	B3-1, B3-2, B3-3, B3-4, MW3-2	Soil and groundwater
	Reported Soil Cleanup Area on South Side of Carpenter Building	None	Confirmed not an issue[2]
	Groundwater	B3-1, B3-2, B3-3, B3-4, MW3-1, MW3-2	Groundwater
AOC 4 - Former Drain Field and Vapor Degreasers	REC 11 - Former Drain Field	B4-1	Soil and groundwater
	REC 12 - Former Vapor Degreaser Areas	HA4-1, HA4-2	Soil
	Groundwater	B4-1, MW4-1	Groundwater
AOC 5 - Former Resin Tank and Grinding Process Area	REC 4 - Former Resin Tank Farm Area	B5-1, MW5-1	Soil and groundwater
	REC 5 - Unpaved Areas and Soil on the South End of the Property	B5-2	Soil and groundwater
	Groundwater	B5-2, MW5-1	Groundwater
AOC 6 - Boiler Room	REC 6 - Soil and Groundwater Near the Boiler Roon	HA6-1, MW6-1	Soil and groundwater
	Groundwater	MW6-1	Groundwater
AOC 7 - Storm Water Retention Pond	REC 9 - Discharges to Storm Drain Including Ditch	SS7-1, B7-1, MW7-1	Soil and groundwater
	REC 10 - Soil Underneath Retention Pond	HA7-1	Soil
	Groundwater	B7-1, MW7-1	Groundwater

Notes:

[1]Will be relocated from AOC 2 if drain field is found in AOC 1.

[2]ERM confirmed abandoned vehicle area not an issue during site reconnaissance in November 2014.

AOC = Area of concern

REC = Recognized environmental condition

Table 5

Sample Collection Containers, Preservatives, and Holding Times

K2 Facility, Vashon, Washington

Analyte	Analytical Method	Soil			Groundwater		
		Container	Preservative	Holding Time	Container	Preservative	Holding Time
Gasoline-Range Petroleum Hydrocarbons	Ecology NWTPH-Gx	2oz WMGS	Cool 2-6°C, no headspace	14 Days	2-40mL AGV	HCl, Cool 2-6°C, no headspace	14 Days
Diesel- and Heavy Oil-Range Petroluem Hydrocarbons	Ecology NWTPH-Dx	8oz WMG	Cool 2-6°C	14 Days	2-500mL AG	Cool 2-6°C	7 Days
Volatile Organic Compounds	USEPA 8260	3-40mL volatile organics analaysis vials	Cool 2-6°C, 2xSodium Bisulfate, 1xMethanol	14 Days	2-40mL volatile organics analaysis vials	HCl, Cool 2-6°C, no headspace	14 Days
Semivolatile Organic Compounds	USEPA 8270	16oz WMG	Cool 2-6°C	14 Days	2-500mL AG	Cool 2-6°C	7 Days
Pesticides	USEPA 8080	16oz WMG	Cool 2-6°C	14 Days	2-500mL AG	Cool 2-6°C	7 Days
Priority Pollutant Metals	USEPA 6010/6020/ 7470A/7471A	4oz WMG	Cool 2-6°C	6 Months	500mL HDPE	HNO_3, Cool 2-6°C	6 Months
Polychlorinated Biphenyls	USEPA 8082B	8oz WMG	Cool 2-6°C	14 Days	- -	- -	- -

Notes:

- - = Not applicable
°C = Degrees Celsius
AG = Amber Glass Boston Round Bottle
AGV = Amber Glass Vial
Ecology = Washington State Department of Ecology
HCl = Hydrochloric acid
HDPE = High-density polyethylene
HNO_3 = Nitric acid
mL = Milliliters
oz = Ounce
USEPA = United States Environmental Protection Agency
WMG = Wide Mouth Glass Jar
WMGS = Wide Mouth Glass Jar with Septa

APPENDIX A

ERM Standard Operating Procedures

OBJECTIVES

Drilling and soil boring includes any activity where a borehole is advanced below ground surface using hand-powered tools or drill rigs. Drilling and borehole abandonment methods will follow the guidelines specified in WAC-173-160.

Prior to beginning any subsurface disturbance, a Subsurface Clearance Location Disturbance Permit will be obtained for each boring location, following ERM's subsurface disturbance procedures. All hazard mitigation identified in the permit will be followed before beginning any subsurface disturbance.

Hand tools commonly include hand augers, slide hammers, and electric or gasoline-powered rotary hammer drills.

The remainder of this Standard Operating Procedures (SOP) will provide detailed directions for the following:

- Hand-powered tool procedures, including hand augers; and
- Drill rig procedures, including:
    - Direct push drilling procedures;
    - Hollow stem auger (HSA) procedures; and
    - Sonic drilling procedures.

Hand-Powered Soil Boring Procedures

Methods for hand auger use are as follows:

- Confirm the hand auger is clean of any contaminants prior to augering. The blades should be pointed slightly inwards and should be slightly sharp to allow for cutting through roots and other organic material. Wear eye protection, gloves, and steel-toed shoes while operating a hand auger.
- Clear the drilling area of any large rocks or other surface debris.
- Push down on the top of the auger and then turn counter-clockwise. Twist from the hips and the shoulders, not from the back.
- Advance the hand auger until the bucket is full (approximately 6 to 9 inches) and then pull the auger from the hole. If the soil is to be logged, place the removed soil onto a plastic liner on the ground. If no logging is necessary,

then place soil into a 5-gallon storage bucket, or equivalent. Soil can be removed from the auger bucket by tipping the auger upside down or by gently hitting the side of the bucket with a hammer.

- Repeat augering until target depth is reached.
- Hand augers are not suitable for removal of large rocks and gravel.

Drill Rig General Procedures

There are multiple drill rigs used in soil/groundwater investigations and remediation activities. Each is useful for different site conditions and purposes. Care should be used when selecting an appropriate drill rig for the project (described below). Drill rigs will be operated by competent subcontractors that have all applicable state licenses for drilling boreholes. Drilling subcontractors must also be approved through ERM's Health and Safety Subcontractor Prequalification process.

The following general methods will be used for any drill rig:

- Generate a boring log for any drilling activity, following procedures provided in the Lithologic Logging Standard Operating Procedures.
- For all drilling methods, confirm that the equipment is clean and free of dangerous wear prior to use.
- While drilling, periodically field-screen the borehole opening for potential airspace impacts from volatile compounds using a photoionization detector or equivalent.
- If soil sampling or logging is included in the project scope, the rig sampler will be brought to the surface periodically to bring soil samples to the ground surface.
- If grab groundwater sampling is included, a slotted polyvinyl chloride screen will be installed in the boring, preferably inside the rod casing. The casing will then be pulled up to expose the zone of interest. Groundwater will be brought to the surface using a pump, or bailer, and discharged into pre-cleaned sampling containers provided by the analytical laboratory.
- Once drilling has been completed at a particular location, the boring shall be properly abandoned (WAC-173-160) in a way that complies with state regulations. Borings will generally be abandoned using grout or bentonite chips. Grout will be composed of a mixture of Portland cement, bentonite, and water, and will be introduced into the borehole from the bottom up using a tremmie pipe.
- All equipment will be decontaminated following completion of borehole abandonment.

- Following completion of all drilling activities, ERM will ensure that the site is restored as closely as possible to its pre-investigation condition.
- All soil cuttings and decontamination liquids will be collected, analyzed for disposal characteristics, and disposed of in accordance with applicable state and federal regulations.
- A borehole log will be produced for each borehole location and will include, at a minimum, the following information: date, borehole identification number, total depth of borehole, diameter of borehole, drilling company, driller, soil and groundwater sample depths, and ERM employee name.

Commonly used drill rigs include, but are not limited to:

- Direct Push (GeoProbe™);
- HAS; and
- Sonic.

Drilling methods differ depending on the drill rig. The remainder of this SOP addresses each drill rig separately. For all drilling methods, confirm that the equipment is clean and free of dangerous wear prior to use.

Direct Push Drilling Procedures

Direct push drill rigs are smaller rigs that use hydraulic pressure and percussion hammering to push a rod into the ground. They are generally mounted on smaller trucks and may be track-mounted. The casing is generally 2 to 4 inches in diameter and maximum boring depths can reach approximately 100 feet below ground surface (bgs). Direct push rigs are best for shorter borehole depths, in areas with low proportions of gravel or cobble-sized materials. They are quick to use and are generally the least expensive option. Direct push rigs are effective for collecting continuous soil samples for logging or sampling purposes. In comparison to other methods, they also generate a small volume of soil cuttings.

Because of the small casing size, direct push rigs are only useful for installing monitoring wells up to 2 inches in diameter. They are also less powerful than other drilling methods and are more susceptible to refusal.

Methods for using a direct push drill rig include the following steps:

- A drill rod, usually 4 to 5 feet long, is fitted with a hollow point (if logging soils or collecting samples), or a solid point (if no soil needed). If the hollow point is used, a clear, acetate liner is inserted inside of the drill rod.
- The drill rod is pushed into the ground to the maximum depth of the rod.

- If collecting soil for logging or sampling, the rod is then pulled out of the ground. The acetate liner is removed from the rod and placed aside for soil logging and sample processing.
- If soils are to be sampled for non-volatile materials, the acetate liner is cut into sections using a hacksaw, or equivalent. The ends are then immediately capped with Teflon sheets and plastic end caps. If the soils are to be logged or if the soils will be sampled for volatile compounds, the acetate liner is sliced open using a utility knife fitted with a hooked blade.
- The sample rod is fitted with a new acetate liner and pushed to the maximum depth again. Additional rods are added to the top of the coring rod to continue advancing the rod. The rod is pulled out of the borehole after each additional section is added so the acetate liner can be removed.
- Once belowground tasks have been completed at a location, the borehole can be abandoned.

Hollow Stem Auger (HSA) Procedures

HSA drilling involves advancing an auger containing helical or spiral flights surrounding a hollow core. As the auger is rotated, a bit at the bottom of the first auger cuts into the subsurface material, and the spiral flights convey the material to the surface. The core of the first auger may be left open to allow for soil sampling, or a plug may be installed to prevent soil from entering the core.

Common casing diameters range from 6 inch outer diameter to 15 inch outer diameter and maximum boring depths can reach approximately 300 feet bgs. HSA rigs are generally less expensive than sonic and are more readily available. HSA is also ideal for collection of geotechnical information, such as standard penetration test (SPT) blow counts and Shelby tubes. Split spoon samplers attached to an HSA rig are an effective method of obtaining soil samples. HSA is also useful for installing monitoring wells in areas with heave. Also, because most of the disturbed soil is removed by the flights, there are less potential problems with well development after installation of a monitoring well by HSA.

Methods for using a HSA drill rig include the following steps:

- Prior to beginning drilling, the ERM employee must determine the quality of soil sample needed. If only basic soil logging and no soil sampling is required, then soil for logging can be obtained from the cuttings pulled up by the flights. If soil samples are to be collected, or if logging must be conducted at specific depths, then the HSA must be fitted with a sampler. This is generally a split spoon that is driven through the stem of the auger.

- An auger is first fitted with a coring bit. If soil samples or a specific log is needed, then the center of the coring bit is left open. If only basic soil logging is required, then the coring bit is plugged.
- Augers are generally 5 to 10 feet long. Each auger is driven into the ground using rotation.
- To collect soil for samples or for logging, a 1.5-foot long split spoon sampler is advanced through the stem of the augers. The sampler may be fitted with brass or steel tubes for collection of soil samples. The sampler is dropped from a known height and the number of "blows" required to advance the sampler 6 inches is recorded. The sampler is then brought to the surface and opened. Sample tubes are capped using Teflon sheets and plastic caps and then processed for shipping to a laboratory. Soil for logging is placed on a plastic liner. This sampling process can be repeated continuously or can be repeated for specific depths.
- Once belowground tasks have been completed at a location, the borehole can be abandoned.

Sonic Drilling Procedures

Sonic drilling works by generating a sonic vibration and rotating/pushing a steel casing into the ground. The sonic vibration allows the casing to "slice" through fines, sands, gravel, and cobbles. Sonic drill rigs may be truck-mounted or track-mounted. Common casing diameters are 4 to 10 inches and maximum boring depths can reach approximately 600 bgs. Sonic rigs are generally quicker than HSA, especially when collecting continuous soil samples for logging purposes. Sonic is also effective at sites with a high degree of cobbles and large gravels, as the sonic vibration tends to shear the rocks. Sonic rigs also generate a relatively small volume of soil cuttings compared to HSA or rotary methods.

Due to the tendency for fines to smear, sonic rigs are not recommended for installing pumping wells. If a sonic rig must be used, then extra care will be needed during well development. Sonic drilling is also not recommended for collecting soil samples for volatile compounds, as the heat generated during the sonic drilling process may drive off volatiles and give false negatives.

Methods for using a sonic drill rig include the following steps:

- A coring rod, usually 5 to 20 feet long, is attached to the sonic rotary head and advanced to the maximum depth of the rod.
- After the rod is advanced to its maximum depth, additional rods are added to the top of the coring rod to continue advancement.

- At a depth determined by the driller, a sampler is advanced through the outer barrel and a soil sample is collected inside the sampler.
- The sampler is brought to the surface and the soil sample is vibrated out of the sampler, into bags that preserve the soil horizons.
- The ERM employee then splits open each bag using a utility blade and conducts soil logging and sampling.
- The sampler is then used to remove all remaining soil from within the coring rod and the driller continues to advance the coring rod.
- Once belowground tasks have been completed at a location, the borehole can be abandoned.

STANDARD OPERATION PROCEDURE
LITHOLOGIC LOGGING

Borings will be drilled by a Washington, state-licensed, driller. An experienced geologist will be present to monitor drilling and well installation operations, record geologic and hydrogeologic information on boring logs, and document borehole advancement and monitoring well construction.

Documentation

The following information will be recorded on the boring log for each location:

- Borehole/monitoring well identification number;
- Location and approximate ground surface elevation;
- Name of drilling company, driller, and attendant geologist;
- Method of drilling;
- Borehole diameter;
- Head space monitoring results;
- Lithologic descriptions and photoionization detector readings for soils encountered, including soil moisture/saturation conditions and corresponding drilling depths;
- Any strong odors encountered while logging and corresponding depth;
- Depth at which saturated soil/groundwater is first encountered while drilling;
- Total depth of completed borehole;
- Reference elevation for all depth measurements;
- Monitoring well construction details (if applicable);
- Weather conditions; and
- Signature of attendant geologist.

Soil Logging

Lithologic descriptions recorded by the geologist on the boring logs will be based on visual inspection of the core and/or drill cuttings. Material will be classified using the Unified Soil Classification System and described according to American Society for Testing and Materials (ASTM) D2488, “Description of Soils

(Visual Manual Procedure)." When precise classification of soils for engineering purposes is required, the procedures prescribed in ASTM D2487 shall be used.

In addition to soil descriptions, the geologist will provide descriptions related to visual or vapor assessment of potential chemical impacts.

Visual assessments of potential chemical impacts generally involve:

- Sheen: a glossy or "rainbow" colored sheen generally indicates non-aqueous phase liquids.
- Staining: red or black color that is NOT caused by natural redoximorphic conditions may indicate precipitation of a compound of concern.

Assessments of organic vapors will involve use of a photoionization detector or flame ionization detector or equivalent and/or an olfactory description of any strong odors.

STANDARD OPERATING PROCEDURE
MONITORING WELL DEVELOPMENT

This procedure describes the standard method and equipment used to perform monitoring well development and purging.

OBJECTIVES

Monitoring wells are developed to remove skin (i.e., near-well-bore formation damage) and to settle and remove fines from the filter pack. Wells will not be developed for 24 hours after completion if a cement bentonite grout is used to seal the annular space. However, wells may be developed before grouting if conditions warrant. Wells must be developed prior to collection of groundwater samples to ensure that samples are representative of site conditions.

There are a number of techniques that can be used to develop a well. Some of the more common methods are bailing, over pumping, backwashing, mechanical surging, surge and pump, and high-velocity jetting. All of these procedures are acceptable. Wells will generally be developed by pumping and surging using a centrifugal or submersible pump. However, final selection of the development method is dependant on the appropriateness of a specific method to the site and the client/facility needs.

Documentation

A template well development log is included below. The following information will be recorded in a field log during development of each monitoring well:

- Date;
- Well number and location;
- Depth at which groundwater is first encountered while drilling and 24 hours after completion;
- Depth of monitoring well;
- Depth and type of monitoring well casing;
- Static water level before and after development;
- Depth to top of the screen;
- Pertinent construction details, such as description of sand pack material;
- Purge method and rate;

- Total volume of water removed during development;
- Documentation of pH and specific conductance meter calibration;
- Temperature, turbidity, pH, and specific conductance field measurements; and
- Signatures of those performing the work.

Required Equipment

- Pump, pump tubing, bailer and rope, or wire line;
- Power source (e.g., generator), if required;
- Water-level meter or weighted surveyor's tape;
- Temperature, conductivity, pH, and turbidity meters;
- Personal protective equipment, as specified in the site-specific Health and Safety Plan (HASP);
- Decontamination supplies, as required; and
- Disposal drums, if required.

Procedure

Before and/or during development, the well cap and the interior of the well casing above the water table will be washed using water only from that well.

Development will continue until a minimum of 10 well volumes are purged, plus a minimum of three times the volume of any potable water added during drilling, or until turbidity is 10 Nephelometric Turbidity Units or less and field parameters have stabilized as follows:

- Temperature: ± 1 degree Celsius;
- pH: ± 0.1 unit;
- Specific conductance: ± 10 percent; and
- Turbidity: ± 10 percent.

The following steps must be followed when developing wells:

- Don personal protective clothing and equipment as specified in the site-specific HASP.
- Open the well cover and check the condition of the wellhead, including the condition of the surveyed reference mark, if any.

- Measure the depth to static water level and depth to bottom of the casing.
- Prepare the necessary equipment for developing the well.
- For screened intervals longer than 10 feet, develop the well in 2- to 3-foot intervals from bottom to top. This will ensure proper packing of the filter pack.
- During development, water will be removed throughout the entire water column in the well by periodically lowering and raising the pump intake, bailer, or surge block.
- Continue pumping or bailing until field parameters stabilize, as discussed above, for three consecutive recording intervals or until 10 well volumes have been purged.
- In a low recharge aquifer, the well may pump or bail to dryness before indicator parameters stabilize. In this case, allow the well to recharge and continue purging until parameters have stabilized. Record pertinent data in the field logbook.
- Remove the pump assembly or bailers from the well, decontaminate (if required), and clean up the area. Lock the well cover before leaving. Dispose of development water as required by the site-specific plans (i.e., store in labeled drums, discharge to the ground surface, discharge into on-site active treatment system, etc.).

STANDARD OPERATION PROCEDURE GROUNDWATER SAMPLING – MONITORING WELLS

OBJECTIVES

Groundwater sampling at monitoring wells is typically completed to evaluate contaminant concentrations, groundwater geochemistry, and/or groundwater physical properties to provide data helpful to understand the nature and extent of contamination, to evaluate contaminant fate and transport, and to assist in the selection and design of appropriate remedial measures. Groundwater samples are typically collected after a prescribed volume of water has been removed ("purged") from the well, or after groundwater physical parameters (at a minimum, temperature, specific conductivity, and pH) have stabilized within established limits.

MATERIALS

The equipment and supplies listed below are the minimum required for completion of groundwater monitoring, though it might not include everything needed for the project. Additional materials may be required to complete tasks as indicated in the proposal, work plan, and/or field briefing.

Minimum required equipment and supplies for groundwater monitoring are as follows:

- Health and safety equipment and supplies per the project Health and Safety Plan (HASP);
- Table or surface for sample handling;
- Plastic sheeting;
- Heavy-duty paper towels;
- Heavy-duty trash bags;
- Sealable plastic bags ("Ziplocs");
- Fine-tipped permanent markers ("Sharpies");
- Water level indicator;
- Well purging and sampling forms;
- 5-gallon plastic buckets;
- Laboratory-prepared sample containers;
- Distilled/deionized water;

- Primary sampling apparatus (submersible pump, peristaltic pump, or bailers) and associated equipment:
    - Submersible or peristaltic pump – Power source, power cables, discharge tubing (Note: Low-flow sampling requires a pump with an adjustable flow rate); and
    - Bailers and nylon rope;
- Backup sampling apparatus, at a minimum bailers and nylon rope;
- Water quality meter(s) with a minimum of temperature, specific conductivity, and pH capability;
- Water quality meter field calibration supplies;
- In-line water filters, if necessary;
- Tools for opening and cleaning well protective casings, including a tool to remove water from flush-mount casings (an empty plastic soda bottle works well for most protective casings);
- Well lock keys;
- 55-gallon drums to contain waste water;
- Summary of well construction details;
- Sample packing equipment and supplies (see Sample Handling and Shipping SOP); and
- Decontamination supplies (see Equipment Decontamination SOP).

PRE-SAMPLING PROCEDURES

Prior to initiating groundwater sampling, the following procedures apply:

- Comply with ERM health and safety procedures and the requirements in the HASP (e.g., communicate risks to subcontractors, complete daily safety briefings, evaluate equipment conditions, etc).
- Confirm well and sample collection locations per the proposal, work plan, and/or field briefing.
- Use available data to determine an appropriate sequence for well monitoring, from least to most contaminated, and follow this sequence when collecting water levels and when sampling.
- Confirm access to monitoring well locations.
- Measure water levels in all site wells, including those not slated for sampling. Water level measurements should be completed in a single day with as little interruption as possible.

- Calibrate water quality monitoring instruments and record equipment calibration procedures and results in the field notes or on an equipment calibration form.

GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling is typically completed in two stages, well purging and sample collection. Well purging involves removing water from the well casing to allow water entrained in the formation surrounding the well to flow into the casing. Sample collection involves filling appropriate containers with groundwater for laboratory analysis.

WELL PURGING

Two general types of well purging are typically used prior to sample collection: standard and low-flow. Standard sampling involves the removal of at least three well casing volumes of groundwater prior to sample collection, while low-flow sampling relies on laminar flow of groundwater out of the formation to minimize the volume of water evacuated from the well prior to sample collection. Low flow purging will be the method of purging for this project.

Plastic sheeting should be placed on the ground surface in the area that sampling equipment and supplies will be staged and used to limit the potential for inadvertent contamination by contact with the ground surface.

Low-Flow Purging Method

This procedure describes the standard method and equipment used to perform low-flow groundwater sampling. The techniques described in this procedure are in general agreement with the procedures outlined in the United States Environmental Protection Agency publication entitled "Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures" (Puls and Barcelona 1995). Certain states also have state-specific low-flow groundwater sample procedures, which should also be consulted prior to conducting low-flow sampling for any application where results may be reported to a state regulatory agency.

The low-flow (minimal drawdown) groundwater sampling procedures are used to facilitate the collection of representative groundwater samples and offer the following advantages over the standard procedure described above:

- The water column in the well experiences minimal disturbance during the purging and sampling procedure;

- The volume of purge water to achieve stabilization parameters is greatly reduced; and
- The work effort associated with field decontamination of sampling equipment is greatly reduced.

Note that low-flow sampling techniques should not be used in the following conditions:

- Groundwater yield is primarily from segregated and discontinuous zones across the screened interval (e.g., bedrock fractures or coarse-grained beds within a glacial till unit); and/or
- Groundwater yield will not allow sustained pumping at a minimum of 100 milliliters per minute with a resultant water level drawdown of less than 20 centimeters.

Unless otherwise indicated in the proposal, work plan, or field briefing, the following procedures apply to low-flow purging in preparation for groundwater sample collection:

- Attach a fresh length of disposable polyethylene (or equivalent) tubing to the outlet of the decontaminated pump.
- Attach flow-through cell for groundwater parameter measurement to the discharge tubing.
- Lower the pump slowly into the well to minimize the mixing of casing water and the suspension of any silt at the bottom of the well, placing the pump intake near the middle or slightly above the middle of the screened interval.
- Purge the well at 100 to 500 milliliters per minute; the goal is to minimize drawdown in the well (ideally less than 10 centimeters drawdown). Remove air bubbles from the pump discharge tubing or in-line flow cell as soon as possible after purging begins.
- During purging, the following water quality parameters will be monitored using an in-line flow cell; purge water temperature (C°), pH, electrical conductivity (EC, mS/cm), dissolved oxygen (mg/L), reduction-oxidation (Redox, mVolts) and turbidity (NTU) every 3 to 5 minutes. Note that these parameters are a minimum requirement. Confirm project-specific monitoring requirements with project documentation and/or ERM project manager.
- Stop purging when the following parameters have stabilized for three successive readings:
    - Temperature: +1 degree Celsius;
    - pH: +0.1 units;

- Specific conductance: +10 percent; and
- Turbidity readings are less than 10 NTUs.

If parameters are not stabilized, continue purging water from the well and measure parameters until stabilization is verified within the indicated ranges.

- Record in the field notes the time of start and end of purging, the volume of water purged, and any observations made during sampling (e.g., well damage, water odor, or color).

Groundwater Sample Collection

After purging has been completed as outlined in the section above, groundwater samples should be collected from the monitoring well using the following procedure:

- Fill out sample labels completely on laboratory-provided sample containers using a fine felt-tipped marker (IMPORTANT: Do not use ball-point pen, as the ink may wash off).
- Prior to groundwater sample collection, disconnect the flow cell and attach a 0.45 micron filter for the dissolved metals analysis.
- Collect groundwater samples into laboratory-provided sample containers directly from the bailer or pump discharge tubing. If an in-line flow cell is used, detach flow cell prior to sample collection. Take care to not contact the sample containers with any part of the sampling equipment or supplies (e.g., don't place the pump discharge tubing end in the sample container). Note that sampling for volatile organic compounds using a peristaltic pump should be avoided.
- Place the groundwater samples in sealable plastic bags, and then into a cooler and log them on the chain-of-custody (COC) form. See the Sample Handling SOP for details on managing, documenting, handling, and shipping of the samples.
- Record the time of sampling in the field notes.

Note that for filtered samples, the filter should be threaded into the end of the pump discharge for sample collection. If a filtered sample is required for a well sampled using a bailer, the bailed water should be placed in a clean laboratory-supplied glass container (e.g., a 1-liter amber bottle) and transferred through a filter using a peristaltic pump. Note that the glass container should not be reused.

Sample Preservation

Note that sample bottles for various analyses will be provided by the laboratory with preservative materials (e.g., hydrochloric acid or nitric acid) included in the container. Take care not to spill the preservative from the bottle prior to sampling, and minimize any bottle overfills that may dilute the preservative. Also, if a bottle contains or has contained preservative, it should never be used to collect a sample that should be unpreserved (e.g., an unfiltered dissolved metals sample destined for laboratory filtration).

If sample preservatives are not included in the sample bottles and must be added in the field, the procedure should be established in project documentation or by discussions with the ERM project manager prior to the field effort.

EQUIPMENT DECONTAMINATION AND WASTE HANDLING

After sample collection is complete at each well, follow the procedures outlined below to complete equipment decontamination and waste containment:

- After completion of sampling at each well, discard disposable equipment and complete reusable equipment decontamination per the Equipment Decontamination SOP or project-specific requirements.
- Place purge water and decontamination water in an appropriate container (55-gallon drum). Container should be labeled on the side (not lid) with date(s) of accumulation, contents, source of contents (e.g., boring number), and a unique number in sequence with other investigation-derived waste containers at the site. Note that some sites may require segregation of water from certain wells into specific drums because of disposal requirements or other considerations. Confirm appropriate waste segregation requirements before placing waste into holding containers.
- Complete a drum log in the field notes that includes the unique number, contents, dates of accumulation, and sources of contents.

REFERENCES

- United States Environmental Protection Agency, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers

APPENDIX B

ERM Sample Chain of Custody

Environmental Resources Management

CHAIN OF CUSTODY RECORD

NO: 1708

1001 S.W. 5th Avenue, Suite 1010 • Portland, OR • 97204 • (503) 488-5282 • FAX (503) 488-5142

PROJECT #	PROJECT NAME

SAMPLER: **(PRINT NAME)**	**(SIGNATURE)**

RECEIVING LABORATORY

SAMPLE I.D.	DATE	TIME	COMP	GRAB	SAMPLING METHOD	PRESER-VATIVE	ICE (Y/N)	SAMPLING VOLUME	# OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	MATRIX: GAS	REQUESTED PARAMETERS										

RELINQUISHED BY *(SIGNATURE)*	DATE	TIME	RECEIVED BY	DATE	TIME
RELINQUISHED BY *(SIGNATURE)*	DATE	TIME	RECEIVED BY	DATE	TIME
RELINQUISHED BY *(SIGNATURE)*	DATE	TIME	RECEIVED BY	DATE	TIME

FIELD REMARKS

REMARKS ON SAMPLE RECEIPT	ERM REMARKS
☐ BOTTLE INTACT ☐ CUSTODY SEALS ☐ CHILLED ☐ PRESERVED ☐ SEALS INTACT ☐ SEE REMARKS	

SEND REPORT TO:

WHITE – LABORATORY COPY   CANARY – FIELD COPY   PINK – DATABASE   GOLD – PROJECT FILE