APPENDIX E

Compliance Monitoring Plan

REPORT

Compliance Monitoring Plan

Union Pacific Railroad, Aluminum Recycling Trentwood Site

Submitted to:

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society of Testing and Materials
bgs	below ground surface
CAP	Cleanup Action Plan
CMP	Compliance Monitoring Plan
COC	constituent of concern
CUL	cleanup level
EB	Equipment Blank
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EO	Enforcement Order
FCR	Field Change Request
FD	Field Duplicate
FEDD	Field Electronic Data Deliverable
GPS	global positioning system
HASP	Health and Safety Plan
IDW	investigation derived waste
I&M	Inspection and Maintenance
IWC	Imperial West Chemical
LEDD	Laboratory Electronic Data Deliverable
MSL	mean sea level
MS/MSD	matrix spike/matrix spike duplicate
MTCA	Model Toxics Control Act
NIST	National Institute of Instruments and Technology
OSHA	Occupational Safety and Health Administration
PEDD	Planning Electronic Data Deliverable
PDI	Pre-Design Investigation
PPE	Personal Protective Equipment
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAO	Remedial Action Objective
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
SDG	sample delivery group
SPCC	Spill Prevention, Control, and Countermeasure
SVRP	Spokane Valley-Rathdrum Prairie
UPRR	Union Pacific Railroad Company
USEPA	United States Environmental Protection Agency
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation
XRF	X-ray fluorescence

1.0 INTRODUCTION

This Compliance Monitoring Plan (CMP) has been prepared by Golder Associates USA Inc. (Golder), on behalf of Union Pacific Railroad Company (UPRR), for the Aluminum Recycling Trentwood Site (Site) located within the incorporated limits of the City of Spokane Valley, Washington. The CMP is required as part of the site cleanup and monitoring process under the Model Toxics Control Act (MTCA), as established in Chapter 173-340 of the Washington Administrative Code (WAC) and consultations with the Washington State Department of Ecology (Ecology).

The Site's physical address is 2317 North Sullivan Road, Veradale, Washington. The Site is identified by Ecology as Facility/Site No. 628 (Figure 1). The Site boundaries, as defined under MTCA, consist of approximately 9 acres, and include property owned by UPRR, Washington State Department of Transportation (WSDOT), and Pentzer Venture Holdings II, Inc. (Pentzer) as identified in Figure 2. All three properties are zoned for industrial use. However, only the UPRR property qualifies as an industrial property under WAC 173-340-745. A dross material stockpile occupies the western portion of the UPRR property and extends onto the Pentzer property to the west. Kemira Water Solutions (Kemira) leases and operates a water treatment facility on the eastern part of the UPRR property.

A Revised Feasibility Study (FS) report for the Site was submitted by UPRR in March 2021 (Golder 2021c). The recommended remedial alternative identified in the FS consists of excavation and off-site disposal of the dross stockpile and dross-containing soil impacted with Site constituents of concern (COCs) at concentrations that exceed the proposed Site cleanup levels (CULs). Remediation levels may be implemented on the UPRR property. Those soils with concentrations of COCs greater than CULs and less than remediation levels may stay in place and be capped.

1.1 Purpose and Scope

The Revised FS identified excavation and off-site disposal of the dross stockpile and dross-containing soil COCs at concentrations that exceed Site CULs as the recommended remedial alternative (Golder 2021c). Ecology provided a Cleanup Action Plan (CAP) that identifies the CULs and remediation levels for the Site (Exhibit C of the Enforcement Order [EO]; Ecology 2021b). The CULs and remediation levels are provided in Tables 1 and 2. The CAP identifies the locations on-site, known as points of compliance, at which cleanup criteria must be met. The CMP describes the environmental monitoring required to ensure that the selected remedy meets the cleanup criteria at the points of compliance. Monitoring will be performed on both a short-term and a long-term basis. Short-term monitoring will be performed during the remedial action and is comprised of field screening and laboratory analysis of soil samples. Long-term monitoring consists of an annual inspection of the cap and associated engineering controls. The long-term monitoring is addressed in the inspection and maintenance (I&M) plan.

1.2 Objectives

The objective of the CMP is to provide data of sufficient quantity and quality to demonstrate that the implementation of the remedial actions is consistent with the remedial design and ensure the Site meets the performance criteria (CULs and remediation levels) to prevent or minimize the direct contact, ingestion, inhalation or uptake of stockpile materials dross-containing soil by humans or ecological receptors.

1.3 Compliance Monitoring Plan Organization

This CMP is organized as follows:

- Section 1 – Introduction: Statement of the purpose and scope of the UPRR Trentwood Site CMP.
- Section 2 – Background: Description of the Site, property history, previous environmental investigations, topography and climate, geology, and hydrogeology.
- Section 3 – Compliance Monitoring: Description of protection, performance, and confirmational monitoring activities to meet MTCA requirements associated with the Site cleanup, CULs, and point of compliance.
- Section 4 – Excavation Plan: Outlines the general plan for excavation activities detailed in the Engineering Design Report (EDR).
- Section 5 - Sampling and Analysis Plan: Scope of work and tasks for excavation and removal of contaminated soil at the Site to ensure the long-term effectiveness of the remedy.
- Section 6 – Quality Assurance Project Plan (QAPP): Identification of procedures for field and laboratory quality control, decontamination, chain of custody, and data validation, and reporting.
- Attachment A – Golder Technical Procedures.
- Attachment B - USEPA Method 6200 for X-ray fluorescence (XRF).
- Attachment C – Pre-Design Investigation: Correlation Graphs of XRF Test Results and Analytical Laboratory Results.
- Attachment D - Field Forms.

2.0 BACKGROUND

2.1 Site Description and History

The Site consists of three separate parcels (Figure 2) owned by UPRR, Pentzer, and WSDOT. All three properties are zoned industrial. The Site is approximately 9 acres, approximately 4 acres of which are covered by a stockpile of mixed aluminum process materials referred to as dross.

Starting in approximately 1966, UPRR's predecessor leased its property to a number of industrial tenants who engaged in operations generating aluminum dross which is presently stockpiled on the Site. Industrial tenants include the following: The Hillyard Processing Co., Hillyard Aluminum Recovery Corporation, Imperial West Chemical Co. (IWC), Kemwater North America Company, and Kemiron Northwest, Inc. n/k/a Kemira Water Solutions, Inc. (Kemira), the current tenant.[1]

The stockpile varies in depth from 5 to 30 feet. The total volume of the stockpile is approximately 62,000 cubic yards and extends to the adjacent property owned by Pentzer (Figure 2). A silt fence and "ecology blocks" have been installed around the stockpile as an interim measure to control surface water runoff from the stockpile. The Spokane River is approximately 450 feet west of the Site.

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[1] New information has been uncovered which supplements previously understood site history reported by Golder in earlier reports.

2.2 Previous Environmental Investigations

UPRR conducted a Remedial Investigation/Feasibility Study (RI/FS) at the Site pursuant to a 2010 Agreed Order with Ecology under the Washington State MTCA Cleanup Regulation Chapter 173-340 WAC. The RI/FS report (PBW 2012) summarized the following:

- Site history;
- Previous investigations;
- RI fieldwork conducted in 2010;
- Risks associated with soil, groundwater, and ecological receptors;
- Remedial action objectives (RAOs);
- A conceptual site model;
- Proposed CULs;
- An evaluation of cleanup alternatives; and,
- A preferred alternative recommended for the cleanup action.

The 2012 RI/FS determined that groundwater, which is approximately 45 to 55 feet below ground surface (bgs), and surface water and sediments in the nearby Spokane River were not impacted by COCs. The 2012 RI/FS also determined that the dross material is not a dangerous waste under Washington State's Dangerous Waste Regulations Chapter 173-303 WAC (Ecology 2020), and this was confirmed in the Revised FS (Golder 2021c).

The 2012 RI/FS further identified the extent of COCs in the dross stockpile and dross-containing soil on the three affected properties. This data was used to evaluate the extent of dross-containing soil for the 2020 independent soil removal action during which some of the impacted surface soil on the WSDOT and Pentzer properties adjacent to the dross stockpile were removed and placed on the dross stockpile.

The 2020 Pre-Design Investigation (PDI) further delineated the extent of the impacts on the WSDOT and Pentzer properties (Golder 2021a). Through the processes of stormwater runoff and wind erosion of both dross material currently stockpiled on-site and likely historical dross placed on-site, including dross placed on the east side of the Kemira facility, came to be deposited on the WSDOT and Pentzer properties and migrated into the soil column over the years since the Site has been used to stockpile dross. The primary COCs associated with aluminum dross in soil at the Site are metals including aluminum, arsenic, barium, copper, and to a lesser extent chromium (total) and mercury.

Ecology has provided a CAP that identifies CULs and remediation levels for the Site (Exhibit C of the EO; Ecology 2021b). The CULs and remediation levels are provided in Tables 1 and 2. The soil remediation levels are based on MTCA Method A or B CULs for industrial properties. Ecology identified the Site soil CULs and remediation levels in the Final CAP.

A Revised FS was submitted by UPRR in March 2021 (Golder 2021c) to re-visit the remediation technologies presented in the 2012 RI/FS. The PDI data was used to support the design of the recommended remedial alternative. The recommended remedial alternative identified in the Revised FS consists of excavation and off-site disposal of the dross stockpile and dross-containing soil with COCs at concentrations that exceed the Site CULs.

All stockpile material and dross-containing soil with concentrations above CULs on the Pentzer and WSDOT properties (Figure 3) will be removed from those properties and transported by truck using Sullivan Road to Graham Road Landfill for disposal. All stockpile material and dross-containing soil that exceed remediation levels will be removed from the UPRR property and transported to the Graham Road Landfill. The anticipated dross stockpile removal footprint is shown in Figure 2. An ecological cap will be required to cover these areas in addition to requiring institutional controls. However, if removal of stockpile material or dross-containing soil achieves CULs on the UPRR property, an ecological cap and institutional controls will not be required.

2.3 Topography and Climate

The surface elevation of the Site ranges from 1,956 feet mean sea level (MSL) to 2,020 feet MSL; the elevation of the stockpile ranges from approximately 1,988 to 2,030 feet MSL. The Site gently slopes southwest towards the Spokane River. The elevation of the Spokane River near the Site is approximately 1,934 feet MSL.

The Spokane Valley is a semi-arid region that has warm, dry summers and cool, moist winters. Annual rainfall averages 20 inches, with most precipitation occurring from November to March, frequently as snowfall. Snowfall accumulations of 1 foot or more are frequent in the Spokane area, but the snow usually melts within a few days (Molenaar 1988). Average temperatures in the area range from 27°F during the winter months to 69°F during the summer months. Precipitation in the area ranges from less than 1 inch during the months of July, August, and September, slightly more than 2 inches during the months of November and December, and slightly less than 2 inches during January through June (NOAA 2021). Wind data from Felts Field, located approximately 5 miles west of the Site, indicates that the prevailing wind direction is SW or SSW from November through June and NNE from July through October (Western Regional Climate Center 2021).

2.4 Geology

The surface geology in the Site vicinity consists of Pleistocene-aged glacial flood deposits (Hart Crowser 2009). The glacial flood deposits consist of poorly to moderately well-sorted, massive- to thick-bedded, stratified deposits of boulders, cobbles, pebbles, and sand resulting from multiple episodes of catastrophic outbursts from glacially dammed Lake Missoula. Undifferentiated alluvium and loess deposits may be present along the Spokane River. The top of the bedrock (metamorphic rocks) is at an elevation of approximately 1,700 to 1,750 feet MSL, or at a depth of approximately 250 to 300 feet below grade.

Based on observation of subsurface materials collected during the 2012 RI/FS, the Site geology is consistent with the scientific literature and descriptions reported in other environmental investigations conducted in the area. A 1 to 2 foot thick surface soil layer was observed across the Site. This soil layer consisted of unconsolidated silt, sand, and gravel. Beneath this surficial soil layer are poorly sorted sandy gravel, gravelly sand, and sand consistent with glacial flood deposits. These soils are typically dark gray and tan, have angular grains, and contain some cobbles and pebbles.

2.5 Hydrogeology

The Pleistocene-aged glacial flood deposits present at the Site are part of a regional aquifer system called the Spokane Valley-Rathdrum Prairie (SVRP) aquifer. The SVRP aquifer is designated as a Sole Source Aquifer by the United States Environmental Protection Agency (USEPA). The SVRP provides drinking water to approximately 500,000 residents in the region and covers approximately 370 square miles (Hart Crowser 2009). In the vicinity of the Site, the aquifer is called the Spokane aquifer, which underlies about 135 square miles in the Spokane River valley. The Spokane aquifer is unconfined and is recharged by surface infiltration, from the

Spokane and Little Spokane Rivers, and contribution from the Spokane-Rathdrum Prairie aquifer that is hydraulically connected and located to the east. Groundwater flow in the aquifer is generally to the west, with flow in the vicinity of the Site to the west/southwest (Hart Crowser 2009). Groundwater flow in general is influenced by the Spokane and Little Spokane Rivers, which have a close hydraulic connection to the aquifer. The Spokane aquifer is highly permeable and consists of coarse sand, gravel, cobbles, and boulders deposited by historic floods which account for a large amount of water storage and high hydraulic conductivity in the aquifer. The thickness of the aquifer varies from relatively thin in the City of Spokane where basalt bedrock approaches the surface, to a thickness of greater than 300 feet near the state border with Idaho. In the vicinity of the Site, the thickness is estimated to be approximately 200 to 350 feet, and the groundwater flow velocity is approximately 33 feet per day (Hart Crowser 2009).

During the 2012 RI/FS investigation, groundwater was encountered in the Site's monitoring wells at a depth of approximately 45 to 55 feet bgs. Groundwater flow is from east to west toward the Spokane River, which can act as a losing or gaining water body depending on river flow and recent precipitation. The groundwater gradient across the Site is approximately 0.003 feet/foot based on water level data collected during the 2012 RI/FS.

3.0 COMPLIANCE MONITORING

The purpose of the CMP is to describe short- and long-term compliance monitoring to be conducted at the Site during remediation and following its completion. Under WAC 173-340-410, compliance monitoring consists of protection monitoring, performance monitoring, and confirmational monitoring, as described below. The Sampling and Analysis Plan (SAP), which is a required element of the CMP, is provided in Section 5.0.

3.1 Protection Monitoring

Protection monitoring is short-term monitoring conducted to "confirm that human health and the environment are adequately protected during construction and the operation and maintenance period of a cleanup action as described in the safety and health plan" [WAC 173-340-420(a)]. Protection monitoring in the form of dust monitoring will be conducted during excavation and loading to protect Site workers and ensure that remediation activities have not mobilized contamination, further releasing it to the environment or off-site.

Health and safety hazards associated with this cleanup action include operation of heavy equipment and exposure to on-site contamination. Monitoring for protection of human health and the environment is addressed in the Health and Safety Plan (HASP), which is provided as Appendix D of the EDR.

The HASP was developed in conjunction with the completion of the engineering plans and specifications and prior to remediation activities. The HASP supports protection monitoring by specifying emergency procedures, site hazards, protective clothing, equipment, and dust monitoring required for protection of human health and the environment during excavation and sampling activities.

3.2 Performance Monitoring

Performance monitoring is short-term monitoring that confirms that the cleanup action has attained cleanup standards or other performance standards [WAC 173-340-410(b)]. Performance monitoring will consist of the collection of soil samples for field screening and laboratory analysis.

Performance monitoring will direct remediation activities and confirm that CULs have been attained. As identified in the CAP, dross-containing soil with COCs at concentrations that exceed CULs will be excavated from WSDOT and Pentzer properties to achieve CULs (Figure 3). Dross and dross-containing soil with concentrations of COCs that exceed remediation levels will be excavated from the UPRR property.

The FS (Revised) estimated that 80,000 cubic yards (120,000 tons) of dross and dross-containing soil will be removed from the Site ranging in depths from between 1 and 6 feet bgs. However, performance monitoring results will define the actual extent of excavation. Therefore, if human health criteria are exceeded at 6 feet bgs, additional excavation will be conducted as needed to achieve compliance to a maximum extent of 15 feet bgs. It should be noted that excavations will not extend to the water table.

Performance monitoring will consist of field screening and laboratory testing of soils representative of those remaining in place following excavation. A minimum of three XRF samples tested in the field for each excavation will be sent to the laboratory for confirmatory analysis of site COCs. Analytical laboratory results will be used to verify the relative performance of the selected field analysis method. Areas of soil with indicator parameters above CULs, whether contiguous or not, will be excavated to a maximum depth of 6 feet.

When on-site field analysis results indicate that remedial goals have been achieved, confirmatory soil samples will be collected/processed. All confirmatory samples will be submitted for laboratory analysis. In general, the excavation(s) will not be backfilled until laboratory results have confirmed that COCs are below their respective CULs. However, some excavations adjacent to power utility infrastructure will be backfilled immediately following sampling.

3.3 Confirmational Monitoring

Confirmational monitoring is long-term monitoring performed following completion of the cleanup action to verify its long-term effectiveness [WAC 173-340-410(c)] (i.e., the site remedy is performing as expected over time). Confirmational monitoring will consist of an annual inspection of the cap to identify signs of deterioration, damage or conditions that impact the ability of the CAP to function as intended, ensuring soil beneath the cap remains contained in place and preventing ecological receptors from contact with underlying impacted soils.

UPRR will submit an annual compliance monitoring report to Ecology within 60 days of monitoring events. The I&M plan provided as Appendix F of the ERD report outlines inspection and maintenance procedures. The report will summarize inspection activities and observations. If during an annual inspection it is determined that the integrity of the cap has been compromised and there is potential for ecological receptors to come in contact with underlying soil, Ecology will be notified within 10 working days. Corrective actions will be provided in the compliance monitoring report for Ecology approval.

3.4 Cleanup Levels

Cleanup levels are concentrations at which individual substances do not threaten human health or the environment. The selected remedy must address material exceeding designated CULs. The Final RI/FS (PBW 2012) and the Revised FS (Golder 2021c) documented the presence of soil contamination at the Site.

In the CAP, Ecology established unrestricted site use, Method A CULs for soil and groundwater (Exhibit C of the EO; Ecology 2021b). Although groundwater sampling results were below conservative screening levels, CULs were developed to ensure groundwater is not impacted. CULs were established in accordance with the MTCA Cleanup Regulation Method A or B for unrestricted land use criteria and are presented in Table 1.

3.5 Points of Compliance

The MTCA Cleanup Regulation defines the point of compliance as the location(s) at which CULs must be achieved. Once CULs have been met at all designated points of compliance, the Site is no longer a threat to human health or the environment.

The standard point of compliance for soil CULs based on human health throughout the Site is from ground surface to 15 feet bgs in accordance with WAC 173-340-740(6)(d). For sites with institutional controls (i.e., UPRR property) to prevent excavation of deeper soil, a conditional point of compliance may be set at the biologically active soil zone. This zone is assumed to extend to 6 feet bgs

The standard soil point of compliance for indicator parameters based on human health protection is established at a depth of 15 feet bgs, and for ecological receptor protection at a depth of 6 feet bgs. Since soil cleanup levels are based on protection of ecological receptors and background, and site investigations did not find contamination exceeding human health levels from 6 to 15 feet bgs, the soil point of compliance Ecology set the soil point of compliance in the CAP (Ecology 2021c) at 6 feet bgs throughout the Site.

4.0 EXCAVATION PLAN

The following outlines the general remedial action excavation activities. Detailed information regarding excavation of dross and dross containing soils with concentrations of site COCs that exceed cleanup criteria and earth moving activities including loading and transportation are presented in the EDR.

Excavations will consist of shallow (approximate 2 foot deep) large areal soil removals identified in Figure 3 and targeted deeper excavations, i.e., Excavations 1 through 9. Based on existing COC concentration data from the 2012 RI and 2021 PDI soil sample results, the depth of the excavation is anticipated to be between 2 and 6 feet bgs. Excavation will be performed according to standard industry practices. Temporary fencing will be placed around the perimeter of unattended excavations exceeding 4 feet in depth if not properly sloped. If the excavation depth exceeds 4 feet, the excavation side slopes will be 1.5 feet horizontal to 1 foot vertical (WAC 296-155-657) or properly shored for stability. Means of egress for both personnel and equipment will be provided in accordance with Washington State Labor and Industry requirements (WAC 296-155).

Conventional construction equipment such as backhoes, front loaders, and scrapers will be used for soil excavation. Excavation equipment will have previously been cleaned and decontaminated prior to arrival on-site. Excavation equipment will not require additional decontamination until completion of the project. Equipment will be decontaminated prior to removal from the Site.

Water spray will be used if necessary for dust suppression in accordance with the EDR during excavation, loading, and trucking activities. Low volume water sprays will be applied to material surfaces using equipment appropriate for the task. Water trucks will be used for suppression of roadway dust if necessary. The temporary water source is located on the south side of the Kemira facility and identified on Sheet 060 of the EDR.

Excavated soils may be placed directly into the transport vehicles, or loading may occur from temporary stockpiles adjacent to the excavation.

On-site stockpiles will be placed on sheeting and surrounded by berms constructed of soil, hay bales, or other suitable materials sufficient to prevent off-site migration of the stockpiled soils. Stockpiles will be covered overnight to minimize wind-blown dust or exposure to precipitation.

Prior to initiation of excavation activities, the lead field engineer will review the site health and safety plan with the field team. The briefing will include a summary of the COCs and required personal protective equipment (PPE). PPE will consist of steel-toed boots, Tyvek coveralls, gloves, eye and ear protection, and a hardhat

5.0 SAMPLING AND ANALYSIS PLAN

This section summarizes the sampling and analysis necessary to document excavation and removal of stockpile material and dross-containing soil with concentrations above CULs on the Pentzer and WSDOT properties or concentrations above remediation levels on the UPRR property and to ensure the long-term effectiveness of the remedy. The lateral and vertical delineation of dross-impacted soil for the remedial action incorporates data from the 2012 RI and the 2021 PDI.

5.1 Performance Monitoring

Performance monitoring for dross and soil containing dross removals actions will consist of field screening, and confirmatory soil sampling and chemical analysis by an analytical laboratory. Evaluation of the removal actions will be based on performance monitoring of soil remaining in place following excavation. During excavation activities, visual observations of underlying soils will be recorded in compliance with Golder Technical Procedure TP-1.2-6 “Field Identification of Soil” provided in Attachment A. Photographs of soil conditions will also be obtained. A portable handheld XRF analyzer[2] will be used to evaluate concentrations of indicator parameters (a subset of the Site’s metal COCs) remaining after excavation activities have been conducted in an area as prescribed in the EDR. XRF is widely used for elemental analysis in environmental investigations with metal COCs. Use of an XRF analyzer proved useful for screening purposes during the PDI.

Based on the XRF screening results, visual inspection for indications of any remaining impacted soil, and performance of prescribed excavations, soils samples will be collected from soils remaining in place for chemical analyses.

Performance monitoring will be conducted in support of two general excavation scenarios.

1) XRF screening and discrete soil sampling will be conducted to support targeted excavations 1 through 9 (Figure 3). The number and location of soil samples will be collected from excavations in general accordance with Site Assessment Guidance for Underground Storage Tank Systems (Ecology 2021a).

2) The site will be divided into four compliance units (Figure 5). XRF screening of broad excavation areas will be based on a systematic grid sampling approach on the WSDOT, Pentzer, and UPRR property removal areas will be based on a random grid sampling approach within the compliance units (6, 7, and 8). Select samples with elevated XRF readings will also be submitted to the analytical laboratory for chemical analysis to evaluate the correlation between analytical results and XRF readings.

Compliance units will be evaluated to determine if the removal actions have statistically been successful in attaining the applicable cleanup criteria. The approximated outlines for the compliance units are identified in Figure 5. Development of the compliance units were based on:

- The appropriate cleanup criteria i.e., unrestricted CULs or remediation levels applicable to the subject area,

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[2] An XRF analyzer exposes samples to X-ray and gamma-ray sources which causes the emission of characteristic "secondary" or fluorescence of energy shells within the elements of concern. The detector portion of the instrument receives the fluorescence, separates the energy from interferences, and provides estimates of individual element concentrations in the sample based upon the intensity of the fluorescence.

- Property boundaries,
- Relative size of the area subject areas and,
- Professional judgement.

Exact outlines for the compliance units are subject to change based on field conditions and extent of final excavations. The compliance units range between approximately 75,000 and 120,000 square feet and are composed of 29 to 47 approximately 50-foot by 50-foot based grid cells. Some grid cells are not square and encompass additional area that does not fit the square grid pattern. The numbered compliance unit's grids are presented in Figures 6, 7, and 8.

5.2 XRF Testing

Analyses conducted with the XRF analyzer will follow the USEPA Method 6200 protocol Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment (USEPA 2007; Method 6200) as described in Section 5.2.3. The Method 6200 protocol document is provided in Attachment B.

The exact model of XRF to be used will be determined prior to field work. The instrument will likely be similar to the Innov-X Model A-4000S. This instrument uses X-ray tubes with silicon positive-intrinsic-detectors to provide exposure and fluorescing capabilities. The Innov-X instrument does not contain a radioactive source, and as such is not subject to any handling and health and safety procedures commonly associated with radioactive source materials. The startup and calibration procedures are summarized in Section 5.2.2.

5.2.1 XRF Testing and Correlation with Site PDI Analytical Data

XRF screening results were compared to the analytical laboratory results during the 2020 PDI. Comparison of metal concentrations obtained in the field with the XRF, and analytical results obtained for the surface soil samples showed a good correlation between copper XRF and laboratory results (Golder 2021b). The XRF responses for aluminum were substantially under reported compared to analytical laboratory aluminum concentrations: this effect was more pronounced at higher concentrations. The lower atomic mass of aluminum hinders the ability of a handheld XRF analyzer to detect it. The XRF analyzer does not test for barium. Overall, the XRF analyzer proved to be a reliable detector of copper, arsenic, and lead concentrations. Coincidently, copper concentrations obtained via XRF are also a good indicator of analytical laboratory aluminum concentrations. Select correlation graphs provided in the 2020 PDI completion report (Golder 2021b) are provided in Attachment C of this document.

5.2.2 Calibration Standards

A preliminary site visit will be conducted prior to formally mobilizing to the Site for the PDI during which four samples of contaminated surface soil from the UPRR, WSDOT, and Pentzer properties and one sample of unimpacted soil will be collected. The samples will be submitted to the analytical laboratory for chemical analysis of metals as described in Section 6.5. These samples will be shipped back to Golder to be used as site-specific standards for calibrating the XRF.

The XRF instrument will be calibrated using the manufacturer's recommended procedures on the Site soil samples with known concentrations of metals. Aluminum, arsenic, and copper will be used as indicator parameters based on the correlation between XRF response and analytical results from the 2020 PDI. The sample aliquots returned by the analytical laboratory will be used as calibration standards for the XRF. The site-specific standards will be run on the XRF daily in accordance with USEPA Method 6200 to check the calibration of the instrument.

5.2.3 XRF Testing - USEPA Test Method 6200

All soil analysis will be conducted in accordance with USEPA Test Method 6200 provided in Attachment B. The test method requires the following startup and calibration procedures:

1) Run the National Institute of Instruments and Technology (NIST) blank and the site-specific laboratory standards daily before analyzing soil samples (Section 6.4.10).
2) Analyze the three site-specific laboratory standards after every 20 samples analyzed.
3) Run the NIST Blank and the site-specific laboratory standards before the instrument is shut down for the day.
4) Run one precision run on the instrument per day. The precision run consists of analyzing the NIST blank and then analyzing each site-specific laboratory standard for at least seven consecutive readings. If feasible, integrate the precision run into the normal Quality Assurance/Quality Control (QA/QC) schedule, i.e., substitute the precision run for one of the QA/QC runs.

5.2.4 XRF Field Testing Procedures

Soil from the Ziploc® bags collected in accordance with Section 5.3 will be processed in a temporary field laboratory to produce a sieved and dried soil sample for XRF testing. The soil contained in Ziploc® bags from representative grid or excavation locations will be partitioned to allow processing material for the XRF testing. Homogenizing before the partitioning step identified in Section 5.3.1 is essential and will be completed thoroughly.

The portion used to process the XRF shall be placed into a glass pan (i.e., Pyrex® or comparable) and microwaved, using a commercially available unit, for up to 5 minutes. At this point, moisture is reduced, the sample is free-flowing and will pass through a 10 mesh sieve (2 mm opening sieve) to remove cobble, pebbles, and material not expected to respond accurately to XRF (i.e., organics, deleterious materials, etc.). The material is significantly reduced in volume but remains representative. A portion of the processed soil will be placed into an XRF dedicated sample cup with mylar covering for direct reading of XRF fluorescence. The remaining soil processed will be retained for potential laboratory analysis by USEPA 6010B for metal COCs. Each reading will take approximately 120 seconds, to record element response, and to store data within the instrument software. The processing crew will test the prepared sample with the XRF in-house, to secure XRF results. The results will be matched with a daily routine of calibration and instrument checks to ensure proper operation of the XRF and later compared against any associated analytical laboratory confirmation sample results as available.

5.3 Confirmatory Soil Collection Methods

XRF represents one of the two primary components of project performance monitoring. Confirmatory soil sampling and analysis represents the other. The exact number and locations of the samples will be based on XRF test results and random grid cell selection.

5.3.1 Soil Sample Collection

The following provides the general procedures for collecting XRF and confirmatory samples:

- Following excavation of an area or target excavation discrete soil samples will be collected from target location soils with a trowel or stainless-steel spoon. No more than 6-inches (in depth) of soil will be removed for any one sample. For example, if an excavation sidewall sample is collected, the depth of the sample will not exceed 6-inches into the exposed sidewall. Disposable gloves will be worn and changed between the collection of each sample.
- A global positioning system (GPS) unit will be used to identify the coordinates of each location.
- Soil material will be placed directly into a zip-lock bag and thoroughly homogenized. The test location and date will be written on the bag. The gravel and larger fractions of soil will not be transferred into the Ziploc® bags.
- The soil samples will be examined for visual evidence of dross. Soil lithology will be visually described following the ASTM International (ASTM) D-2488 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure; ASTM 2017). Relevant soil sample information will be recorded on the Soil Sample Record Form and UPRR Field Electronic Data Deliverable forms (Attachment D). Data and information required to complete the forms will minimally include Location, Sample Id, Sample Date, Sample Time, Soil Description, Sample Type, Depth, Latitude (NAD 83), and Longitude (NAD 83).
- The homogenized material will be tested with the XRF analyzer in accordance with the XRF field testing procedures outlined in Section 5.2.4 If the cell from which the sample was collected has been identified for confirmational sample analysis (Section 5.4.4) the homogenized material will be placed in a laboratory-provided sample container (Section 6.4.5), provided the XRF results do not indicate the sample is significantly contaminated. If XRF readings indicate contamination remains at concentrations that significantly exceed an area’s respective criteria additional excavation will be conducted. If XRF readings indicate concentrations slightly exceed the area’s respective criteria at the field leader’s discretion the soil sample may be submitted for chemical analysis.
- Non-disposable sampling equipment, such as hand augers, and other digging tools, will be decontaminated before the collection of each sample (Section 6.4.8).

5.3.2 Sample Handling Requirements

Procedures described below address sample handling requirements after soil sample materials have been placed in the laboratory-supplied containers.

- After soil sample material has been placed in the appropriate sample container, sample labels will be completed using the nomenclature outlined in Section 6.4.4 and include sample numbers, locations, and time of sample collection. Sample labels will be completed with permanent ink.
- Completed sample labels will be adhered to the individual sample containers at the time of sampling.
- The sample label affixed to the container will be inspected to confirm that all of the required information has been provided.

- One or more sample containers will be sealed in a zip-lock plastic bag, wrapped in bubble pack, and packed in a cooler containing ice in a manner to minimize shifting or movement. Coolers will contain ample ice to maintain samples at a temperature between 2˚C and 6˚C until they are received by the analytical laboratory.
- Samples will be submitted to the analytical laboratory identified for chemical analysis per Section 6.5.
- For each cooler sent to the laboratory, a chain-of-custody form will be completed in accordance with Section 6.4.7. Information on the chain-of-custody form and the sample container labels will be checked against the field logbook entries and the samples will be recounted.
- Field sampling personnel will be personally responsible for the care and custody of the samples until transferred or properly dispatched to the laboratory.

QA/QC samples will be collected in conjunction with all field sampling activities. Internal (laboratory) and external (field) QA/QC samples will be used to monitor the performance of analytical methods and field sampling procedures. QA/QC sampling requirements and procedures are detailed further in Section 6.7. All soil and QA/QC samples will be assigned a unique identification number that will be used on sample labels, chain of custody sheets, field logbooks, and in the project database. Nomenclature conventions for sample identification numbers are provided in Section 6.4.4.

5.4 Soil Screening and Confirmatory Sampling

The following sections detail soil testing using an XRF analyzer and subsequent collection and analysis of confirmatory samples to evaluate the completeness of removal actions.

5.4.1 XRF Screening for Target Excavations

Target Excavations 1 through 9 are designed to remove soil with COC concentrations that exceed CULs. Excavation will not exceed the ecological point of compliance depth of six feet bgs. Once soil removal at target excavations reached the required depth per the EDR, excavation will be suspended. Samples representative of the soil remaining in place on the bottom and sidewalls of the excavation soil will be tested using XRF screening methods. The number and location of the XRF screening samples will be collected in general accordance with the Site Assessment Guidance for Underground Storage Tank Systems (Ecology 2021a). Soil representative of the XRF test location will be placed in plastic bags as described in Section 5.3.1 and retained until XRF results are evaluated.

5.4.2 Confirmatory Soil Sampling for Target Excavations

If the XRF testing indicates the removal actions meet CULs, confirmatory soil samples representative of the bottom and of the bagged sidewall samples will be placed into glass sample jars and submitted to the analytical laboratory for confirmatory chemical analysis in accordance with Section 6.5. The excavation will generally remain open and secured until sampling results have confirmed that the selected cleanup criteria have been achieved. Based on proximity to power utilities’ infrastructure and coordination with power entities some excavations may be automatically extended to 6 feet bgs (ecological point of compliance) and backfilled following collection of confirmatory sampling. Concentrations of COCs have been shown not to exceed human health criteria below 6 feet bgs. However, if human health criteria are exceeded at six feet bgs. additional excavation will be conducted as needed to achieve compliance to a maximum extent of 15 feet bgs.

5.4.3 XRF Screening for Compliance Units

The XRF test locations for compliance units are generally identified as the center points of the cells covering the UPRR, WSDOT, and Pentzer properties. However, professional judgment is used to adjust the test locations along the margins to better represent removal areas, refine lateral delineation, or cells that are not represented by a 50-foot by 50-foot square. XRF tests will be conducted on soil representative of the approximate center or adjusted test locations for each numbered cell presented in Figures 6, 7, and 8. Table 3 provides the northing and easting coordinates in the State Plane coordinate system for the test locations of individual cells. A GPS unit will be used in the field to locate the individual test location to within approximately 5 feet using the northing and easting coordinates. XRF test locations moved more than 10 feet due to field conditions will be recorded in the field using the GPS. Each sampling point will be documented in the field notes. Upon establishing the test location of a cell, an XRF test of a representative soil sample will be conducted. XRF testing will be performed on the sidewalls/perimeter as well as an approximate center location for selected cells that are covered in large part by a target excavation. Soil representative of the XRF test location will be placed in plastic bags as described in Section 5.3.1 and retained until XRF results are evaluated.

Based on the planned scope of removal actions, it is estimated that between 160 and 200 XRF tests will be conducted in association with the compliance units for the UPRR, WSDOT, and Pentzer properties. Bagged XRF soil samples will be trained for potential chemical analysis.

5.4.4 Confirmatory Soil Sampling for Compliance Units

Once field screening results including XRF test results indicate that cleanup criteria have generally been achieved within a compliance unit, excavation will be suspended. Soil samples will be analyzed from 10 cells within each of the compliance unit grid systems. Soil sampling will be conducted under a simple random sampling approach per USEPA SW-846 Test Method for Evaluating Solid Waste - Chapter 9 Sampling Plan (SW-846 Chapter 9).

Figures 6, 7, and 8 show the numbered cells in the respective sample grids superimposed over the designated compliance unit areas. Confirmatory sampling and analysis will be conducted for 10 cells within each compliance unit. USEPA’s Visual Sample Plan (VSP) Tool version 7.0 was used to evaluate the number of samples required per compliance unit to determine with at least 95% confidence that the true mean of each COC is less than the applicable CUL or remediation level, as applicable. The grid cell samples for each compliance unit will be selected using a random generator number. Selected cells that are covered in large part by a sampled target excavation will be sampled at the edge of an excavation, XRF testing will be performed on the sidewalls/perimeter as well as an approximate center location. Soil samples from those cells identified by the random number generator will be processed and submitted to the analytical laboratory for chemical analysis. In addition, select soil samples collected from the three cells exhibiting the highest XRF readings soil samples will be submitted to the analytical laboratory for chemical analysis.

5.4.5 Confirmatory Soil Samples

Discrete soil samples will be collected from exposed soil in the approximate center of 10 grid cells collected in accordance with Section 5.3.1. The location of the sample may be field adjusted based on field conditions (i.e., it is located within the boundaries of a target excavation, utility infrastructure occupies the location, etc.). A GPS unit will be used to identify sample locations in the field using the predesignated coordinates and subsequently document each location each sample was collected. Soil will be processed for confirmatory samples in accordance with Section 5.3.2. Nomenclature conventions for sample identification numbers are provided in

Section 6.4.4. Representative bagged soil retained in association with XRF testing, may be used in place of repeated efforts to collect confirmatory samples from XRF locations.

5.4.6 Evaluation of Confirmatory Soil Sample Results

Analytical results for each compliance unit will be reviewed in accordance with WAC Chapter 173-340-740(7) and statistically evaluated in accordance with Ecology's Statistical Guidance for Ecology Site Managers (Ecology 1992) to determine if the individual compliance units have achieved cleanup (< cleanup criteria). If a compliance unit is determined to have not met its respective cleanup criteria, the cells adjacent to cells that exhibit COCs that exceed cleanup criteria will be sampled to delineate the extent of exceedance, or if warranted large areas will be further excavated without prior testing.

5.5 Transportation and Disposal

All stockpile material and dross-containing soil with concentrations above CULs on the Pentzer and WSDOT properties (Figures 5, 6, and 7) will be removed from those properties and transported by truck using Sullivan Road to the Graham Road Landfill for disposal. All stockpile material and dross-containing soil with concentrations above remediation levels on the UPRR property will also be removed and transported to the Graham Road Landfill. An ecological cap will be required to cover these areas on the UPRR property in addition to requirements for institutional controls. However, if removal of stockpile material or dross-containing soil achieves CULs on the UPRR property, an ecological cap and institutional controls will not be required.

Transport vehicles and transportation will be provided by the selected construction contractor. Conventional highway-approved equipment will be used, and could include standard dump trucks, pony trailers, and roll-off containers if required. All excavated soil loads will be covered during transport to the disposal facility.

All excess water (if present) will be drained from soil in trucks prior to transporting soil from the excavation area. Impacted drainage from the trucks will be captured, later removed by vac-truck, then transported off-site for treatment and disposal at a regulated facility. The volume and tare weight of each truckload of contaminated soil leaving the Site will be documented.

The Graham Road Landfill is located 5 miles east of Spokane. Landfill personnel indicate that this material will be useful to them as daily cover at the landfill.

5.6 Backfill

Once the cleanup action requirements are satisfied, excavations will be backfilled with clean fill and the area will be returned to grade. Backfill material will consist of imported material supplied by the contractor. The backfill will be from a commercial source but will not be a soil recycling source. Backfill will be tested to confirm the backfill meets the acceptance criteria provided in Appendix B (CQA) Attachment A Table 1 of the EDR prior to placement. If on-site soils with COC concentrations below remediation levels are excavated, a portion of these soils may be used as fill to dress the slope on the south side of the UPRR property or lessen the degree of slope.

Backfill will be placed in lifts of the maximum thickness indicated in the specifications (on the Drawings) and compacted with a minimum number of passes of specified equipment.

6.0 QUALITY ASSURANCE PROJECT PLAN

The QAPP format and elements presented in this section were developed in accordance with guidance developed by USEPA (USEPA 2001, 2002a, 2002b, and 2012). This QAPP presents functional activities and other specific QA/QC activities designed to achieve the precision, accuracy, completeness, comparability, and representativeness required to make the data quality acceptable for the cleanup action.

6.1 Project Organization

The organizational structure for construction and compliance monitoring activities for the UPRR Aluminum Recycling Trentwood Site remedial action is shown in Appendix B "Construction Quality Assurance Plan Union Pacific Railroad, Aluminum Recycling Trentwood Site", Figure 2-1. Key project contacts are as follows:

	Project Coordinator (Ecology)	**Project Coordinator (UPRR)**	**Project Manager (Golder)**	**Field Team Lead (Golder)**
Contact:	Sandra Treccani	Kristen Stevens	Ted Norton	TBD
Company:	Washington Department of Ecology	Union Pacific Railroad	Golder Associates Inc.	
Address:	4601 N. Monroe St Spokane WA, 99205	2401 E Sepulveda Blvd. Long Beach, CA 90810	18300 NE Union Hill Rd, Redmond, WA 98052	
Phone:	(509) 329-3412	(562) 756-0074	(425) 883-0777	
Email	Satr461@ecy.wa.gov	kmseven@UP.com	tnorton@golder.com	

Project Manager

The project manager, Ted Norton, is responsible for planning and executing all environmental sampling and analysis, and for preparation of analytical data reports, the Cleanup Action Report, and all associated technical memoranda and submittals to Ecology. The project manager will prepare laboratory specifications and administer the subcontracts. The project manager also acts as the QA coordinator and reviews CMP tasks, referenced method quantitation limits, regulatory cleanup criteria, and other pertinent documents to ensure that data quality objectives are met.

Field Team Leader

The Field Team Leader, TBD, is responsible for execution of the construction oversight, completion of the field work and environmental sampling and analysis in accordance with the CMP and detailed in the EDR.

Health and Safety Officer

The health and safety officer, Eric Adams, is responsible for developing the HASP and for providing on-site safety information to the field personnel including personal protective measures, equipment, emergency preparedness, and incident protocol.

Chemist/Validator

The chemist/validator reports to the project manager and will perform on-site analysis of soil samples and coordinate with the laboratory for required off-site analyses. The chemist/validator will complete and submit the UPRR Planning Electronic Data Deliverable (PEDD) used to define the data quality objectives and analytical scope of work for a sampling event and to communicate this information to the project team. If the analytical scope changes at any time during the process, the PEDD will be revised to reflect these changes. The chemist/validator will also oversee sample tracking, chain of custody, and other sampling and analysis documentation. The chemist/validator maintains the data files and is responsible for tabulating, compiling, and archiving data. The chemist/validator will also review and validate laboratory reports.

Additionally, UPRR requires a 3rd party chemist/validator to oversee laboratory and data management. The chemist/validator from GHD Group will review samples, chains of custody, and review and validate laboratory reports. The contracted laboratory will provide GHD Group with the laboratory reports and a Laboratory Electronic Data Deliverable (LEDD) for their use.

Field Sampling Personnel

The field sampling personnel report to the Field Team Leader. Field sampling personnel are responsible for collecting samples in accordance with the CMP and QAPP. In addition, the field sampling personnel assemble and organize field documentation (including the UPRR Field Electronic Data Deliverable [FEDD], sampling logbook, daily activity logbook, chain of custody forms, and water level measurements).

6.2 Subcontractors

Pace Analytical Laboratories (Pace) of Mt. Juliet, Tennessee will perform the off-site analyses. Appropriate and established methods will be used, and samples will be processed within holding times. Pace is accredited by Ecology for inorganic analytical testing. Pace conforms to USEPA’s “Guidance on Preparation of Laboratory Quality Assurance Plans” (USEPA 1992) and holds accreditation through Ecology for analytical methods listed in Table 4 and can achieve the reporting limits.

The contractor selected for excavation will also be licensed in the State of Washington. Golder field personnel will ensure the work performed by this subcontractor is in conformance with Golder Technical Procedures. The excavation subcontractor must provide crew members with current Occupational Safety and Health Administration (OSHA) 40-hour Health and Safety certification, in compliance with Washington State Labor and Industries Regulation “Hazardous Waste Operations and Treatment, Storage, and Disposal Facilities” (WAC 296-62-3040).

6.3 Quality Objectives

An objective of the field sampling activities is to provide analytical data that is of known and defensible quality. The Site COCs associated with aluminum dross are aluminum, arsenic, barium, copper, and to a lesser extent total chromium and mercury. Laboratory analytical methods to be used to analyze soil samples for these COCs are presented in Section 6.5

The analytical data quality objectives are defined in terms of the quantitation limits achievable using the referenced analytical methods, and in terms of the goals for precision, accuracy, representativeness, completeness, and comparability of analytical data. Quantitation limits will be provided for each analytical parameter in the PEDD and are cross-referenced to applicable standard USEPA reference methods. The quality objectives established for monitoring are as follows:

- Precision: Analytical precision will be reported on field duplicates, laboratory duplicates blank spike/blank spike duplicates, and matrix spike/matrix spike duplicate (MS/MSD) sample data as required by the USEPA methods.
- Accuracy (Bias): A measure of the closeness of an individual measurement to a known or reference value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations. Accuracy will be reported from certified standard recovery, blank spike recovery, and matrix spike recoveries as required by the USEPA reference methods cited in Table 4.
- Representativeness: Goals for sample representativeness are addressed qualitatively by the sampling locations and intervals defined in the CMP. In addition, the use of standard procedures for sample acquisition (as described in Section 5.3.1) will facilitate the collection of representative data.
- Completeness: Completeness is the percentage of valid analytical determinations with respect to the total number of requested determinations in a given sample delivery group (SDG). Valid analytical determinations will include all data results that are not rejected as a result of the data validation process described in Section 6.6. Completeness goals are established at 90%. Failure to meet this criterion will be documented and evaluated in the data validation process described in Section 6.6, and corrective action taken as warranted on a case-by-case basis.
- Comparability: Approved analytical procedures will require the consistent use of the reporting techniques and units specified by the USEPA reference methods cited in Table 4 to facilitate the comparability of data sets from historical and sequential sampling rounds in terms of their precision and accuracy.

6.4 Sampling and Other Field Procedures

6.4.1 Selected Procedures by Task

Technical procedures have been developed to support sampling activities, monitoring actions, data validation, and other technical activities. A list of technical procedures applicable to individual activities is provided in Table 5 and provided in Attachment A and will be maintained on-site for access by field personnel.

Technical Procedures provide guidance to personnel with respect to specific tasks. Duplicate information may be present among technical procedures for the purpose of individual completeness. Significant deviations from technical procedures will be identified and included on a Field Change Request (FCR) form provided in Attachment D.

6.4.2 Document Distribution, Variation Request, and Change Control Considerations

The technical procedures and all other procedures cited in this CMP are subject to the distribution control requirements of QP-5.1 "Document Preparation, Distribution, and Change Control" (Attachment A). Variations from established field procedure requirements may be necessary in response to unique circumstances encountered during sampling activities. All such variations must be documented on an FCR form and submitted to the project manager for review and approval. Specific Golder technical and quality procedures referenced in this section are presented in Table 5.

The project manager or designated field sampling personnel are authorized to implement non-substantive variations based on immediate need, provided that the project manager is notified within 24 hours of the variation, and the FCR is forwarded to the project manager for review within 2 working days. Substantive variations require approval of the project manager and the UPRR Project Manager prior to implementation. An FCR must be forwarded for review within two working days for substantive variations. If the variation is unacceptable to either reviewer, the activity will be re-performed or otherwise corrected, as indicated in the "Comments" section of the FCR. A copy of the FCR will be included with all field reports, as well as with the data validation report.

UPRR maintains a data access portal, SysDat, for laboratory and data management/validation practices for sampling events that may occur at their sites. Laboratory management practices include utilizing UPRR-approved laboratories only and the use of the PEDD to define data quality objectives and the analytical scope of work for a sampling event. The PEDD is used to communicate this information to the project team and the laboratory. The PEDD will be prepared by Golder and submitted to Pace for their agreement and sign off prior to sample collection. If there are any changes in the analytical scope of work, the PEDD will be revised immediately to reflect these changes and re-distributed to the project team and laboratory.

The FEDD is used to import field sample information and data including sample information, field parameters, water levels and spatial information into SysDat. The FEDD will be prepared by Golder and submitted to GHD Group via email within one week of sample collection.

6.4.3 Sample Quantities, Types, Locations, and Intervals

Sample quantities, types, locations, and intervals for soil sampling will be as specified in the CMP. Field quality control (QC) samples will be included in the minimum quantities specified in Section 6.7. Appropriate documentation of the purpose of the sample and assigned sample number will be maintained in the field log. Copies of sample identification records will be separately provided to the data validator.

6.4.4 Sample Identification and Labeling Requirements

A label marked with an identification number will be attached to each container as samples are collected. This unique identifier will appear on all bottles or containers filled for each sample. The number system will ensure field QC samples will remain indistinguishable from normal field samples.

All UPRR sample IDs must be unique and use the standard format: **XX-FFFF- ## -DDMMYY:**

XX = sample matrix code
FFFF = UPRR Facility number - **2494**
= sample number
DDMMYY = sample date in day/month/year format

For example, a soil sample collected on 03/12/21 from site no. 2494 will be:

- SO-2494-SO01-120321

QC samples such as field duplicates will be designated with the primary sample identification and a QC suffix as noted below.

Suffix Description	Quality Control
Field Duplicate (FD)	SO-2494-FD01-120321
Equipment Blank (EB)	WG-2494-EB01-120321

Each sample bottle label will also identify the laboratory analysis to be performed, noting the identified method number as stated in Table 4. Identification numbers will be recorded on the field report forms shown in the applicable sampling procedures, and on the chain of custody/sample analysis request form supplied by the analytical laboratory.

6.4.5 Sample Container Type, Volume, and Preservation Requirements

All sample containers and sample storage coolers will be provided by the analytical laboratory as part of their agreement for services. Sample container type, volume requirements, holding time, and special handling requirements for soil are listed in Table 6.

All samples will be sealed, labeled, properly identified, and submitted to the analytical laboratory under formal chain of custody requirements as described in Sections 6.4.4 and 6.4.7. Sample coolers will be secured with a custody seal on the outside including a signature and date provided by the field scientist.

6.4.6 Field Custody Procedures

All samples to be submitted for off-site analysis will be placed into appropriate containers supplied by the project laboratory. Table 6 identifies the appropriate sample containers. Samples will be labeled immediately after collection in the field and assigned a unique identification number (Section 6.4.4), which will be used on chain of custody sheets, sample labels, and in a bound field notebook for identification and tracking purposes and for use in the project database. The sample location, depth, date, and time of sample collection, and any special handling will be recorded in the field records.

All samples will be placed on ice in a cooler immediately after collection. Samples will be shipped to the laboratory in sealed ice coolers with leak-proof ice-filled bags sufficient to maintain a temperature of approximately 6°C for 48 hours. While awaiting shipment, samples will be stored temporarily in a secured area under custody of the sampler. Signed custody seals will be placed on each cooler or package of samples. Packing material will be used to prevent breakage and shifting of sample containers during shipping.

All samples collected for submittal to the analytical laboratory will be controlled as required by procedure TG-1.2-23 "Chain of Custody" provided in Attachment A. Chain of custody documentation will be completed for each sample collected as described in the following section.

6.4.7 Chain of Custody Procedures

The chain of custody form will provide an accurate written record verifying that the samples were under appropriate custody at all times before arrival at the laboratory. Chain of custody forms will specifically identify the applicable reference methods specified in Table 4 as appropriate for each individual sample. Field information records will be completed for all samples collected, the location and sample depth cross-referenced with the sample identification entered on the chain of custody. Laboratory procedures will ensure traceability of analytical results to the original samples through the field sample identification number, the analytical method referenced on the chain of custody, and the laboratory tracking number.

The chain of custody will be signed by each individual who has possession of the samples until they are delivered to the laboratory. A copy of the chain of custody will be retained for record management purposes. Each form will be placed in a water-tight plastic bag taped to the underside of the lid of the cooler containing the samples designated on the form. Coolers will be sealed with custody seals. Upon arrival at the laboratory, samples will be received and inspected by a laboratory representative. Samples contained in the shipment will be compared to the chain of custody to ensure that all samples were received and that analytical instructions are clear. The laboratory will then provide confirmation to the QA coordinator that the samples were received.

6.4.8 Sampling Equipment Decontamination Procedures

Decontamination procedures will be performed as outlined in procedure QP-4 “Decontamination of Equipment” provided in Attachment A. Personnel performing decontamination will wear rubber gloves, face or eye shields, and any other safety equipment specified in the HASP, which is provided in Appendix D of the EDR.

All non-dedicated sampling equipment (in contact with sample) will be thoroughly cleaned at the start of and at the completion of sample collection to prevent cross-contamination between samples and to ensure accurate representation of indicator parameters in each sample. Decontamination procedures will consist of a thorough wash and rinse, consisting of a brush and rinse to remove loose material, followed by a wash with a non-phosphate detergent (Alconox^{TM} or equivalent) and tap water solution, followed by a rinse with de-ionized/distilled water. Equipment rinsate blank samples will be collected as specified in Section 6.7 to document the effectiveness of decontamination.

The results of soil sampling and analysis will be used to determine the appropriate means of decontamination rinsate disposal. The decontamination rinsate will be disposed in accordance with all applicable regulatory requirements.

Excavation equipment will not require decontamination until completion of the project, providing the equipment remains within the fenced project area. Equipment will be decontaminated prior to removal from the Site in accordance with the EDR.

All materials, including liquids, generated during decontamination processes will be containerized and handled as investigation derived waste (IDW) as detailed in Section 6.4.9.

6.4.9 Investigation Derived Waste

Contaminated soil removed from the excavations will be designated as IDW that cannot, or otherwise will not, be returned to excavation areas. IDW will be segregated to the extent possible. In most cases, the IDW will be temporarily stockpiled at the Site. Stockpiled soil will be placed on sheeting and prevented from migrating off-site by berms constructed of soil, hay bales, or other suitable materials. Stockpiles will be covered overnight to minimize windblown dust or exposure to precipitation. From the stockpiles, contaminated soils will be loaded onto trucks provided by the excavation subcontractor and transported to the Graham Road Landfill. Clean soils stockpiled during the excavation may be used as backfill material. All PPE and solid waste will be placed in garbage bags and disposed of off-site as general municipal waste.

Decontamination fluids will be captured and placed in 55-gallon DOT-approved drums. The drums will be transferred onto trucks provided by the excavation subcontractor and transported to and disposed of at a permitted liquid disposal facility.

Soil and water samples submitted for analysis will become the responsibility of the laboratory. As such, the laboratory is responsible for disposal of samples upon completion of testing.

6.4.10 Calibration Requirements

Calibration of all measuring and test equipment, whether in existing inventory or purchased for this investigation, will be controlled as required by procedure QP-11.1 "Calibration and Maintenance of Measuring and Test Equipment" provided in Attachment A. Leased equipment will require certifications or other documentation demonstrating acceptable calibration status for the entire period of use for this project. Field calibration requirements will comply with the applicable technical procedure and/or the manufacturer's instructions.

Calibration requirements applicable to the individual analytical laboratory are addressed by the individual laboratory QA plan.

A portable handheld XRF analyzer will be used to field screen surface soils for indicator parameters aluminum, arsenic, and copper. Analyses conducted with the XRF analyzer will follow the USEPA Method 6200 protocol Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment (USEPA 2007; Method 6200).

A preliminary site visit will be conducted prior to formally mobilizing to the Site for the RI during which three samples of contaminated surface soil from the WSDOT and Pentzer properties and one sample of unimpacted soil will be collected. The samples will be submitted to the analytical laboratory for chemical analysis of metals as described in Table 4. These samples will be shipped back to Golder to be used as site-specific standards for calibrating the XRF.

The XRF instrument will be calibrated using the manufacturer's recommended procedures on the Site soil samples with known concentrations of metals. Aluminum, arsenic, and copper will be used as indicator parameters based on Site COCs and the correlation between XRF response and analytical results. The sample aliquots returned by the analytical laboratory will be used as calibration standards for the XRF. The site-specific standards will be run on the XRF daily in accordance with USEPA Method 6200 to check the calibration of the instrument. The test method requires the following startup and calibration procedures:

1) Run the National Institute of Instruments and Technology (NIST) blank and the site-specific laboratory standards daily before analyzing soil samples.
2) Analyze the three site-specific laboratory standards after every 20 samples analyzed.
3) Run the NIST blank and the site-specific laboratory standards before the instrument is shut down for the day.
4) Perform one precision run on the instrument per day. The precision run consists of analyzing the NIST blank and then analyzing each site-specific laboratory standard for at least seven consecutive readings. If feasible, integrate the precision run into the normal QA/QC schedule (i.e., substitute the precision run for one of the QA/QC runs).

6.5 Analytical Procedures

Samples will be delivered to Pace Analytical Laboratories in Mt. Juliet, Tennessee by overnight delivery service.

The analytical laboratory shipping address is:

Pace Analytical Laboratories
ATTN: Sample Receiving
12065 Lebanon Road
Mt. Juliet, Tennessee
(615) 758-5858

The laboratory will provide shipping labels in ice coolers use to send sample containers for return shipments with samples. If samples are sent on a Friday, the Saturday delivery shipping label will be used.

All soil samples submitted to the analytical laboratory for chemical analysis will be analyzed for a subset of RCRA metals that includes aluminum, arsenic, barium, copper, total chromium, and mercury. The Site metals COC list is presented in Table 4 with the prescribed analytical method and reporting limits for each constituent.

Soil samples to be analyzed for this subset of metals will be placed in laboratory-supplied 4-ounce glass jars with a Teflon-lined lid. The holding time for metals analysis using USEPA Methods 3050B/6010C for soils is 180 days. No preservation is required other than maintaining sample temperature.

6.6 Data Reduction, Validation, and Reporting

6.6.1 Minimum Requirements for Laboratory Analytical Data Packages

All analytical data packages submitted by the analytical laboratory will include the following:

- Sample receipt “condition found” record, noting dates of sample receipt; chain of custody and shipping documentation, including identification of field sampling personnel, and shipping personnel (or organization);
- A summary of analytical results for each sample containing neat or dilution adjusted results for all analytes/constituents requested in the chain of custody, request for analysis, or purchase order;
- Analytical QC results and summary documents for laboratory method blanks, duplicates, laboratory control samples, blank spike/blank spike duplicates, matrix spike/matrix spike duplicates, serial dilutions, surrogates, and internal standards;
- Sample extraction and preparation summary data, including dates of sample extraction and analysis and analytical sequence information for each sample set, and each sample dilution and reanalysis, and
- Electronic deliverables that provide the summarized results, date of extraction and analysis, QC data results and true values, client and laboratory sample identifications, analysis methods, dilutions applied, and appropriate detection or reporting limits.

All data packages will be reviewed and approved by the analytical laboratory's QA Officer prior to submittal for validation.

6.6.2 General Validation Requirements

Laboratory analytical data will be reviewed for data quality to ensure that the following criteria are met:

- Completeness: Requested analyses and any additional required information are reported.
- Consistency: Redundant information is reported in the same manner throughout laboratory deliverables.
- Correctness: Algorithms for calculation of sample concentrations are applied correctly (e.g., dilution factors applied properly).
- Compliance: QA/QC requirements have been satisfied.

All analytical data will be validated using Tier II criteria in accordance with USEPA National Functional Guidelines (USEPA 2014). The data validator will prepare a technical report or provide a summary checklist documenting the evaluation of laboratory blanks, field blanks, equipment blanks, duplicates, MS/MSD, laboratory control samples, calibration data (as applicable for the specified method), and any re-qualification of analytical results required as a result of the validation exercise.

The data validator will document all contacts made with the laboratory to resolve questions related to the data package. Deficiencies identified during data quality review will require correction prior to data analysis. The validation report, laboratory contact documentation, copies of the laboratory sample summary reports, and the as-reviewed laboratory data package will be routed to the project manager and to the permanent project records.

Following data validation, the analytical data will be tabulated and compared to the Site CULs. Decisions regarding the excavation of additional material, if necessary, will be made after review of the data and in consultation with UPRR and Ecology.

6.7 Quality Control

All analytical samples will be subject to QC measures in both the field and laboratory.

The use of internal QA/QC samples is detailed in the laboratory's QA program. External QC samples monitor sample collection and shipping, as well as analytical performance. External QA/QC sampling will consist of duplicate soil samples and equipment blanks. The following minimum field QC requirements apply to all analyses. These requirements are adapted from "Test Methods for Evaluating Solid Waste" (SW-846; USEPA 1986).

- Field duplicate samples. An effort will be made to obtain sufficient sample quantities for the collection of field duplicates. Field duplicates will be collected at a minimum rate of 1 in 20. Each duplicate will be retrieved from the same location as the original sample, using the same equipment and sampling technique, and will be placed into identically prepared and preserved containers. All field duplicates will be labeled with a unique sample identification number and will be analyzed independently to provide an indication of any gross errors in sampling techniques.

- Equipment blanks. Equipment blanks will be collected at the same frequency as field duplicate samples from locations determined to have the highest potential to introduce contamination. No more than two equipment blanks will be collected from non-dedicated single-use sampling equipment. Equipment blanks will consist of pure deionized/distilled water washed over decontaminated non-dedicated multi-use sampling equipment and placed in containers identical to those used for field samples. Equipment blanks verify the adequacy of sample containers and sampling equipment decontamination procedures. The internal QC checks performed by the analytical laboratory will meet the following minimum requirements:

- For every 20 samples, one duplicate soil sample will be identified as MS/MSD to direct the laboratory to run internal QC samples. The spike will be made in a replicate of a field sample or field duplicate sample. Replicate samples are separate aliquots removed from the same sample container in the laboratory. Spike compound selection, quantities, and concentrations will be described in the laboratory's analytical procedures. One per analytical batch, or once every 20 samples, whichever is greater, will be spiked.

- QC reference samples (check samples). A QC reference sample will be prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. The QC reference sample is analyzed after initial calibration and before any samples are analyzed, and will be run with every analytical batch, or every 10 samples, whichever is greater. Reference samples are required as an independent check on analytical technique and methodology.

- Method blanks. Method blanks are prepared in the laboratory to assess the presence of fugitive vapors, reagent contaminants, and preparation vessel carryover contaminants. The method blank will be prepared at the same time as the field samples using the same procedure and reagents. The method blank must be tested after the QC reference sample and before any samples are analyzed and will be run with every analytical batch or once every 20 samples, whichever is more frequent.

6.8 Data Assessment Procedures

Analytical data will be compiled by the analytical laboratory and reduced to include the specified deliverable elements. The data will be validated by project personnel in compliance with existing validation guidelines and subsequently reported to the project manager, and UPRR. Data assessment will consist primarily of comparisons of the validated data to applicable CULs to assist in completion of the cleanup action.

6.9 Data Management

Data management consists of routing and storage of all incoming data and project correspondence to facilitate security, ease of access, and compliance with project goals. The following sections describe the data management standards.

6.9.1 Records Management

All records generated during the cleanup action will be maintained in project archives as required by procedure QP-16.1 “Quality Assurance Records Management” provided in Attachment A. Records are defined as completed and signed documents providing evidence of a service or a communication relevant to the project. Records may include, but are not limited to:

- Incoming and outgoing correspondence and facsimile transmissions;
- Analytical data packages and analytical quotes;
- Project contracts, agreements, and amendments;
- Purchase orders and subcontractor agreements, quotes, and receipts;
- Historical data and correspondence provided by UPRR, Ecology, and/or the Washington State Department of Health;
- The CMP, QAPP, and HASP;
- Technical field logs and field reports;
- Field changes, surveillance inspection reports, and non-conformance/ incidence reports; and
- Electronic copies of analytical data.

6.9.2 Analytical Data Management

The laboratory will provide analytical data to Golder and the data validator in electronic format by email delivery. Validated analytical data packages will be routed to the project records for controlled storage and the validated data will be uploaded to the project database.

6.9.3 Data Review and Reporting

Following receipt and final data validation of analytical results, concentrations of detected analytes will be compared to CULs (Table 1). In the CAP, Ecology established these CULs for the COCs, determined to contribute the majority of overall Site risk (Exhibit C of the EO; Ecology 2021b). CULs were established in accordance with the MTCA Cleanup Regulation Method A or B for unrestricted land use criteria.

A report will be prepared after the data has been received, validated, and reviewed. The report will include the date(s) of the sampling event, a discussion of soil findings, a tabular presentation of soil analytical results, and comparison to CULs.

6.9.4 Records Turnover

Records turnover will be conducted at times specified by UPRR and/or the Ecology project manager, subject to the authorization of the Golder project manager. The scope of the interim record distribution will be as specified by UPRR and or the Ecology project manager. Records turnovers will be inspected prior to transmittal by the Golder project manager or his designee.

Signature Page

Golder Associates USA Inc.

Caitlin Dobsky

Caitlin Dobsky
Staff Geologist

Ted Norton
Senior Consultant, Associate

CD/TN/ks

https://golderassociates.sharepoint.com/sites/116727/project files/5 technical work/2021 edr/edr/final edr/appendix e - cmp/19119180-rev0-trentwood compliance monitoring plan-05172022.docx

7.0 REFERENCES

Golder Associates Inc. (Golder). 2021a. Pre-Design Investigation Union Pacific Railroad, Aluminum Recycling Trentwood Site. January 15.

Golder. 2021b. Completion Report Pre-Design Investigation Union Pacific Railroad, Aluminum Recycling Trentwood Site. February 5.

Golder. 2021c. Union Pacific Railroad Co. – Feasibility Study (Revised), Aluminum Recycling Trentwood Site. April 20.

Hart Crowser. 2009. Draft Site-Wide Groundwater Remedial Investigation, Kaiser Trentwood Facility, Spokane Valley, Washington. May.

Molenaar, 1988. The Spokane Aquifer, Washington: Its Geologic Origin and Water-Bearing and Water-Quality Characteristics. U.S. Geological Survey Water-Supply Paper 2265, United States Government Printing Office, 1988.

National Oceanic and Atmospheric Administration (NOAA). 2021. Climate Data Online – NOAA Online Weather Data, https://www.ncdc.noaa.gov/cdo-web/, accessed 4/9/2021.

Pastor, Behling & Wheeler, LLC (PBW). 2012. Remedial Investigation/Feasibility Study Report. Report Submitted to Washington State Department of Ecology. September 6.

United States Environmental Protection Agency (USEPA). 1986. SW-846 Test Methods for Evaluating Solid Waste, Third Edition, Office of Solid Waste and Emergency Response. November. Rev. May 1997.

USEPA. 1992. Guidance on Preparation of Laboratory Quality Assurance Plans. EPA 910/9-92-32.

USEPA. 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5A. EPA/240/B-01/003. March.

USEPA. 2002a. Guidance for Quality Assurance Project Plans. EPA QA/G-5. EPA/240/R-02/009. December.

USEPA. 2002b. Guidance on Environmental Data Verification and Data Validation (QA/G-8). USEPA, Office of Environmental Information, USEPA/240/R-02/004.

USEPA. 2007. Method 6200 Protocol Field Portable X-ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment.

USEPA. 2012. Draft Final U.S. Environmental Protection Agency Guidance on Quality Assurance Project Plans, CI0 2106-G-05 QAPP, January.

USEPA. 2014. Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review. USEPA-540-R-013-001. October.

Washington State Department of Ecology (Ecology). 1992. Washington State Department of Ecology Toxics Cleanup Program, Statistical Guidance for Ecology Site Managers, Publication 92-54. August.

Ecology. 1994. Natural Background Soil Metals in Washington State. Toxics Cleanup Program, Department of Ecology. Publication No. 94-115. October. https://apps.ecology.wa.gov/publications/documents/94115.pdf.

Ecology. 2010. Agreed Order No. 6968 In the Matter of Remedial Action by: Union Pacific Railroad Company. August 6.

Ecology. 2020. Chapter 173-303 Washington Administrative Code. Dangerous Waste Regulations. September 20.

Ecology. 2021a. Site Assessment Guidance for Underground Storage Tank Systems Publication 21-09-050. January.

Ecology. 2021b. Union Pacific Railroad Company. Enforcement Order. No. DE 20752. Aluminum Recycling Trentwood Site. September.

Ecology. 2021c. Cleanup Action Plan Aluminum Recycling Site Trentwood Facility Site ID 628 Cleanup Site ID 1081. September.

Western Regional Climate Center. 2021. Western U.S. Climate Historical Summaries, https://wrcc.dri.edu/Climate/comp_table_show.php?stype=wind_dir_avg, accessed 4/9/2021.

Tables

Table 1: Cleanup Levels - Unrestricted Land Use
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Constituent of Concern (COC)	Units	Maximum Value	Method A Unrestricted(a)	Method B Unrestricted Non-Cancer(b)	Method B Unrestricted Cancer(c)	Ecological Indicator Values(d)	Background(e) (Spokane Co.)	Unrestricted Land Use Cleanup Level (mg/kg)	Primary COC	Basis
Aluminum	mg/kg	121,000	-	80,000	-	50	21,400	21,400	yes	Background
Arsenic	mg/kg	16	20	24	0.67	10	9	10	yes	Ecological
Barium	mg/kg	381	-	16,000	-	102	-	102	yes	Ecological
Chromium (III)	mg/kg	172	2000*	120,000	-	42	18	42	yes	Ecological
Copper	mg/kg	1,460	-	3,200	-	50	22	50	yes	Ecological
Lead	mg/kg	93.8	250*	-	-	50	15	50	no**	Cm<Cul
Mercury	mg/kg	5	2*	-	-	0.1	0.02	0.1	yes	Ecological

Notes:
- Not Available
* - Method A number based on protection of groundwater and Site RI determined groundwater was not impacted.
(a) - Method A unrestricted land use values based on WAC 173-900, Table 740-1.
(b) - Method B unrestricted land use non-cancer values based on WAC 173-740 Equation 740-1.
(c) - Method B unrestricted land use cancer values based on WAC 173-740 Equation 740-2.
(d) - Ecological indicator values are based on WAC 173-900, Table 749-3 for protection of plants, soil biota and wildlife.
(e) - Natural Background Soil Metals Concentrations in Washington State (Ecology 1994).

Table 2: Remediation Levels - Industrial Land Use
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Constituent of Concern (COC)	Units	Maximum Value	Method A Industrial[(a)]	Method C Industrial Non-Cancer[(b)]	Method C Industrial Cancer[(c)]	Ecological Indicator Values[(d)]	Protection of Groundwater[(e)]	Remediation Levels[(f)]	Basis
Aluminum	mg/kg	121,000	-	3,500,000	-	50	6,900,000	3,500,000	Human Health
Arsenic	mg/kg	16	20	1,100	88	132	42	42	Human Health
Barium	mg/kg	381	-	70,000	-	500	24,000	700,000	Human Health
Chromium (III)	mg/kg	172	2000*	5,300,000	-	67	6,900,000	5,300,000	Human Health
Copper	mg/kg	1,460	-	140,000	-	217	4,100	140,000	Human Health
Mercury	mg/kg	5	2*	-	-	5.5	30	5.5	Ecological

Notes:

- Not Available

(a) - Method A Industrial values based on WAC 173-900, Table 745-1.

(b) - Method C industrial non-cancer values based on WAC 173-745 Equation 745-1.

(c) - Method C industrial cancer values based on WAC 173-745 Equation 745-2.

(d) - Ecological indicator values are based on WAC 173-900, Table 749-3 for protection of plants, soil biota and wildlife.

(e) - Use of remediation levels requires institutional controls and construction of ecological cap in areas where COC concentrations exceed unrestricted CULs and are below remediation levels on industrial (Union Pacific) property.

(f) - Protective of Unsaturated zone of Groundwater, using site specific groundwater flow and infiltration values.

Table 3: Compliance Units XRF Sample Locations and Coordinates
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Compliance Unit	Cell	Location ID	Northing	Easting
UPRR Industrial 1 (UP1)	1	UP1-01	268,330	2,534,661
	2	UP1-02	268,345	2,534,708
	3	UP1-03	268,360	2,534,756
	4	UP1-04	268,376	2,534,806
	5	UP1-05	268,391	2,534,851
	6	UP1-06	268,406	2,534,899
	7	UP1-07	268,421	2,534,946
	8	UP1-08	268,436	2,534,994
	9	UP1-09	268,275	2,534,675
	10	UP1-10	268,291	2,534,723
	11	UP1-11	268,306	2,534,771
	12	UP1-12	268,321	2,534,820
	13	UP1-13	268,336	2,534,866
	14	UP1-14	268,351	2,534,914
	15	UP1-15	268,367	2,534,961
	16	UP1-16	268,382	2,535,009
	17	UP1-17	268,217	2,534,656
	18	UP1-18	268,229	2,534,693
	19	UP1-19	268,244	2,534,741
	20	UP1-20	268,259	2,534,788
	21	UP1-21	268,274	2,534,838
	22	UP1-22	268,289	2,534,884
	23	UP1-23	268,305	2,534,931
	24	UP1-24	268,320	2,534,979
	25	UP1-25	268,335	2,535,026
	26	UP1-26	268,167	2,534,666
	27	UP1-27	268,181	2,534,708
	28	UP1-28	268,196	2,534,756
	29	UP1-29	268,211	2,534,803
	30	UP1-30	268,227	2,534,853
	31	UP1-31	268,242	2,534,899
	32	UP1-32	268,257	2,534,946
	33	UP1-33	268,272	2,534,994
	34	UP1-34	268,117	2,534,674
	35	UP1-35	268,133	2,534,724
	36	UP1-36	268,149	2,534,771
	37	UP1-37	268,163	2,534,819
	38	UP1-38	268,179	2,534,868
	39	UP1-39	268,194	2,534,914
	40	UP1-40	268,209	2,534,962
	41	UP1-41	268,225	2,535,009

Table 3: Compliance Units XRF Sample Locations and Coordinates
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Compliance Unit	Cell	Location ID	Northing	Easting
UPRR Industrial 2 (UP2)	1	UP2-01	268,069	2,534,689
	2	UP2-02	268,085	2,534,737
	3	UP2-03	268,100	2,534,784
	4	UP2-04	268,115	2,534,834
	5	UP2-05	268,130	2,534,879
	6	UP2-06	268,145	2,534,927
	7	UP2-07	268,161	2,534,975
	8	UP2-08	268,176	2,535,022
	9	UP2-09	268,192	2,535,072
	10	UP2-10	268,207	2,535,120
	11	UP2-11	268,211	2,535,171
	12	UP2-12	268,250	2,535,290
	13	UP2-13	268,284	2,535,359
	14	UP2-14	268,036	2,534,665
	15	UP2-15	268,022	2,534,706
	16	UP2-16	268,037	2,534,753
	17	UP2-17	268,052	2,534,799
	18	UP2-18	268,067	2,534,847
	19	UP2-19	268,082	2,534,895
	20	UP2-20	268,097	2,534,942
	21	UP2-21	268,113	2,534,992
	22	UP2-22	268,128	2,535,037
	23	UP2-23	268,143	2,535,085
	24	UP2-24	268,158	2,535,133
	25	UP2-25	268,174	2,535,180
	26	UP2-26	268,189	2,535,228
	27	UP2-27	268,206	2,535,278
	28	UP2-28	268,221	2,535,326
	29	UP2-29	268,236	2,535,373

Table 3: Compliance Units XRF Sample Locations and Coordinates
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Compliance Unit	Cell	Location ID	Northing	Easting
WSDOT Unrestricted 1 (W1)	1	W1-01	267,973	2,534,714
	2	W1-02	267,988	2,534,762
	3	W1-03	268,003	2,534,810
	4	W1-04	268,019	2,534,859
	5	W1-05	268,034	2,534,905
	6	W1-06	268,049	2,534,952
	7	W1-07	268,064	2,535,000
	8	W1-08	268,079	2,535,048
	9	W1-09	268,096	2,535,098
	10	W1-10	268,111	2,535,145
	11	W1-11	268,126	2,535,193
	12	W1-12	268,140	2,535,238
	13	W1-13	268,155	2,535,286
	14	W1-14	268,171	2,535,334
	15	W1-15	267,925	2,534,730
	16	W1-16	267,940	2,534,777
	17	W1-17	267,955	2,534,823
	18	W1-18	267,970	2,534,871
	19	W1-19	267,985	2,534,919
	20	W1-20	268,000	2,534,966
	21	W1-21	268,016	2,535,016
	22	W1-22	268,031	2,535,061
	23	W1-23	268,046	2,535,109
	24	W1-24	268,061	2,535,157
	25	W1-25	268,077	2,535,204
	26	W1-26	268,092	2,535,252
	27	W1-27	268,109	2,535,302
	28	W1-28	268,124	2,535,350
	29	W1-29	267,888	2,534,735
	30	W1-30	267,893	2,534,795
	31	W1-31	267,908	2,534,840
	32	W1-32	267,924	2,534,888
	33	W1-33	267,939	2,534,935
	34	W1-34	267,954	2,534,983
	35	W1-35	267,970	2,535,033
	36	W1-36	267,985	2,535,081
	37	W1-37	268,000	2,535,128
	38	W1-38	268,016	2,535,178
	39	W1-39	268,050	2,535,241
	40	W1-40	268,081	2,535,336
	41	W1-41	267,863	2,534,841
	42	W1-42	267,876	2,534,903
	43	W1-43	267,891	2,534,950
	44	W1-44	267,906	2,534,998
	45	W1-45	267,921	2,535,046
	46	W1-46	267,936	2,535,093
	47	W1-47	267,952	2,535,141

Table 3: Compliance Units XRF Sample Locations and Coordinates
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Compliance Unit	Cell	Location ID	Northing	Easting
Pentzer Unrestricted 1 (P1)	1	P1-01	268,155	2,534,242
	2	P1-02	268,168	2,534,284
	3	P1-03	268,183	2,534,332
	4	P1-04	268,199	2,534,382
	5	P1-05	268,214	2,534,427
	6	P1-06	268,229	2,534,475
	7	P1-07	268,244	2,534,522
	8	P1-08	268,260	2,534,570
	9	P1-09	268,275	2,534,618
	10	P1-10	268,117	2,534,288
	11	P1-11	268,136	2,534,347
	12	P1-12	268,151	2,534,397
	13	P1-13	268,166	2,534,442
	14	P1-14	268,182	2,534,490
	15	P1-15	268,197	2,534,538
	16	P1-16	268,212	2,534,585
	17	P1-17	268,224	2,534,624
	18	P1-18	268,084	2,534,305
	19	P1-19	268,088	2,534,362
	20	P1-20	268,103	2,534,410
	21	P1-21	268,119	2,534,460
	22	P1-22	268,134	2,534,505
	23	P1-23	268,149	2,534,553
	24	P1-24	268,164	2,534,601
	25	P1-25	268,169	2,534,635
	26	P1-26	268,041	2,534,378
	27	P1-27	268,057	2,534,428
	28	P1-28	268,072	2,534,475
	29	P1-29	268,087	2,534,523
	30	P1-30	268,103	2,534,572
	31	P1-31	268,118	2,534,618
	32	P1-32	268,008	2,534,440
	33	P1-33	268,024	2,534,488
	34	P1-34	268,039	2,534,536
	35	P1-35	268,055	2,534,586
	36	P1-36	268,070	2,534,633
	37	P1-37	267,972	2,534,491
	38	P1-38	267,992	2,534,553
	39	P1-39	268,007	2,534,599
	40	P1-40	268,019	2,534,639
	41	P1-41	267,934	2,534,517
	42	P1-42	267,943	2,534,567
	43	P1-43	267,959	2,534,614
	44	P1-44	267,974	2,534,661
	45	P1-45	267,914	2,534,615
	46	P1-46	267,926	2,534,677

Note: NAD 83, Washington State Plane, North zone, feet

Table 4: Constituent List, Analytical Methods and Reporting Limits
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Procedure Number	USEPA Analysis Method	Method Reporting Limits (mg/Kg)
Aluminum	3050B/6010C	10
Arsenic		2.0
Barium		0.5
Total Chromium		1.0
Copper		2.0
Mercury	7471A	0.03

Table 5: Golder Technical and Quality Procedures List
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

Procedure Number	Procedure Title
TG-1.2-23[a]	Chain of Custody
TP-1.2-6[b]	Field Identification of Soil
TP-1.2-18	Sampling Surface Soil for Chemical Analysis
TP-2.2-12	Analytical Data Management
QP-4[c]	Decontamination of Equipment
QP-5.1	Document Preparation, Distribution, and Change Control
QP-11.1	Calibration and Maintenance of Measuring and Test Equipment
QP-16.1	Quality Assurance Records Management

Notes:

(a) TG - technical guideline

(b) TP - technical procedure

(c) QP - quality procedure

Table 6: Soil Sample Container Types, Volumes, Handling, Preservation, and Holding Times
Aluminum Recycling Trentwood - Compliance Monitoring Plan
Union Pacific Railroad

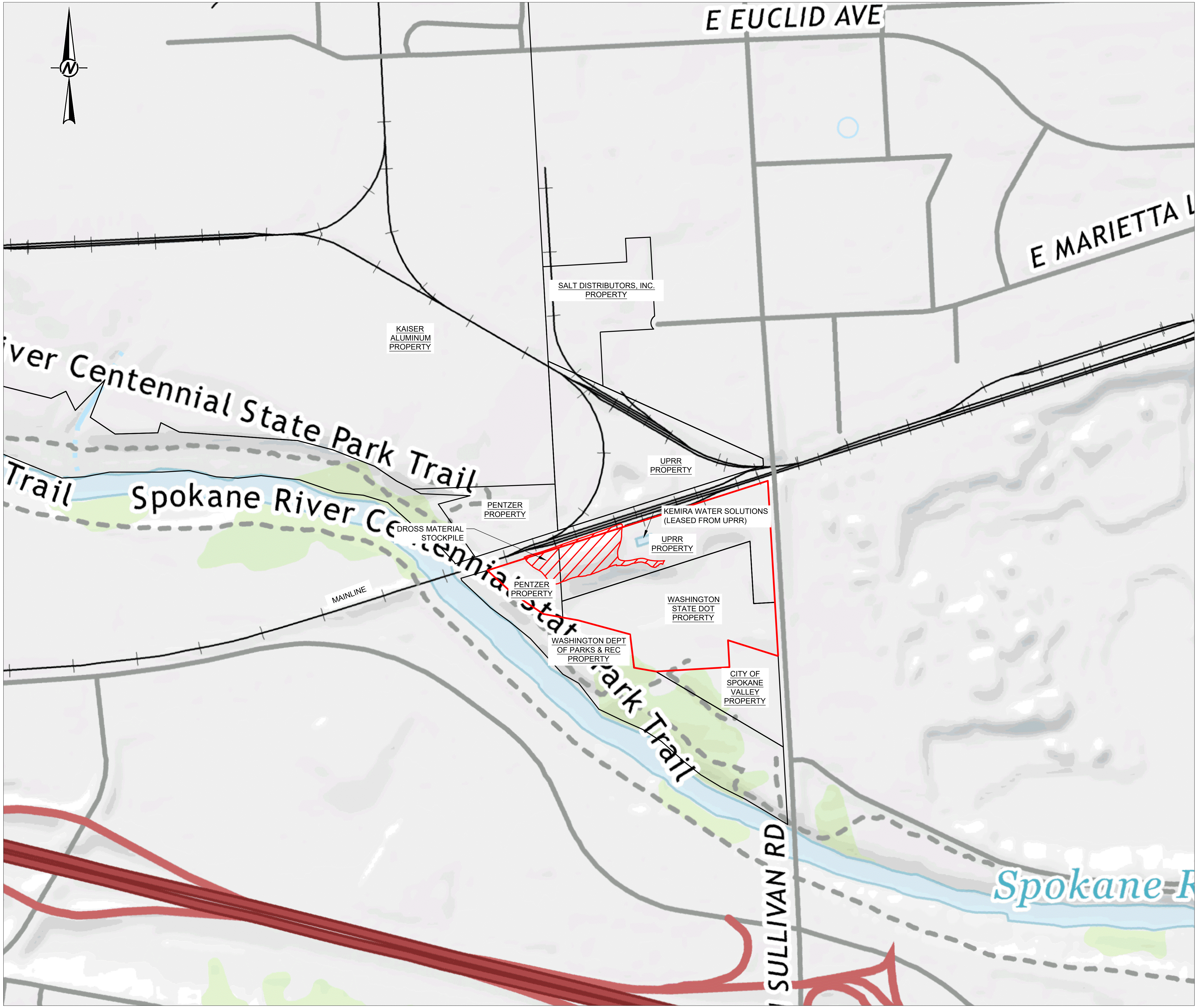
Analyte	Method	Method Reporting Limits (mg/Kg)	Container	Preservation	Holding Time[b]
Metals[a]	3050B/6010C	2 or 4 oz	Glass Jar	Cool to ≤ 6°C	6 months
Mercury	7471A	2 or 4 oz	Glass Jar	Cool to ≤ 6°C	28 days

Notes:

(a) Metals: Aluminum, Arsenic, Barium, Chromium (III), and Copper

(b) From time of sample collection

Figures



LEGEND

▭	APPROXIMATE MTCA SITE BOUNDARY
▨	LIMITS OF DROSS STOCKPILE

REFERENCE(S)

BASE MAP TAKEN FROM USGS.GOV, GREENACRES, WASH 7.5 MIN. USGS QUADRANGLE DATED 2020, DOWNLOADED IN PDF FORMAT.

0 300 600
1" = 300' FEET

CLIENT
UNION PACIFIC RAILROAD CO.

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
SITE MAP

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-11-19
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	A	1

Path: \\golder.gds\complexdata\office\Redmond\geomatics\UnionPacificRailroad\TrentwoodWA\99_PROJECTS\19119180\1000A\02_PRODUCTION\DWG\ | File Name: 19119180_1000A_008.dwg | Last Edited By: vrayner Date: 2022-05-15 Time:8:53:31 AM | Printed By: VRayner Date: 2022-05-16 Time:9:16:53 AM

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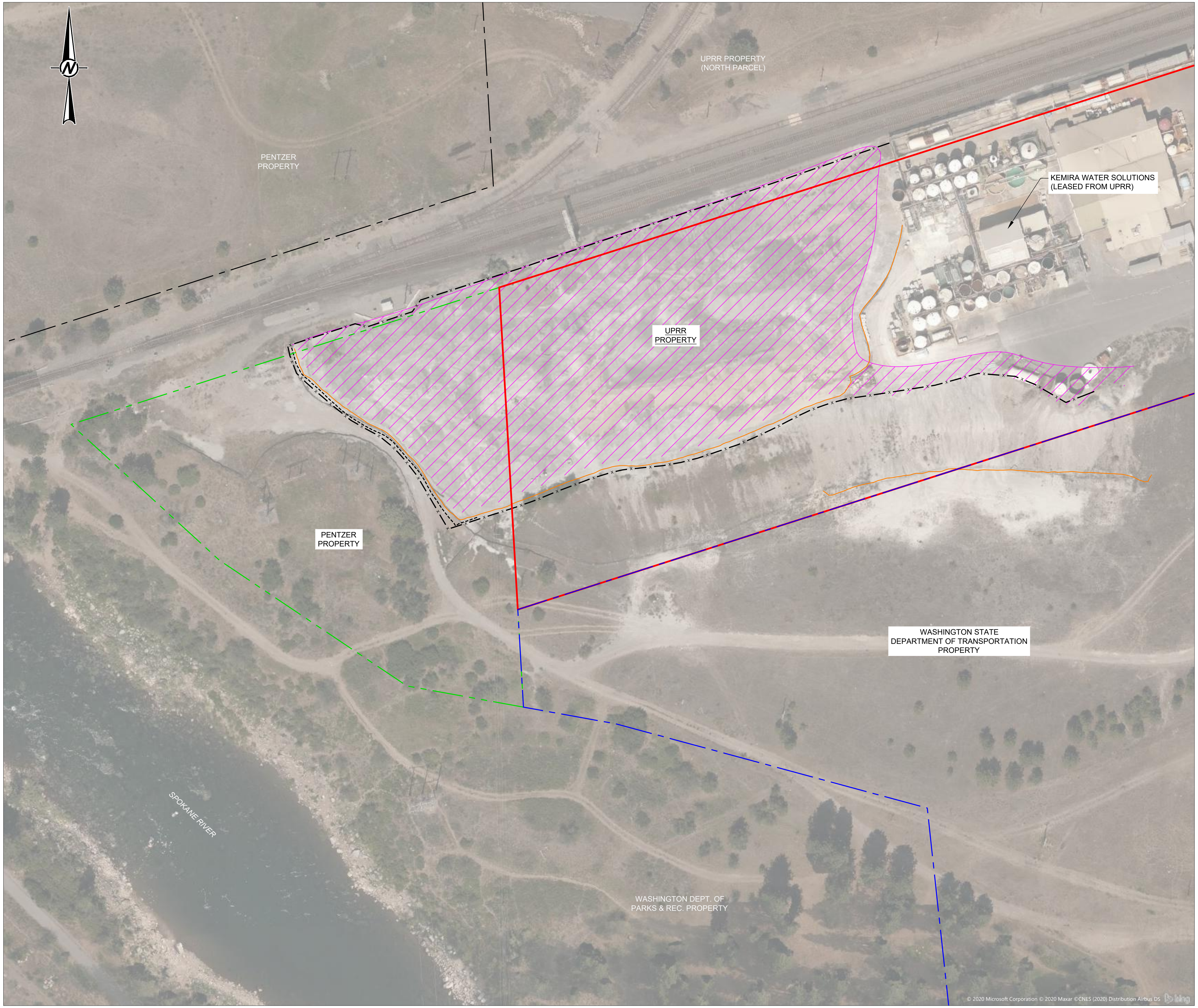

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LEGEND

🟥	APPROXIMATE UPRR PROPERTY BOUNDARY (SOUTH PARCEL)
🟩	APPROXIMATE PENTZER PROPERTY BOUNDARY
🟦	APPROXIMATE WSDOT PROPERTY BOUNDARY
▨	LIMITS OF DROSS STOCKPILE
—x—x—	SECURITY FENCE
—	SILT FENCE
- - - - -	ECOLOGY BLOCK LOCATION

NOTE(S)

1. BLACK LABELED PROPERTIES ARE PART OF MTCA SITE.

0 50 100
1" = 50' FEET

CLIENT
UNION PACIFIC RAILROAD CO.

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
SITE PLAN

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-11-19
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	A	2

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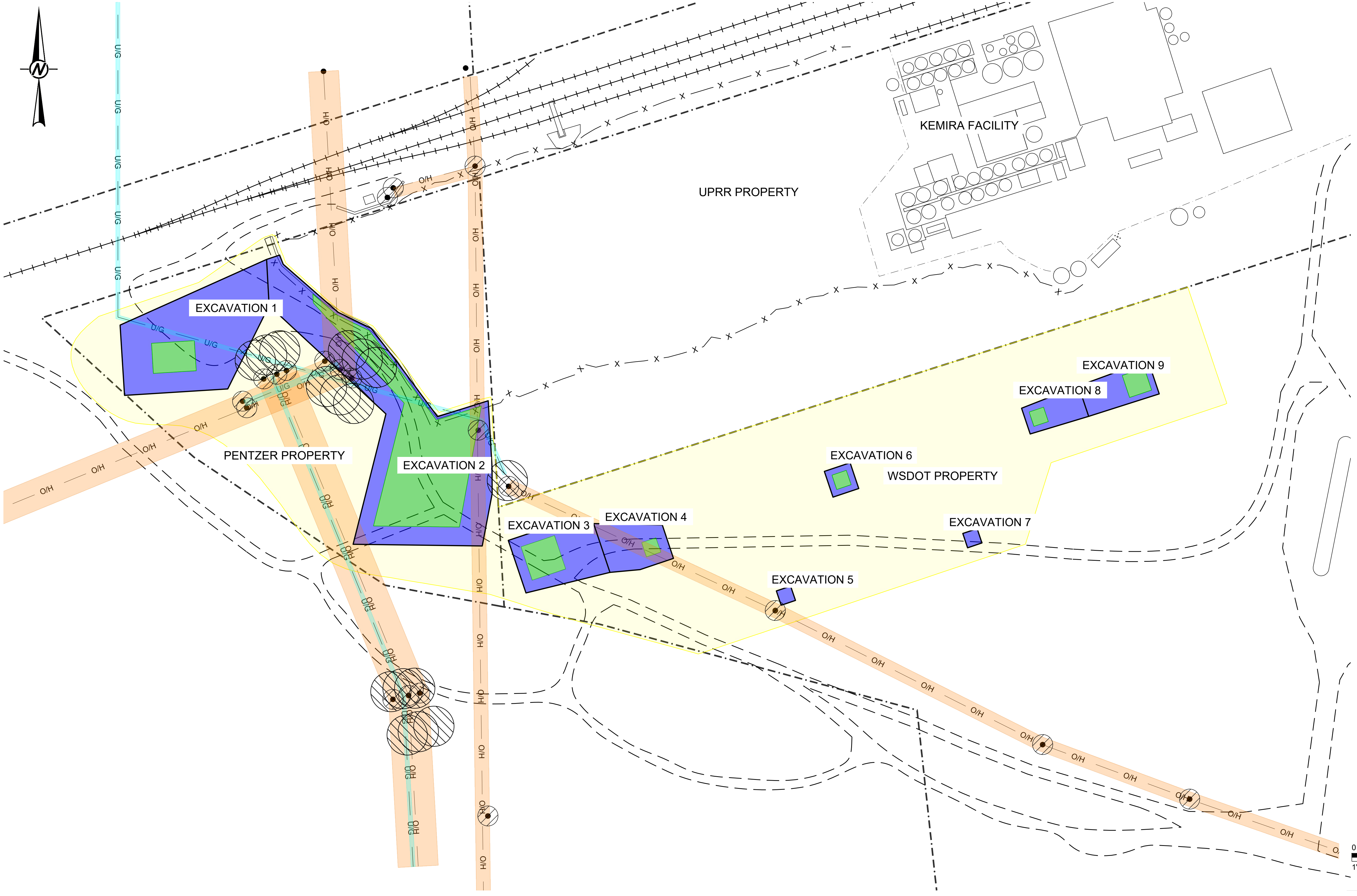

LEGEND

┌ ─ · ─ ┐	PROPERTY BOUNDARY
— — —	ACCESS ROAD
┼┼┼┼┼	RAILROAD TRACK
●	POWER POLE
— O/H —	OVERHEAD POWER LINE
— U/G —	UNDERGROUND POWER LINE
— · — · —	APPROXIMATE EDGE OF PAVEMENT
— X —	SECURITY FENCE
— SF —	
▨	UTILITY COORDINATION ZONE - POWER POLE
▨	UTILITY COORDINATION ZONE - POWER POLE ANCHOR
🟧	UTILITY COORDINATION ZONE - OVERHEAD POWER LINE (NOTE 3)
🟦	UTILITY COORDINATION ZONE - UNDERGROUND POWER LINE (NOTE 3)
🟨	EXCAVATION TO APPROXIMATELY 2FT BELOW GRADE
🟪	EXCAVATION TO APPROXIMATELY 4FT BELOW GRADE
🟩	EXCAVATION TO APPROXIMATELY 6FT BELOW GRADE

NOTE(S)

1. POWER LINE LOCATIONS BASED ON EVALUATION OF ORTHO PHOTO AND INFORMATION PROVIDED BY POWER LINE COMPANIES. CONTRACTOR TO PERFORM UTILITY LOCATE AND VERIFY IN FIELD LOCATION.
2. MAINTAIN VERTICAL DISTANCE (TO BE DETERMINED) UNDER ALL OVER HEAD POWER LINE LIMITS.
3. TO BE FIELD VERIFIED.
4. EXCAVATION LIMITS AROUND UTILITIES TO BE CONFIRMED WITH UTILITY COMPANIES.

CLIENT
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GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-11-19
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
APPROXIMATE AREA SUBJECT TO CLEANUP ACTIONS (COCS>CULSs)

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	A	3

Path: \\golder.gds\gal\redmond\geomatics\UnionPacificRailroad\TrentwoodWA\99_PROJECTS\19119180\1000A\02_PRODUCTION\DWG\ | File Name: 19119180_1000A_006.dwg | Last Edited By: vrayner Date: 2022-05-15 Time:8:52:54 AM | Printed By: VRayner Date: 2022-05-16 Time:9:18:02 AM

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CONSULTANT

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YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
AREA QUALIFYING FOR USE OF REMEDIATION LEVELS

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	B	4

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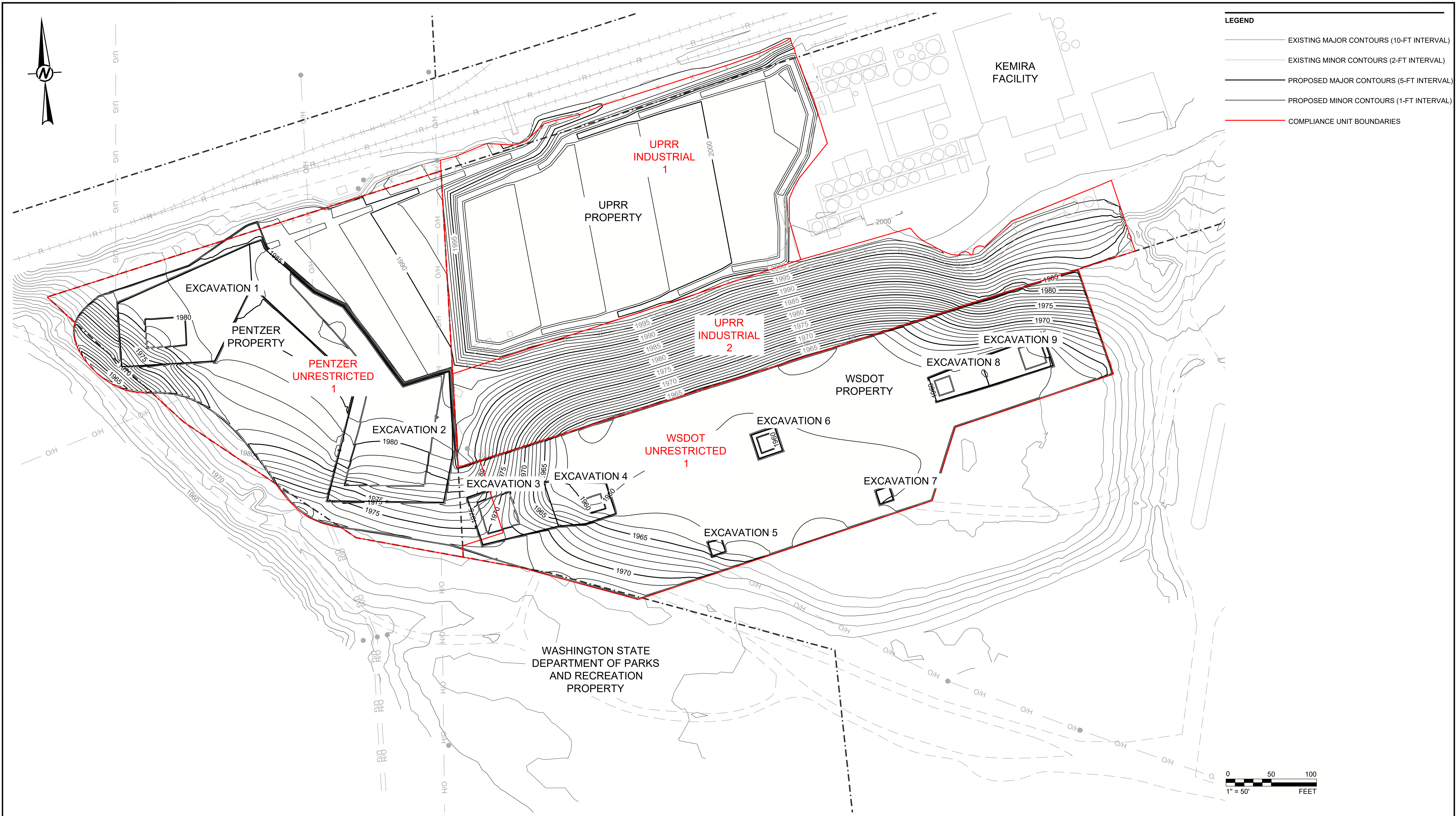

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CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
UNRESTRICTED USE AND INDUSTRIAL USE COMPLIANCE UNITS

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	B	5

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UNION PACIFIC RAILROAD CO.

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
PENTZER UNRESTRICTED USE COMPLIANCE UNIT (P1) AND CELL GRID

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	B	6

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GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
WSDOT UNRESTRICTED USE COMPLIANCE UNIT (W1) AND CELL GRID

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	B	7

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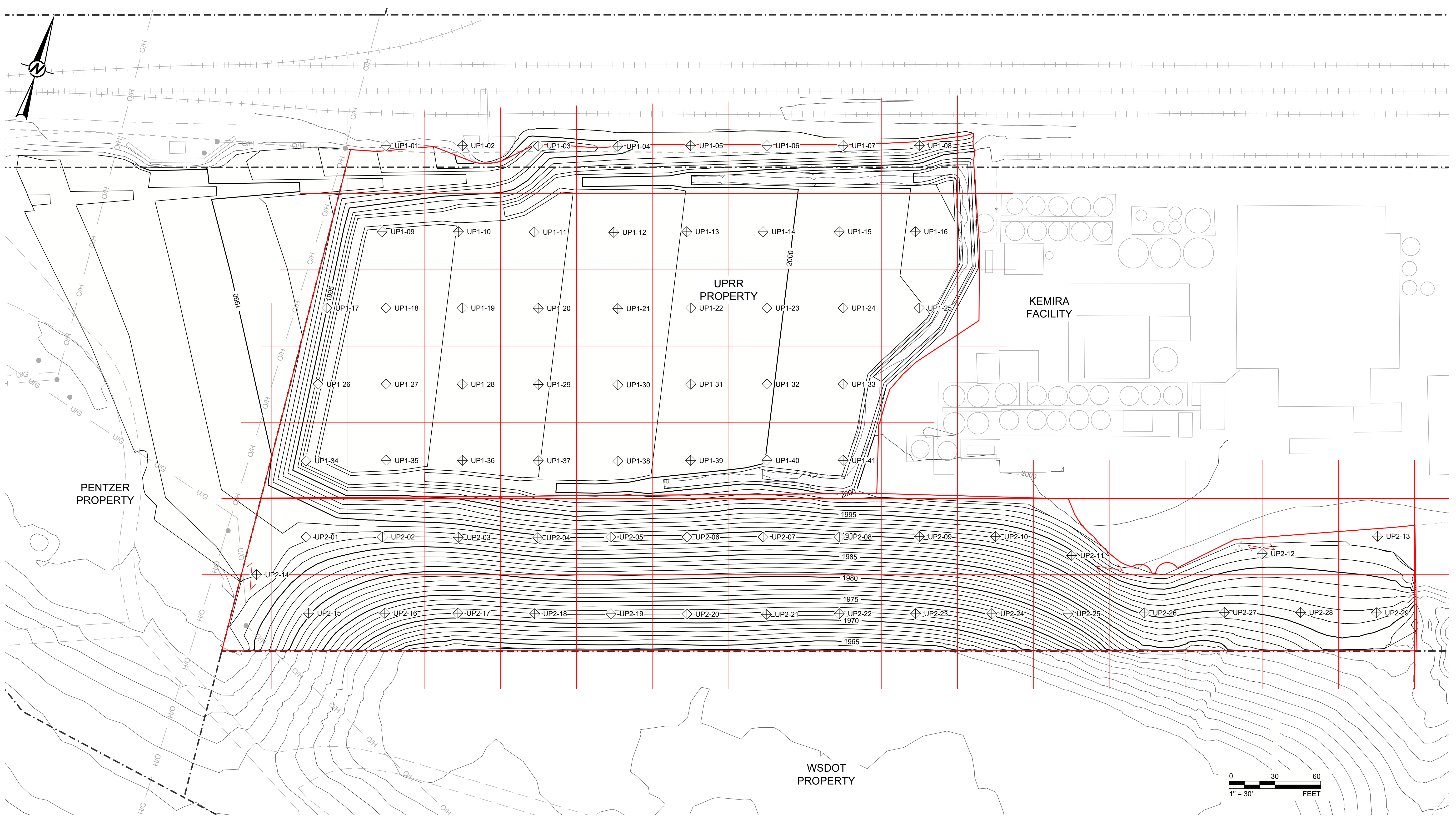

2022-05-17 VMN REDMOND TJN TJN

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UNION PACIFIC RAILROAD CO.

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	TJN
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
COMPLIANCE MONITORING PLAN
SPOKANE VALLEY, WASHINGTON

TITLE
UPRR INDUSTRIAL USE COMPLIANCE UNITS (U1 AND U2) AND CELL GRIDS

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	B	8

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ATTACHMENT A

Technical Procedures

TECHNICAL GUIDELINE FOR
CHAIN OF CUSTODY

TG-1.2-23
Rev. #2
8/20/2009

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Exhibit C Chain of Custody Form
Exhibit D Field Change Request Form

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Figure 8-1 Sample Container Packing Arrangement

TG-1.2-23 Chain of Custody

1.0 PURPOSE

This technical guideline establishes the requirements for documenting and maintaining environmental sample chain of custody from point of origin to receipt of the sample at the analytical laboratory.

2.0 APPLICABILITY

When specifically invoked by project work plans, sampling plans, or QA plans, this technical guideline shall apply to all types of air, soil, water, sediment, biological, and/or core samples to be analytically tested in support of environmental investigations by Golder Associates Inc., and is applicable from the time of sample acquisition until custody of the sample is transferred to an analytical laboratory.

3.0 DEFINITIONS

3.1. Custody

Custody refers to the physical responsibility for sample integrity, handling, and/or transportation. Custody responsibilities are effectively met if the samples are:

- in the responsible individual's physical possession;
- in the responsible individual's visual range after having taken possession;
- secured by the responsible individual so that no tampering can occur; or
- secured or locked by the responsible individual in an area in which access is restricted to authorized personnel.

3.2. Chain of Custody

Chain of custody refers to the history of the physical transfer of samples between the sampler, the transporter, or carrier, and the laboratory technician. Chain of custody documentation is required as evidence that the integrity of samples was maintained during transfer.

4.0 DISCUSSION

Environmental samples must be tracked, handled and transported in a manner such that sample integrity and identification (to the location and interval at which they were obtained) is maintained. The sample custodian must maintain proper storage and custody of samples from the time of collection until transport to the laboratory. The sampler shall initiate Chain of Custody forms which accompany samples from the collection site to the laboratory and provide documentation of any transfer of custody throughout transport. Sample identification and integrity shall be ensured by the application of seals and labels to the sample containers at the time of sample collection. Seals and labels shall be verified upon receipt of samples at the analytical laboratory; unacceptable samples shall be identified on the Chain of Custody form, and referred to the Geologist/Field Engineer or Project Manager for evaluation and appropriate disposition.

5.0 RESPONSIBILITIES

5.1. Project Manager

The Project Manager is responsible for the overall management of environmental sampling activities, for designating the sample shipment method (considering permitted sample holding times), for delegating sampling responsibilities to qualified personnel, and reviewing any Field Change Requests that may be initiated during the investigation.

5.2. Geologist/Field Engineer

The Geologist/Field Engineer is responsible for: 1) providing general supervision of sampling operations as directed by the Project Manager; 2) ensuring proper temporary storage of samples and proper transportation of samples from the sampling site to the laboratory; and 3) initiating Field Change Requests when required. The Geologist/Field Engineer is also responsible for tracking Chain of Custody forms for samples to ensure timely receipt of the completed original, for reviewing Chain of Custody forms to ensure appropriate documentation of sample transfers, and for advising the Project Manager of any problems observed that are related to sample integrity and chain of custody. The Geologist/Field Engineer may delegate document tracking and review responsibilities to suitably qualified personnel.

5.3. Sampler

The sampler may be the same individual as the Geologist/Field Engineer and is responsible for: 1) sample acquisition in compliance with applicable guidelines and procedures; 2) checking sample integrity and documentation prior to transfer; 3) initiating the Chain of Custody form; 4) maintaining custody of the samples while completing the sampling project; and 5) physically transferring the samples to the transporter or directly to the laboratory.

5.4. Laboratory Sample Custodian

The laboratory sample custodian or designated sample receiving technician is responsible for: 1) inspecting transferred samples to ensure that seals are intact, that labels are affixed, that sample condition is acceptable, and that Sample Integrity Data Sheets are completed, when required for a particular project; 2) completing the Chain of Custody form upon receipt; 3)forwarding copies of the completed Chain of Custody form to the Project Manager; and 4) segregating and identifying unacceptable samples, and subsequently notifying the Golder Project Manager.

5.5. Document Custodian

The document custodian (project manager or administrative assistant) is responsible for maintaining completed Chain of Custody forms in the project files.

6.0 EQUIPMENT AND MATERIALS

- Seals and labels (Exhibit A)
- Sample Integrity Data Sheets (Exhibit B), if required by the applicable sampling procedure, work plan, sampling plan, or quality assurance (QA) plan, or if requested by the Project Manager
- Chain of Custody forms (Exhibit C)
- Field Change Request form (Exhibit D)
- Packing and shipping materials, which may include coolers or insulated packing boxes, ice, "blue ice" or dry ice, cardboard packing boxes, wooden core storage boxes, and shipping labels. If dry ice is used, caution should be used so that samples do not freeze resulting in broken jars and negative impact to other samples in the same carrier.

7.0 GUIDELINE

7.1. Seals, Labels, and Initial Storage

At the time of collection, all samples shall be sealed, labeled, and appropriately stored in the custody of the sample custodian as defined in 3.1 above. Examples of standard seals and labels are included in Exhibit A.

7.2. Sample Packaging

All samples shall be packaged appropriately for shipping to protect them from damage, to ensure that moisture content is maintained where necessary, and to ensure that appropriate temperatures are maintained as required. All sample shipping containers shall be sealed (see Exhibit A) to prevent tampering.

Environmental core sample boxing, marking, and labeling shall be in compliance with TG-1.2-2, "Geotechnical Rock Core Logging." Other types of environmental samples stored in jars or bottles may be packaged in insulated coolers, or, if sample temperature is not a concern, in the original sample container packing boxes. Where cooling is required, samples shall be shipped in insulated coolers containing bagged or pre-packaged ice sufficient to keep the samples at 4°C ± 2°. All samples should be carefully placed in the appropriate container(s) and packaged with paper or bubble-wrap to prevent significant movement or breakage during transport.

Samples from boreholes shall be packaged, where appropriate, by placing the jars in shipping containers from the top right corner downward, and from left to right, beginning with the first sample taken as shown in Figure 8-1. An alternative packaging order may be appropriate to isolate contaminated samples to minimize the risk for cross-contamination.

A label containing the following information should be affixed to the front of each shipping container containing environmental samples:

- Project Number
- Location
- Borehole number(s) (if appropriate)
- Date collected
- Sample numbers enclosed

Boxes should be numbered consecutively; the last box from a borehole or drillhole shall also be identified "EOH," (i.e., end of hole).

7.3. Sample Examination

Prior to transfer of samples, the sampler shall ensure that:

- labels and seals are affixed and completely filled out;
- Chain of Custody documentation corresponds to the samples in the shipment;
- special handling and storage requirements are identified where required;
- Sample Integrity Data Sheets are available where required by applicable sampling guidelines or the Project Manager;

- there are no indications of sample container leaks or other questionable conditions that may affect the integrity of the sample; and
- hazardous and/or radioactive samples are clearly identified as such.

Samples that do not meet the requirements for initial transfer shall be referred to the Geologist/Field Engineer or Project Manager for disposition.

7.4. Chain of Custody Form Initiation

The sampler shall initiate the Chain of Custody form (Exhibit C) for the initial transfer of samples. Chain of Custody forms supplied by the analytical laboratory may be used in lieu of the form shown in Exhibit C. At a minimum, the following information shall be entered on the form:

- the destination of the samples and the transporter or carrier;
- the project identification and sampling site;
- the date and time of sample collection;
- the sample identification numbers and descriptions (e.g., media, container);
- analysis required for samples included in the shipment; and
- QA and reporting instructions for the laboratory.

When all required information has been entered the sampler shall sign and date the Chain of Custody form as the initiator.

7.5. Transfer of Custody

To document the initial transfer of samples, the sampler relinquishing custody and the transporter accepting custody shall sign, date, and note the time of transfer on the Chain of Custody form. If the transporter is not an employee of Golder Associates Inc., the sampler may identify the carrier and reference the bill of lading number in lieu of the transporter's signature. The Chain of Custody form should be in triplicate. One copy of the Chain of Custody form shall be forwarded to the Geologist/Field Engineer by the sampler. The original form and the remaining copy shall accompany the samples.

7.6. Receipt at Destination

The laboratory sample custodian shall inspect the transferred samples to ensure that:

- the seals are intact;
- the labels are affixed and legible;
- Sample Integrity Data Sheets are available where required;
- the physical condition of the samples is acceptable; and
- the samples being transferred directly correspond to those listed on the Chain of Custody form.

If the integrity of the samples is questionable, the laboratory technician shall notify the Golder Project Manager, segregate the unacceptable samples and identify them on the Chain of Custody Form. Otherwise, the laboratory sample custodian and the transporter shall sign, date, and note the time of transfer on the Chain of Custody form. If the transporter is not an employee of Golder Associates Inc., the laboratory sample custodian may identify the carrier and reference the bill of lading number in lieu of the transporter's signature. The laboratory sample custodian shall retain the remaining copy of the Chain of Custody form and forward the original signed copy to the Geologist/Field Engineer. Appropriate laboratory custody procedures shall be initiated upon completion of transfer of custody in compliance with the laboratory's internal QA program requirements.

7.7. Document Tracking

The copy of the Chain of Custody form recording the initial transfer of samples shall be forwarded to the Geologist/Field Engineer, followed by the completed original. The Geologist/Field Engineer shall track the Chain of Custody form to ensure timely completion and receipt of the original, based on the laboratory acknowledgement due date indicated on the form and/or subcontractor agreement.

After receipt of the completed original, the Geologist/Field Engineer may discard the copy. The completed original Chain of Custody form shall be placed in the project files. Chain of Custody forms determined to be overdue or incorrectly completed shall be referred to the Project Manager for appropriate action.

7.8. Field Change Request

Variation from established guideline requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established guidelines shall be documented on a Field Change Request form (Exhibit D) and reviewed by the Project Manager.

The Project Manager may authorize individual Geologist/Field Engineers to initiate necessary variations. If possible, the request for variation shall be reviewed by the Project Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Geologist/Field Engineer, provided that the Project Manager is notified of the variation within 24 hours of the implementation, and the Field Change Request is forwarded to the Project Manager within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be redone or action shall be taken as indicated in the comments section of the reviewed Field Change Request. All completed Field Change Requests shall be maintained in project records.

8.0 REFERENCED GUIDELINES

Golder Associates Technical Guideline TG-1.2-2, "Geotechnical Rock Core Logging."

9.0 ADDITIONAL GUIDELINES AND PROCEDURES

EPA, 2002, “Standard Operating Procedure for Chain of Custody of Samples,” EPA Region 1 Office of Environmental Measurement and Evaluation, North Chelmsford, Massachusetts.

American Society for Testing and Materials, 2004. Standard Guide for Sampling Chain-of-Custody Procedures, ASTM D-4840-99(2004).

Figure 8-1

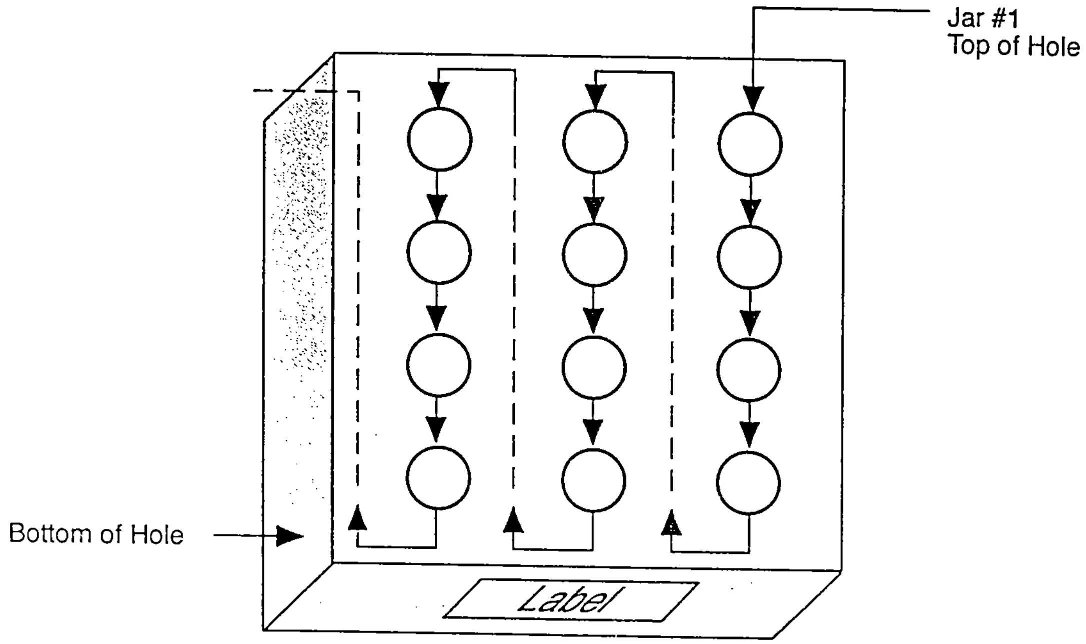

FIGURE **8-1**

SAMPLE CONTAINER PACKING ARRANGEMENT

TP-1.2-23

PROJECT NO IP3 1024.200 DRAWING NO. 66972 DATE 8/15/96 DRAWN BY EA

Golder Associates

EXHIBIT A

Golder Associates

Location ____________________
Job No. ________ Date ________
Boring No. ________ Sample No. ________
Depth ________ Blows ________
Description ____________________
____
____
____
Driller ________ Engr. ________

Golder Associates

Sample I.D. No.

Date ________ Time ________
Station ________ Depth ________
Media ____________________
Preservative ____________________
Sampled by ____________________

Golder Associates
Seal Number
2455
Golder Associates
Sent By: ____________
Date: ____________

EXHIBIT **A**
SEALS AND LABELS
TP-1.2-23

PROJECT NO.IP3-1024 DRAWING NO. 67021 DATE 8/7/96/96 DRAWN BY DD

Golder Associates

EXHIBIT B

SAMPLE INTEGRITY DATA SHEET

Plant/Site ____________________ Project No. ____________

Site Location ____________________ Sample ID ____________

Sampling Location ________________________________

Technical Procedure Reference(s) ________________________

Type of Sampler ________________________________

Date ____________ Time ____________

Media ____________ Station ____________

Sample Type: grab time composite space composite

Sample Acquisition Measurements (depth, volume of static well water and purged water, etc.)

Sample Description ________________________________

Field Measurements on Sample(pH, conductivity, etc.) ____________________

Aliquot Amount	Container	Preservation/Amount

Sampler (signature) ____________ Date ____________

Superviser (signature) ____________ Date ____________

Golder Associates

EXHIBIT **B**

Sample Integrity Data Sheet

TP-1.2-23

EXHIBIT C

CHAIN OF CUSTODY RECORD

PROJ. NO.

SITE/LOCATION

SAMPLERS: *(Signature)*

STA. NO.	DATE	TIME	SAMPLE TYPE	MEDIA	SAMPLE IDENTIFICATION	NO. OF CON-TAINERS	AMOUNT/ PRESERVATIVE						SEAL NO.	SEAL INTACT ? (Y or N)	REMARKS (with initials)

Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*
Relinquished by: *(Signature/Firm)*	Date/Time	Received by: *(Signature/Firm)*	Date/Time	Remarks (attachments if necessary)	

EXHIBIT **C**

CHAIN OF CUSTODY FORM

TP-1.2-23

PROJECT NO. IP3 1024 DRAWING NO. 67019 DATE 7/17/96 DRAWN BY CB

Golder Associates

EXHIBIT D

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number:

Other Affected Documents:

Requested Change:

Reason for Change:

Change Requested by: Date

Reviewed by: Date
GAI Project Manager

Comments:

Reviewed by: Date
GAI QA Manager

Comments:

Golder Associates Inc.

EXHIBIT **D**

FIELD CHANGE REQUEST FORM

TP-1.2-23

PROJECT NO. IP3 1024 DRAWING NO. 67018 DATE 7/17/96 DRAWN BY CB

Golder Associates

Golder Associates

Technical Procedure

Number: TP-1.2-6
Title: FIELD IDENTIFICATION OF SOIL

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
	Jim John 7/8/96	7-16-96	7-19-96	-7-

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TP-1.2-6
Revision Level -7-
RECORD OF REVISIONS

Section	Description of Revisions
All	New format throughout
4.	Updated ASTM standard
5.	Changed "foundation" engineering to "geotechnical" engineering
7. & Table 1	Changed one-half-inch (12 mm) rebar to 1/4-inch steel hand probe
8.1	Added more detail to soil descriptions
Figure 2	Updated Record of Borehole log to reflect current form

1. PURPOSE

This technical procedure describes uniform procedures for identification of soils.

2. APPLICABILITY

This technical procedure is applicable to all persons engaged in soils identification.

3. DEFINITIONS

Definitions are contained within Section 8.

4. REFERENCES

ASTM Standards, Standard Recommended Practice for Description of Soils (Visual-Manual Procedure), D 2488-93, American Society for Testing and Materials, Philadelphia, Pennsylvania.

Rock-Color Chart, Geological Society of America, Boulder, Colorado.

5. DISCUSSION

Soil identification techniques are employed to characterize and describe soil for geologic and hydrologic interpretation, geotechnical engineering, well screen sizing, and a wide range of other purposes.

6. RESPONSIBILITY

Each individual designated responsibilities for soil identification shall utilize this procedure.

7. EQUIPMENT AND MATERIALS

Supplies required for Golder Associates field personnel generally include the following:

- Supply of water
- Pocket knife or small spatula
- Small test tube with stopper or glass jar with sealed lid
- Small hand lens
- Pocket penetrometer or shear gage
- 1/4" steel hand probe
- Notebook
- Exploration logs

8. PROCEDURE

8.1 General

The recommended Soils Classification System is based on the Unified Soil Classification System as summarized on Figure 1.

The soil description involves the following general format:

(1) Consistency or Density,
(2) Color,
(3) Structural Characteristics,
(4) Composition with Major Component in Capital Letters,
(5) Minor Characteristics,
(6) Uses Classification in Capital Letters,
(7) Geologic Description in Capital Letters.

Thus, for example, a typical description might include:

> Stiff, Light Grey (N7), stratified, SILTY CLAY, trace Sand, slickensides, (CL) (LACUSTRINE)

The following sections discuss the different elements (1-7 above) of the soil description.

8.2 Determination of Consistency or Relative Density

8.2.1 N-Values

The standard penetration test (SPT), or number of blows required by a 140-pound hammer or weight dropped 30 inches to drive a two-inch O.D. (1 3/8-inch ID) drive-open sampler, will indicate the relative density of cohesionless soils and the consistency of cohesive soils. The standard tests penetrates 18 inches. N values are the blows required to drive the sampler the last 12 inches. The blows required to drive the sampler the first six inches are normally not taken into account unless one or both of the subsequent blow counts are affected by gravel of cobbles. Blows are recorded for each six-inch interval. The relative density or coarse-grained soils is shown in Table 1.

8.2.1.1 Relative Density of Granular Soils

The relative density modifiers given in Table 1 for coarse-grained soils should also be used for fine-grained non-plastic soils described predominately by SILT.

8.2.1.2 Consistency of Fine-Grained, Cohesive Soils

Shown in Table 2 are criteria for the quantitative and qualitative determination of the consistency of fine-grained, cohesive soils. The criterion based on N-Values is considered unreliable and should be used with caution. The criterion based on undrained shear strength may be used when values of undrained shear strength are available. The field identification test is simple and reliable and is the method which can be used in most instances.

8.3 Determination of Color

Color can be an important property in identifying materials of similar geologic origin and in identifying organic soils. Although qualitative color names are somewhat helpful, positive color identifications obtained by comparison with a standard color chart are even more useful. If the sample contains layers or patches of varying colors, this should be noted and all representative colors should be described for moist samples. If possible, color should be described for moist samples. The Geologic Society of America Rock-Color Chart should be used to identify color. Provide both the color name and chromal hue symbols in soil descriptions. Mottled soils show the presence of spots, streaks, or splotches of one or more colors in a soil mass of another predominant color. In mottled soils, the colors are not mixed and blended, but each is more or less distinct in the general ground color.

8.4 Definitions of Structural Characteristics

8.4.1 Stratified

Composed of, or arranged in, layers. The layers are parallel to one another, and composed of soils visibly different from each other.

8.4.2 Parting

Paper-thin separation of one soil type within another. Usually applied to cohesive soils.

8.4.3 Rhythmic

Consisting of alternative thin layers of sand, silt or clay. Each layer generally less than one-half-inch in thickness. Lacustrine deposits with annual layers are termed varves or are said to be varned.

8.4.4 Lenses

A particular soil type significantly different from the surrounding soils which thins out laterally is said be a lens or be lens-shaped.

8.4.5 Pocket

A different soil type of limited thickness and lateral extent.

8.4.6 Homogenous

Of uniform structure.

8.4.7 Heterogeneous

Consisting of dissimilar constituents, mixed.

8.4.8 Slickensided/Polished/Scratched Surfaces

A polished and scratched surface that results from friction of one block of material moving relative to another block. Polished and/or scratched surfaces may be related to minor movement along discontinuities or may be related to faults and termed slickensides.

8.4.9 Fissured

This term applies to hard, over-consolidated silts and clays and refers to physical discontinuities such as fissures and cracks that formed during or after consolidation. The abundance and character of the fissuring can be described as follows:

"Highly Fissured" - Fractures are spaced one-half-inch or closer over most of the interval described.

"Moderately Fissured" - Sample contains two or more fractures or thin fracture zones per six-inch sample, but average spacing is wider than one-half inch.

"Locally Fissured" - Only one fracture or narrow (less than three inches) fracture zone is observed in a sample.

Fissuring characteristics that can be noted and/or described include attitude, length, width, aperture (closed, tight, open), staining/infilling, roughness, curvature, continuity, slickensides, polish, gouge, relation to other structures and other distinguishing features.

8.5 Determination of Soil Composition

8.5.1 General

For purposes of soil description, the material is considered to be composed of the coarse fraction or of particles larger than the No. 200 sieve (+.074 mm) and the fine fraction or those smaller than the No. 200 sieve. The coarse fraction is described based on its particle size while the fines are described on its plasticity.

The following terminology is used to denote the percentage by dry weight of each soil component:

Descriptive Term	Range of Proportion
Trace	0-5%
Little	5-12%
Some or Adjective*	12-30%
And	30-50%

*Adjective: silty, sandy, gravelly, etc.

For example: "SILT, some Sand, trace Gravel" describes a basic soil component of silt (30-50 percent), with minor components of sand (12-30 percent), and gravel (0-5%).

Soils are to be described according to the following criteria with the principal constituents written in capital letters. Other constituents are preceded by descriptive terminology that is used to denote the percentage by weight of each component. Soil descriptions are determined visually except where laboratory classification test data are available. The following abbreviations are acceptable:

c = coarse
m = medium
f = fine

8.5.2 Field Indication Tests - Fines

8.5.2.1 Fine-Grained Soil Descriptions

The description of fine-grained soil components (i.e., passing the No. 200 sieve or smaller than 0.074 mm) is based on plasticity and not grain size. Thus, terms like SILT, trace Clay or Silt, little Clay are not used. Rather, the terms, SILT, CLAYEY SILT, SILTY CLAY, and CLAY are applied to the fine-grained component as a whole. Their characteristics are described in Table 4.

8.5.2.2 Field Test for Plasticity

Plasticity refers to the ability of a material to be deformed rapidly without cracking or crumbling and then maintain that deformed shape after the deforming force has been released. A soil is said to be highly plastic if there is a wide range of moisture content over which it remains in the plastic state. High plasticity indicates a high clay content. Identification of cohesive soils in relation to their plasticity can be made on the following basis: The natural soil is worked until its moisture content is such that a 1.5-inch diameter ball formed from the soil shows a flattened contact surface of 7/8-inch diameter when dropped from a height of two feet (gravel sizes are not included in the ball). The smallest thread possible without crumbling is then rolled from the above soil sample. The approximate relationships below are then used for identification:

Thread Diameter	Descriptive Term
1/4-inch	SILT
1/8- to 1/16-inch	CLAYEY SILT
1/32-inch	SILTY CLAY
1/64-inch	CLAY

8.5.2.3 Dry Strength

A portion of the soil is allowed to dry out completely in air. An angular fragment (about one-half-inch) of the dried soil is pressed between the fingers. The dry strength of the fragment is expressed as very low, low, medium, high and very high. Fragments with very high strength cannot be injured at all, whereas, those of very low strength disintegrate completely on gentle pressure. The strength is called medium if the fragment can be reduced to powder only with great effort. Those materials with greater dry strengths are predominately clayey, and those with less dry strength are predominately silty.

8.5.2.4 Stickiness

A high degree of stickiness in the natural state is indicative of higher plasticity.

8.5.2.5 Shine Test

If a moist lump of soil is stroked with considerable pressure with the flat of a pen knife blade or fingernail, the type of surface imparted is an indication of the soil. If a shiny surface results, the presence of clay is indicated. Silt is indicated if a dull surface is produced.

8.5.2.6 Grittiness Test

THIS TEST SHOULD NOT BE PERFORMED WHEN HAZARDOUS WASTE CONTAMINATION IS SUSPECTED OR KNOWN TO BE PRESENT. In other cases, when a small amount of the uncontaminated soil is placed between the teeth, the presence of grit will indicate silt or sand, but if no grit is detected, a pure clay is present.

8.5.3 Field Identification Tests - Organic Soils

8.5.3.1 Organic Soil

Description of organic soils depends on the percentage and distribution or organics in the soil. If the soil matrix is inorganic with occasional pieces or organic matter, this can be described under Minor Characteristics.

If the soil is primarily inorganic, but contains a significant amount of organic, the modifier organic can be used. If the soil is primarily organic, then it should be called a Peat. Examples include:

- Silty SAND, occasional organic matter
- Organic SILT
- Sandy PEAT

Table 5 includes a system for classifying organic soils.

8.5.3.2 Organic Cohesive Soils

Organic cohesive soils display the following characteristics.

- A dark-brown, dark-gray, black color indicates the presence of organic matter.
- An odor of decaying vegetation is typical. If organic matter cannot be distinguished, it can sometimes be brought out by a small amount of heat.
- The presence of fibrous or root structures, twigs, leaves or shells is common.
- At least a three-quarter reduction in the liquid limit value after oven-drying is considered positive identification of organic soil.
- The plasticity of fine-grained organic soils is greatly reduced on oven-drying due to irreversible changes in organic colloids.
- Organic clays feel spongy in the plastic range as compared to inorganic clays.

8.5.3.3 Organic Soil - Peat

Peat is usually dark brown to black; contains fibrous particles of vegetation in varying states of decay; has characteristic organic odor; is usually spongy and compressible; commonly contains natural moisture contents of over 100 percent and can contain organic and inorganic silts and clays in varying amounts and concentrations.

8.5.4 Field Identification Tests - Cohesionless Soils

8.5.4.1 Visual Identification of Grain Size

The constituent parts of a soil sample are defined by grain size, as indicated in Table 3.

8.5.4.2 Grittiness Test

THIS TEST SHALL NOT BE PERFORMED WHEN HAZARDOUS WASTE CONTAMINATION OF THE SOIL IS SUSPECTED OR KNOWN TO BE PRESENT.

The soil is handled lightly between the thumb and forefinger to get an idea of the grittiness or softness of the soil. A pinch of uncontaminated soil is smeared with considerable pressure between the thumb and forefinger to determine the degree of harshness and grittiness. When a small amount of uncontaminated soil is placed between the teeth, the presence of grit will indicate silt or sand, but if no grit is detected, an almost pure clay is present.

- Coarse to medium sand exhibits a typically harsh and very gritty smear.
- Coarse to fine sand has a less harsh feel, but exhibits a very gritty smear.
- Medium to fine sand exhibits a less gritty feel and smear.
- Fine sand has a softer feel and much less gritty smear.

8.5.4.3 Test Tube Test

A small sample of the soil (lumps are first broken up) is shaken in a test tube or glass jar filled with water and is allowed to settle. All the fine sand will settle out (four-inch fall) in 30 seconds; the silt in 50 minutes. A rough idea of the grain sizes can be obtained by this test.

8.5.4.4 Dilatancy Test

When a wet pat of soil is shaken vigorously in the hand, the surface will become glassy and show free water. If the pat of soil is then squeezed in the fingers with free water disappearing and the surface becomes dull, the soil is NOT a clay soil, but a silt or fine sand. If the free water on the surface disappears immediately (as walking on the beach adjacent to the water), the soil is most likely a fine sand. If the free water tends to ooze away, the soil is most likely silt.

8.5.5 Determination of Soil Types

Based on the tests and observations described in the previous text, the soil description can be made by compiling the properties of the soil and comparing them to Table 2.

8.6 Minor and/or Usual Characteristics

8.6.1 General

Minor characteristics of the soil sample should be included in its description. These characteristics include occasional traces of organic debris, mention of other types of deleterious materials such as a trash or cinder fill, portions of cobbles or boulders received in the sampler, and pockets and/or lenses of material other than those already mentioned in the description. A minor constituent, such as gravel, which is part of the overall soil matrix, would be described using the modifiers presented in 8.5.1.2 (i.e., trace, little, etc.). In some cases, a minor constituent is scattered throughout the unit and is not part of the matrix. In this case, it would not be described as a minor characteristic. An example would be a lacustrine clay with ice rafted pebbles. Thus, the soil would be described as SILTY CLAY, scattered pebbles, and not SILTY CLAY, little gravel.

8.6.2 Determination of Moisture Content

Moisture descriptions should not generally be used and can be misleading. A general qualitative description can be applied if necessary. The following descriptions can be used:

• Dry:	No discernible moisture present.
• Damp:	Enough moisture present to darken the appearance, but no moisture on materials adheres to the hand.
• Moist:	Will moisten the hand.
• Wet:	Visible water present; plastic materials will leave sticky residue in hand when remolded.

As an example, hard clays often appear dry, but may be saturated even above the water table. However, in soft soils or granular soils, the moisture content can be relevant.

8.7 Unified Symbols

The Unified Soil Classification System symbols should be indicated on the final boring and test pit logs. These symbols are based on soil groupings as shown on Figure 1.

8.8 Definitions of General Geologic Descriptions

Generally, a geologic term, in capital letters, should be applied to major soil units, if appropriate. However, in many cases, there is inadequate information to determine a precise geologic description. In these cases, the term "possible" can be applied (i.e., possible TILL).

As appropriate, specific geologic names such as Lawton Clay can be used. However, when used, there should be sufficient specific geologic evidence of the name designation. If in doubt, do not use specific name or add "possible."

8.8.1 Fill

Material placed by humans.

8.8.2 Peat or Organic Matter

Natural deposit composed primarily of organic matter.

8.8.3 Lacustrine Deposits

Deposited in lakes.

8.8.4 Alluvial Soil

Any soil that has been deposited by a stream. Such soils usually contain some sand and rounded gravel or cobbles.

8.8.5 Till

A nonstratified random mixture of clay, silt, sand, gravel and boulders deposited by glaciers. Alternating layers of clayey till and till containing boulders are possible.

8.8.6 Outwash

A stratified alluvial soil transported and deposited by a glacial meltwater stream.

8.8.7 Loess

A uniform aeolian (wind) deposit of silty material having an open structure and relatively high cohesion due to a clay matrix or cementation by calcareous material at grain contacts. A characteristic of loess deposits is that they display nearly vertical slopes.

8.8.8 Pedogenic Soils

Soils that have formed in place due to decomposition of rock. Shales form residual clays. Limestones form lean brown and fat red clays. Granitic rocks form silty sand with angular sand grains.

8.8.9 Colluvial Soil

A nonstratified mixture of angular sand, gravel and boulder size material accumulated at the foot of a slope or on the slope itself chiefly under the influence of gravity.

8.9 Reaction To Dilute Hydrochloric Acid

Some soils show definite evidence of cementation in the intact state. Where this is noted, the degree of cementation may be described as weak or strong. Since calcium carbonate is the most common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important. The intensity of the HC1 reaction should be described as none (NR), weak (WR), or strong (SR).

8.10 Report Format

The boring logs used in the report should conform to the general format shown on the attached example boring log, Figure 2. In addition to the logs, all reports should include the Classification System as shown in Tables 1 through 6. Some specific comments on the final boring log include:

- ACTUAL BLOW COUNTS: The actual blow count raw data shall be shown on the logs; i.e., blows per six inches.
- UNIFIED SYMBOL: A column will be used to show the Unified Symbol for the soil.
- PENETRATION/RECOVERY: The amount of sample penetration and recovery will be shown on the log.
- COLUMN FOR LAB TESTS: The locations of all lab tests (except for water contents and Atterberg limits which are shown graphically) should be indicated in shorthand as shown on the Sample Log and on Figure 1.

- SOIL CONTACTS: Under "Description" on Figure 2, horizontal solid and dashed lines are used to represent soil contacts. Solid lines represent soil contacts between major units; dashed lines represent gradation contacts within the same major unit. Inclined lines in the "USCS Class" column represent uncertainty of the depth of actual soil contact.

- TYPED: Logs shall be typed and not hand-lettered unless requested by the client.

- PLOTTING OF BLOW COUNTS AND MOISTURE CONTENTS: All logs shall include a disclaimer relating to these plots due to the liability associated with interpretations that could be applied to these graphs.

TABLE 1

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N, Blows/Foot*	Field Identification
Very Loose	0-4	Easily penetrated with shovel handle.
Loose	4-10	Easily penetrated with 1/4-inch steel probe pushed by hand. Easily excavated with hand shovel.
Compact	10-30	Penetrated 6" or less with 1/4-inch steel probe pushed by hand. Difficult to excavate with hand shovel.
Dense	30-50	Penetrated 2" or less with 1/4-inch steel probe pushed by hand. Must be loosened with pick to excavate.
Very Dense	>50	Cannot be penetrated with 1/4-inch steel probe pushed by hand.

*Judgment required if soils contain gravel and cobbles since the "N" value may be unreliable in determining relative density.

TABLE 2

CONSISTENCY OF COHESIVE SOILS

Consistency	N (blows/ft.) (unreliable)	Undrained Shear Strength* (psf)	Field Identification
Very soft	0-2	Less than 250	Extrudes from between fingers when squeezed in hand
Soft	2-4	250-500	Molded by light finger pressure
Firm	4-8	500-1,000	Molded by strong finger pressure
Stiff	8-15	1,000-2,000	Indented by thumb
Very Stiff	15-30	2,000-4,000	Indented by thumbnail
Hard	Greater than 30	Greater than 4,000	Difficult to indent with thumbnail

*Undrained shear strength equals one-half the unconfined compressive strength.

TABLE 3

COMPONENT DEFINITIONS BY GRADATION

Component	Size Range
Boulders Cobbles	Above 12 inches in diameter 3 to 12 inches
Gravel Coarse Gravel Fine Gravel	3 inches to No. 4 (4.76 mm) 3 inches to 3/4 inch 3/4 inches to No. 4 (4.76 mm)
Sand Coarse Sand Medium Sand Fine Sand	No. 4 (4.76 mm) to No. 200 (0.074 mm) No. 4 (4.76 mm) to No. 10 (2.0 mm) No. 10 (2.0 mm) to No. 40 (0.42 mm) No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Finer than No. 200 (0.074 mm)

COMPONENT PROPORTION

Descriptive Term	Range of Proportion
Trace Little Some or Adjective*	0-5% 5-12% 12-30%

*Adjective: silty, sandy, gravelly, etc.

For example: "SILT, some Sand, trace Gravel" describes a basic soil component of silt (30-50 percent), with minor components of sand (12-30 percent), and gravel (0-5%).

TABLE 4

FINE GRAIN DESCRIPTIONS

Descriptive Term	Plastic Index*	Characteristics
SILT	Less than 2	Rapid pronounced response to shaking test, very low cry strength; has almost a granular appearance and feel; thread cannot be rolled or can only be rolled with great difficulty.
CLAYEY SILT	2-15	Noticeable response to shaking and squeezing test, but appreciably less pronounced than for silt; low medium dry strength; slightly sticky, slightly slick and smooth smear; can roll a thread easily.
SILTY CLAY	15-40	No response to shaking and squeezing test; medium to high dry strength; rather sticky when moistened; moderately slick and smooth smear; can roll a thread when moderately dry.
CLAY	Greater than 40	No response to shaking test; high to very high dry strength; slick and waxy, can roll a thread when quite dry.

*Plastic Index: Liquid limit minus plastic limit.

DESCRIPTION BASED ON FIELD TEST FOR PLASTICITY

Thread Diameter	Descriptive Term
1/4-inch	SILT
1/8- to 1/16-inch	CLAYEY SILT
1/32-inch	SILTY CLAY
1/64-inch	CLAY

TABLE 5

SOIL CLASSIFICATION FOR ORGANIC SOILS

Category	Name	Organic Content (% by wt.)	Group Symbols (See Table 3)	Distinguishing Characteristics For Visual Identification	Range of Laboratory Test Values
ORGANIC MATTER	FIBROUS PEAT (woody, mats, etc.)	75 to 100% Organics either visible or inferred	Pt	Light weight, spongy and often elastic at w_n - - shrinks considerably on air drying. Much water squeezes from sample.	w_n -- 500 to 1200% γ – 60 to 70 pcf G – 1.2 to 1.8 $C_c/(1+e_o)=.4+$
	FINE GRAINED PEAT (amorphous)			Light weight, spongy but not often elastic at w_n -- shrinks considerably on air drying. Much water squeeze from sample.	w_n -- 400 to 800% LL -- 400 to 900% PI -- 200 to 500 γ - 60 to 70 pcf G – 1.2 to 1.8 $C_c/(1+e_o)=.35$ to .44
HIGHLY ORGANIC SOILS	Silty Peat	30 to 75% Organics either visible or inferred	Pt	Relatively light weight, spongy. Thread usually weak and spongy near PL Shrinks on air drying; medium dry strength. Usually can squeeze water from sample readily --slow dilatency.	w_n -- 250 to 500% LL -- 250 to 600% PI -- 150 to 350 γ - 65 to 90 pcf G – 1.8 to 2.3 $C_c/(1+e_o)=.3$ to .4
	Sandy Peat			Sand fraction visible. Thread weak and friable near PL; shrinks on air drying; low dry strength. Usually can squeeze water from sample readily--high dilatency--"gritty."	w_n -- 100 to 400% LL -- 150 to 300% (plot below A line) PI -- 50 to 150 γ – 70 to 100 pcf G -- 1.8 to 2.4 $C_c/(1+e_o)=.2$ to .3
ORGANIC SOILS	Clayey ORGANIC SILT	5 to 30% Organics either visible or inferred	OH OL	Often has strong H_2S odor. Thread may be tough depending on clay fraction. Medium dry strength, slow dilatency.	w_n – 65 to 200% LL -- 65 to 150% (usually plot at or near A line) PI -- 50 to 150 γ – 70 to 100 pcf G -- 2.3 to 2.6 $C_c/(1+e_o)=.20$ to .35
	Organic SAND or SILT			Threads weak and friable near PL – or may not roll at all. Low dry strength; medium to high dilatency.	w_n -- 30 to 125% LL -- 30 to 100% (usually plot well below A line) PI – non-plastic to 40 γ – 90 to 110 pcf G -- 2.4 to 2.6 $C_c/(1+e_o)=.1$ to .25
SLIGHTLY ORGANIC SOILS	SOIL FRACTION add slightly Organic	Less than 5% Organics combined visible and inferred	Depend upon inorganic fraction	Depend upon the characteristics of the inorganic fraction.	Depend upon inorganic fractions.

TABLE 6

DESCRIPTION OF SOIL BASED ON OBSERVATION AND TESTS

Typical Name	Description
BOULDERS	Larger than 12 inches in diameter
COBBLES	3 to 12 inches in diameter
GRAVEL	No. 4 sieve to 3 inches in diameter
Coarse to Fine SAND	No. 200 to No. 4 sieve sizes; all particles are visible to the naked eye

	Dilatency Test	Test Tube Test	Plasticity	Dry Strength	Stickiness	Shine Test
fine SAND	rapid	30 sec	none	extremely	none	none
SILT	moderate	50 min	none	very low	none	none
SILT	slow	+50 min	slight	low	none	none
CLAYEY SILT	none	hours	medium	low to high	slight	smooth & dull
SILTY CLAY	none	hours	high	medium to high	moderate to high	moderately slick & smooth
CLAY	none	+24 hours	very high	high to very high	high to very high	slick & waxy
organic SILT	moderate	±50 min	slight to medium	low	none	dull & silky
organic CLAY	none	±24 hrs	medium to high	medium to high	moderate to high	dull, smooth & silky

Unified Soil Classification System

Criteria for Assigning Group Symbols and Names			Soil Classification Generalized Group Descriptions	
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 Sieve	CLEAN GRAVELS Less than 5% fines	GW	Well-graded Gravels
			GP	Poorly-graded gravels
		GRAVELS WITH FINES More than 12% fines	GM	Gravel and Silt Mixtures
			GC	Gravel and Clay Mixtures
	SANDS 50% or more of coarse fraction passes No. 4 Sieve	CLEAN SANDS Less than 5% fines	SW	Well-graded Sands
			SP	Poorly-graded Sands
		SANDS WITH FINES More than 12% fines	SM	Sand and Silt Mixtures
			SC	Sand and Clay Mixtures
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS AND CLAYS Liquid limit less than 50	INORGANIC	CL	Low-plasticity Clays
			ML	Non-plastic and Low-Plasticity Silts
		ORGANIC	OL	Non-plastic and Low-Plasticity Organic Clays Non-plastic and Low-Plasticity Organic Silts
	SILTS AND CLAYS Liquid limit greater than 50	INORGANIC	CH	High-plasticity Clays
			MH	High-plasticity Silts
		ORGANIC	OH	High-plasticity Organic Clays High-plasticity Organic Silts
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat

Relative Density or Consistency Utilizing Standard Penetration Test Values

Cohesionless Soils (a)			Cohesive Soils (b)		
Density (c)	N, blows/ft. (c)	Relative Density (%)	Consistency	N, blows/ft. (c)	Undrained Shear Strength (d) (psf)
Very loose	0 to 4	0 - 15	Very soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250-500
Compact	10 to 30	35 - 65	Firm	4 to 8	500-1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000-2000
Very Dense	over 50	>85	Very Stiff	15 to 30	2000-4000
			Hard	over 30	>4000

(a) Soils consisting of gravel, sand, and silt, either separately or in combination, possessing no characteristics of plasticity, and exhibiting drained behavior.

(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.

(c) Refer to text of ASTM D 1586-84 for a definition of N; in normally consolidated cohesionless soils Relative Density terms are based on N values corrected for overburden pressures.

(d) Undrained shear strength = 1/2 unconfined compression strength.

Descriptive Terminology Denoting Component Proportions

Descriptive Terms	Range of Proportion
Trace	0-5%
Little	5-12%
Some or Adjective (a)	12-30%
And	30-50%

(a) Use Gravelly, Sandy or Silty as appropriate.

Component Definitions by Gradation

Component	Size Range
Boulders	Above 12 in.
Cobbles	3 in. to 12 in.
Gravel	3 in. to No. 4 (4.76mm)
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 (4.76mm)
Sand	No. 4 (4.76mm) to No. 200 (0.074mm)
Coarse sand	No. 4 (4.76mm) to No. 10 (2.0mm)
Medium sand	No. 10 (2.0mm) to No. 40 (0.42mm)
Fine sand	No. 40 (0.42mm) to No. 200 (0.074mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

Samples

SS	SPT Sampler (2.0" OD)
HD	Heavy Duty Split Spoon
SH	Shelby Tube
P	Pitcher Sampler
B	Bulk
C	Cored

Unless otherwise noted, drive samples advanced with 140 lb. hammer with 30 in. drop.

Laboratory Tests

Test	Designation
Moisture	(1)
Density	D
Grain Size	G
Hydrometer	H
Atterberg Limits	(1)
Consolidation	C
Unconfined	U
UU Triax	UU
CU Triax	CU
CD Triax	CD
Permeability	P

(1) Moisture and Atterberg Limits plotted on log.

Silt and Clay Descriptions

Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay	CL
Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

FIGURE 1

SOIL CLASSIFICATION

TP-1.2-6

PROJECT:

RECORD OF BOREHOLE BH-01

SHEET 1 **OF** 2

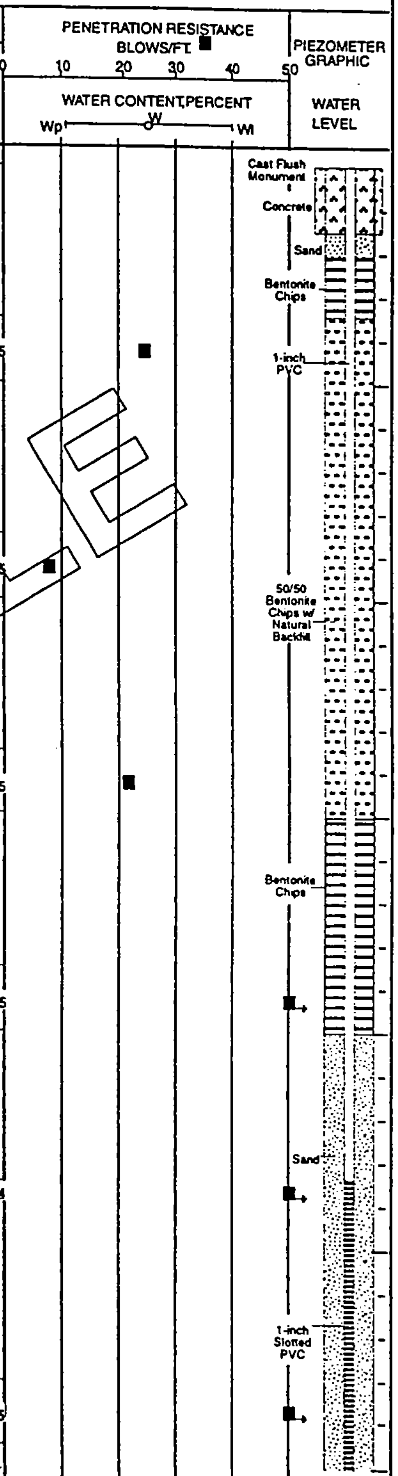
DATUM: MSL

PROJECT NUMBER:

BORING LOCATION:

BORING DATE:

DEPTH FEET	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT
0	4-inch HSA	Loose, brownish black (5R 2/2), unstratified fine SAND and SILT, contains roots and other organics, (OL) (TOPSOIL)	OL	121.0					
		Compact, dark yellowish brown (10YR 4/2), unstratified, fine to coarse SAND and SILT, little to trace fine to coarse Gravel, (SM)	SM	120.5 0.5					
		Loose to very dense, dark yellowish brown (10YR 4/2), unstratifed fine to coarse SAND, some to little fine to coarse Gravel, some to little Silt, (SM) (RECESSIONAL DRIFT - Qvr)	SM	117.0 4.0	1	SS	10-15-11	26	0.5/1.5
5									
					2	SS	4-3-4	7	0.9/1.5
10			SM						
					3	SS	5-7-14	21	0.6/1.5
15									
					4	SS	17-33-27	>50	1.2/1.5
20		Very dense, dark yellowish brown (10YR/4/2), unstratified, fine to coarse SAND and fine to coarse GRAVEL, some to little Cobbles, some to little Silt, trace Boulders, (SM to GM) (RECESSIONAL DRIFT - Qvr)		101.0 20.0					
					5	SS	50/0.4	>50	0.4/0.4
25			SM to GM						
					6	SS	12-31-35	>50	1.1/1.5
30		Log continued on next page							



DRILL RIG:
DRILLING CONTRACTOR:
DRILLER:

LOGGED:
CHECKED:
DATE:

Golder Associates

IP3 1024/RB 1.2-6

FIGURE 2
RECORD OF BOREHOLE FORM

Golder Associates

Technical Procedure

Number: TP-1.2-18
Title: SAMPLING SURFACE SOIL FOR CHEMICAL ANALYSIS

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
9/4/96	9/4/96	9-4-96	9-12-96	-5-

1. PURPOSE

This technical procedure establishes uniform methods for sampling surface soils for chemical analysis.

2. APPLICABILITY

This Technical Procedure shall be used by all Golder Associates Inc. (Golder) personnel sampling surface soils for chemical analysis.

3. DEFINITIONS

3.1 Surface Soil

Surface soil is defined as consolidated soil on the land surface or as exposed by an excavation or boring within twenty (20) feet of the land surface.

3.2 Sampling Interval

The sampling interval is defined as the stratigraphic depth represented by the soil sample.

3.3 In Situ Soils

The term in-situ soils refers to soils as they occur in place within the soil column.

4. REFERENCES

Golder Associates Technical Procedure TP-1.2-23, "Chain of Custody."

Golder Associates Technical Procedure TP-1.1-2, "Geodetic Surveys."

5. DISCUSSION

None

6. RESPONSIBILITIES

6.1 Sampling Technician

The Sampling Technician is responsible for completing the sampling assignment in accordance with this Technical Procedure and governing project plans or instructions.

6.2 Task Leader

The Task Leader is responsible, within the guidelines of governing plans or instructions, for determining which soils shall be sampled and for monitoring the sampling process to ensure that procedures and documentation are in accordance with this document.

6.3 Project Manager

The Project Manager or a qualified designee is responsible for determining the type of chemical analyses to be performed on soil samples, and for defining such requirements to project staff through appropriate plans or instructions.

7. EQUIPMENT AND MATERIALS

- Brunton compass, 0° to 360° divisions;
- site map and clipboard;
- bound field logbook or field report forms (Exhibit A);
- assorted standard field equipment (e.g., hammers, post-hole digger, shovel, hand auger) for exposing soils to be sampled;
- measuring tape;
- engineer's rule (six feet long, with 0.10 foot graduations);
- indelible ink pens;
- two-inch wood stakes and colored flagging material;
- if required, sampling equipment appropriate for soils to be analyzed for non-volatile constituents; all such equipment shall be metal (steel, stainless steel or aluminum) and may include hand augers, hand scoops, sampling thiefs, sampling dredges, core samplers, or sampling triers. If volatile constituents are to be analyzed in the soil samples, sampling equipment shall be designed to minimize exposure to the atmosphere. As an example, a metal drive tube appropriate for the size of the soil particles and slightly smaller in diameter than the wide-mouth glass sample bottles may be used, with appropriate sample extraction accessories;
- sample bottles, sized appropriately for the desired sample and soil particle size;
- Chain of Custody records, seals, and sample labels as required by procedure TP-1.2-23, "Chain of Custody";
- appropriate decontamination solutions such as organic free distilled/deionized water, non-phosphate detergent, tap water;
- decontamination equipment such as brushes and sprayers, and drums or applicable plan or containers for capturing decontamination waste solution; and

- thermometer controlled in accordance with Golder's quality procedure for calibration of measuring and test equipment.

8. PROCEDURE

8.1 Sample Location

Location mapping shall be to the level of detail required by the applicable plan or instructions, and sound engineering and geologic practice. If the base map for the sampling site is of sufficient accuracy, the sample location may be approximated within a 10' radius and physically identified by a wood stake marker. If the base map does not have the required accuracy, locations shall be described by either (1) tape measurement from three permanent features identifiable on the base map; (2) measured along a compass bearing from a permanent feature; or (3) triangulated with compass bearings from three permanent features identifiable on the base map. Compasses may be used only when the site does not contain magnetic or large metal objects. The locations so derived will be identified by a wood stake marker with test pit designation, and recorded as described in Section 8.2. When required by project directive, all location markers will be geodetically surveyed in accordance with TP-1.1-2, "Geodetic Surveys."

8.2 Documentation

Final sample location, sample types and numbers, and relevant sampling events (including on-site personnel and all visitors) shall be recorded on Field Report forms (Exhibit A) or bound field logbooks. Events shall be recorded chronologically, with the time of each event noted.

8.3 Decontamination

All sampling equipment shall be decontaminated prior to the start of sampling activities and between each use. Unless other decontamination procedures are specified in the project plans or instructions, the following steps will be followed. The sampling equipment shall be washed with non-phosphate detergent solution. Brushes shall be used to aid in removing all visible soil or grit. A tap water rinse shall be used to thoroughly remove all detergent solution. The final rinse shall be with organic free distilled/deionized water. All waste wash solutions shall be captured and disposed of in the manner defined by the applicable project plan or instruction, in compliance with applicable regulatory requirements.

8.4 Sampling

The soils to be sampled shall be exposed prior to sample acquisition. If the upper six inches of soils are to be sampled, then surface vegetation shall be removed. If samples are to represent discrete depth intervals below land surface, then overlying soils shall be removed by a shovel, post-hole digger, hand auger, or other appropriate method to the desired interval. For loose watery sediments from stream bottoms, a pond sampler, sampling dredge, pail, or ladle can be used. The sediment sample should be allowed to settle and the extra water decanted prior to transferring samples to containers. For cohesive wet or dry stream-bottom samples, a vertical-pipe, sampling dredge, or core sampler can be used and driven into the stream bed to the selected depth. An in-situ soil sample shall be obtained from the desired sampling interval. If the required analyses do not include volatile constituents, an in-situ soil sample can be obtained using a hand scoop, hand auger, sampling thief, or sampling trier. The soils shall be visually inspected and immediately put into the appropriate sample bottle as required by the governing project plan or instruction. No preservatives shall be added to the sample.

If soils are to be analyzed for volatile constituents, the sample shall be obtained from the desired interval using a drive tube sampler. Contact between the atmosphere and the sample must be minimized; the drive tube sampler shall be driven into the materials with a hammer, and the sample extruded directly into the appropriate sample bottle. An air-tight cap shall be immediately placed on the sample bottle; no preservatives shall be added.

If a backhoe is used to expose sampling intervals for analysis of volatile constituents, a hand auger or drive tube may be used to sample the test pit walls or floor when the test pit is less than four (4) feet deep. If the test pit is greater than four (4) feet, a relatively undisturbed sample may be obtained from the backhoe bucket using a drive tube sampler.

8.5 Composite Samples

If soil sample composites are to be established, equal volumes of individual samples shall be added together for the composite sample. At least three small, equal sized samples from several points within a five foot radius shall be collected. Samples will be placed into a clean, decontaminated stainless steel container and each portion will be stirred together into one composite. The composite sample shall be given an individual sample number, and the sample number of each contributing sample recorded in the field logbook or Field Report form.

8.6 Sample Labeling, Handling, and Shipment

Samples shall be immediately labeled, sealed with a tamper-proof seal and relevant data recorded on individual Chain of Custody forms as required by TP-1.2-23, "Chain of Custody." Samples shall be placed in a chilled cooler at approximately 4° C, ± 2°C, as soon as possible. A thermometer shall be placed in the cooler for temperature monitoring purposes. The cooler shall remain in sight of the Sampling Technician at all times, or be kept in locked storage, as required by TP-1.2-23.

Samples shall be forwarded to the analytical laboratory accompanied by the Chain of Custody record, in compliance with TP-1.2-23 requirements. When samples are ready for shipment, the Task Leader shall release the sample to the carrier, who shall also sign the custody form. The Chain of Custody form is in triplicate. One copy of the form shall be retained by the Task Leader; the original form and the remaining copy shall be shipped with the sample. Upon receipt at the laboratory, the laboratory custodian shall verify the integrity and identification of the sample, sign the form, and return the original copy to the Task Leader or Project Manager. All originals shall be retained in the project records.

8.7 Site Restoration

Any excavation or hole made to obtain samples shall be backfilled with the excess material removed from the hole, unless other requirements are invoked by governing plans or instructions.

8.8 Field Change Request

Variation from established procedure requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established procedures shall be documented on a Field Change Request form (Exhibit B) and reviewed by the Project Manager and the QA Manager.

The Project Manager may authorize individual Field Engineers to initiate variations as necessary. If practical, the request for variation shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the Field Engineer, provided that the Project Manager is notified of the variation within 24 hours of implementation, and the Field Change Request is forwarded to the Project Manager and QA Manager for review within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be reperformed or action shall be taken as indicated in the Comments section of the Field Change Request form.

All completed Field Change Request forms shall be maintained in the project records.

TP1'2'18.RV5

GOLDER ASSOCIATES
4104 148th Avenue NE
Redmond, Washington 98052

(206) 883-0777

DATE	JOB NO
PROJECT	
LOCATION	
CONTRACTOR	OWNER
WEATHER	TEMP °at AM °at PM
PRESENT AT SITE	

TO

THE FOLLOWING WAS NOTED:

COPIES TO

FIELD REPORT

SIGNED

EXHIBIT **A**

FIELD REPORT

TP 1.2-18

PROJECT NO. IP3 1024 DRAWING NO. 48020 DATE 1/18/94 DRAWN BY TK

Golder Associates

FIELD CHANGE REQUEST

Golder Associates

Job/Task Number:

Other Affected Documents:

Requested Change:

Reason for Change:

Change Requested by: Date

Reviewed by: Date
GAI Project Manager

Comments:

Reviewed by: Date
GAI QA Manager

Comments:

EXHIBIT **B**
FIELD CHANGE REQUEST FORM
TP-1.2-18

IP3 1024/65946

Golder Associates Inc.

Golder Associates

Technical Procedure

Number: TP-2.2-12
Title: ANALYTICAL DATA MANAGEMENT

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
S. Sutton-Schuldt		12/16/93	12/30/93	-0-
S. Sutton-Schuldt 3/28/95	3/28/95	3-28-95	3/30/95	-1-

RECORD OF REVISIONS

TP-2.2-12
Revision -1-

Complete procedure revision. Procedure was updated to reflect actual practices in accordance with CAR 94-29.

1. PURPOSE

This technical procedure is to be used to manage analytical data received and processed by personnel assigned the responsibility of data management, data verification and data validation. This procedure details how analytical data in written and electronic format is to be handled, processed and maintained to facilitate incorporation into reports, for numerical evaluation and processing, transmittal to clients and incorporation into project specific database management systems.

2. APPLICABILITY

This technical procedure is applicable when required by project-specific planning documents, or at the direction of the Project Manager, to all Golder Associates Inc. (Golder) personnel and assigned subcontractors for the computerized management of analytical data. The procedures outlined herein are intended to be guidance for the use of a variety of computer-based data management systems.

3. DEFINITIONS

3.1 Analytical Data Management

Analytical data management is the process of receiving and processing analytical data results both in written and electronic format to provide data users with summary information about the data. Summary information may include tabular presentation of the data, summary and trend information about the data and status reports about the data.

3.2 Data User

Data users are the Project and Task Managers responsible for the review and evaluation of analytical data contained in any project-specific analytical data management system.

4. REFERENCES

Golder Associates Inc. Procedure QP-9.1, "Specific Work Instructions"

5. DISCUSSION

Analytical data shall be organized, entered into a database, verified for accuracy, and corrected as necessary. The database shall be updated to include validation results, and all updates shall be documented. Data management activities shall be assigned by Specific Work Instructions (SWIs) in accordance with procedure QP-9.1, "Specific Work Instructions." SWIs shall include references to client-specified validation procedures as applicable. Summary results and updated data reports shall be transmitted to data users at their request. Records associated with the implementation of this procedure shall be managed in accordance with the requirements of the governing Quality Assurance Project

Plan (QAPjP) or Quality Assurance Program Plan (QAPP) or as directed by the Project Manager.

6. RESPONSIBILITIES

6.1 Project Manager

The Golder Project Manager has overall responsibility for coordinating data management activities in compliance with this procedure; for assigning data management activities to properly qualified and trained personnel; for coordinating any corrective action issues with any supporting analytical laboratory or organization providing analytical data and for ensuring that processed analytical data records, reports and supporting documentation are routed to the project QA records system for retention as directed by governing QA program and/or project plans, or the Project Manager.

6.2 Data Manager

The Golder Data Manager is responsible for assignment of task responsibilities to Data Management Specialists under the direction of the Project Manager. The Data Manager shall be responsible for construction and modification of all computer based data management files and for ensuring that said files meet project specific technical and QA requirements as directed by governing QA program and/or project plans, or the Project Manager. The Data Manager shall be responsible for documenting the results of all data management activities, resolving questions, data gaps or errors with analytical data through coordination with the Project Manager and project QA representatives.

6.3 Data Management Specialist

Data Management Specialist (DMS) is responsible for performing all data management activities under the direction of the Data Manager; for processing electronic and hardcopy media in accordance with this procedure and for documenting all processing, checking, updates and corrections to all analytical data.

7. EQUIPMENT AND MATERIALS

Materials and equipment necessary to complete the activities addressed by this procedure include:

- copies of applicable forms from the analytical data packages for processing and any special instructions from the Data Manager or Project Manager with regards to the analytical data.

- lists of the appropriate acronyms and abbreviations of terms to be used in processing the data, entering and updating any database used for processing.

- copies of applicable data processing forms included as attachments to this procedure.
- computer with database software capability and software instruction reference manuals as applicable to the data management requirements.
- office space and office supplies for performance of data management activities.
- sufficient number of properly formatted electronic diskettes for making backup copies of all electronic files generated as part of this procedure for data security and integrity.

8. PROCEDURE

8.1 General Requirements

The Project Manager shall assign a Data Manager for the project. The Data Manager shall, with the concurrence of the Project Manager, assign Data Management Specialists (DMSs) as appropriate for the activities. All work assignments shall be made by SWI in accordance with procedure QP-9.1, "Specific Work Instructions." SWIs shall include reference to applicable portions of client-specified procedures as appropriate. The Data Manager shall provide the DMS with the current copies of applicable project specific data management plans, QAPP/QAPjP, laboratory statements of work, laboratory QAPjPs, work plan analyte lists, analyte detection limit goals and software reference manuals and shall specify the analytes of interest, reference analytical methods, contract required quantitation limits (CRQLs), and contract required detection limits (CRDLs).

The DMS shall complete several tasks on each batch of analytical data or sample delivery group (SDG) or data package. [Note: a SDG shall be defined as a group of samples (usually 20 or fewer) reported within the same laboratory data package]. These tasks are summarized in Sections 8.1.1 and 8.1.2 below. If a backup procedure is not otherwise in effect through network systems a disk backup of each database shall be prepared each day of entry or update.

8.1.1 Data Processing in Support of Environmental Assessment

8.1.1.1 Processing of Hardcopy Analytical Data in Support of Environmental Assessment

The following processing steps shall be completed by the Data Manager or their designee.

- Receive the Data and Assign Batch Identification - Receive the analytical results. Organize and review the analytical results to determine analytical fractions. Batch the result forms and attach a batch tag as provided in Attachment 1, with identifying information completed, and enter the batch into the batch log as provided in Attachment 2.

The following processing steps shall be completed by the Data Management Specialist.

- Construct Database Files - Construct sample, results, and compound database files according to the project requirements. (See Attachment 3 for a suggested format.)

- Enter Data - Enter results and qualifiers into the result database file from the batch of result forms. Enter sample number, sample date, sample location, and additional information, as required for the project, into the sample database file.

- Verify and Inventory - Upon completion of data entry, verify the entries, and complete and initial the batch tag. Forward the batch tag along with an inventory listing of the samples and analytical fractions in the batch to the project file.

- Incorporate - After any required corrections are made, incorporate new records into the database.

- Maintain Files - Maintain a copy of the batch tag and the associated hard copy data for DMS use.

8.1.1.2 Processing of Electronic Analytical Data in Support of Environmental Assessment

The following processing steps shall be completed by the Data Manager or their designee.

- Receive the Data and Assign Batch Identification - Receive electronic disks. Determine fractions contained in files. Attach a batch tag (see Attachment 1) containing identifying information to the disks. Log the batch (see Attachment 2), and submit a copy of the disks (marked with the batch number from the batch tag) and an inventory listing of the files contained on the disks to the project file.

The following steps shall be completed by the Data Management Specialist.

- Construct Database Files - Construct sample, results, and compound database files according to the project requirements. (See Attachment 3 for a suggested format.)

- Convert, Incorporate, and Enter Data - Convert electronic files into database software-compatible format. Incorporate converted data into the database. Enter sample number, sample date, sample location, and additional information, as required for the project, into the sample database file.

- Inventory - Complete and initial the batch tag. Forward the batch tag along with an inventory listing of the samples and analytical fractions in the batch to the project file.

- Maintain Files - Maintain a copy of the batch tag, the inventory listing, and the associated disk for DMS use.

8.1.1.3 Modification of Data in Support of Environmental Assessment

All modifications of data must be documented by submitting a listing of the pre- and post-change records to the project file. The DMS shall also maintain a copy of the listings.

8.1.2 Data Processing in Support of Data Validation

8.1.2.1 Processing of Analytical Data in Support of Data Validation

The following steps shall be taken by the Project Manager or their designee.

- Log and Copy - Log in a personal log, or otherwise track each package for status purposes. Copy the sample results forms, chain-of-custody forms, and case narratives. (Make two copies of the results forms, one for data entry, one for validation.)

- Organize and Review - Organize and review the analytical results to determine the type, analytical fractions, and analyses performed.

The following steps shall be completed by the Data Manager or Data Management Specialist.

- Construct the Database - Construct sample, results, and compound database files according to the format provided in Attachment 3.

- Enter Data - Enter the sample number, form type, form #, lab ID, results, qualifiers, error, MDA, and units into the result database file from the result forms. Enter the sample number, project name, sample date, sample location, data package number, and analytical fraction into the sample database file.

- Log and Verify - Enter the data package number, analytical fraction, and entry date for the sample results into the Data Processing Log provided in Attachment 4, and initial. Verify the entries, and initial the log.

- Modify Data - Based on copies of the modified results forms for the validated data, modify qualifiers in the results database, along with other editorial items as noted on the results forms by the data validator.

- Log and Generate Report - Enter the data package number, the date of modification, and initials into the Data Processing Log (Attachment 4). Generate the data package summary report as shown in Attachment 5, verify the entries, and forward it to the data validator.

8.2 Records Management

Within the context of governing QAPjP or QAPP requirements or as directed by the Project Manager, the DMS(s) shall comply with all records management and document control program requirements to protect all records associated with implementation of this procedure.

8.3 Documentation Requirements

Processing Forms, Logs and Update Forms (see Attachments) shall be completed and attached to the appropriate records for routing to the project files as data management tasks are completed.

8.4 Data Summary Reports

Tabular data summary reports to be included in validation reports shall be routed to the project files as required by governing QAPjP or QAPP, or as directed by the Project Manager.

ATTACHMENT 1

BATCH TAG

PROJECT NUMBER:		DATE:
DATA MANAGEMENT SPECIALIST:		
BATCH NUMBER [FROM BATCH LOG]:		
ELECTRONIC MEDIA		HARDCOPY MEDIA
SOFTWARE:	CLP:	ENTERED (FILENAME):
		VERIFIED:
		CORRECTED:
CONVERTED:		INVENTORIED:
FILENAME:		INCORPORATED:
INCORPORATED:		
INVENTORIED:		
COMMENTS:		

ATTACHMENT 2

BATCH LOG

BATCH #	DATE RECEIVED	FILENAME	DATA TYPE	MEDIA

ATTACHMENT 3

DATABASE FILE FORMATS

FIELD NAME	VALID VALUES	COLUMN	TYPE (SIZE)
DATABASE FILE FORMAT - RESULTS TABLE			
Sample Number	Client or Golder field sample identification number	1 - 12	CHAR(12)
Form Type	CLP, LAS, NCLP	13 - 16	CHAR(4)
Form Number	1A, 1B, 1C, 1D, 1E, 1F, I, NA, R, C	17 - 19	CHAR(3)
Lab Code	Client or Golder Lab Code	20 - 25	CHAR(6)
Constituent ID	Client-specific, CAS numbers, Element symbol and isotope or approved abbreviation	26 - 35	CHAR(10)
Media	BI - biota GW - groundwater SS - surface soil GS - geologic soil SW - surface water AT - air toxics SG - soil gas SL - sludge SE - sediment	36 - 38	CHAR(3)
Value Reported	The result associated with the analysis	39 - 51	NUMBER(13.3)
Concentration Flag	CLP Inorganic form I flag (B, J, R, U, UJ)	52 - 53	CHAR(2)

FIELD NAME	VALID VALUES	COLUMN	TYPE (SIZE)
DATABASE FILE FORMAT - RESULTS TABLE			
Qualifier	The validated result qualifier from the qualifier table, annotated form 1, Q qualifier form CLP organic forms or laboratory forms.	54 - 61	CHAR(8)
Counting Error	A measure of the error in the value reported resulting from equipment variability.	62 - 71	NUMBER(10.3)
MDA	Minimum detectable amount from radio-chemistry results	72 - 81	NUMBER(10.3)
Analysis Units	The reporting units in which the result was originally reported.	82 - 86	CHAR(5)
Changed	Field used for flagging whether record has been changed or not from the original unvalidated Form 1's, valid values are Y for yes, N for no	77 - 78	CHAR(2)

FIELD NAME	VALID VALUES	COLUMN	TYPE (SIZE)
DATABASE FILE FORMAT - SAMPLES TABLE			
Sample Number	Client or Golder field sample identification number	1 - 12	CHAR(12)

FIELD NAME	VALID VALUES	COLUMN	TYPE (SIZE)
DATABASE FILE FORMAT - SAMPLES TABLE			
Data Package ID, Batch or SDG	Client data package ID, data processing batch or laboratory SDG	13 - 32	CHAR(20)
Sample date	Sample collection date	33 - 40	CHAR(8) or DATE format
Location	Sample location or where the sample was collected, sample depth	41 - 55	CHAR(15)
Date package received	Date when data package received from Client or laboratory	56 - 63	CHAR(8) or DATE format
Date validation started	Date when data validation was started on the data package	64 - 71	CHAR(8) or date format
Date validation completed	Date when data validation was completed	72 - 79	CHAR(8) or date format
Date validation report completed	Date when validation report completed and transmitted	80 - 87	CHAR(8) or date format
Comments	Comments concerning the sample or sample type	88 - 127	CHAR(40)

FIELD NAME	VALID VALUES	COLUMN	TYPE(SIZE)
DATABASE FILE FORM - CONSTITUENTS TABLE			
Constituent ID	Client-specific, CAS number, element symbol, element symbol and isotope, approved abbreviation	1 - 10	CHAR(10)
Constituent Name	Client-specific, descriptive name associated with the constituent ID	11 - 50	CHAR(40)
Form Number	1A, 1B, 1C, 1D, 1E, 1F, I, NA, R, C	51 - 53	CHAR(3)
Order	Order in which results appear on the hard-copy form. Used for preparing summary reports.	54 - 60	NUMBER(7)

ATTACHMENT 4

DATA PROCESSING LOG

DATA PROCESSING LOG

DATA PKG ID	PROJECT	DATE ENTERED	FILENAME	DATA TYPE	MEDIA	INITIALS VERIFIED	DATE CORRECTED	INITIALS VERIFIED	COMMENTS

ATTACHMENT 5

EXAMPLE DATA SUMMARY REPORT

Validated Data Summary, Data Package: W0351-QES

	Samp# Date Location Depth Type Comments	BODHM9 12-27-94 699-96-43 --- WATER		BODHN0 12-27-94 699-96-43 --- WATER		BODHN1 12-27-94 699-97-43 --- WATER		BODHN2 12-27-94 699-97-43 --- WATER		BODHN7 12-27-94 699-97-43 --- WATER EQUIPMENT BLANK		BODHN8 12-27-94 699-97-43 --- WATER EQUIPMENT BLANK	
Parameter	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
ALUMINUM	UG/L	30.300	U	30.300	U	30.300	U	30.300	U	42.900	U	30.300	U
ANTIMONY	UG/L	32.800	U	32.800	U	32.800	U	32.800	U	32.800	U	32.800	U
BARIUM	UG/L	41.800	B	43.300	B	40.000	B	40.000	B	2.800	B	16.900	B
BERYLLIUM	UG/L	0.840	U	0.840	U	0.850	U	0.850	U	0.850	U	0.200	U
CALCIUM	UG/L	44600.000		45500.000		44300.000		44100.000		1520.000	B	16100.000	
CADMIUM	UG/L	3.800	U	3.800	U	3.800	U	3.800	U	3.800	U	3.800	U
CHROMIUM	UG/L	160.000		159.000		178.000		169.000		2.900	U	2.900	U
COBALT	UG/L	4.100	U	4.100	U	4.100	U	4.100	U	4.100	U	4.100	U
COPPER	UG/L	5.000	U	5.000	U	5.000	U	5.000	U	12.500	B	7.000	B
IRON	UG/L	15.600	BJ	8.100	U	92.300	BJ	9.600	BJ	19.400	BJ	18.200	BJ
MAGNESIUM	UG/L	12300.000		12500.000		10000.000		9950.000		288.000	B	3620.000	B
MANGANESE	UG/L	0.800	UJ	0.800	UJ	1.600	BJ	0.800	UJ	0.810	BJ	0.800	UJ
NICKEL	UG/L	15.200	U	15.200	U	15.200	U	15.200	U	15.200	U	15.200	U
POTASSIUM	UG/L	5100.000		5210.000		4370.000	B	4310.000	B	2660.000	U	2660.000	U
SILVER	UG/L	5.300	U	5.300	U	5.300	U	5.300	U	5.300	U	5.300	U
SODIUM	UG/L	20800.000		21200.000		22100.000		22100.000		553.000	B	1850.000	
VANADIUM	UG/L	11.300	U	11.300	U	11.300	U	11.300	U	11.300	U	11.300	U
ZINC	UG/L	11.100	U	18.000	B	11.100	U	11.100	U	16.700	B	929.000	

The decimal places shown do not reflect the precision reported by the laboratory

PROCEDURE NO. 4
DECONTAMINATION OF EQUIPMENT

WHEN? Sampling and monitoring equipment should be decontaminated prior to mobilizing to a site, between sampling locations (e.g., test pits or boreholes), between samples (where applicable), and at the conclusion of the day's sampling.

WHY? Appropriate decontamination of equipment should be conducted to: 1) prevent cross-contamination between samples and sampling locations; 2) ensure that results of chemical analysis are reliable and representative; 3) ensure proper functioning of some types of equipment; and 4) protect workers from exposure to potentially hazardous contaminant residues.

HOW? General guidelines for the basic decontamination of equipment are provided in the procedure. Judgment must be used in the selection of appropriate decontamination methods, detergents and solvents; see Table 4-1 for guidelines for basic decontamination. Determine the appropriate method(s) level of effort. For additional guidance, see the recommended readings section at the end of this procedure.

The guidelines include the following:

Essential Information

- ✓ available information on the known or suspected characteristics, location and extent of contamination
- ✓ information pertaining to the field program, including: the type of mechanical equipment and sampling equipment to be used (e.g., excavator or backhoe, drill rig, pump or bailer)
- ✓ details of facilities available at site, including source(s) of and access to potable water, potential water discharge location(s) such as a sanitary sewer, any applicable sewer discharge permits

Equipment

See Table _4 - 1 for Guidance

Several of the following may be required:

- ✓ potable water supply (available on-site or brought in)
- ✓ deionized water
- ✓ distilled water
- ✓ laboratory-grade non-phosphate detergent (e.g., Alconox)
- ✓ paper towels
- ✓ containers (e.g., buckets or drums with lids, or a tank) to collect wash water, if necessary
- ✓ appropriate solvents (e.g., technical grade hexane, acetone, methanol, and/or dilute nitric acid solution)
- ✓ squeeze bottles (for distilled / deionized water)
- ✓ garbage bag
- ✓ bottle brush (appropriate size and length) or other scrub brush
- ✓ pressure washer or steam cleaner (check with drilling contractor re: availability)
- ✓ broom
- ✓ plywood or plastic sheeting
- ✓ several pairs of latex gloves (or other gloves as appropriate; see ***Health and Safety Plan,*** Procedure No. 2)
- ✓ field notebook, pens, pencils
- ✓ any existing decontamination procedures identified as part of the field program

1. Planning and Preparing for Decontamination of Equipment

General Planning:

☐ Review sampling or field program, including decontamination procedures, if available.

☐ Review available information regarding the site characteristics, including type and extent of contamination.

☐ Determine whether a source of potable water is required (e.g., for decontamination or drilling purposes) and whether it is available on-site.

☐ Establish which types of equipment will be used during the field program, including, if applicable:

- soil sampling equipment such as a drill rig (determine the type), excavator, backhoe or bobcat
- water sampling equipment such as submersible pumps or bailers
- groundwater monitoring equipment such as water level probes, interface probes
- sample collection equipment such as split spoon samplers, metal trowels, metal bowls
- miscellaneous equipment such as filtering devices

Potential Substitutions:

☐ Determine whether any economical substitutions might be made to the field program to minimize the need for decontamination. For example, disposable, in-line filters (one-time use only) could be used with WaTerra tubing or submersible pumps, during the collection of groundwater samples, to avoid having to decontaminate a filtering device.

1. Planning and Preparing for Decontamination of Equipment (continued)

☐ Another means of avoiding time-consuming decontamination when sampling monitoring wells is to install dedicated bailers or WaTerra pumps (one in each groundwater monitoring well) especially if several rounds of samples may be collected.

Considerations for Subsurface Investigations:

☐ At drilling or test pitting locations, consider placing plywood or plastic sheeting adjacent to the sampling location to minimize the potential for below-grade contamination by surface material, or for contamination of the ground surface by drill cuttings or excavated material. Cut a hole (large enough to allow the augers or corebarrel through easily) in the middle of the plywood and drill through the hole.

☐ If drilling or test pit excavation is part of the field program, contact the contractor to establish which decontamination equipment will be mobilized on site. Generally, drilling contractors will bring brushes, a supply of clean water, buckets, and a steam cleaner or pressure washer.

☐ Confirm that the drilling or excavation contractor will mobilize equipment that has already been decontaminated. Plan to inspect the equipment for cleanliness prior to commencing the field program.

☐ Determine whether an equipment decontamination area may have to be established on the site (i.e., to collect spray and water generated during cleaning). Such an area may range from a paved area sloping to a sewer catchbasin, to a lined, bermed area designed to contain water for sampling and analysis prior to discharge.

☐ Determine whether a sewer discharge permit (which often specifies discharge limits and sometimes sample collection guidelines) may be required for the disposal of decontamination wash water, or whether such discharges may be prohibited.

1. Planning and Preparing for Decontamination of Equipment (continued)

❏ If wash water must be collected, ensure that appropriate containers (e.g., buckets or drums with lids, or a tank) will be available.

Considerations for Water Sampling:

❏ If possible, plan the timing of the sampling program so that the first samples are collected from the areas expected to have the lowest concentrations of contaminants, and the last samples are collected from the areas expected to have the highest concentrations of contaminants, in order to limit concerns with respect to cross-contamination.

❏ Consider placing sampling equipment, water level probes, sample bottles, lids and filters on clean plywood sheeting or plastic next to the sampling location.

2. Selecting Appropriate Cleaning Methods, Detergents and Solvents

❏ In selecting appropriate decontamination methods, consider the type of soil (if applicable), the characteristics of the known or suspected contaminant(s), and the sample data quality required.

❏ In choosing an appropriate detergent (if applicable), consider the surface to be cleaned, the level of cleanliness and residue removal required, the cleaning method to be used and the performance of the detergent, as follows (based on IGWT, February 1995; see recommended readings):

- Is the detergent likely to be effective for the types of soils being removed?
- Is the detergent designed for the proposed cleaning method? (Compatible with water temperature, manual or machine washing?)
- Is the detergent free-rinsing? (Any remaining residues of concern?)

2. Selecting Appropriate Cleaning Methods, Detergents and Solvents (continued)

- How hazardous is the detergent? (Personal health hazards, alkalinity/acidity, corrosive, reactivity, flammable or volatile solvent?)
- Can the detergent be disposed of easily? (Biodegradable is best)
- How economical is the detergent? (Are the detergents concentrated or do they contain fillers?)

❑ A laboratory-grade, non-phosphate detergent (such as Alconox) is typically used for decontamination purposes.

❑ Solvents such as technical-grade hexane, acetone and/or methanol may be necessary and appropriate if extensive contamination or free product (such as oil or tar) are encountered.

❑ Solvents should be used sparingly and only if necessary, to avoid expense associated with the generation and disposal of large volumes of wash water containing solvents.

❑ In cases where the use of solvents is considered necessary, the equipment should first be scrubbed using water and detergent, followed by a rinse with distilled or potable water. Solvent rinses should then be applied (make sure excess is collected) sequentially, and allowed to evaporate.

❑ The sequence of solvents applied is commonly hexane, followed by acetone and/or methanol; these help dry the equipment and remove any solvent-soluble residues that may remain. The equipment should then by rinsed thoroughly with deionized water.

❑ The following are considered to be basic levels of decontamination. Depending on the characteristics of the contaminant, more intensive decontamination may be necessary.

Table 4-1 Basic Decontamination

Commonly Used Equipment	Minimal Levels of Decontamination
Backhoe, excavator or bobcat bucket	Between test pit excavations, bucket should generally be: I) brushed using a broom or brush to remove loose soil; and/or II) pressure washed or III) steam cleaned
Drill rig augers or core barrel	Between drill holes, augers or core barrel (if applicable) should generally be: I) pressure washed or II) steam cleaned
Split-spoon sampler	Between soil samples, the inside and outside of the sampler should be: I) washed using a brush and bucket of clean water (with detergent if necessary, followed by a rinse with deionized water or II) pressure washed/steam cleaned
Stainless Steel Bailer	Between monitoring wells, the bailer should be: I) scrubbed using an appropriate brush with soapy water (see detergents discussed above) and II) rinsed two to three times with deionized water.
Stainless Steel Bowl and Trowel	Between discrete samples, the trowel and bowl should be: I) scrubbed using an appropriate brush with soapy water and II) rinsed twice with deionized water
Water Level Tape and Probe	Between monitoring well locations, the water level tape and probe should be: I) as a minimum, rinsed with deionized water , e.g., using a squeeze bottle, and wiped using paper towel or II) scrubbed using an appropriate brush and clean water with detergent, followed by two to three rinses with deionized water and wiping with a paper towel.

Table 4-1 Basic Decontamination (continued)

<u>Commonly Used Equipment</u>	<u>Minimal Levels of Decontamination</u>
Oil/Water Interface Probe and Tape	If product is encountered within a monitoring well: I) the probe and tape should be scrubbed using an appropriate brush and soapy water, followed by a three rinses with deionized water. Ensure that the inside of the probe housing does not become contaminated when reeling up the probe. Otherwise, the probe and tape should be: II) rinsed well with deionized water and wiped with a paper towel.
Plastic "Hour-Glass" Filtering Apparatus	Between samples, the filtering apparatus sections should be: I) rinsed with distilled water to remove the soil and sediment II) rinsed with a 10% nitric acid solution <u>and</u> III) rinsed twice with deionized water

3. Implementing Decontamination Procedures During Field Program

❑ Document the selected decontamination procedures and ensure that they are available for reference in the field.

❑ Ensure that any deviations from the established procedures are recorded in the fieldbook, for future reference.

❑ Ensure that containers for the collection of wash water (if necessary) are ready at the sampling location or the decontamination area.

❑ Make sure that all wash water generated is appropriately disposed of or collected in a suitable contained.

❑ If possible and appropriate, separate wash water that is expected to have low concentrations of contaminants and/or solvents from water expected to have high concentrations.

3. Implementing Decontamination Procedures During the Field Program (cont'd)

❑ Ensure that any deviations from the established procedures are recorded in the field notebook, for future reference.

❑ To verify proper decontamination, equipment blanks or "rinsate" blanks can be collected and analyzed for chemical parameters of concern. Select a piece of cleaned sampling equipment and rinse the equipment with deionized water, being sure to collect the rinse water in a sample jar. See ***Quality Control Sample Collection*** (Procedure No. 7) for additional discussion.

==

☞***Recommended Readings:***

"Reduce the Risk of Cross-Contamination". *International Groundwater Technology.* February 1995, pp. 13-15.

☞***See Also:***

Quality Control Sample Collection
Health and Safety Plan

CONTROLLED DOCUMENT

Golder Associates

Quality Procedure

Number: QP-5.1
Title: Document Preparation, Distribution, and Change Control

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
mg Horman	1/27/94	1/28/94	1-31-94	- 0 -

1. PURPOSE

This procedure establishes uniform methods for preparation of technical and quality procedures, and quality plans by Golder Associates Inc. (Golder) personnel. Provisions are also made for the control of the distribution and revision of procedures and plans.

2. APPLICABILITY

The procedures and format described herein are applicable to all Golder technical procedures, quality procedures, and quality plans. Other types of plans (e.g., technical work plans or test plans) may be distributed and revised in accordance with this procedure at the discretion of the QA Manager.

3. DEFINITIONS

3.1 Technical Procedure

A technical procedure is a document that specifies or describes in detail how a technical activity is to be performed. Technical procedures include methods to be employed, equipment or materials to be used, and a planned sequence of operations. Technical procedures are designed to either provide or require a test data sheet, test log, or other work completion records that will provide objective evidence that work was performed in compliance with approved instructions and with appropriate quantitative or qualitative acceptance criteria. To the extent possible, technical procedures shall be written in such a manner as to permit their use on any project. Unique project requirements may be provided for by project-specific addenda to standard procedures, or by modifications written directly into the text of the Specific Work Instructions (SWIs; see procedure QP-9.1, "Specific Work Instructions") governing their use.

3.2 Quality Procedure

A quality procedure is a document that outlines detailed activities required for implementation of a quality program.

3.3 Quality Plan

A quality plan is a program- or project-specific quality planning document that describes the project organization, specifies project quality requirements, and identifies the applicable Golder procedures, national standards, regulatory guides, codes, or other regulations that affect or direct the performance of project activities.

4. RESPONSIBILITIES

4.1 Authors

Authors of technical and quality procedures and quality plans are responsible for obtaining informal reviews from technical or QA staff as appropriate, and for routing procedures and plans through the final review process. Authors are also responsible for resolving all comments resulting from the final review process and for forwarding reviewer comments to the Quality System records.

4.2 QA Manager

The QA Manager is responsible for reviewing and approving all technical and quality procedures, quality plans, and revisions for compliance with applicable requirements prior to submittal for final approval. The QA Manager is also responsible for systematic controlled distribution of all plans and procedures subject to the requirements of this procedure.

4.3 Senior Technical Staff

Senior technical staff with experience appropriate for the discipline involved shall participate in the final review and approval of technical procedures, or procedure revisions which may be necessary for compliance with specific client requirements.

4.4 Managing Principal

The Managing Principal is responsible for performing final review and approval of all quality procedures and revisions.

4.5 Project Manager

The applicable Project Manager is responsible for performing final review and approval of quality plans and revisions.

4.6 Users

Users of procedures and plans are responsible for maintaining all controlled documents issued to them, and for returning the documents when requested. Users are responsible for understanding and implementing the provisions of the distributed procedures and plans, and for participating in training sessions or completing reading training assignments for new and updated procedures and plans.

5. DISCUSSION

Technical procedures, quality procedures, and quality plans shall be prepared, identified, distributed and controlled by the methods and format described in this procedure.

Distribution control requirements may also be applied to other types of work-controlling plans (such as test plans or technical work plans) at the discretion of the QA Manager. Revisions of all procedures and plans require the same level of review and approval as the original documents. The author originating a technical or quality procedure or quality plan is responsible for soliciting internal review comments. The author is responsible for resolving comments and obtaining all required approvals.

6. PROCEDURE

6.1 Document Preparation

6.1.1 Preparation of Technical and Quality Procedures

Current approved versions of Golder technical and quality procedures are maintained, respectively, in the Golder Technical Procedures Manual and Quality Procedures Manual. Technical and quality procedures shall be prepared in accordance with the following guidelines:

- Purpose: Briefly describe the specific purpose of the procedure.
- Applicability: Identify the work activities and/or groups to which the procedure applies.
- Definitions: Define words and phrases having special meaning within the procedure.
- Responsibilities: Identify the organizational positions and responsibilities of the individuals charged with the implementation of the procedure.
- Equipment or materials: For technical procedures only, identify any equipment, materials, or special forms necessary to support the activity described.
- Discussion: Include a brief, general explanation of the use of the procedure.
- Procedure: Describe the specific step-by-step procedure or instructions to be followed. When appropriate, provide a flow chart as an exhibit to enhance user understanding.
- References: List all cited reference documents, such as other related Golder technical or quality procedures, applicable regulatory guidelines, codes, or standards.

The procedure shall contain all information necessary for proper implementation. Such information might include data sources, computer programs to be used, specific QA hold points, documentation requirements, and acceptance, rejection, and/or completion criteria.

Each of the subject headings listed above should be developed to the extent appropriate for the procedure. If no detailed discussion is required, "none" shall be placed under the heading.

The author of the procedure shall determine which groups or individuals may be affected by the procedure and shall obtain informal comments prior to presenting a final draft for review.

6.1.2 Preparation of Quality Plans

The content and format of quality plans shall be in accordance with the contractual quality specifications, and will normally be prepared in compliance with one or more standard quality program guidance documents. If no guidelines for quality plan preparation are specified in the contract, quality plan format shall be as directed by the QA Manager.

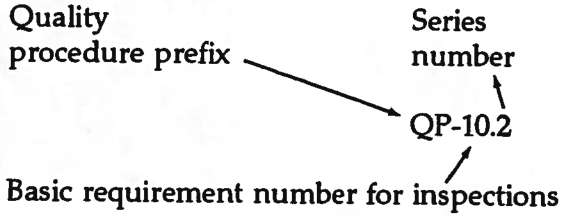
6.2 Document Identification

6.2.1 Identification of Quality Procedures

New quality procedures shall be assigned unique letter-number designators by the QA Manager. The complete letter-number designator for a quality procedure shall include the following:

- The letters "QP"
- The applicable basic requirement number as identified by the QA Manager
- A secondary series number

As an example, the quality procedure for receiving inspection would be as follows:



The first revision of the example quality procedure would be indicated as "QP-10.2, Rev. 1."

6.2.2 Identification of Technical Procedures

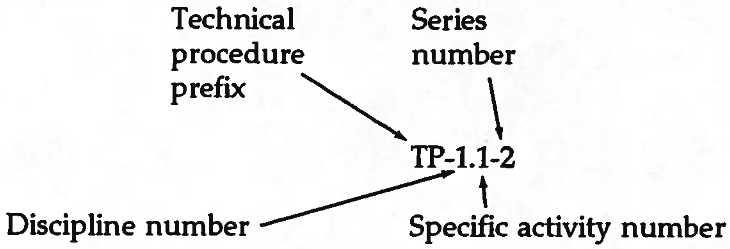
New technical procedures shall be dated and assigned unique letter-number designators by the QA Manager. The letter-number designator for a technical procedure shall include the following:

- The letters "TP"
- The applicable discipline number and specific activity number
- A secondary series number

The following discipline numbers are established for identification of Technical Procedures.

Discipline Description	Number
Field Investigations	1.0
Special Studies	2.0
Laboratory Testing	3.0
(Reserved)	4.0
Data Gathering	5.0
Preparation of Maps or Specialized Graphics	6.0
Geologic Analysis	7.0

Specific activities for each discipline shall be numbered consecutively as technical procedures are written. For example, the second technical procedure written for surveying activities supporting field investigations would be as follows:



The first revision of the example technical procedure would be noted as "TP-1.1-2, Rev. 1."

6.2.3 Identification of Quality Plans

The cover sheet of each quality plan shall include the title of the plan, the revision level, the client, the client contract number, the Golder Associates job number, and approval signatures (see section 6.3.3). No unique document number is required.

6.3 Document Review and Approval

6.3.1 Technical Procedures Review and Approval

The author of a technical procedure shall obtain at least one informal review for technical content by appropriate personnel prior to initiation of the formal review cycle. The author shall then route the procedure to the QA Manager and an appropriate senior technical staff member for review and approval. Subsequent comments shall be resolved by the author to the reviewers' satisfaction. A cover sheet indicating the current revision level shall be routed with the final draft for approval signatures. All review comments made during final review shall be retained in the Quality System records in accordance with QP-16.1, "Quality Assurance Records Management," and shall be identified to the individual reviewer.

6.3.2 Quality Procedure Review and Approval

The author of a quality procedure shall route the procedure to the QA Manager and the Managing Principal for review and approval. Subsequent comments shall be resolved to the reviewers' satisfaction. A cover sheet indicating the current revision level shall be routed with the final draft for approval signatures. Any review comments made during final review shall be retained in the Quality System records in accordance with QP-16.1 and shall be identified to the individual reviewer.

6.3.3 Quality Plan Review and Approval

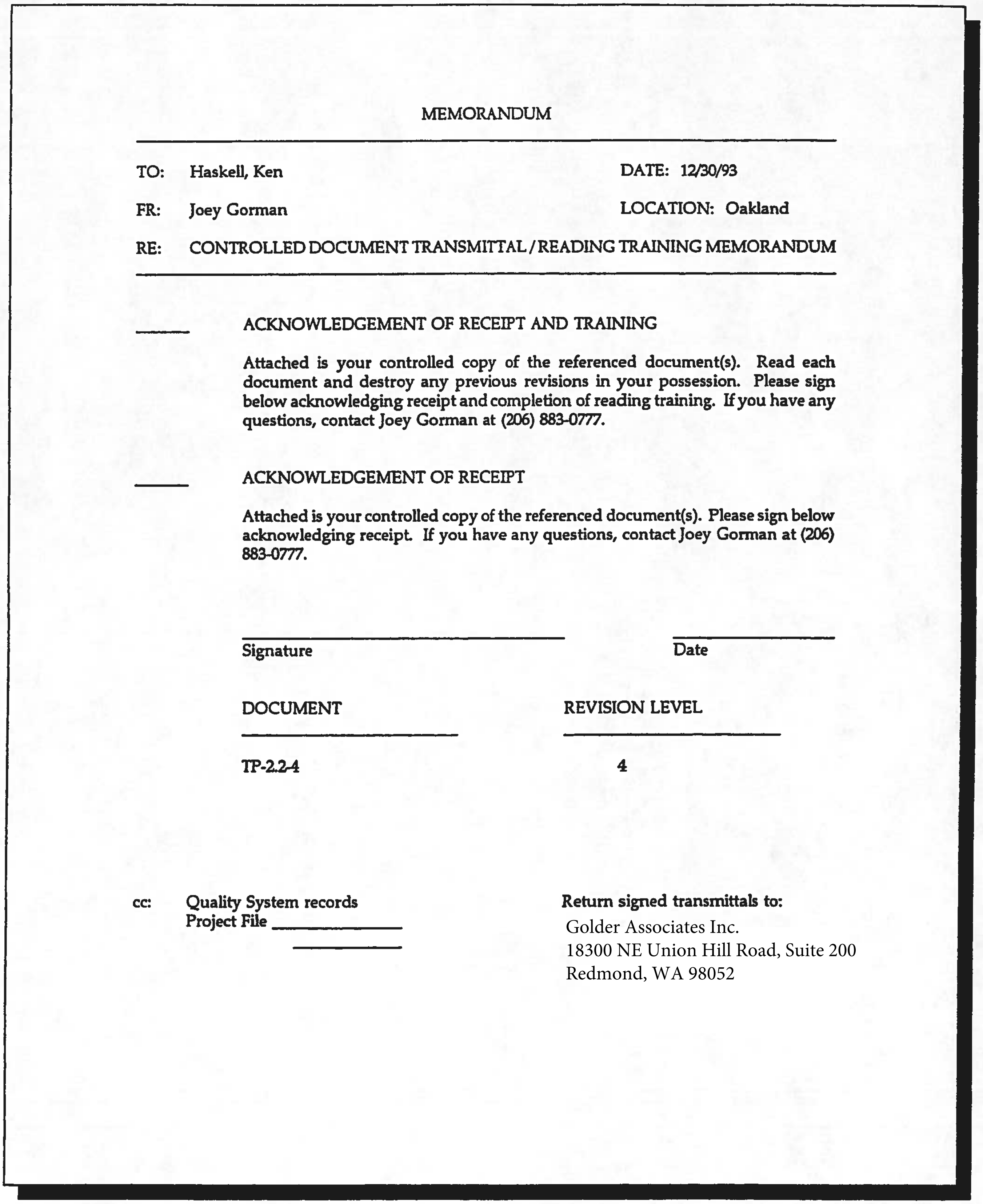
Quality plans shall be reviewed and approved in accordance with the contract quality specifications, or, if no guidelines are specified in the contract, as directed by the QA Manager. At a minimum, however, all quality plans shall be reviewed and approved by the Project Manager and the QA Manager.

6.3.4 Client Approval Considerations

The QA Manager shall determine when client approval of new documents or revisions is required. When client approval is required, the QA Manager shall make the necessary submittals and coordinate resolution of any client comments.

6.4 Distribution

All procedures, quality plans, various technical plans, as required, and subsequent revisions and interim changes, shall be issued either as controlled documents or for information only, as determined by the QA Manager. In all cases, the first page of the issued document shall be marked or stamped to indicate whether it is controlled or for information only. The QA Manager shall supervise distribution of copies of documents to all affected individuals and departments, and shall supervise external distribution to field offices, subcontractors, consultants, or clients. Each controlled document shall be distributed with a controlled document transmittal/reading training memorandum (see the example in Figure 6-1) indicating which document and revision level was issued. The individual receiving the document shall follow the instructions of the checked requirements, sign the memo, and return it to the QA Manager for filing in the Quality System records in accordance with QP-16.1, "Quality Assurance Records Management". Appropriate procedures and plans shall be distributed to personnel prior to the initiation of work. Project Managers shall provide definition of distribution needs when required. All documents shall be returned to the QA Manager upon termination of employment or upon request if there is no longer a requirement for their use.



MEMORANDUM

TO: Haskell, Ken
DATE: 12/30/93
FR: Joey Gorman
LOCATION: Oakland
RE: CONTROLLED DOCUMENT TRANSMITTAL / READING TRAINING MEMORANDUM

______ ACKNOWLEDGEMENT OF RECEIPT AND TRAINING

Attached is your controlled copy of the referenced document(s). Read each document and destroy any previous revisions in your possession. Please sign below acknowledging receipt and completion of reading training. If you have any questions, contact Joey Gorman at (206) 883-0777.

______ ACKNOWLEDGEMENT OF RECEIPT

Attached is your controlled copy of the referenced document(s). Please sign below acknowledging receipt. If you have any questions, contact Joey Gorman at (206) 883-0777.

Signature ____________________ Date __________

DOCUMENT	REVISION LEVEL
TP-2.2-4	4

cc: Quality System records
Project File ____________

Return signed transmittals to:
Golder Associates Inc.
18300 NE Union Hill Road, Suite 200
Redmond, WA 98052

FIGURE **6-1**

CONTROLLED DOCUMENT TRANSMITTAL/ READING TRAINING MEMORANDUM

QP - 5.1

PROJECT NO. IP3 0020.000 DRAWING NO. 48474 DATE 1/19/94 DRAWN BY TB

Golder Associates

6.5 Document Revisions

6.5.1 Technical and Quality Procedure Revisions

All quality procedures currently distributed for project use shall be reviewed on at least an annual basis. Technical procedures shall be reviewed at least biennially. The QA Manager is responsible for coordinating the review of quality and technical procedures. All or portions of any required revision may be delegated by the individual responsible for review. Revised procedures shall be reviewed in the same manner as the previous version per the requirements in Section 6.3. Reviewers shall assess changes that may be required by the latest editions of applicable national standards, regulatory guides, codes or other regulations. Reviewers shall evaluate suggested changes that may have accumulated during the previous year, and incorporate if appropriate.

6.5.2 Plan Revisions

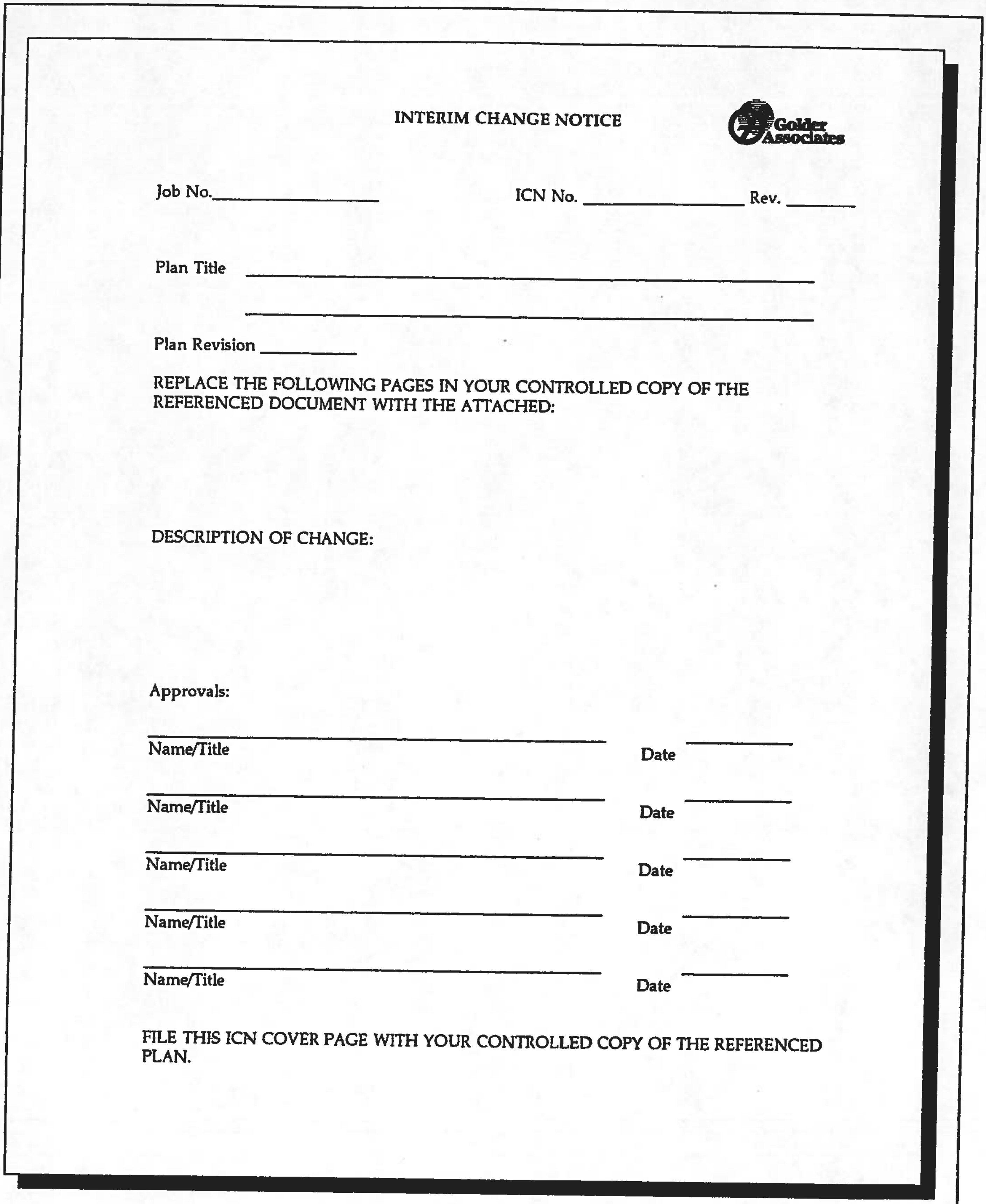
Requirements for periodic quality plan review may be included in each individual plan. At a minimum, however, quality plans shall be revised as necessary to accommodate changes in contract requirements, or changes in applicable standards, regulatory guides, codes, or other regulations. If necessary, quality plans and other technical work plans or test plans controlled by this procedure may be revised on an interim basis. Interim changes to plans shall be documented on an Interim Change Notice (ICN) as shown in Figure 6-2. All ICNs and plan revisions shall be approved in the same manner as the original plan. ICNs shall be numbered sequentially for each plan and shall be clearly identifiable to the associated plan and revision level. Interim changes shall be incorporated into subsequent revisions of plans as appropriate. ICNs shall be listed with the applicable plan on the Master Plan Index (see Section 6.6).

6.5.3 Revision Level Identification

Each page of a revised procedure or plan shall contain the page number, date, and the most current revision number. The revised sentence or paragraph of each page of a revised document shall be indicated with a vertical line in the right hand margin. Revisions shall be numbered and the revision history documented on the record of revisions page of each document. A controlled copy shall be transmitted to each individual or organization on controlled distribution as described in Section 6.4. Records of all previous versions of procedures and plans shall be maintained in the Quality System records in accordance with QP-16.1. All recipients of a revised document shall immediately remove the obsolete document from their personal notebook and destroy it or return it to the QA Manager with the signed document distribution and reading training memorandum.

6.6 Master Procedure and Plan Indexes

Master technical and quality procedure indexes and a master plan index shall be maintained under the supervision of the QA Manager. The procedure indexes shall be retained in the



INTERIM CHANGE NOTICE

Golder Associates

Job No._______________ ICN No. _______________ Rev. _______

Plan Title ____

____

Plan Revision _________

REPLACE THE FOLLOWING PAGES IN YOUR CONTROLLED COPY OF THE REFERENCED DOCUMENT WITH THE ATTACHED:

DESCRIPTION OF CHANGE:

Approvals:

______________________________ Name/Title Date __________

______________________________ Name/Title Date __________

______________________________ Name/Title Date __________

______________________________ Name/Title Date __________

______________________________ Name/Title Date __________

FILE THIS ICN COVER PAGE WITH YOUR CONTROLLED COPY OF THE REFERENCED PLAN.

FIGURE 6-2
INTERM CHANGE NOTICE (ICN)
QP - 5.1

PROJECT NO. IP3 0020.000 DRAWING NO. 48475 DATE 1/7/94 DRAWN BY TB

Golder Associates

Golder Technical Procedures Manual and Quality Procedures Manual, and shall include all active procedures by number and title and the current revision of each. The plan index shall include all active, controlled plans by title, the current revision of each, and all outstanding Interim Change Notices for each plan. The indexes shall be updated with each status change (i.e., updating revisions, adding newly approved documents, or removing documents determined to be obsolete), and shall include the index issue date. Each index may be updated by hand on an interim basis, but shall be formally updated at least quarterly.

7. REFERENCES

- Golder Associates Inc., Procedure QP-16.1, "Quality Assurance Records Management".

Golder Associates

CONTROLLED DOCUMENT

Quality Procedure

Number: **QP-11.1**
Title: **Calibration and Maintenance of Measuring and Test Equipment**

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
	1/31/94	1/31/94	2-1-94	-0-
2-28-94	2/28/94	2/28/94	2-28-94	-1-
6/24/94	6/24/94	6/24/94	6-24-94	-2-
9-6-96	9-6-96		9-12-96	-3-

RECORD OF REVISIONS

QP-11.1
Revision -3-

Section	Description of Revision
Throughout	Changed Managing Principal to Office Manager; minor editorial changes

1. PURPOSE

This procedure defines the system to be used for the calibration, control, and maintenance of measuring and test equipment and in-house calibration standards.

2. APPLICABILITY

This procedure is applicable to all measuring and test equipment used in geotechnical and chemistry laboratory analyses and field investigations that is owned by Golder Associates Inc. (Golder) or, at the direction of the Office Manager, is leased on a long-term basis. Use of personal equipment is prohibited unless it is calibrated and maintained in compliance with this procedure. This procedure does not apply to rented equipment.[1]

3. DEFINITIONS

3.1 Calibration

Calibration is defined as the periodic comparison of an instrument or measurement device to a standard of known and greater accuracy, in order to assure the continuity and accuracy of measurements or data. If no standards meeting the requirements of Section 3.2 exist, then the basis or justification of calibration method must be documented in individual equipment files.

3.2 Calibration Standard

A calibration standard is a device or reference used as a means of comparison for determining quantitatively the accuracy, precision, and repeatability of instruments or measurement devices. Calibration standards must have a traceable, known relationship to nationally recognized standards such as those maintained by the National Institute of Standards and Technology (NIST) or various US Environmental Protection Agency (EPA) standards.

---

[1] Note: Rented equipment shall be supplied with calibration certifications demonstrating currency of calibration for the time period applicable to its use on Golder projects. Such certifications shall be traceable to the serial number of the leased equipment, and the equipment shall be labeled to indicate the next calibration due date.

4. RESPONSIBILITIES

4.1 Laboratory Manager/Equipment Manager

Each Laboratory Manager and/or Equipment Manager is responsible for the implementation of the calibration and maintenance program for all laboratory and field equipment owned by Golder, or, at the direction of the Office Manager, managed by Golder under long-term lease. Detailed responsibilities for implementation include:

- Establishment of an identification system for all laboratory and field equipment meeting the applicability requirements of Section 2; unique serial numbers shall be assigned to each piece of equipment in inventory;
- Assurance of the acceptable calibration status for all equipment, by use of a locator/recall system and, for stored equipment, review of calibration status labels prior to releasing for project work;
- Performance or direction of calibration and maintenance activities for all Golder-controlled instruments and equipment;
- Maintenance and development of a master equipment file, which contains, as applicable for the type of equipment, equipment calibration and maintenance instructions, established calibration intervals, definition of special shipping and handling requirements, and calibration documentation;
- Maintenance of suitable storage facilities and instructions for use and care of laboratory standards, separate from other tools and equipment in the calibrated inventory; and
- Review of all condition-found reports for equipment found to be out of calibration, and for preparation of technical memoranda evaluating the potential effect on measurements made with such instruments over the previous calibration interval.

Activities performed in support of these responsibilities may be delegated to qualified personnel.

4.2 Field or Laboratory Personnel

Equipment users are responsible for verifying acceptable calibration status of all equipment or instrumentation used during a test or analysis, and for returning such equipment to the applicable Laboratory Manager or Equipment Manager, or (for rented equipment) owner, when recalibration or maintenance is required.

4.3 Project Manager

Project Managers are responsible for assuring that the equipment or instrumentation procured for or selected for field or laboratory use on a project (or to implement specific Golder technical procedures) is of sufficient range, accuracy, tolerance, and construction to provide meaningful data or measurements. In addition, the Project Manager is responsible for assuring that all equipment or instrumentation procured for a particular project (or to implement specific Golder technical procedures) is routed through the applicable Laboratory Manager or Equipment Manager for assignment of equipment control numbers, entry of information into individual equipment files, establishment of calibration intervals, and entry into the applicable locator/recall system; and for notifying the Laboratory Manager/Equipment Manager when client calibration needs exceed existing standards and new requirements must be incorporated into the equipment file.

4.4 QA Manager

The QA Manager is responsible for initiating Corrective Action Requests (CARs; see QP-14.1, "Corrective Action") as required to address significantly out-of-tolerance equipment; and, for scheduling periodic internal audits or surveillances to monitor the effectiveness of the calibration program in compliance with QP-10.1, "Surveillance Inspection" or QP-17.1, "Quality Audits."

5. DISCUSSION

Calibration and maintenance of measuring and test equipment is required so that the accuracy and precision of data collected (and, potentially, the calculations based on the data) are known. Calibration should not be construed as the instrument adjustments or accuracy checks commonly performed during or as part of test operations, but rather consists of those systematic, periodic evaluations of instrumentation or equipment that verify performance within specified levels of accuracy, precision, and repeatability. Calibration shall be performed in a clean environment, giving due consideration for dust, relative humidity, temperature, and vibration, as necessary for the equipment being calibrated. Calibration records shall be retained in each laboratory or field equipment storage area. Copies of records specific to certain tests shall be forwarded to project QA records when requested.

6. PROCEDURE

6.1 Equipment Designation and Tagging

The responsible Laboratory Manager or Equipment Manager shall assign unique numerical designators to all measuring and test equipment within their assigned inventories. Designator assignment should be logical based on the type or expected use of the instrument or equipment. If system components can be used in another application, the individual components should be labeled with a unique number. Calibrated equipment shall have a readily visible calibration tag (see Figure 6-1) affixed indicating calibration acceptance, date of last calibration, recall date, initials of the person performing the calibration, and the equipment number. If calibration is performed by an external service, functionally equivalent labels provided by the supplier may be used in lieu of Golder labels. Labels for equipment calibrated with each use shall be marked to indicate "user" or "Golder" in the "calibrated by" blank, and "each use" in the calibration date blank. This requirement does not apply to equipment normally subjected to adjustments or operational checks before use; such adjustment is not considered calibration as defined in Section 3.1. Equipment with expired calibration shall be tagged with a red tag indicating "Out of Service" (see Figure 6-1).

6.2 Calibration Interval

The required calibration interval shall be assigned by the responsible Laboratory Manager or Equipment Manager. In no case shall the calibration interval exceed the maintenance interval. The calibration interval shall be based, as appropriate, on manufacturer's recommendations, the level of projected use, the probable usage environment, and usage history.

6.3 Recall Date

The recall date shall present the date by which the equipment must be withdrawn from service for calibration and/or routine maintenance.

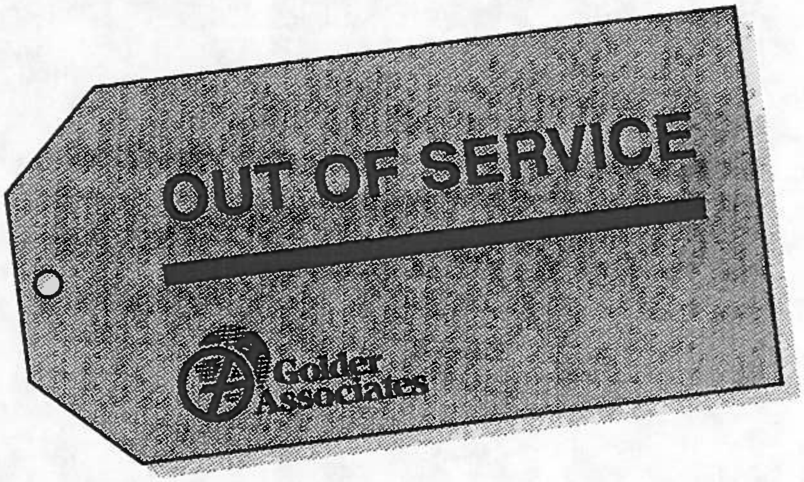
6.4 Equipment File

Each Laboratory Manager or Equipment Manager shall develop and maintain a comprehensive equipment file which contains, by equipment number, specific calibration instructions, original calibration certifications (as applicable), calibration intervals, maintenance instructions, storage requirements, special handling requirements, calibration history (as applicable, including condition-found reports for each calibration), and, if appropriate, reference to the project that it was originally procured against. Any limitations on use shall be specifically defined; laboratory calibration standards shall not be used as measuring or test devices beyond the scope of their calibration functions. Whenever possible, the Laboratory Manager or Equipment Manager shall provide a range of tolerance for the equipment, beyond routine calibration limits but beyond which the technical results obtained with the equipment may be questionable and should therefor prompt a condition-found investigation as described in Section 6.6. Equipment calibration and maintenance requirements shall be summarized on the form provided as Figure 6-2. Final records shall be produced in ink; supporting worksheets and graphs may be prepared in pencil. Use of whiteout or correction tape is prohibited.

6.5 Calibration Sources

Calibration may be performed internally under the direction of the responsible Laboratory Manager or Equipment Manager, or by qualified external sources. Calibration methods shall be as defined for the specific equipment item in the applicable Equipment File. Regardless of whether the calibration is performed internally or by an external source, all

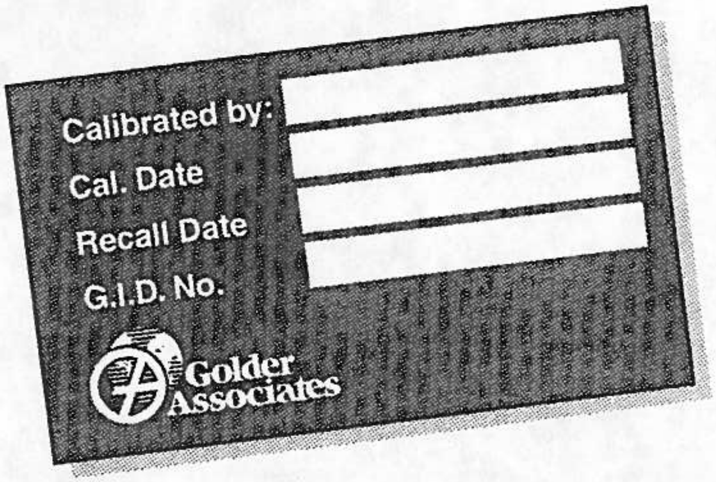
Out of Service Tag



OUT OF SERVICE

Golder Associates

Calibration Label



Calibrated by:

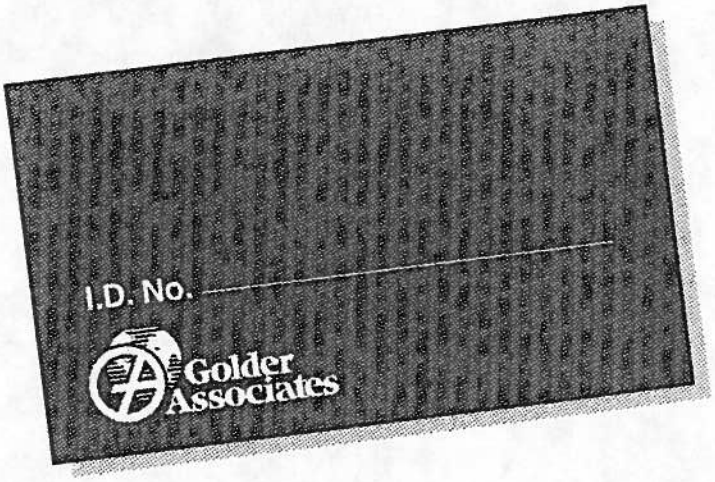
Cal. Date

Recall Date

G.I.D. No.

Golder Associates

Identification Label



I.D. No.

Golder Associates

Note: Tag and labels not to scale

FIGURE 6-1
MEASURING AND TEST EQUIPMENT LABELS
QP-11.1

PROJECT NO. IP3 0020.000 DRAWING NO. 48620 DATE 1/28/94 DRAWN BY CB

EQUIPMENT CALIBRATION/ MAINTENANCE REQUIREMENTS

Golder Associates

Equipment Number: __________

Equipment Name/Model Number: __________

Calibration Interval: __________

Calibration Instructions: __________

Maintenance Interval: __________

Maintenance Instructions: __________

Condition-found Investigation Required Beyond (provide range): __________

Special Storage/Handling Requirements: __________

Golder Associates Inc.

FIGURE **6-2**

EQUIPMENT CALIBRATION/ MAINTENANCE REQUIREMENTS FORM

QP 11.1

PROJECT NO. IP3 0020.000 DRAWING NO. 53110 DATE 6/23/94 DRAWN BY EA

Golder Associates

reference standards shall be traceable to nationally recognized standards. If no standards exist, written justification of the calibration method must be a permanent part of the equipment file. Procurement documents for calibration and maintenance services shall require the source to perform the calibration and maintenance to established procedures with traceability to nationally recognized standards, or to provide appropriate method descriptions and justification if no standards exist. The procurement document shall also require the source to provide a condition-found report and certificates of calibration (and records of maintenance, if a regular maintenance cycle is required) with the equipment when it is returned to Golder. This documentation shall be reviewed by the responsible Laboratory Manager or Equipment Manager for compliance with procurement requirements, prior to accepting the equipment into inventory and subsequent release for project use.

6.6 Condition-Found Report

Records of internal or subcontracted calibrations shall document the as-found calibration status of all equipment. The responsible Laboratory Manager or Equipment Manager shall review the condition-found information so provided to determine if out-of-tolerance conditions existed beyond the permissable range defined by the associated Equipment Calibration/Maintenance Requirements form. If excessive out-of-tolerance conditions are noted, the responsible Laboratory Manager or Equipment Manager shall determine the potential effect of the condition on measurements performed during the previous calibration interval and shall document the results of such determinations by a memo to the equipment file and QA Manager. If significant out-of-tolerance conditions have been identified, the QA Manager shall initiate a CAR, which shall be documented and resolved in compliance with QP 14.1, "Correction Action." See Section 6.10 below.

6.7 Equipment Tracking and Recall System

The Laboratory Manager/Equipment Manager is responsible for the maintenance of a system for controlling the issue of equipment, maintaining visibility of equipment location and calibration due dates, and issue of recall notices for recalibration and maintenance. The system may be maintained manually, or may be computerized, but in either case shall initiate recall activity well in advance of the calibration expiration dates in order for project managers to plan for equipment downtime.

6.8 Storage and Special Handling

Storage requirements shall be as specified by the manufacturer or in accordance with accepted industry practice. Equipment and reference calibration standards shall be used only for their intended purposes. They shall be adequately protected from moisture, dust, atmospheric contamination, and physical damage. Calibrated instruments being shipped or transported to field operations shall be securely packaged to prevent damage or loss of calibration due to shock, vibration, extremes of temperature, or moisture, and shall contain all required user manuals, in protective plastic coverings. Damaged equipment shall be tagged with a red "Out of Service" tag (see Figure 6-1). If the date of equipment damage cannot be determined, the equipment shall be considered out of calibration, and addressed as a nonconformance (see Section 6.10).

6.9 Surveillance Inspections or Audits

At the direction of the QA Manager, surveillance inspections or audits shall be conducted periodically to verify compliance with this procedure, per the requirements of procedures QP-10.1, "Surveillance Inspection" and QP-17.1, "Quality Audits." Frequency shall be as defined by governing QA program plans.

6.10 Calibration-Related Nonconformances and Audit Findings

When use of equipment with expired calibration, no calibration, or damage is observed in a surveillance inspection or audit, the situation shall be documented as a nonconformance, finding, or observation, and resolved in compliance with QP-14.1, "Corrective Action." Resolution shall include a technical evaluation by the responsible Laboratory Manager or Equipment Manager of the validity of test results obtained through the use of the equipment since its last calibration date.

7. REFERENCES

- Golder Associates Quality Procedure QP-14.1, "Corrective Action"
- Golder Associates Quality Procedure QP-17.1, "Quality Audits"
- Golder Associates Quality Procedure QP-10.1, "Surveillance Inspection"

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Golder Associates

CONTROLLED DOCUMENT

Quality Procedure

Number: QP-16.1
Title: Quality Assurance Records Management

Prepared by	Approved by	Approved by	Effective Date	Rev. Level
MgGorman	1/26/94	1/25/94	1-31-94	-0-
MgGorman 2-28-94	2/25/94	2/25/94	2-28-94	-1-
MgGorman 1-31-95	2/1/95	2/1/95	2-20-95 ~~2-1-95~~ 2-7-95	-2-
MgGorman 6-14-95	MgGorman 6-14-95	6/1/95	6-16-95	-3-
MgGorman 2-?-96	MgGorman	5/22/96	7-26-96	-4-

Record of Revisions
QP-16.1
Revision Level -4-

Section	Description of Revision
3.2 3.4 4.7 5. 6.4	Added or updated to address electronic records for all sections noted

Reference ABS QE CAR 30798-B-03

1. PURPOSE

This procedure provides the methodology for the collection, storage, maintenance, retrieval and turnover of Golder Associates Inc. (Golder) Quality Assurance records.

2. APPLICABILITY

This procedure applies to the management of all completed documents that provide evidence of the quality of items or activities affecting quality on projects conducted by Golder personnel.

3. DEFINITIONS

3.1 Quality Assurance Records

Quality Assurance (QA) records are completed, legible documents which furnish objective evidence of the quality of items or services, activities affecting quality, or the completeness and quality of data.

3.1.1 Project QA Records

Project QA records are defined as QA records that are maintained for a specific project. Examples include contractual documents, incoming and outgoing correspondence, project deliverables, technical review documentation, field notes or logbooks, and Specific Work Instructions.

3.1.2 Quality System Records

Quality System records are defined as those QA records which may generally be drawn upon to support the quality program requirements of all projects or the system as a whole. Such records may include quality procedures, technical procedures, personnel training records, audit records, and other records for which QA staff are directly responsible. If a client requires certain types of Quality Systems records as part of project QA records, duplicate records will be provided.

3.1.3 Procurement Records

Procurement Records are those records maintained as evidence of specific procurement activities, such as purchase orders, invoices, receiving inspection documentation, and subcontracts. Such records may be in regard to a specific project or to general office activities.

3.2 Records Index

A records index is an actively updated list of the project QA records, Quality System records, Procurement records, or electronic records which defines the location of the records within the filing system.

3.3 QA Records Center

The QA Records Center is a locking, fire resistant room with controlled access in which project QA records are normally stored.

3.4 Electronic Records

Electronic records are electronic files stored in the computer system which are not represented in either hard copy or electronic form in another of the records systems listed above, but are depended upon for implementation of the quality program. Examples include the Archives Database which lists all records stored in the off-site archives facility and the Document Control Database which tracks controlled distribution of procedures and plans to individuals. Examples of files NOT INCLUDED in this records category are word processing and CAD files, for which a hard copy of the completed document or drawing is included in the Project QA Records.

4. RESPONSIBILITIES

4.1 Project Manager

The Project Manager is responsible for establishing the basic project structure by dividing project activity into individual tasks, and for providing guidance in the design of the project records index based on the resulting task structure.

4.2 Project Secretary

The Project Secretary is responsible for designing the Project Records Index in cooperation with the Records Manager and with guidance from the Project Manager.

4.3 Project Personnel

All project personnel are responsible for submitting completed documents in a timely manner for validation and forwarding to the project QA records.

4.4 QA Manager (or designee)

The QA Manager is responsible for the maintenance of the Quality System records and their associated index.

4.5 Records Manager

The Records Manager is responsible for design of the Project Records Index in cooperation with the Project Secretary, based on guidance from the Project Manager; production and maintenance of the Project Records Index; and for validation, storage, and control of project QA records. Records management activities may be delegated to the records staff.

4.6 Branch Accounting Manager

The Branch Accounting Manager is responsible for maintenance of the Procurement records and their associated index.

4.7 Information Systems Manager

The Information Systems Manager is responsible for the backup of electronic records and for storage of the backup files.

5. DISCUSSION

This procedure addresses Quality Assurance records, which fall into several categories: QA records maintained for a specific project, Quality System records which may be drawn upon to support all project QA programs or the system as a whole, Procurement records and electronic records. A client may require that certain types of Quality System records (e.g., personnel training records, quality plans, or procedures) or Procurement records be included in the project QA records. In such cases, copies will be routed to the project files and handled as original project QA records. Project QA records are reviewed by the Project Secretary and validated by the Records Manager prior to filing. Original project QA records are normally stored under the control of the Records Manager in the QA Records Center. Quality System records are stored in fire-resistant, locking cabinets under the control of the QA Manager. Procurement records are stored in fire-resistant locking cabinets under the control of the Branch Accounting Manager. Access to records is further controlled by a formal checkout system. Electronic records are located in various protected directories as noted on the Electronic Records Index and are backed up regularly.

6. PROCEDURE

6.1 Project QA Records

6.1.1 Project Records Index

At the beginning of each project, a Project Records Index shall be designed which provides the basic structure of the project filing system. The first Index produced identifies the types of records anticipated for the project and assigns a location in the filing system for each type. As the project progresses, the Index shall be updated as appropriate to include increasingly specific information. The Index shall be designed in a cooperative effort by the Project

Secretary and the Records Manager. The Project Manager shall provide guidance in the design of the Index based on the project structure and the division of the project activities into job tasks.

As a minimum, the Project Records Index shall include:

- The Golder job number
- The Project Manager and Records Manager
- The client contract number
- The project title
- A numerical listing of the files
- The title of the file associated with each number. The title shall be specific enough to allow easy retrieval and filing of records.

The Records Manager shall produce the Index and update it on a regular basis.

6.1.2 Collection and Validation

Project personnel who generate documents in support of a project shall submit the completed documents to the Project Secretary.

The Project Secretary shall review each document to ensure that completeness is indicated at the level required by the appropriate quality procedure (e.g., all required signatures are present), legible, identified with the project number, and contains sufficient information to permit identification between the document and the activity to which it applies. If problems are identified, the document may be returned to the preparer for resolution. After ensuring completeness, the Project Secretary shall forward project records to the Records Manager on at least a weekly basis. The Records Manager shall assign a file number to the document based on the Project Records Index and shall validate each document by applying a dated records stamp, or by initialing and dating the document. Validated documents shall be filed in the appropriate location in the project QA records. Completed documents awaiting validation and/or entry into the project QA records shall be temporarily stored during non-working hours in a locking file cabinet, or locking, access-controlled file room.

6.1.3 Storage Requirements

Project QA records are normally stored in the QA Records Center by the Records Manager. However, when acceptable to the QA Manager and the Project Manager, records may be stored in another location which has access controls commensurate with those described in Section 6.1.4 of this procedure. In either case, records shall be stored in a manner which effectively prevents deterioration or damage from natural disasters or environmental conditions. Records shall be stored in binders, folders, or envelopes in metal cabinets or on shelving in containers. Records files shall be organized separately by project and in accordance with the individual Project Records Index. Specially processed records such as photographs, negatives, and magnetic media shall not be stored in stacks and shall be protected from excessive light, electromagnetic fields, and excessive temperatures and humidity, as appropriate for the record type.

6.1.4 QA Records Center Access

Access to the QA Records Center shall be limited to those personnel who have a need for ongoing routine access. The Records Manager shall compile a list of personnel authorized for direct access to the QA Records Center. The list shall be posted outside the Records Center. Other personnel shall be escorted by an authorized individual, or may have access by permission of the Records Manager. The QA Records Center shall remain locked when unattended. The keys shall be held by the Records Manager.

6.1.5 Records Retrieval

Individuals may request that files or individual records be retrieved by the Records Manager for their use. Outcards shall be inserted to replace removed items.

6.1.6 Corrections and Revisions

Records shall be corrected by drawing a single line through the incorrect information and initialing and dating the new entry. Records requiring formal change control [e.g., plans, procedures, Specific Work Instructions (SWIs; see procedure QP-9.1 "Specific Work Instructions")] shall be revised in accordance with applicable procedures. Approval of the revision must be equivalent to the level and/or type of approval required for the original information, or as directed by SWI.

6.1.7 Retention Time

Project QA records for active projects shall be maintained in the project QA records files described in section 6.1.3. At the close of a project, as determined by the Project Manager, project QA records may be transferred to the Golder archives facility. Records shall be stored permanently unless directed otherwise by the client or Golder's General Counsel. Records transferred to the archives shall remain accessible, but shall no longer be subject to the other requirements of this procedure.

6.1.8 Records Turnover

Records shall be turned over to the client at their request. Records which have been turned over are the property of the client and maintenance of those records will no longer be considered the responsibility of Golder Associates.

Records to be turned over to the client shall be packaged securely for shipping. Each package of records shall contain an index of the records in that package and shall be clearly labeled as to client, project number, and total number of packages in the shipment. A set of indexes shall be sent to the client under separate cover. Additional requirements may be specified by the client.

6.2 Quality System Records

6.2.1 Quality System Records Index

The Quality System Records Index shall list and provide the location of the records in the Quality System records files. The QA Manager shall ensure that the index is updated as necessary to reflect changes.

6.2.2 Records Storage Requirements

Quality System records shall be stored in locking, fire-resistant file cabinets. The QA Manager shall maintain control of the keys. QA staff performing records filing functions shall verify the legibility of all documents placed in the file.

6.2.3 Records Access Control and Retrieval

Access to Quality System records shall be limited to personnel requiring ongoing routine access. A list of personnel authorized for direct access to the files shall be posted on each cabinet. Others may gain access by permission of the QA Manager. Individuals may request retrieval of files or individual records for their use from authorized personnel. Outcards shall be inserted in place of removed items.

6.2.4 Quality System Records Transfer

Quality System records meeting the following conditions shall remain in the Quality System records files, and shall be subject to the requirements of this procedure:

- records relative to the current and immediately previous year;
- records relative to the current and immediately previous revision of active documents; and
- records relative to current Golder employees.

At the discretion of the QA Manager, other Quality System records may be removed from the files and transferred to the Golder archives facility. Quality system records shall be stored permanently unless directed otherwise by General Counsel. Transferred records shall remain accessible, but shall no longer be subject to the other requirements of this procedure. Examples of Quality System records that may be transferred to the archives include obsolete plans and procedures, audit and surveillance inspection records from two or more years ago, and training records for terminated employees.

6.3 Procurement Records

6.3.1 Procurement Records Index

The Procurement Records Index shall list and provide the location of the records in the Procurement records files. The Branch Accounting Manager shall ensure that the index is updated as necessary to reflect changes.

6.3.2 Records Storage Requirements

Procurement records shall be stored in locking, fire-resistant file cabinets. The Branch Accounting Manager or designee shall maintain control of the keys. Cost Control staff performing filing functions shall verify the legibility of all documents placed in the file.

6.3.3 Records Access Control and Retrieval

Access to Procurement records shall be limited to personnel requiring ongoing routine access. A list of personnel authorized for direct access to the files shall be posted on each cabinet. Others may gain access by permission of the Branch Accounting Manager. Individuals may request retrieval of files or individual records for their use from authorized personnel. Outcards shall be inserted in place of removed items.

6.3.4 Procurement Records Transfer

Procurement records relative to the current and immediately previous year shall be maintained in the Procurement records files. At the discretion of the Branch Accounting Manager, other Procurement records may be transferred to the Golder archives facility. Records shall be stored permanently unless directed otherwise by General Counsel. Transferred records shall remain accessible, but shall no longer be subject to the other requirements of this procedure.

6.4 Electronic Records

6.4.1 Electronic Records Index

The Electronic Records Index shall list the electronic databases and logs that have been identified as formal records under this procedure. The Index shall include the location of each electronic file in the computer system and the individual responsible for file maintenance. The QA Manager shall ensure that the index is updated as necessary to reflect changes.

6.4.2 Electronic Records Access Control and Backup

Electronic records files shall be maintained in protected, access restricted locations in the computer system. Individuals allowed access to each file shall be determined by the individual responsible for file maintenance as listed on the Electronic Records Index.

The Information Systems Manager shall ensure that electronic records are backed up daily to avoid loss of data due to unforeseen circumstances. Backup files shall be stored on tape or other electronic media in an on-site fire-resistant location, or at an off-site facility.

6.4.3 Electronic Records Transfer

Electronic records that are not applicable to current project activity may be transferred to the Golder archives facility in electronic or hard copy format at any time determined appropriate by the individual responsible for file maintenance. Records shall be stored permanently unless directed otherwise by General Counsel. Transferred records shall remain accessible, but shall no longer be subject to the other requirements of this procedure.

7. REFERENCES

- Golder Associates Procedure QP-9.1, "Specific Work Instructions."

QP16-1.RV4

ATTACHMENT B

USEPA Method 6200 for XRF

METHOD 6200

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the in situ and intrusive analysis of the 26 analytes listed below for soil and sediment samples. Some common elements are not listed in this method because they are considered "light" elements that cannot be detected by field portable x-ray fluorescence (FPXRF). These light elements are: lithium, beryllium, sodium, magnesium, aluminum, silicon, and phosphorus. Most of the analytes listed below are of environmental concern, while a few others have interference effects or change the elemental composition of the matrix, affecting quantitation of the analytes of interest. Generally elements of atomic number 16 or greater can be detected and quantitated by FPXRF. The following RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Antimony (Sb)	7440-36-0
Arsenic (As)	7440-38-0
Barium (Ba)	7440-39-3
Cadmium (Cd)	7440-43-9
Chromium (Cr)	7440-47-3
Cobalt (Co)	7440-48-4
Copper (Cu)	7440-50-8
Lead (Pb)	7439-92-1
Mercury (Hg)	7439-97-6
Nickel (Ni)	7440-02-0
Selenium (Se)	7782-49-2
Silver (Ag)	7440-22-4
Thallium (Tl)	7440-28-0
Tin (Sn)	7440-31-5

Analytes	CAS Registry No.
Vanadium (V)	7440-62-2
Zinc (Zn)	7440-66-6

In addition, the following non-RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Calcium (Ca)	7440-70-2
Iron (Fe)	7439-89-6
Manganese (Mn)	7439-96-5
Molybdenum (Mo)	7439-93-7
Potassium (K)	7440-09-7
Rubidium (Rb)	7440-17-7
Strontium (Sr)	7440-24-6
Thorium (Th)	7440-29-1
Titanium (Ti)	7440-32-6
Zirconium (Zr)	7440-67-7

1.2 This method is a screening method to be used with confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnance atomic absorption spectrometry (GFAA), inductively coupled plasma-atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)). This method’s main strength is that it is a rapid field screening procedure. The method's lower limits of detection are typically above the toxicity characteristic regulatory level for most RCRA analytes. However, when the obtainable values for precision, accuracy, and laboratory-established sensitivity of this method meet project-specific data quality objectives (DQOs), FPXRF is a fast, powerful, cost effective technology for site characterization.

1.3 The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the type of detector used, the type of excitation source, the strength of the excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences. Example lower limits of detection for analytes of interest in environmental applications are shown in Table 1. These limits apply to a clean spiked matrix of quartz sand (silicon dioxide) free of interelement spectral interferences using long (100 -600 second) count times. These sensitivity values are given for guidance only and may not always be achievable, since they will vary depending on the sample matrix, which instrument is used, and operating conditions. A discussion of performance-based sensitivity is presented in Sec. 9.6.

1.4 Analysts should consult the disclaimer statement at the front of the manual and the information in Chapter Two for guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies, and on the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by EPA as guidance to be used by the analyst and the regulated community in making judgments necessary to generate results that meet the data quality objectives for the intended application.

1.5 Use of this method is restricted to use by, or under supervision of, personnel appropriately experienced and trained in the use and operation of an XRF instrument. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

2.1 The FPXRF technologies described in this method use either sealed radioisotope sources or x-ray tubes to irradiate samples with x-rays. When a sample is irradiated with x-rays, the source x-rays may undergo either scattering or absorption by sample atoms. This latter process is known as the photoelectric effect. When an atom absorbs the source x-rays, the incident radiation dislodges electrons from the innermost shells of the atom, creating vacancies. The electron vacancies are filled by electrons cascading in from outer electron shells. Electrons in outer shells have higher energy states than inner shell electrons, and the outer shell electrons give off energy as they cascade down into the inner shell vacancies. This rearrangement of electrons results in emission of x-rays characteristic of the given atom. The emission of x-rays, in this manner, is termed x-ray fluorescence.

Three electron shells are generally involved in emission of x-rays during FPXRF analysis of environmental samples. The three electron shells include the K, L, and M shells. A typical emission pattern, also called an emission spectrum, for a given metal has multiple intensity peaks generated from the emission of K, L, or M shell electrons. The most commonly measured x-ray emissions are from the K and L shells; only metals with an atomic number greater than 57 have measurable M shell emissions.

Each characteristic x-ray line is defined with the letter K, L, or M, which signifies which shell had the original vacancy and by a subscript alpha (α), beta (β), or gamma (γ) etc., which indicates the higher shell from which electrons fell to fill the vacancy and produce the x-ray. For example, a K_α line is produced by a vacancy in the K shell filled by an L shell electron, whereas a K_β line is produced by a vacancy in the K shell filled by an M shell electron. The K_α transition is on average 6 to 7 times more probable than the K_β transition; therefore, the K_α line is approximately 7 times more intense than the K_β line for a given element, making the K_α line the choice for quantitation purposes.

The K lines for a given element are the most energetic lines and are the preferred lines for analysis. For a given atom, the x-rays emitted from L transitions are always less energetic than those emitted from K transitions. Unlike the K lines, the main L emission lines (L_α and L_β) for an element are of nearly equal intensity. The choice of one or the other depends on what interfering element lines might be present. The L emission lines are useful for analyses involving elements of atomic number (Z) 58 (cerium) through 92 (uranium).

An x-ray source can excite characteristic x-rays from an element only if the source energy is greater than the absorption edge energy for the particular line group of the element, that is, the K absorption edge, L absorption edge, or M absorption edge energy. The absorption edge energy is somewhat greater than the corresponding line energy. Actually, the K absorption edge energy is approximately the sum of the K, L, and M line energies of the particular element, and the L absorption edge energy is approximately the sum of the L and M line energies. FPXRF is more sensitive to an element with an absorption edge energy close to but less than the excitation energy of the source. For example, when using a cadmium-109 source, which has an excitation energy of 22.1 kiloelectron volts (keV), FPXRF would exhibit better sensitivity for zirconium which has a K line energy of 15.77 keV than to chromium, which has a K line energy of 5.41 keV.

2.2 Under this method, inorganic analytes of interest are identified and quantitated using a field portable energy-dispersive x-ray fluorescence spectrometer. Radiation from one or more radioisotope sources or an electrically excited x-ray tube is used to generate characteristic x-ray emissions from elements in a sample. Up to three sources may be used to irradiate a sample. Each source emits a specific set of primary x-rays that excite a corresponding range of elements in a sample. When more than one source can excite the element of interest, the source is selected according to its excitation efficiency for the element of interest.

For measurement, the sample is positioned in front of the probe window. This can be done in two manners using FPXRF instruments, specifically, in situ or intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. The sample cup is then placed on top of the window inside a protective cover for analysis.

Sample analysis is then initiated by exposing the sample to primary radiation from the source. Fluorescent and backscattered x-rays from the sample enter through the detector window and are converted into electric pulses in the detector. The detector in FPXRF instruments is usually either a solid-state detector or a gas-filled proportional counter. Within the detector, energies of the characteristic x-rays are converted into a train of electric pulses, the amplitudes of which are linearly proportional to the energy of the x-rays. An electronic multichannel analyzer (MCA) measures the pulse amplitudes, which is the basis of qualitative x-ray analysis. The number of counts at a given energy per unit of time is representative of the element concentration in a sample and is the basis for quantitative analysis. Most FPXRF instruments are menu-driven from software built into the units or from personal computers (PC).

The measurement time of each source is user-selectable. Shorter source measurement times (30 seconds) are generally used for initial screening and hot spot delineation, and longer measurement times (up to 300 seconds) are typically used to meet higher precision and accuracy requirements.

FPXRF instruments can be calibrated using the following methods: internally using fundamental parameters determined by the manufacturer, empirically based on site-specific calibration standards (SSCS), or based on Compton peak ratios. The Compton peak is produced by backscattering of the source radiation. Some FPXRF instruments can be calibrated using multiple methods.

3.0 DEFINITIONS

3.1 FPXRF -- Field portable x-ray fluorescence.

3.2 MCA -- Multichannel analyzer for measuring pulse amplitude.

3.3 SSCS -- Site-specific calibration standards.

3.4 FP -- Fundamental parameter.

3.5 ROI -- Region of interest.

3.6 SRM -- Standard reference material; a standard containing certified amounts of metals in soil or sediment.

3.7 eV -- Electron volt; a unit of energy equivalent to the amount of energy gained by an electron passing through a potential difference of one volt.

3.8 Refer to Chapter One, Chapter Three, and the manufacturer's instructions for other definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 The total method error for FPXRF analysis is defined as the square root of the sum of squares of both instrument precision and user- or application-related error. Generally, instrument precision is the least significant source of error in FPXRF analysis. User- or application-related error is generally more significant and varies with each site and method used. Some sources of interference can be minimized or controlled by the instrument operator, but others cannot. Common sources of user- or application-related error are discussed below.

4.2 Physical matrix effects result from variations in the physical character of the sample. These variations may include such parameters as particle size, uniformity, homogeneity, and surface condition. For example, if any analyte exists in the form of very fine particles in a coarser-grained matrix, the analyte’s concentration measured by the FPXRF will vary depending on how fine particles are distributed within the coarser-grained matrix. If the fine particles "settle" to the bottom of the sample cup (i.e., against the cup window), the analyte concentration measurement will be higher than if the fine particles are not mixed in well and stay on top of the coarser-grained particles in the sample cup. One way to reduce such error is to grind and sieve all soil samples to a uniform particle size thus reducing sample-to-sample particle size variability. Homogeneity is always a concern when dealing with soil samples. Every effort should be made to thoroughly mix and homogenize soil samples before analysis. Field studies have shown heterogeneity of the sample generally has the largest impact on comparability with confirmatory samples.

4.3 Moisture content may affect the accuracy of analysis of soil and sediment sample analyses. When the moisture content is between 5 and 20 percent, the overall error from moisture may be minimal. However, moisture content may be a major source of error when analyzing samples of surface soil or sediment that are saturated with water. This error can be minimized by drying the samples in a convection or toaster oven. Microwave drying is not recommended because field studies have shown that microwave drying can increase variability between FPXRF data and confirmatory analysis and because metal fragments in the sample can cause arcing to occur in a microwave.

4.4 Inconsistent positioning of samples in front of the probe window is a potential source of error because the x-ray signal decreases as the distance from the radioactive source increases. This error is minimized by maintaining the same distance between the window and each sample. For the best results, the window of the probe should be in direct contact with the sample, which means that the sample should be flat and smooth to provide a good contact surface.

4.5 Chemical matrix effects result from differences in the concentrations of interfering elements. These effects occur as either spectral interferences (peak overlaps) or as x-ray absorption and enhancement phenomena. Both effects are common in soils contaminated with heavy metals. As examples of absorption and enhancement effects; iron (Fe) tends to absorb copper (Cu) x-rays, reducing the intensity of the Cu measured by the detector, while chromium (Cr) will be enhanced at the expense of Fe because the absorption edge of Cr is slightly lower in energy than the fluorescent peak of iron. The effects can be corrected mathematically through the use of fundamental parameter (FP) coefficients. The effects also can be compensated for using SSCS, which contain all the elements present on site that can interfere with one another.

4.6 When present in a sample, certain x-ray lines from different elements can be very close in energy and, therefore, can cause interference by producing a severely overlapped spectrum. The degree to which a detector can resolve the two different peaks depends on the energy resolution of the detector. If the energy difference between the two peaks in electron volts is less than the resolution of the detector in electron volts, then the detector will not be able to fully resolve the peaks.

The most common spectrum overlaps involve the K_β line of element Z-1 with the K_α line of element Z. This is called the K_α/K_β interference. Because the $K_\alpha:K_\beta$ intensity ratio for a given element usually is about 7:1, the interfering element, Z-1, must be present at large concentrations to cause a problem. Two examples of this type of spectral interference involve the presence of large concentrations of vanadium (V) when attempting to measure Cr or the presence of large concentrations of Fe when attempting to measure cobalt (Co). The V K_α and K_β energies are 4.95 and 5.43 keV, respectively, and the Cr K_α energy is 5.41 keV. The Fe K_α and K_β energies are 6.40 and 7.06 keV, respectively, and the Co K_α energy is 6.92 keV. The difference between the V K_β and Cr K_α energies is 20 eV, and the difference between the Fe K_β and the Co K_α energies is 140 eV. The resolution of the highest-resolution detectors in FPXRF instruments is 170 eV. Therefore, large amounts of V and Fe will interfere with quantitation of Cr or Co, respectively. The presence of Fe is a frequent problem because it is often found in soils at tens of thousands of parts per million (ppm).

4.7 Other interferences can arise from K/L, K/M, and L/M line overlaps, although these overlaps are less common. Examples of such overlap involve arsenic (As) K_α/lead (Pb) L_α and sulfur (S) K_α/Pb M_α. In the As/Pb case, Pb can be measured from the Pb L_β line, and As can be measured from either the As K_α or the As K_β line; in this way the interference can be corrected. If the As K_β line is used, sensitivity will be decreased by a factor of two to five times because it is a less intense line than the As K_α line. If the As K_α line is used in the presence of Pb, mathematical corrections within the instrument software can be used to subtract out the Pb interference. However, because of the limits of mathematical corrections, As concentrations cannot be efficiently calculated for samples with Pb:As ratios of 10:1 or more. This high ratio of Pb to As may result in reporting of a "nondetect" or a "less than" value (e.g., <300 ppm) for As, regardless of the actual concentration present.

No instrument can fully compensate for this interference. It is important for an operator to understand this limitation of FPXRF instruments and consult with the manufacturer of the FPXRF instrument to evaluate options to minimize this limitation. The operator's decision will be based on action levels for metals in soil established for the site, matrix effects, capabilities of the instrument, data quality objectives, and the ratio of lead to arsenic known to be present at the site. If a site is encountered that contains lead at concentrations greater than ten times the concentration of arsenic it is advisable that all critical soil samples be sent off site for confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnance atomic absorption spectrometry (GFAA), inductively coupled plasma-atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)).

4.8 If SSCS are used to calibrate an FPXRF instrument, the samples collected must be representative of the site under investigation. Representative soil sampling ensures that a sample or group of samples accurately reflects the concentrations of the contaminants of concern at a given time and location. Analytical results for representative samples reflect variations in the presence and concentration ranges of contaminants throughout a site. Variables affecting sample representativeness include differences in soil type, contaminant concentration variability, sample collection and preparation variability, and analytical variability, all of which should be minimized as much as possible.

4.9 Soil physical and chemical effects may be corrected using SSCS that have been analyzed by inductively coupled plasma (ICP) or atomic absorption (AA) methods. However, a major source of error can be introduced if these samples are not representative of the site or if the analytical error is large. Another concern is the type of digestion procedure used to prepare the soil samples for the reference analysis. Analytical results for the confirmatory method will vary depending on whether a partial digestion procedure, such as Method 3050, or a total digestion procedure, such as Method 3052, is used. It is known that depending on the nature of the soil or sediment, Method 3050 will achieve differing extraction efficiencies for different analytes of interest. The confirmatory method should meet the project-specific data quality objectives (DQOs).

XRF measures the total concentration of an element; therefore, to achieve the greatest comparability of this method with the reference method (reduced bias), a total digestion procedure should be used for sample preparation. However, in the study used to generate the performance data for this method (see Table 8), the confirmatory method used was Method 3050, and the FPXRF data compared very well with regression correlation coefficients (r often exceeding 0.95, except for barium and chromium). The critical factor is that the digestion procedure and analytical reference method used should meet the DQOs of the project and match the method used for confirmation analysis.

4.10 Ambient temperature changes can affect the gain of the amplifiers producing instrument drift. Gain or drift is primarily a function of the electronics (amplifier or preamplifier) and not the detector as most instrument detectors are cooled to a constant temperature. Most FPXRF instruments have a built-in automatic gain control. If the automatic gain control is allowed to make periodic adjustments, the instrument will compensate for the influence of temperature changes on its energy scale. If the FPXRF instrument has an automatic gain control function, the operator will not have to adjust the instrument's gain unless an error message appears. If an error message appears, the operator should follow the manufacturer's procedures for troubleshooting the problem. Often, this involves performing a new energy calibration. The performance of an energy calibration check to assess drift is a quality control measure discussed in Sec. 9.2.

If the operator is instructed by the manufacturer to manually conduct a gain check because of increasing or decreasing ambient temperature, it is standard to perform a gain check after every 10 to 20 sample measurements or once an hour whichever is more frequent. It is also suggested that a gain check be performed if the temperature fluctuates more than 10° F. The operator should follow the manufacturer's recommendations for gain check frequency.

5.0 SAFETY

5.1 This method does not address all safety issues associated with its use. The user is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals listed in this method. A reference file of material safety data sheets (MSDSs) should be available to all personnel involved in these analyses.

NOTE: No MSDS applies directly to the radiation-producing instrument because that is covered under the Nuclear Regulatory Commission (NRC) or applicable state regulations.

5.2 Proper training for the safe operation of the instrument and radiation training should be completed by the analyst prior to analysis. Radiation safety for each specific instrument can be found in the operator's manual. Protective shielding should never be removed by the analyst or any personnel other than the manufacturer. The analyst should be aware of the local state and national regulations that pertain to the use of radiation-producing equipment and radioactive materials with which compliance is required. There should be a person appointed within the organization that is solely responsible for properly instructing all personnel, maintaining inspection records, and monitoring x-ray equipment at regular intervals.

Licenses for radioactive materials are of two types, specifically: (1) a general license which is usually initiated by the manufacturer for receiving, acquiring, owning, possessing, using, and transferring radioactive material incorporated in a device or equipment, and (2) a specific license which is issued to named persons for the operation of radioactive instruments as required by local, state, or federal agencies. A copy of the radioactive material license (for specific licenses only) and leak tests should be present with the instrument at all times and available to local and national authorities upon request.

X-ray tubes do not require radioactive material licenses or leak tests, but do require approvals and licenses which vary from state to state. In addition, fail-safe x-ray warning lights should be illuminated whenever an x-ray tube is energized. Provisions listed above concerning radiation safety regulations, shielding, training, and responsible personnel apply to x-ray tubes just as to radioactive sources. In addition, a log of the times and operating conditions should be kept whenever an x-ray tube is energized. An additional hazard present with x-ray tubes is the danger of electric shock from the high voltage supply, however, if the tube is properly positioned within the instrument, this is only a negligible risk. Any instrument (x-ray tube or radioisotope based) is capable of delivering an electric shock from the basic circuitry when the system is inappropriately opened.

5.3 Radiation monitoring equipment should be used with the handling and operation of the instrument. The operator and the surrounding environment should be monitored continually for analyst exposure to radiation. Thermal luminescent detectors (TLD) in the form of badges and rings are used to monitor operator radiation exposure. The TLDs or badges should be worn in the area of maximum exposure. The maximum permissible whole-body dose from occupational exposure is 5 Roentgen Equivalent Man (REM) per year. Possible exposure pathways for radiation to enter the body are ingestion, inhaling, and absorption. The best precaution to prevent radiation exposure is distance and shielding.

6.0 EQUIPMENT AND SUPPLIES

The mention of trade names or commercial products in this manual is for illustrative purposes only, and does not constitute an EPA endorsement or exclusive recommendation for use. The products and instrument settings cited in SW-846 methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

6.1 FPXRF spectrometer -- An FPXRF spectrometer consists of four major components: (1) a source that provides x-rays; (2) a sample presentation device; (3) a detector that converts x-ray-generated photons emitted from the sample into measurable electronic signals; and (4) a data processing unit that contains an emission or fluorescence energy analyzer, such as an MCA, that processes the signals into an x-ray energy spectrum from which elemental concentrations in the sample may be calculated, and a data display and storage system. These components and additional, optional items, are discussed below.

6.1.1 Excitation sources -- FPXRF instruments use either a sealed radioisotope source or an x-ray tube to provide the excitation source. Many FPXRF instruments use sealed radioisotope sources to produce x-rays in order to irradiate samples. The FPXRF instrument may contain between one and three radioisotope sources. Common radioisotope sources used for analysis for metals in soils are iron Fe-55 (^{55}Fe), cadmium Cd-109 (^{109}Cd), americium Am-241 (^{241}Am), and curium Cm-244 (^{244}Cm). These sources may be contained in a probe along with a window and the detector; the probe may be connected to a data reduction and handling system by means of a flexible cable. Alternatively, the sources, window, and detector may be included in the same unit as the data reduction and handling system.

The relative strength of the radioisotope sources is measured in units of millicuries (mCi). All other components of the FPXRF system being equal, the stronger the source, the greater the sensitivity and precision of a given instrument. Radioisotope sources undergo constant decay. In fact, it is this decay process that emits the primary x-rays used to excite samples for FPXRF analysis. The decay of radioisotopes is measured in "half-lives." The half-life of a radioisotope is defined as the length of time required to reduce the radioisotopes strength or activity by half. Developers of FPXRF technologies recommend source replacement at regular intervals based on the source's half-life. This is due to the ever increasing time required for the analysis rather than a decrease in instrument performance. The characteristic x-rays emitted from each of the different sources have energies capable of exciting a certain range of analytes in a sample. Table 2 summarizes the characteristics of four common radioisotope sources.

X-ray tubes have higher radiation output, no intrinsic lifetime limit, produce constant output over their lifetime, and do not have the disposal problems of radioactive sources but are just now appearing in FPXRF instruments. An electrically-excited x-ray tube operates by bombarding an anode with electrons accelerated by a high voltage. The electrons gain an energy in electron volts equal to the accelerating voltage and can excite atomic transitions in the anode, which then produces characteristic x-rays. These characteristic x-rays are emitted through a window which contains the vacuum necessary for the electron acceleration. An important difference between x-ray tubes and radioactive sources is that the electrons which bombard the anode also produce a continuum of x-rays across a broad range of energies in addition to the characteristic x-rays. This continuum is weak compared to the characteristic x-rays but can provide substantial excitation since it covers a broad energy range. It has the undesired property of producing background in the spectrum near the analyte x-ray lines when it is scattered by the sample. For this reason a filter is often used between the x-ray tube and the sample to suppress the continuum radiation while passing the characteristic x-rays from the anode. This filter is sometimes incorporated into the window of the x-ray tube. The choice of accelerating voltage is governed both by the anode material, since the electrons must have sufficient energy to excite the anode, which requires a voltage greater than the absorption edge of the anode material and by the instrument's ability to cool the x-ray tube. The anode is most efficiently excited by voltages 2 to 2.5 times the edge energy (most x-rays per unit power to the tube), although voltages as low as 1.5 times the absorption edge energy will work. The characteristic x-rays emitted by the anode are capable of exciting a range of elements in the sample just as with a radioactive source. Table 3 gives the recommended operating voltages and the sample elements excited for some common anodes.

6.1.2 Sample presentation device -- FPXRF instruments can be operated in two modes: in situ and intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. For FPXRF instruments operated in the intrusive mode, the probe may be rotated so that the window faces either upward or downward. A protective sample cover is placed over the window, and the sample cup is placed on top of the window inside the protective sample cover for analysis.

6.1.3 Detectors -- The detectors in the FPXRF instruments can be either solid-state detectors or gas-filled, proportional counter detectors. Common solid-state detectors include mercuric iodide (HgI_2), silicon pin diode and lithium-drifted silicon Si(Li). The HgI_2 detector is operated at a moderately subambient temperature controlled by a low power thermoelectric cooler. The silicon pin diode detector also is cooled via the thermoelectric Peltier effect. The Si(Li) detector must be cooled to at least -90 °C either with liquid nitrogen or by thermoelectric cooling via the Peltier effect. Instruments with a Si(Li) detector have an internal liquid nitrogen dewar with a capacity of 0.5 to 1.0 L. Proportional counter detectors are rugged and lightweight, which are important features of a field portable detector. However, the resolution of a proportional counter detector is not as good as that of a solid-state detector. The energy resolution of a detector for characteristic x-rays is usually expressed in terms of full width at half-maximum (FWHM) height of the manganese K_α peak at 5.89 keV. The typical resolutions of the above mentioned detectors are as follows: HgI_2-270 eV; silicon pin diode-250 eV; Si(Li)–170 eV; and gas-filled, proportional counter-750 eV.

During operation of a solid-state detector, an x-ray photon strikes a biased, solid-state crystal and loses energy in the crystal by producing electron-hole pairs. The electric charge produced is collected and provides a current pulse that is directly proportional to the energy of the x-ray photon absorbed by the crystal of the detector. A gas-filled, proportional counter detector is an ionization chamber filled with a mixture of noble and other gases. An x-ray photon entering the chamber ionizes the gas atoms. The electric charge produced is collected and provides an electric signal that is directly proportional to the energy of the x-ray photon absorbed by the gas in the detector.

6.1.4 Data processing units -- The key component in the data processing unit of an FPXRF instrument is the MCA. The MCA receives pulses from the detector and sorts them by their amplitudes (energy level). The MCA counts pulses per second to determine the height of the peak in a spectrum, which is indicative of the target analyte's concentration. The spectrum of element peaks are built on the MCA. The MCAs in FPXRF instruments have from 256 to 2,048 channels. The concentrations of target analytes are usually shown in ppm on a liquid crystal display (LCD) in the instrument. FPXRF instruments can store both spectra and from 3,000 to 5,000 sets of numerical analytical results. Most FPXRF instruments are menu-driven from software built into the units or from PCs. Once the data–storage memory of an FPXRF unit is full or at any other time, data can be downloaded by means of an RS-232 port and cable to a PC.

6.2 Spare battery and battery charger.

6.3 Polyethylene sample cups -- 31 to 40 mm in diameter with collar, or equivalent (appropriate for FPXRF instrument).

6.4 X-ray window film -- Mylar^{TM}, Kapton^{TM}, Spectrolene^{TM}, polypropylene, or equivalent; 2.5 to 6.0 µm thick.

6.5 Mortar and pestle -- Glass, agate, or aluminum oxide; for grinding soil and sediment samples.

6.6 Containers -- Glass or plastic to store samples.

6.7 Sieves -- 60-mesh (0.25 mm), stainless-steel, Nylon, or equivalent for preparing soil and sediment samples.

6.8 Trowels -- For smoothing soil surfaces and collecting soil samples.

6.9 Plastic bags -- Used for collection and homogenization of soil samples.

6.10 Drying oven -- Standard convection or toaster oven, for soil and sediment samples that require drying.

7.0 REAGENTS AND STANDARDS

7.1 Reagent grade chemicals must be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 Pure element standards -- Each pure, single-element standard is intended to produce strong characteristic x-ray peaks of the element of interest only. Other elements present must not contribute to the fluorescence spectrum. A set of pure element standards for commonly sought analytes is supplied by the instrument manufacturer, if designated for the instrument; not all instruments require the pure element standards. The standards are used to set the region of interest (ROI) for each element. They also can be used as energy calibration and resolution check samples.

7.3 Site-specific calibration standards -- Instruments that employ fundamental parameters (FP) or similar mathematical models in minimizing matrix effects may not require SSCS. If the FP calibration model is to be optimized or if empirical calibration is necessary, then SSCSs must be collected, prepared, and analyzed.

7.3.1 The SSCS must be representative of the matrix to be analyzed by FPXRF. These samples must be well homogenized. A minimum of 10 samples spanning the concentration ranges of the analytes of interest and of the interfering elements must be obtained from the site. A sample size of 4 to 8 ounces is recommended, and standard glass sampling jars should be used.

7.3.2 Each sample should be oven-dried for 2 to 4 hr at a temperature of less than 150 °C. If mercury is to be analyzed, a separate sample portion should be dried at ambient temperature as heating may volatilize the mercury. When the sample is dry, all large, organic debris and nonrepresentative material, such as twigs, leaves, roots, insects, asphalt, and rock should be removed. The sample should be homogenized (see Sec. 7.3.3) and then a representative portion ground with a mortar and pestle or other mechanical means, prior to passing through a 60-mesh sieve. Only the coarse rock fraction should remain on the screen.

7.3.3 The sample should be homogenized by using a riffle splitter or by placing 150 to 200 g of the dried, sieved sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifted alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times. Approximately 5 g of the sample should then be removed and placed in a sample cup for FPXRF analysis. The rest of the prepared sample should be sent off site for ICP or AA analysis. The method use for confirmatory analysis should meet the data quality objectives of the project.

7.4 Blank samples -- The blank samples should be from a "clean" quartz or silicon dioxide matrix that is free of any analytes at concentrations above the established lower limit of detection. These samples are used to monitor for cross-contamination and laboratory-induced contaminants or interferences.

7.5 Standard reference materials -- Standard reference materials (SRMs) are standards containing certified amounts of metals in soil or sediment. These standards are used for accuracy and performance checks of FPXRF analyses. SRMs can be obtained from the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), the Canadian National Research Council, and the national bureau of standards in foreign nations. Pertinent NIST SRMs for FPXRF analysis include 2704, Buffalo River Sediment; 2709, San Joaquin Soil; and 2710 and 2711, Montana Soil. These SRMs contain soil or sediment from actual sites that has been analyzed using independent inorganic analytical methods by many different laboratories. When these SRMs are unavailable, alternate standards may be used (e.g., NIST 2702).

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

Sample handling and preservation procedures used in FPXRF analyses should follow the guidelines in Chapter Three, "Inorganic Analytes."

9.0 QUALITY CONTROL

9.1 Follow the manufacturer’s instructions for the quality control procedures specific to use of the testing product. Refer to Chapter One for additional guidance on quality assurance (QA) and quality control (QC) protocols. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Quality Assurance Project Plan (QAPP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those that will implement the project and assess the results.

9.2 Energy calibration check -- To determine whether an FPXRF instrument is operating within resolution and stability tolerances, an energy calibration check should be run. The energy calibration check determines whether the characteristic x-ray lines are shifting, which would indicate drift within the instrument. As discussed in Sec. 4.10, this check also serves as a gain check in the event that ambient temperatures are fluctuating greatly (more than 10 °F).

9.2.1 The energy calibration check should be run at a frequency consistent with manufacturer’s recommendations. Generally, this would be at the beginning of each working day, after the batteries are changed or the instrument is shut off, at the end of each working day, and at any other time when the instrument operator believes that drift is occurring during analysis. A pure element such as iron, manganese, copper, or lead is often used for the energy calibration check. A manufacturer-recommended count time per source should be used for the check.

9.2.2 The instrument manufacturer’s manual specifies the channel or kiloelectron volt level at which a pure element peak should appear and the expected intensity of the peak. The intensity and channel number of the pure element as measured using the source should be checked and compared to the manufacturer's recommendation. If the energy calibration check does not meet the manufacturer's criteria, then the pure element sample should be repositioned and reanalyzed. If the criteria are still not met, then an energy calibration should be performed as described in the manufacturer's manual. With some FPXRF instruments, once a spectrum is acquired from the energy calibration check, the peak can be optimized and realigned to the manufacturer's specifications using their software.

9.3 Blank samples -- Two types of blank samples should be analyzed for FPXRF analysis, specifically, instrument blanks and method blanks.

9.3.1 An instrument blank is used to verify that no contamination exists in the spectrometer or on the probe window. The instrument blank can be silicon dioxide, a polytetraflurorethylene (PTFE) block, a quartz block, "clean" sand, or lithium carbonate. This instrument blank should be analyzed on each working day before and after analyses are conducted and once per every twenty samples. An instrument blank should also be analyzed whenever contamination is suspected by the analyst. The frequency of analysis will vary with the data quality objectives of the project. A manufacturer-recommended count time per source should be used for the blank analysis. No element concentrations above the established lower limit of detection should be found in the instrument blank. If concentrations exceed these limits, then the probe window and the check sample should be checked for contamination. If contamination is not a problem, then the instrument must be "zeroed" by following the manufacturer's instructions.

9.3.2 A method blank is used to monitor for laboratory-induced contaminants or interferences. The method blank can be "clean" silica sand or lithium carbonate that undergoes the same preparation procedure as the samples. A method blank must be analyzed at least daily. The frequency of analysis will depend on the data quality objectives of the project. If the method blank does not contain the target analyte at a level that interferes with the project-specific data quality objectives then the method blank would be considered acceptable. In the absence of project-specific data quality objectives, if the blank is less than the lowest level of detection or less than 10% of the lowest sample concentration for the analyte, whichever is greater, then the method blank would be considered acceptable. If the method blank cannot be considered acceptable, the cause of the problem must be identified, and all samples analyzed with the method blank must be reanalyzed.

9.4 Calibration verification checks -- A calibration verification check sample is used to check the accuracy of the instrument and to assess the stability and consistency of the analysis for the analytes of interest. A check sample should be analyzed at the beginning of each working day, during active sample analyses, and at the end of each working day. The frequency of calibration checks during active analysis will depend on the data quality objectives of the project. The check sample should be a well characterized soil sample from the site that is representative of site samples in terms of particle size and degree of homogeneity and that contains contaminants at concentrations near the action levels. If a site-specific sample is not available, then an NIST or other SRM that contains the analytes of interest can be used to verify the accuracy of the instrument. The measured value for each target analyte should be within ±20 percent (%D) of the true value for the calibration verification check to be acceptable. If a measured value falls outside this range, then the check sample should be reanalyzed. If the value continues to fall outside the acceptance range, the instrument should be recalibrated, and the batch of samples analyzed before the unacceptable calibration verification check must be reanalyzed.

9.5 Precision measurements -- The precision of the method is monitored by analyzing a sample with low, moderate, or high concentrations of target analytes. The frequency of precision measurements will depend on the data quality objectives for the data. A minimum of one precision sample should be run per day. Each precision sample should be analyzed 7 times in replicate. It is recommended that precision measurements be obtained for samples with varying concentration ranges to assess the effect of concentration on method precision. Determining method precision for analytes at concentrations near the site action levels can be extremely important if the FPXRF results are to be used in an enforcement action; therefore, selection of at least one sample with target analyte concentrations at or near the site action levels or levels of concern is recommended. A precision sample is analyzed by the instrument for the same field analysis time as used for other project samples. The relative standard deviation (RSD) of the sample mean is used to assess method precision. For FPXRF data to be considered adequately precise, the RSD should not be greater than 20 percent with the exception of chromium. RSD values for chromium should not be greater than 30 percent. If both in situ and intrusive analytical techniques are used during the course of one day, it is recommended that separate precision calculations be performed for each analysis type.

The equation for calculating RSD is as follows:

$$\text{RSD} = (\text{SD}/\text{Mean Concentration}) \times 100$$

where:

RSD = Relative standard deviation for the precision measurement for the analyte
SD = Standard deviation of the concentration for the analyte
Mean concentration = Mean concentration for the analyte

The precision or reproducibility of a measurement will improve with increasing count time, however, increasing the count time by a factor of 4 will provide only 2 times better precision, so there is a point of diminishing return. Increasing the count time also improves the sensitivity, but decreases sample throughput.

9.6 The lower limits of detection should be established from actual measured performance based on spike recoveries in the matrix of concern or from acceptable method performance on a certified reference material of the appropriate matrix and within the appropriate calibration range for the application. This is considered the best estimate of the true method sensitivity as opposed to a statistical determination based on the standard deviation of replicate analyses of a low-concentration sample. While the statistical approach demonstrates the potential data variability for a given sample matrix at one point in time, it does not represent what can be detected or most importantly the lowest concentration that can be calibrated. For this reason the sensitivity should be established as the lowest point of detection based on acceptable target analyte recovery in the desired sample matrix.

9.7 Confirmatory samples -- The comparability of the FPXRF analysis is determined by submitting FPXRF-analyzed samples for analysis at a laboratory. The method of confirmatory analysis must meet the project and XRF measurement data quality objectives. The confirmatory samples must be splits of the well homogenized sample material. In some cases the prepared sample cups can be submitted. A minimum of 1 sample for each 20 FPXRF-analyzed samples should be submitted for confirmatory analysis. This frequency will depend on project-specific data quality objectives. The confirmatory analyses can also be used to verify the quality of the FPXRF data. The confirmatory samples should be selected from the lower, middle, and upper range of concentrations measured by the FPXRF. They should also include samples with analyte concentrations at or near the site action levels. The results of the confirmatory analysis and FPXRF analyses should be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data should be log-transformed to standardize variance which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the FPXRF data to be considered screening level data. If the r is 0.9 or greater and inferential statistics indicate the FPXRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data could potentially meet definitive level data criteria.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Instrument calibration -- Instrument calibration procedures vary among FPXRF instruments. Users of this method should follow the calibration procedures outlined in the operator's manual for each specific FPXRF instrument. Generally, however, three types of calibration procedures exist for FPXRF instruments, namely: FP calibration, empirical calibration, and the Compton peak ratio or normalization method. These three types of calibration are discussed below.

10.2 Fundamental parameters calibration -- FP calibration procedures are extremely variable. An FP calibration provides the analyst with a "standardless" calibration. The advantages of FP calibrations over empirical calibrations include the following:

- No previously collected site-specific samples are necessary, although site-specific samples with confirmed and validated analytical results for all elements present could be used.

- Cost is reduced because fewer confirmatory laboratory results or calibration standards are necessary.

However, the analyst should be aware of the limitations imposed on FP calibration by particle size and matrix effects. These limitations can be minimized by adhering to the preparation procedure described in Sec. 7.3. The two FP calibration processes discussed below are based on an effective energy FP routine and a back scatter with FP (BFP) routine. Each FPXRF FP calibration process is based on a different iterative algorithmic method. The calibration procedure for each routine is explained in detail in the manufacturer's user manual for each FPXRF instrument; in addition, training courses are offered for each instrument.

10.2.1 Effective energy FP calibration -- The effective energy FP calibration is performed by the manufacturer before an instrument is sent to the analyst. Although SSCS can be used, the calibration relies on pure element standards or SRMs such as those obtained from NIST for the FP calibration. The effective energy routine relies on the spectrometer response to pure elements and FP iterative algorithms to compensate for various matrix effects.

Alpha coefficients are calculated using a variation of the Sherman equation, which calculates theoretical intensities from the measurement of pure element samples. These coefficients indicate the quantitative effect of each matrix element on an analyte's measured x-ray intensity. Next, the Lachance Traill algorithm is solved as a set of simultaneous equations based on the theoretical intensities. The alpha coefficients are then downloaded into the specific instrument.

The working effective energy FP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of sampling. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. A manufacturer-recommended count time per source should be used for the calibration check. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A percent difference (%D) is then calculated for each target analyte. The %D should be within ±20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line or the y-intercept value for the analyte. The SRM or SSCS is reanalyzed until the %D falls within ±20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

The equation to calibrate %D is as follows:

$$\%D = ((C_s - C_k) / C_k) \times 100$$

where:

%D = Percent difference
C_k = Certified concentration of standard sample
C_s = Measured concentration of standard sample

10.2.2 BFP calibration -- BFP calibration relies on the ability of the liquid nitrogen-cooled, Si(Li) solid-state detector to separate the coherent (Compton) and incoherent (Rayleigh) backscatter peaks of primary radiation. These peak intensities are known to be a function of sample composition, and the ratio of the Compton to Rayleigh peak is a function of the mass absorption of the sample. The calibration procedure is explained in detail in the instrument manufacturer's manual. Following is a general description of the BFP calibration procedure.

The concentrations of all detected and quantified elements are entered into the computer software system. Certified element results for an NIST SRM or confirmed and validated results for an SSCS can be used. In addition, the concentrations of oxygen and silicon must be entered; these two concentrations are not found in standard metals analyses. The manufacturer provides silicon and oxygen concentrations for typical soil types. Pure element standards are then analyzed using a manufacturer-recommended count time per source. The results are used to calculate correction factors in order to adjust for spectrum overlap of elements.

The working BFP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of the analysis. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. The standard sample is analyzed using a manufacturer-recommended count time per source to check the calibration curve. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A %D is then calculated for each target analyte. The %D should fall within ±20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line the y-intercept value for the analyte. The standard sample is reanalyzed until the %D falls within ±20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

10.3 Empirical calibration -- An empirical calibration can be performed with SSCS, site-typical standards, or standards prepared from metal oxides. A discussion of SSCS is included in Sec. 7.3; if no previously characterized samples exist for a specific site, site-typical standards can be used. Site-typical standards may be selected from commercially available characterized soils or from SSCS prepared for another site. The site-typical standards should closely approximate the site's soil matrix with respect to particle size distribution, mineralogy, and contaminant analytes. If neither SSCS nor site-typical standards are available, it is possible to make gravimetric standards by adding metal oxides to a "clean" sand or silicon dioxide matrix that simulates soil. Metal oxides can be purchased from various chemical vendors. If standards are made on site, a balance capable of weighing items to at least two decimal places is necessary. Concentrated ICP or AA standard solutions can also be used to make standards. These solutions are available in concentrations of 10,000 parts per million, thus only small volumes have to be added to the soil.

An empirical calibration using SSCS involves analysis of SSCS by the FPXRF instrument and by a conventional analytical method such as ICP or AA. A total acid digestion procedure should be used by the laboratory for sample preparation. Generally, a minimum of 10 and a maximum of 30 well characterized SSCS, site-typical standards, or prepared metal oxide standards are necessary to perform an adequate empirical calibration. The exact number of standards depends on the number of analytes of interest and interfering elements. Theoretically, an empirical calibration with SSCS should provide the most accurate data for a site because the calibration compensates for site-specific matrix effects.

The first step in an empirical calibration is to analyze the pure element standards for the elements of interest. This enables the instrument to set channel limits for each element for spectral deconvolution. Next the SSCS, site-typical standards, or prepared metal oxide standards are analyzed using a count time of 200 seconds per source or a count time recommended by the manufacturer. This will produce a spectrum and net intensity of each analyte in each standard. The analyte concentrations for each standard are then entered into the instrument software; these concentrations are those obtained from the laboratory, the certified results, or the gravimetrically determined concentrations of the prepared standards. This gives the instrument analyte values to regress against corresponding intensities during the modeling stage. The regression equation correlates the concentrations of an analyte with its net intensity.

The calibration equation is developed using a least squares fit regression analysis. After the regression terms to be used in the equation are defined, a mathematical equation can be developed to calculate the analyte concentration in an unknown sample. In some FPXRF instruments, the software of the instrument calculates the regression equation. The software uses calculated intercept and slope values to form a multiterm equation. In conjunction with the software in the instrument, the operator can adjust the multiterm equation to minimize interelement interferences and optimize the intensity calibration curve.

It is possible to define up to six linear or nonlinear terms in the regression equation. Terms can be added and deleted to optimize the equation. The goal is to produce an equation with the smallest regression error and the highest correlation coefficient. These values are automatically computed by the software as the regression terms are added, deleted, or modified. It is also possible to delete data points from the regression line if these points are significant outliers or if they are heavily weighing the data. Once the regression equation has been selected for an analyte, the equation can be entered into the software for quantitation of analytes in subsequent samples. For an empirical calibration to be acceptable, the regression equation for a specific analyte should have a correlation coefficient of 0.98 or greater or meet the DQOs of the project.

In an empirical calibration, one must apply the DQOs of the project and ascertain critical or action levels for the analytes of interest. It is within these concentration ranges or around these action levels that the FPXRF instrument should be calibrated most accurately. It may not be possible to develop a good regression equation over several orders of analyte concentration.

10.4 Compton normalization method -- The Compton normalization method is based on analysis of a single, certified standard and normalization for the Compton peak. The Compton peak is produced from incoherent backscattering of x-ray radiation from the excitation source and is present in the spectrum of every sample. The Compton peak intensity changes with differing matrices. Generally, matrices dominated by lighter elements produce a larger Compton peak, and those dominated by heavier elements produce a smaller Compton peak. Normalizing to the Compton peak can reduce problems with varying matrix effects among samples. Compton normalization is similar to the use of internal standards in organics analysis. The Compton normalization method may not be effective when analyte concentrations exceed a few percent.

The certified standard used for this type of calibration could be an NIST SRM such as 2710 or 2711. The SRM must be a matrix similar to the samples and must contain the analytes of interests at concentrations near those expected in the samples. First, a response factor has to be determined for each analyte. This factor is calculated by dividing the net peak intensity by the analyte concentration. The net peak intensity is gross intensity corrected for baseline reading. Concentrations of analytes in samples are then determined by multiplying the baseline corrected analyte signal intensity by the normalization factor and by the response factor. The normalization factor is the quotient of the baseline corrected Compton K_α peak intensity of the SRM divided by that of the samples. Depending on the FPXRF instrument used, these calculations may be done manually or by the instrument software.

11.0 PROCEDURE

11.1 Operation of the various FPXRF instruments will vary according to the manufacturers' protocols. Before operating any FPXRF instrument, one should consult the manufacturer's manual. Most manufacturers recommend that their instruments be allowed to warm up for 15 to 30 minutes before analysis of samples. This will help alleviate drift or energy calibration problems later during analysis.

11.2 Each FPXRF instrument should be operated according to the manufacturer's recommendations. There are two modes in which FPXRF instruments can be operated: in situ and intrusive. The in situ mode involves analysis of an undisturbed soil sediment or sample. Intrusive analysis involves collection and preparation of a soil or sediment sample before analysis. Some FPXRF instruments can operate in both modes of analysis, while others are designed to operate in only one mode. The two modes of analysis are discussed below.

11.3 For in situ analysis, remove any large or nonrepresentative debris from the soil surface before analysis. This debris includes rocks, pebbles, leaves, vegetation, roots, and concrete. Also, the soil surface must be as smooth as possible so that the probe window will have good contact with the surface. This may require some leveling of the surface with a stainless-steel trowel. During the study conducted to provide example performance data for this method, this modest amount of sample preparation was found to take less than 5 min per sample location. The last requirement is that the soil or sediment not be saturated with water. Manufacturers state that their FPXRF instruments will perform adequately for soils with moisture contents of 5 to 20 percent but will not perform well for saturated soils, especially if ponded water exists on the surface. Another recommended technique for in situ analysis is to tamp the soil to increase soil density and compactness for better repeatability and representativeness. This condition is especially important for heavy element analysis, such as barium. Source count times for in situ analysis usually range from 30 to 120 seconds, but source count times will vary among instruments and depending on the desired method sensitivity. Due to the heterogeneous nature of the soil sample, in situ analysis can provide only “screening” type data.

11.4 For intrusive analysis of surface or sediment, it is recommended that a sample be collected from a 4- by 4-inch square that is 1 inch deep. This will produce a soil sample of approximately 375 g or 250 cm^3, which is enough soil to fill an 8-ounce jar. However, the exact dimensions and sample depth should take into consideration the heterogeneous deposition of contaminants and will ultimately depend on the desired project-specific data quality objectives. The sample should be homogenized, dried, and ground before analysis. The sample can be homogenized before or after drying. The homogenization technique to be used after drying is discussed in Sec. 4.2. If the sample is homogenized before drying, it should be thoroughly mixed in a beaker or similar container, or if the sample is moist and has a high clay content, it can be kneaded in a plastic bag. One way to monitor homogenization when the sample is kneaded in a plastic bag is to add sodium fluorescein dye to the sample. After the moist sample has been homogenized, it is examined under an ultraviolet light to assess the distribution of sodium fluorescein throughout the sample. If the fluorescent dye is evenly distributed in the sample, homogenization is considered complete; if the dye is not evenly distributed, mixing should continue until the sample has been thoroughly homogenized. During the study conducted to provide data for this method, the time necessary for homogenization procedure using the fluorescein dye ranged from 3 to 5 min per sample. As demonstrated in Secs. 13.5 and 13.7, homogenization has the greatest impact on the reduction of sampling variability. It produces little or no contamination. Often, the direct analysis through the plastic bag is possible without the more labor intensive steps of drying, grinding, and sieving given in Secs. 11.5 and 11.6. Of course, to achieve the best data quality possible all four steps should be followed.

11.5 Once the soil or sediment sample has been homogenized, it should be dried. This can be accomplished with a toaster oven or convection oven. A small aliquot of the sample (20 to 50 g) is placed in a suitable container for drying. The sample should be dried for 2 to 4 hr in the convection or toaster oven at a temperature not greater than 150 °C. Samples may also be air dried under ambient temperature conditions using a 10- to 20-g portion. Regardless of what drying mechanism is used, the drying process is considered complete when a constant sample weight can be obtained. Care should be taken to avoid sample cross-contamination and these measures can be evaluated by including an appropriate method blank sample along with any sample preparation process.

CAUTION: Microwave drying is not a recommended procedure. Field studies have shown that microwave drying can increase variability between the FPXRF data and confirmatory analysis. High levels of metals in a sample can cause arcing in the microwave oven, and sometimes slag forms in the sample. Microwave oven drying can also melt plastic containers used to hold the sample.

11.6 The homogenized dried sample material should be ground with a mortar and pestle and passed through a 60-mesh sieve to achieve a uniform particle size. Sample grinding should continue until at least 90 percent of the original sample passes through the sieve. The grinding step normally takes an average of 10 min per sample. An aliquot of the sieved sample should then be placed in a 31.0-mm polyethylene sample cup (or equivalent) for analysis. The sample cup should be one-half to three-quarters full at a minimum. The sample cup should be covered with a 2.5 µm Mylar (or equivalent) film for analysis. The rest of the soil sample should be placed in a jar, labeled, and archived for possible confirmation analysis. All equipment including the mortar, pestle, and sieves must be thoroughly cleaned so that any cross-contamination is below the established lower limit of detection of the procedure or DQOs of the analysis. If all recommended sample preparation steps are followed, there is a high probability the desired laboratory data quality may be obtained.

12.0 DATA ANALYSIS AND CALCULATIONS

Most FPXRF instruments have software capable of storing all analytical results and spectra. The results are displayed in ppm and can be downloaded to a personal computer, which can be used to provide a hard copy printout. Individual measurements that are smaller than three times their associated SD should not be used for quantitation. See the manufacturer's instructions regarding data analysis and calculations.

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in SW-846 methods only as examples and guidance. The data do not represent required performance criteria for users of the methods. Instead, performance criteria should be developed on a project-specific basis, and the laboratory should establish in-house QC performance criteria for the application of this method. <u>These performance data are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.</u>

13.2 The sections to follow discuss three performance evaluation factors; namely, precision, accuracy, and comparability. The example data presented in Tables 4 through 8 were generated from results obtained from six FPXRF instruments (see Sec. 13.3). The soil samples analyzed by the six FPXRF instruments were collected from two sites in the United States. The soil samples contained several of the target analytes at concentrations ranging from "nondetect" to tens of thousands of mg/kg. These data are provided for guidance purposes only.

13.3 The six FPXRF instruments included the TN 9000 and TN Lead Analyzer manufactured by TN Spectrace; the X-MET 920 with a SiLi detector and X-MET 920 with a gas-filled proportional detector manufactured by Metorex, Inc.; the XL Spectrum Analyzer manufactured by Niton; and the MAP Spectrum Analyzer manufactured by Scitec. The TN 9000 and TN Lead Analyzer both have a HgI_2 detector. The TN 9000 utilized an Fe-55, Cd-109, and Am-241 source. The TN Lead Analyzer had only a Cd-109 source. The X-Met 920 with the SiLi detector had a Cd-109 and Am-241 source. The X-MET 920 with the gas-filled proportional detector had only a Cd-109 source. The XL Spectrum Analyzer utilized a silicon pin-diode detector and a Cd-109 source. The MAP Spectrum Analyzer utilized a solid-state silicon detector and a Cd-109 source.

13.4 All example data presented in Tables 4 through 8 were generated using the following calibrations and source count times. The TN 9000 and TN Lead Analyzer were calibrated using fundamental parameters using NIST SRM 2710 as a calibration check sample. The TN 9000 was operated using 100, 60, and 60 second count times for the Cd-109, Fe-55, and Am-241 sources, respectively. The TN Lead analyzer was operated using a 60 second count time for the Cd-109 source. The X-MET 920 with the Si(Li) detector was calibrated using fundamental parameters and one well characterized site-specific soil standard as a calibration check. It used 140 and 100 second count times for the Cd-109 and Am-241 sources, respectively. The X-MET 920 with the gas-filled proportional detector was calibrated empirically using between 10 and 20 well characterized site-specific soil standards. It used 120 second times for the Cd-109 source. The XL Spectrum Analyzer utilized NIST SRM 2710 for calibration and the Compton peak normalization procedure for quantitation based on 60 second count times for the Cd-109 source. The MAP Spectrum Analyzer was internally calibrated by the manufacturer. The calibration was checked using a well-characterized site-specific soil standard. It used 240 second times for the Cd-109 source.

13.5 Precision measurements -- The example precision data are presented in Table 4. These data are provided for guidance purposes only. Each of the six FPXRF instruments performed 10 replicate measurements on 12 soil samples that had analyte concentrations ranging from "nondetects" to thousands of mg/kg. Each of the 12 soil samples underwent 4 different preparation techniques from in situ (no preparation) to dried and ground in a sample cup. Therefore, there were 48 precision data points for five of the instruments and 24 precision points for the MAP Spectrum Analyzer. The replicate measurements were taken using the source count times discussed at the beginning of this section.

For each detectable analyte in each precision sample a mean concentration, standard deviation, and RSD was calculated for each analyte. The data presented in Table 4 is an average RSD for the precision samples that had analyte concentrations at 5 to 10 times the lower limit of detection for that analyte for each instrument. Some analytes such as mercury, selenium, silver, and thorium were not detected in any of the precision samples so these analytes are not listed in Table 4. Some analytes such as cadmium, nickel, and tin were only detected at concentrations near the lower limit of detection so that an RSD value calculated at 5 to 10 times this limit was not possible.

One FPXRF instrument collected replicate measurements on an additional nine soil samples to provide a better assessment of the effect of sample preparation on precision. Table 5 shows these results. These data are provided for guidance purposes only. The additional nine soil samples were comprised of three from each texture and had analyte concentrations ranging from near the lower limit of detection for the FPXRF analyzer to thousands of mg/kg. The FPXRF analyzer only collected replicate measurements from three of the preparation methods; no measurements were collected from the in situ homogenized samples. The FPXRF analyzer conducted five replicate measurements of the in situ field samples by taking measurements at five different points within the 4-inch by 4-inch sample square. Ten replicate measurements were collected for both the intrusive undried and unground and intrusive dried and ground samples contained in cups. The cups were shaken between each replicate measurement.

Table 5 shows that the precision dramatically improved from the in situ to the intrusive measurements. In general there was a slight improvement in precision when the sample was dried and ground. Two factors caused the precision for the in situ measurements to be poorer. The major factor is soil heterogeneity. By moving the probe within the 4-inch by 4-inch square, measurements of different soil samples were actually taking place within the square. Table 5 illustrates the dominant effect of soil heterogeneity. It overwhelmed instrument precision when the FPXRF analyzer was used in this mode. The second factor that caused the RSD values to be higher for the in situ measurements is the fact that only five instead of ten replicates were taken. A lesser number of measurements caused the standard deviation to be larger which in turn elevated the RSD values.

13.6 Accuracy measurements -- Five of the FPXRF instruments (not including the MAP Spectrum Analyzer) analyzed 18 SRMs using the source count times and calibration methods given at the beginning of this section. The 18 SRMs included 9 soil SRMs, 4 stream or river sediment SRMs, 2 sludge SRMs, and 3 ash SRMs. Each of the SRMs contained known concentrations of certain target analytes. A percent recovery was calculated for each analyte in each SRM for each FPXRF instrument. Table 6 presents a summary of this data. With the exception of cadmium, chromium, and nickel, the values presented in Table 6 were generated from the 13 soil and sediment SRMs only. The 2 sludge and 3 ash SRMs were included for cadmium, chromium, and nickel because of the low or nondetectable concentrations of these three analytes in the soil and sediment SRMs.

Only 12 analytes are presented in Table 6. These are the analytes that are of environmental concern and provided a significant number of detections in the SRMs for an accuracy assessment. No data is presented for the X-MET 920 with the gas-filled proportional detector. This FPXRF instrument was calibrated empirically using site-specific soil samples. The percent recovery values from this instrument were very sporadic and the data did not lend itself to presentation in Table 6.

Table 7 provides a more detailed summary of accuracy data for one particular FPXRF instrument (TN 9000) for the 9 soil SRMs and 4 sediment SRMs. These data are provided for guidance purposes only. Table 7 shows the certified value, measured value, and percent recovery for five analytes. These analytes were chosen because they are of environmental concern and were most prevalently certified for in the SRM and detected by the FPXRF instrument. The first nine SRMs are soil and the last 4 SRMs are sediment. Percent recoveries for the four NIST SRMs were often between 90 and 110 percent for all analytes.

13.7 Comparability -- Comparability refers to the confidence with which one data set can be compared to another. In this case, FPXRF data generated from a large study of six FPXRF instruments was compared to SW-846 Methods 3050 and 6010 which are the standard soil extraction for metals and analysis by inductively coupled plasma. An evaluation of comparability was conducted by using linear regression analysis. Three factors were determined using the linear regression. These factors were the y-intercept, the slope of the line, and the coefficient of determination (r^2).

As part of the comparability assessment, the effects of soil type and preparation methods were studied. Three soil types (textures) and four preparation methods were examined during the study. The preparation methods evaluated the cumulative effect of particle size, moisture, and homogenization on comparability. Due to the large volume of data produced during this study, linear regression data for six analytes from only one FPXRF instrument is presented in Table 8. Similar trends in the data were seen for all instruments. These data are provided for guidance purposes only.

Table 8 shows the regression parameters for the whole data set, broken out by soil type, and by preparation method. These data are provided for guidance purposes only. The soil types are as follows: soil 1--sand; soil 2--loam; and soil 3--silty clay. The preparation methods are as follows: preparation 1--in situ in the field; preparation 2--intrusive, sample collected and homogenized; preparation 3--intrusive, with sample in a sample cup but sample still wet and not ground; and preparation 4–intrusive, with sample dried, ground, passed through a 40-mesh sieve, and placed in sample cup.

For arsenic, copper, lead, and zinc, the comparability to the confirmatory laboratory was excellent with r^2 values ranging from 0.80 to 0.99 for all six FPXRF instruments. The slopes of the regression lines for arsenic, copper, lead, and zinc, were generally between 0.90 and 1.00 indicating the data would need to be corrected very little or not at all to match the confirmatory laboratory data. The r^2 values and slopes of the regression lines for barium and chromium were not as good as for the other for analytes, indicating the data would have to be corrected to match the confirmatory laboratory.

Table 8 demonstrates that there was little effect of soil type on the regression parameters for any of the six analytes. The only exceptions were for barium in soil 1 and copper in soil 3. In both of these cases, however, it is actually a concentration effect and not a soil effect causing the poorer comparability. All barium and copper concentrations in soil 1 and 3, respectively, were less than 350 mg/kg.

Table 8 shows there was a preparation effect on the regression parameters for all six analytes. With the exception of chromium, the regression parameters were primarily improved going from preparation 1 to preparation 2. In this step, the sample was removed from the soil surface, all large debris was removed, and the sample was thoroughly homogenized. The additional two preparation methods did little to improve the regression parameters. This data indicates that homogenization is the most critical factor when comparing the results. It is essential that the sample sent to the confirmatory laboratory match the FPXRF sample as closely as possible.

Sec. 11.0 of this method discusses the time necessary for each of the sample preparation techniques. Based on the data quality objectives for the project, an analyst must decide if it is worth the extra time necessary to dry and grind the sample for small improvements in comparability. Homogenization requires 3 to 5 min. Drying the sample requires one to two hours. Grinding and sieving requires another 10 to 15 min per sample. Lastly, when grinding and sieving is conducted, time has to be allotted to decontaminate the mortars, pestles, and sieves. Drying and grinding the samples and decontamination procedures will often dictate that an extra person be on site so that the analyst can keep up with the sample collection crew. The cost of requiring an extra person on site to prepare samples must be balanced with the gain in data quality and sample throughput.

13.8 The following documents may provide additional guidance and insight on this method and technique:

13.8.1 A. D. Hewitt, "Screening for Metals by X-ray Fluorescence Spectrometry/Response Factor/Compton K_α Peak Normalization Analysis," American Environmental Laboratory, pp 24-32, 1994.

13.8.2 S. Piorek and J. R. Pasmore, "Standardless, In Situ Analysis of Metallic Contaminants in the Natural Environment With a PC-Based, High Resolution Portable X-Ray Analyzer," Third International Symposium on Field Screening Methods for Hazardous Waste and Toxic Chemicals, Las Vegas, Nevada, February 24-26, 1993, Vol 2, pp 1135-1151, 1993.

13.8.3 S. Shefsky, "Sample Handling Strategies for Accurate Lead-in-soil Measurements in the Field and Laboratory," *International Symposium of Field Screening Methods for Hazardous Waste and Toxic Chemicals*, Las Vegas, NV, January 29-31, 1997.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction* available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th St., N.W. Washington, D.C. 20036, http://www.acs.org.

15.0 WASTE MANAGEMENT

The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. Metorex, X-MET 920 User's Manual.

2. Spectrace Instruments, "Energy Dispersive X-ray Fluorescence Spectrometry: An Introduction," 1994.

3. TN Spectrace, Spectrace 9000 Field Portable/Benchtop XRF Training and Applications Manual.

4. Unpublished SITE data, received from PRC Environment Management, Inc.

17.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

The following pages contain the tables referenced by this method. A flow diagram of the procedure follows the tables.

TABLE 1

EXAMPLE INTERFERENCE FREE LOWER LIMITS OF DETECTION

Analyte	Chemical Abstract Series Number	Lower Limit of Detection in Quartz Sand (milligrams per kilogram)
Antimony (Sb)	7440-36-0	40
Arsenic (As)	7440-38-0	40
Barium (Ba)	7440-39-3	20
Cadmium (Cd)	7440-43-9	100
Calcium (Ca)	7440-70-2	70
Chromium (Cr)	7440-47-3	150
Cobalt (Co)	7440-48-4	60
Copper (Cu)	7440-50-8	50
Iron (Fe)	7439-89-6	60
Lead (Pb)	7439-92-1	20
Manganese (Mn)	7439-96-5	70
Mercury (Hg)	7439-97-6	30
Molybdenum (Mo)	7439-93-7	10
Nickel (Ni)	7440-02-0	50
Potassium (K)	7440-09-7	200
Rubidium (Rb)	7440-17-7	10
Selenium (Se)	7782-49-2	40
Silver (Ag)	7440-22-4	70
Strontium (Sr)	7440-24-6	10
Thallium (Tl)	7440-28-0	20
Thorium (Th)	7440-29-1	10
Tin (Sn)	7440-31-5	60
Titanium (Ti)	7440-32-6	50
Vanadium (V)	7440-62-2	50
Zinc (Zn)	7440-66-6	50
Zirconium (Zr)	7440-67-7	10

Source: Refs. 1, 2, and 3
These data are provided for guidance purposes only.

TABLE 2

SUMMARY OF RADIOISOTOPE SOURCE CHARACTERISTICS

Source	Activity (mCi)	Half-Life (Years)	Excitation Energy (keV)	Elemental Analysis Range	
Fe-55	20-50	2.7	5.9	Sulfur to Chromium	K Lines
				Molybdenum to Barium	L Lines
Cd-109	5-30	1.3	22.1 and 87.9	Calcium to Rhodium	K Lines
				Tantalum to Lead	K Lines
				Barium to Uranium	L Lines
Am-241	5-30	432	26.4 and 59.6	Copper to Thulium	K Lines
				Tungsten to Uranium	L Lines
Cm-244	60-100	17.8	14.2	Titanium to Selenium	K Lines
				Lanthanum to Lead	L Lines

Source: Refs. 1, 2, and 3

TABLE 3

SUMMARY OF X-RAY TUBE SOURCE CHARACTERISTICS

Anode Material	Recommended Voltage Range (kV)	K-alpha Emission (keV)	Elemental Analysis Range	
Cu	18-22	8.04	Potassium to Cobalt	K Lines
			Silver to Gadolinium	L Lines
Mo	40-50	17.4	Cobalt to Yttrium	K Lines
			Europium to Radon	L Lines
Ag	50-65	22.1	Zinc to Technicium	K Lines
			Ytterbium to Neptunium	L Lines

Source: Ref. 4

Notes: The sample elements excited are chosen by taking as the lower limit the same ratio of excitation line energy to element absorption edge as in Table 2 (approximately 0.45) and the requirement that the excitation line energy be above the element absorption edge as the upper limit (L2 edges used for L lines). K-beta excitation lines were ignored.

TABLE 4

EXAMPLE PRECISION VALUES

Analyte	Average Relative Standard Deviation for Each Instrument at 5 to 10 Times the Lower Limit of Detection					
	TN 9000	TN Lead Analyzer	X-MET 920 (SiLi Detector)	X-MET 920 (Gas-Filled Detector)	XL Spectrum Analyzer	MAP Spectrum Analyzer
Antimony	6.54	NR	NR	NR	NR	NR
Arsenic	5.33	4.11	3.23	1.91	12.47	6.68
Barium	4.02	NR	3.31	5.91	NR	NR
Cadmium	29.84[a]	NR	24.80[a]	NR	NR	NR
Calcium	2.16	NR	NR	NR	NR	NR
Chromium	22.25	25.78	22.72	3.91	30.25	NR
Cobalt	33.90	NR	NR	NR	NR	NR
Copper	7.03	9.11	8.49	9.12	12.77	14.86
Iron	1.78	1.67	1.55	NR	2.30	NR
Lead	6.45	5.93	5.05	7.56	6.97	12.16
Manganese	27.04	24.75	NR	NR	NR	NR
Molybdenum	6.95	NR	NR	NR	12.60	NR
Nickel	30.85[a]	NR	24.92[a]	20.92[a]	NA	NR
Potassium	3.90	NR	NR	NR	NR	NR
Rubidium	13.06	NR	NR	NR	32.69[a]	NR
Strontium	4.28	NR	NR	NR	8.86	NR
Tin	24.32[a]	NR	NR	NR	NR	NR
Titanium	4.87	NR	NR	NR	NR	NR
Zinc	7.27	7.48	4.26	2.28	10.95	0.83
Zirconium	3.58	NR	NR	NR	6.49	NR

These data are provided for guidance purposes only.
Source: Ref. 4

[a] These values are biased high because the concentration of these analytes in the soil samples was near the lower limit of detection for that particular FPXRF instrument.

NR Not reported.

NA Not applicable; analyte was reported but was below the established lower limit detection.

TABLE 5

EXAMPLES OF PRECISION AS AFFECTED BY SAMPLE PREPARATION

Analyte	Average Relative Standard Deviation for Each Preparation Method		
	In Situ-Field	Intrusive- Undried and Unground	Intrusive- Dried and Ground
Antimony	30.1	15.0	14.4
Arsenic	22.5	5.36	3.76
Barium	17.3	3.38	2.90
Cadmium[a]	41.2	30.8	28.3
Calcium	17.5	1.68	1.24
Chromium	17.6	28.5	21.9
Cobalt	28.4	31.1	28.4
Copper	26.4	10.2	7.90
Iron	10.3	1.67	1.57
Lead	25.1	8.55	6.03
Manganese	40.5	12.3	13.0
Mercury	ND	ND	ND
Molybdenum	21.6	20.1	19.2
Nickel[a]	29.8	20.4	18.2
Potassium	18.6	3.04	2.57
Rubidium	29.8	16.2	18.9
Selenium	ND	20.2	19.5
Silver[a]	31.9	31.0	29.2
Strontium	15.2	3.38	3.98
Thallium	39.0	16.0	19.5
Thorium	NR	NR	NR
Tin	ND	14.1	15.3
Titanium	13.3	4.15	3.74
Vanadium	NR	NR	NR
Zinc	26.6	13.3	11.1
Zirconium	20.2	5.63	5.18

These data are provided for guidance purposes only.
Source: Ref. 4

[a] These values may be biased high because the concentration of these analytes in the soil samples was near the lower limit of detection.

ND Not detected.
NR Not reported.

TABLE 6

EXAMPLE ACCURACY VALUES

Analyte	Instrument															
	TN 9000				TN Lead Analyzer				X-MET 920 (SiLi Detector)				XL Spectrum Analyzer			
	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec	SD	n	Range of % Rec.	Mean % Rec.	SD
Sb	2	100-149	124.3	NA	--	--	--	--	--	--	--	--	--	--	--	--
As	5	68-115	92.8	17.3	5	44-105	83.4	23.2	4	9.7-91	47.7	39.7	5	38-535	189.8	206
Ba	9	98-198	135.3	36.9	--	--	--	--	9	18-848	168.2	262	--	--	--	--
Cd	2	99-129	114.3	NA	--	--	--	--	6	81-202	110.5	45.7	--	--	--	--
Cr	2	99-178	138.4	NA	--	--	--	--	7	22-273	143.1	93.8	3	98-625	279.2	300
Cu	8	61-140	95.0	28.8	6	38-107	79.1	27.0	11	10-210	111.8	72.1	8	95-480	203.0	147
Fe	6	78-155	103.7	26.1	6	89-159	102.3	28.6	6	48-94	80.4	16.2	6	26-187	108.6	52.9
Pb	11	66-138	98.9	19.2	11	68-131	97.4	18.4	12	23-94	72.7	20.9	13	80-234	107.3	39.9
Mn	4	81-104	93.1	9.70	3	92-152	113.1	33.8	--	--	--	--	--	--	--	--
Ni	3	99-122	109.8	12.0	--	--	--	--	--	--	--	--	3	57-123	87.5	33.5
Sr	8	110-178	132.6	23.8	--	--	--	--	--	--	--	--	7	86-209	125.1	39.5
Zn	11	41-130	94.3	24.0	10	81-133	100.0	19.7	12	46-181	106.6	34.7	11	31-199	94.6	42.5

Source: Ref. 4. These data are provided for guidance purposes only.

n: Number of samples that contained a certified value for the analyte and produced a detectable concentration from the FPXRF instrument.

SD: Standard deviation; NA: Not applicable; only two data points, therefore, a SD was not calculated.

%Rec.: Percent recovery.

-- No data.

TABLE 7

EXAMPLE ACCURACY FOR TN 9000[a]

Standard Reference Material	Arsenic			Barium			Copper			Lead			Zinc		
	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.
RTC CRM-021	24.8	ND	NA	586	1135	193.5	4792	2908	60.7	144742	149947	103.6	546	224	40.9
RTC CRM-020	397	429	92.5	22.3	ND	NA	753	583	77.4	5195	3444	66.3	3022	3916	129.6
BCR CRM 143R	--	--	--	--	--	--	131	105	80.5	180	206	114.8	1055	1043	99.0
BCR CRM 141	--	--	--	--	--	--	32.6	ND	NA	29.4	ND	NA	81.3	ND	NA
USGS GXR-2	25.0	ND	NA	2240	2946	131.5	76.0	106	140.2	690	742	107.6	530	596	112.4
USGS GXR-6	330	294	88.9	1300	2581	198.5	66.0	ND	NA	101	80.9	80.1	118	ND	NA
NIST 2711	105	104	99.3	726	801	110.3	114	ND	NA	1162	1172	100.9	350	333	94.9
NIST 2710	626	722	115.4	707	782	110.6	2950	2834	96.1	5532	5420	98.0	6952	6476	93.2
NIST 2709	17.7	ND	NA	968	950	98.1	34.6	ND	NA	18.9	ND	NA	106	98.5	93.0
NIST 2704	23.4	ND	NA	414	443	107.0	98.6	105	106.2	161	167	103.5	438	427	97.4
CNRC PACS-1	211	143	67.7	--	772	NA	452	302	66.9	404	332	82.3	824	611	74.2
SARM-51	--	--	--	335	466	139.1	268	373	139.2	5200	7199	138.4	2200	2676	121.6
SARM-52	--	--	--	410	527	128.5	219	193	88.1	1200	1107	92.2	264	215	81.4

Source: Ref. 4. These data are provided for guidance purposes only.

[a] All concentrations in milligrams per kilogram.

%Rec.: Percent recovery; ND: Not detected; NA: Not applicable.

-- No data.

TABLE 8

EXAMPLE REGRESSION PARAMETERS FOR COMPARABILITY[1]

	Arsenic				Barium				Copper			
	n	r^2	Int.	Slope	n	r^2	Int.	Slope	n	r^2	Int.	Slope
All Data	824	0.94	1.62	0.94	1255	0.71	60.3	0.54	984	0.93	2.19	0.93
Soil 1	368	0.96	1.41	0.95	393	0.05	42.6	0.11	385	0.94	1.26	0.99
Soil 2	453	0.94	1.51	0.96	462	0.56	30.2	0.66	463	0.92	2.09	0.95
Soil 3	—	—	—	—	400	0.85	44.7	0.59	136	0.46	16.60	0.57
Prep 1	207	0.87	2.69	0.85	312	0.64	53.7	0.55	256	0.87	3.89	0.87
Prep 2	208	0.97	1.38	0.95	315	0.67	64.6	0.52	246	0.96	2.04	0.93
Prep 3	204	0.96	1.20	0.99	315	0.78	64.6	0.53	236	0.97	1.45	0.99
Prep 4	205	0.96	1.45	0.98	313	0.81	58.9	0.55	246	0.96	1.99	0.96

	Lead				Zinc				Chromium			
	n	r^2	Int.	Slope	n	r^2	Int.	Slope	n	r^2	Int.	Slope
All Data	1205	0.92	1.66	0.95	1103	0.89	1.86	0.95	280	0.70	64.6	0.42
Soil 1	357	0.94	1.41	0.96	329	0.93	1.78	0.93	—	—	—	—
Soil 2	451	0.93	1.62	0.97	423	0.85	2.57	0.90	—	—	—	—
Soil 3	397	0.90	2.40	0.90	351	0.90	1.70	0.98	186	0.66	38.9	0.50
Prep 1	305	0.80	2.88	0.86	286	0.79	3.16	0.87	105	0.80	66.1	0.43
Prep 2	298	0.97	1.41	0.96	272	0.95	1.86	0.93	77	0.51	81.3	0.36
Prep 3	302	0.98	1.26	0.99	274	0.93	1.32	1.00	49	0.73	53.7	0.45
Prep 4	300	0.96	1.38	1.00	271	0.94	1.41	1.01	49	0.75	31.6	0.56

Source: Ref. 4. These data are provided for guidance purposes only.

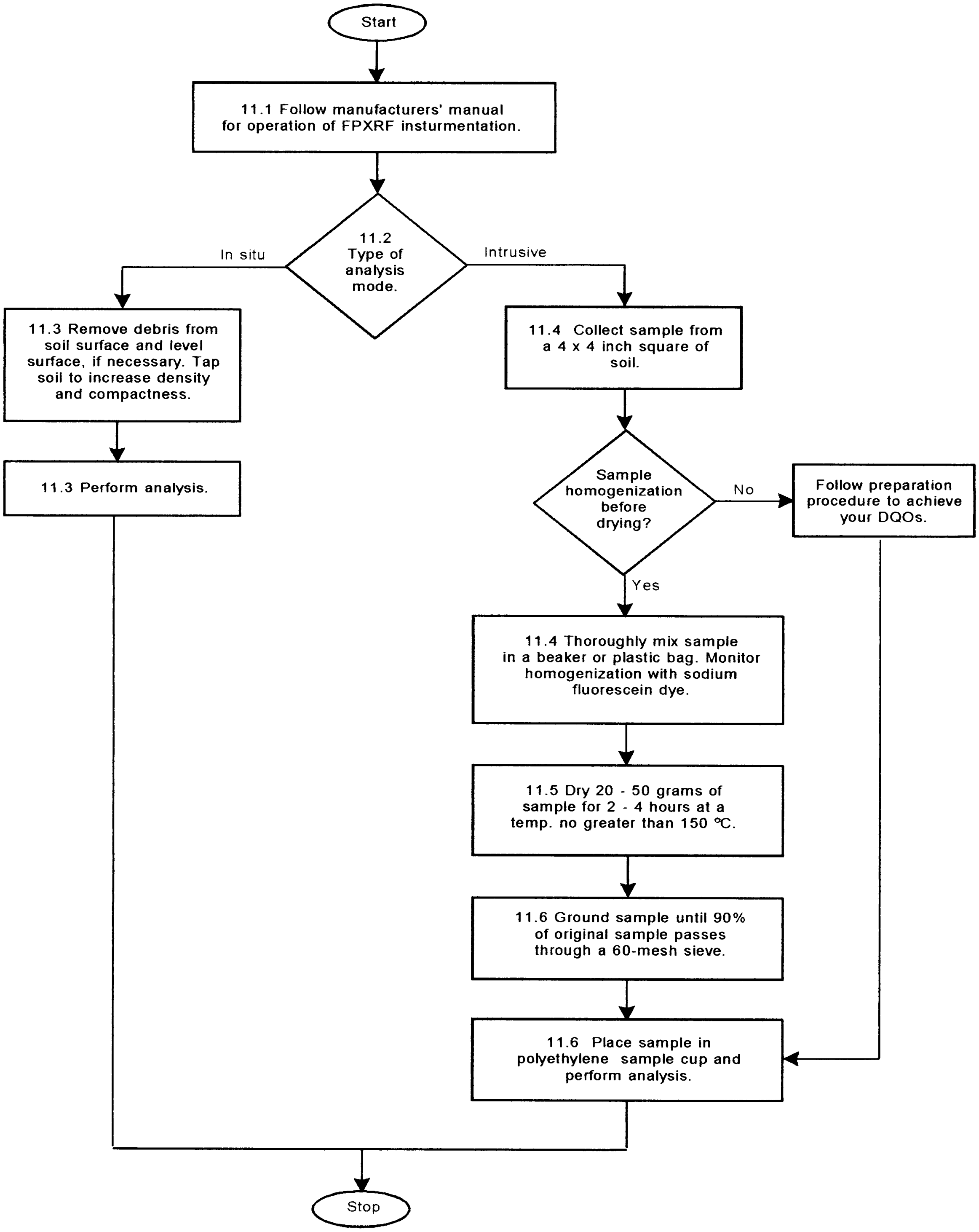
[1] Log-transformed data

n: Number of data points; r^2: Coefficient of determination; Int.: Y-intercept

— No applicable data

METHOD 6200

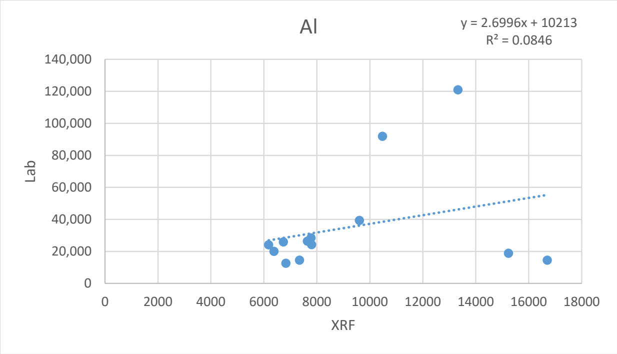
FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT



ATTACHMENT C

2020 PDI Correlation Graphs

TRENTWOOD ALUMINUM RECYCLING
Pre-Desing Investigation
XRF Correlation Graphs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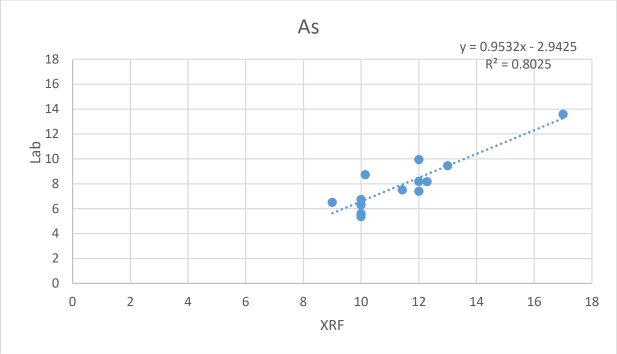
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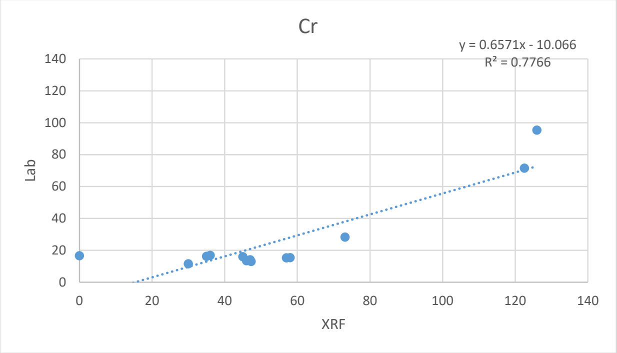
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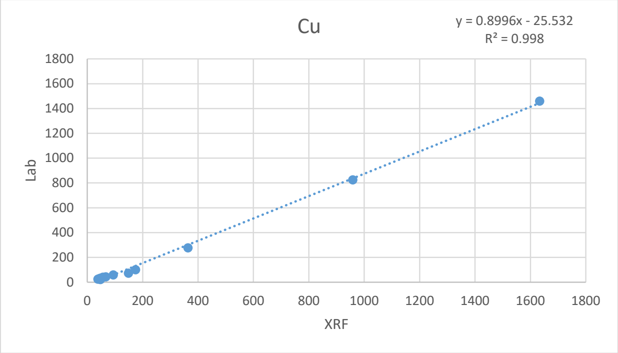
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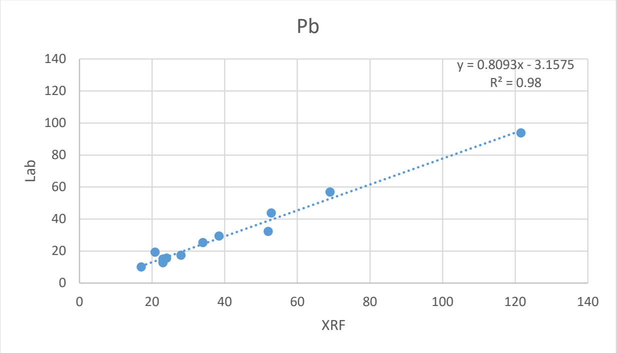
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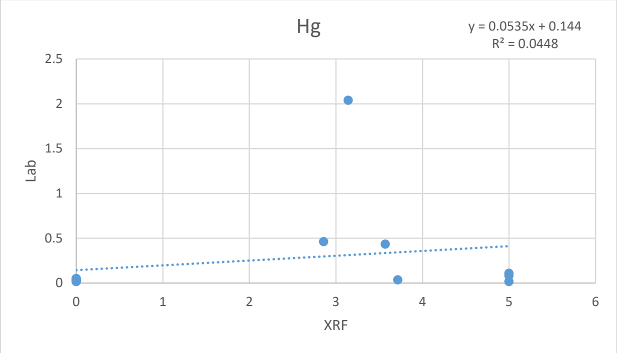
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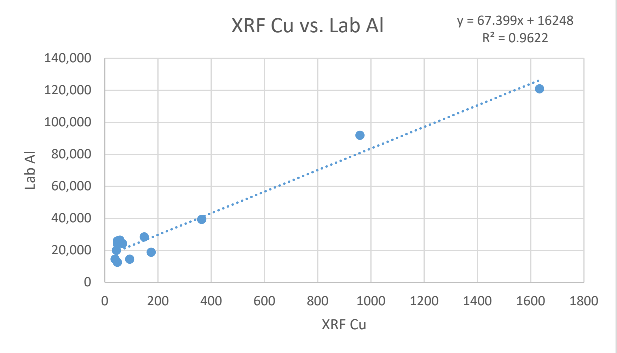
XRF Cu vs. Lab Al

ATTACHMENT D

Field Forms

Soil Sample Record
UPRR Field Electronic Data Deliverable
Field Change Request

SOIL SAMPLING RECORD

Project Number: **Project/Client:** **Date:**

Sampled by:

Cleaning Equipment:

Sampling:

Soil Sample Descriptions:

Sample ID	Sample Time	Description of Sample	Other Observations/ Notes

Comments:

Golder Associates USA Inc.
Local address
Local address
Local phone #

SOIL SAMPLING RECORD

PAGE 1 of 1

Project Number: **Project/Client:** **Date:**

Sampled by:

Field Sketch of Sample Locations:

Comments:

Golder Associates USA Inc.
Local address
Local address
Local phone #

UPRR Field Electronic Data Deliverable (FEDD) - Location and Survey Data

UPRR Site Trentwood WA-Aluminum Dross II

Sampling Event Compliance Monitoring

Sampler

⬜ *Required Field*

🟩 *Populate When Appropriate*

Location Code	Location Type	Completion Date (mm/dd/yyyy)	Total Depth (ft)	X-Coordinate (longitude NAD83)	Y-Coordinate (latitude NAD83)	Z-Coordinate Datum (ft AMSL NGVD88)	Ground Surface Elevation (ft AMSL NGVD88)	Notes

FIELD CHANGE REQUEST (FCR) FORM

Project Name: Aluminum Recycling Trentwood Remedial Action	Project No.: 19119180 Request No.: FCR-_____

Client: Union Pacific Railroad Company
Submitted To: Washington State Department of Ecology Project Coordinator Sandra Treccani

Submitted by: Golder Project Manager (Ted Norton)

CC'd: UPRR Project Coordinator Kristen Stevens

Date: ______________________________

Field Change Request Title: ____

Description:

____
____
____

Recommended Change:

____
____
____

Supervising Contractor Field Coordinator	Signature	Date

Approval:

Supervising Contractor Manager	Signature	Date

Attachments:

APPENDIX F

Inspection and Maintenance Plan

REPORT

Inspection and Maintenance Plan

Union Pacific Railroad, Aluminum Recycling Trentwood Site

Submitted to:

Union Pacific Railroad

Submitted by:

Golder Associates USA Inc.
18300 NE Union Hill Road, Suite 200, Redmond, Washington, USA 98052

+1 425 883-0777

19119180

May 17, 2022

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Maintenance Record

1.0 BACKGROUND AND PURPOSE

1.1 Background

The Aluminum Recycling Trentwood Site (Site) is located at 2317 N. Sullivan Rd., Veradale, Washington 99037. The Site is located in Spokane County, Washington in the Spokane Valley, within the incorporated limits of the City of Spokane Valley. The Site is identified by the Washington State Department of Ecology (Ecology) as Facility Site ID 628 and Cleanup Site ID 1081. The Site consists of properties (or portions thereof) owned by Union Pacific Railroad Company (UPRR), the Washington State Department of Transportation (WSDOT), and Pentzer Venture Holdings, II, Inc. (Pentzer) as shown in Attachment A. All three properties are zoned industrial.

The area of the Site is approximately 9 acres, approximately 4 acres of which was covered by a stockpile of mixed aluminum process materials referred to as dross. The remedy selected for the Site consisted of excavation and disposal of dross and adjacent impacted soils at the Graham Road Landfill, followed by construction of an ecological cap over the former footprint of the dross stockpile and adjacent areas on the UPRR property. The ecological cap consists of 6 inches of gravel over a geotextile above native soil backfill subgrade. Areas on the Pentzer and WSDOT properties where soil with constituents of concern (COCs) exceeding cleanup levels will be removed and backfilled to grade with clean soil and reseeded.

1.2 Purpose

This plan has been prepared to establish the procedures for inspecting and maintaining the ecological cap and surface water management systems at the Site to ensure that they continue to function as designed on an ongoing basis. This Inspection and Maintenance Plan applies only to the UPRR property; inspection and maintenance activities on adjacent properties will be the responsibility of the associated property owners.

2.0 INSPECTION ACTIVITIES

2.1 Ecological Cap

The primary concern related to the ecological cap is loss of integrity that could expose subgrade soils to the environment. Loss of integrity could result from erosion or slope instability. Inspection activities will therefore focus on identifying the signs of these types of problems.

The remediated area will be visually inspected by personnel walking around the perimeter of the area, across the ecological cap in at least one longitudinal and two transverse sections, and across other remediated portions of the UPRR property. The inspector will look for the following types of features:

1) Gullies or bare spots due to sheet erosion, indicating excessive erosion.

2) Ponding or damp areas, including the presence of wetland vegetation, indicating significant local settlement.

3) Cracks, slumps, or scarps, indicating localized differential settlement or slope failure.

2.2 Surface Water Management System

The purpose of the surface water management system is to direct runoff to lined channels in order to control erosion. Inspection activities will therefore focus on identifying conditions that reduce the flow capacity of the system or disrupt its integrity.

The surface water management system will be visually inspected by personnel walking along all berms or ditches, culvert entrances, and culvert discharge locations (if present). The inspector will look for the following types of features as applicable:

1) Loss of quarry spalls in rock-lined channels and discharge aprons.
2) Localized settlement and ponding where not intended.
3) Excessive sediment accumulation.
4) Blockage by debris.
5) Bank sloughing.
6) Excessive debris at culvert entrances.
7) Damage to or deterioration of trash racks and grates.
8) Culvert cross-section significantly deformed.
9) Culvert pipe exposed at ground surface.

2.3 Security Facilities

The inspector will:

- Verify that gates are locked and in working order.
- Perimeter fencing is intact and functional.
- Identify any damaged or missing signs, as applicable.

2.4 Documentation

Inspection documentation will include a completed inspection checklist, marked-up drawings, and digital photographs. The results of the inspection will be recorded on the form presented in Attachment B. Areas of concern and photo locations will be sketched on copies of the figure presented in Attachment A. Digital photographs will be taken during each inspection at specific locations and at areas of concern. Specific locations are shown in Attachment A and have been selected to include overall views of the ecological cap area, slopes, and drainage features. Other photographs will be taken of any areas requiring maintenance and to document the condition of key, small-scale features such as culvert inlets, if necessary.

Copies of the inspection documents will be retained in the project files.

2.5 Frequency

Inspections will begin after remedial construction has been completed and will be performed annually, generally at the end of the winter season.

3.0 MAINTENANCE

3.1 Periodic Maintenance

No regular maintenance should be required for the ecological cap, the adjacent soil areas, or the surface water management system. These are all designed as passive systems that are designed to be stable within the associated design limits.

3.2 As-Needed Maintenance

Maintenance of the ecological cap and surface water management facilities will be performed on an as-needed basis when the results of the inspections indicate that repairs are necessary. The nature of the maintenance will depend on the type of problem. The following activities are typical examples of minor maintenance that could be required. These should be used as general guidelines for maintenance activities and can be modified as necessary to accommodate the actual field conditions. If uncertain, contact the Project Manager who will consult with a qualified engineer as necessary.

3.2.1 Ecological Cap

1) Erosion: Replace gravel to grade. If erosion is a repeated problem, increase the size of the gravel.

2) Ponding: Remove gravel and geotextile in ponded area. Add clean soil backfill to restore design grades. Replace geotextile using procedures and materials as recommended by the geotextile manufacturer. Replace gravel, taking care not to damage the underlying geotextile.

3) Instability: Offsets or deformation in the cap that reflect deep-seated failure should be evaluated by the Golder Design Engineer and appropriate remedial measures implemented to stabilize the subgrade. After these measures have been completed, the cap should be reconstructed in the damaged area.

3.2.2 Surface Water Management System

1) General: Obtain the advice of a Golder Design Engineer prior to making significant changes in materials or geometry of the surface water facilities. All repair and replacement work should be performed in accordance with the original drawings and specifications, unless approved otherwise.

2) Excess sediment: Remove excess sediment from behind berms or within ditches, inlet structures, culverts and pipes, and other facilities. When removing sediment, take care not to disturb the underlying rock lining or other parts of the facility. If these components are disturbed, restore them to their original condition. Dispose of sediment only in approved locations where it will not re-enter the surface water drainage system. Identify sediment source and mitigate, if feasible.

3) Debris: Clear debris from behind berms or within ditches, culvert trash racks, and other facilities. Dispose of garbage in a permitted off site disposal facility. Place vegetation debris on site in approved locations only.

4) Loss of rock ditch lining: Replace rock ditch lining and other protective layers that have been lost. Use rock of similar quality, size, and gradation to original material; place to nominal design thickness. If the protective layer is lost again, use larger rock, grouted riprap, or other more resistant material.

5) Loss of soil ditch lining: Replace soil in scoured sections of swales to original grade. Revegetate, using jute matting or other material to keep seed in place until established. If scour is a repeated problem, add crushed gravel to replacement soil, retaining sufficient fine soil to support vegetation (typically 50% to 75% fine soil).

6) Damage to inlet structures: Replace or repair metal portions of inlet structures that are damaged or corroded. Where appropriate, prevent future corrosion by fabricating from stainless steel, galvanizing, coating with epoxy, or similar approach.

7) Damage to culverts: Replace damaged culverts and pipes that have lost flow capacity. If damage was caused by crushing, use heavier pipe. During replacement, ensure that pipe is placed on suitable granular bedding material and that backfilling is complete and continuous, particularly under pipe haunches.

3.2.3 Security

Repair or replace fencing, gates, locks, warning signs, and other security features as required.

3.3 Documentation

Maintenance reports will be prepared to provide comprehensive documentation of all maintenance activities, using the form provided in Attachment C. Each report will reference the inspection report that triggered the maintenance activity. The report will include a summary of the maintenance activity, the date of the activity, the contractor, sources and descriptions of materials used, and other pertinent information. A complete chronology of maintenance activities will be maintained. Copies of the maintenance reports will be retained in the project files.

4.0 POINTS OF CONTACT

The points of contact at the time of preparing this inspection and maintenance plan are:

The Design Engineer for this project is:

Golder Associates USA Inc.
18300 N.E. Union Hill Rd., Suite 200
Redmond, WA 98052
(425) 883-0777
Ms. Vanessa Nancarrow

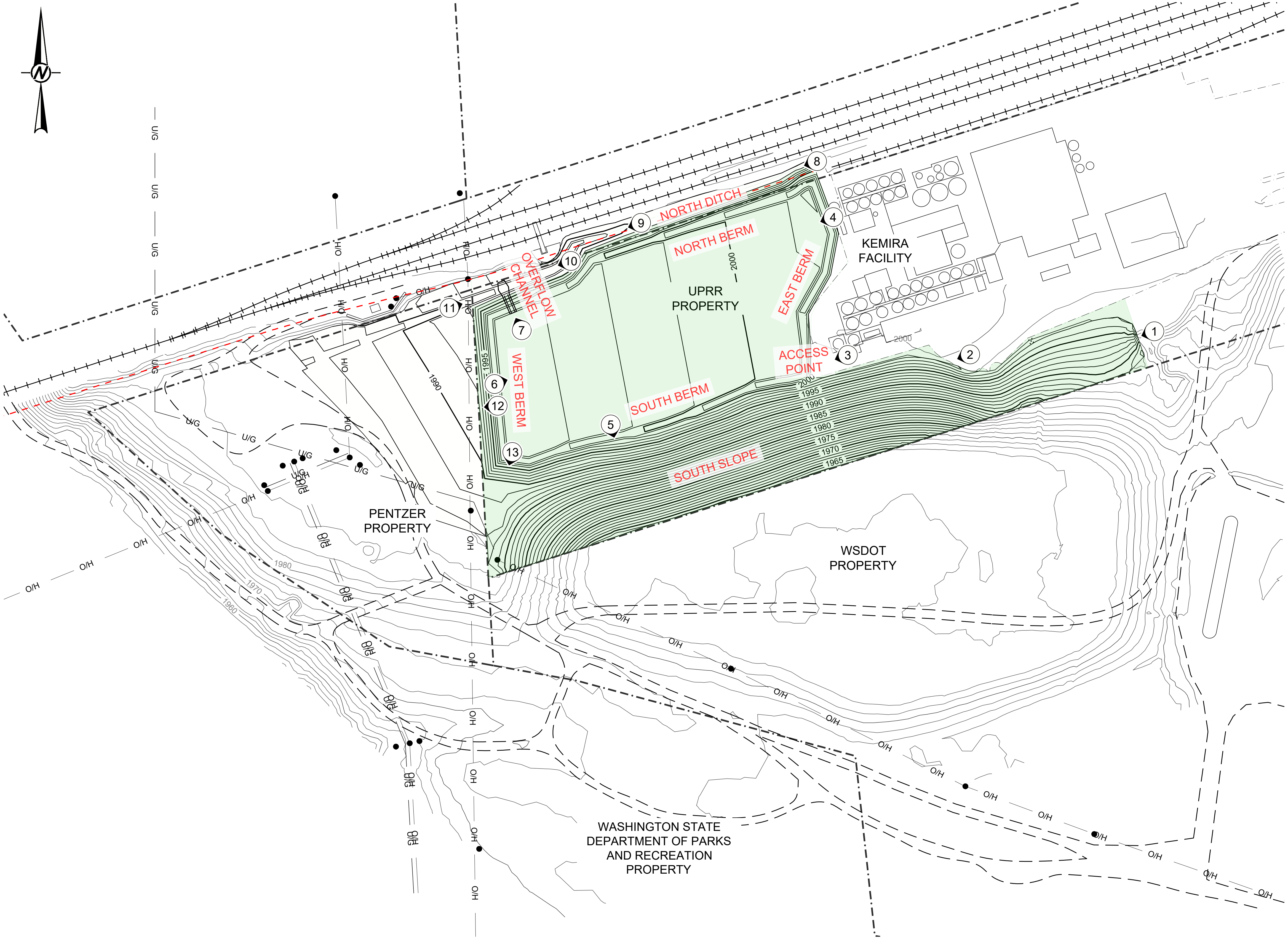
The Owner's Project Coordinator for this project is:

Union Pacific Railroad Company
2401 E Sepulveda Blvd
Long Beach, CA 90810
Ms. Kristen Stevens

Note that personnel may change; if the above individuals are not available, inquire from the associated organization as to their successors.

ATTACHMENT A

Inspection and Maintenance Features



LEGEND

▭	PROPERTY BOUNDARY
— — —	ACCESS ROAD
┼┼┼┼	RAILROAD TRACK
●	POWER POLE
— O/H —	OVERHEAD POWER LINE
— U/G —	UNDERGROUND POWER LINE
— · — ·	APPROXIMATE EDGE OF PAVEMENT
——	EXISTING MAJOR CONTOUR (10-FT INTERVAL)
——	EXISTING MINOR CONTOUR (2-FT INTERVAL)
——	PROPOSED MAJOR CONTOUR (5-FT INTERVAL)
——	PROPOSED MINOR CONTOUR (1-FT INTERVAL)
🟩	ECOLOGICAL CAP
- - -	25FT RAILROAD BUFFER (SEE NOTE 1)
①	PHOTO LOCATION AND DIRECTION

NOTE(S)

1. ALL PERSONNEL WITHOUT PROPER RAILROAD SAFETY TRAINING ARE PROHIBITED FROM ENTERING THE RAILROAD BUFFER ZONE.

0 60 120
1" = 60' FEET

CLIENT
UNION PACIFIC RAILROAD CO.

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-05-17
DESIGNED	VMN
PREPARED	REDMOND
REVIEWED	FSS
APPROVED	TJN

PROJECT
ALUMINUM RECYCLING TRENTWOOD SITE
REMEDIAL ACTION - DROSS REMOVAL PROJECT
SPOKANE VALLEY, WASHINGTON

TITLE
INSPECTION AND MAINTENANCE FEATURES

PROJECT NO.	PHASE	REV.	FIGURE
19119180	1000	B	1

Path: \\golder.gds\gal\redmond\data\office\Redmond\geomatics\UnionPacificRailroad\TrentwoodWA\99_PROJECTS\19119180\1000B\02_PRODUCTION\DWG\ | File Name: 19119180_1000B_030.dwg | Last Edited By: vrayner Date: 2022-05-16 Time:9:14:38 AM | Printed By: VRayner Date: 2022-05-16 Time:10:13:07 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
0 1 in

ATTACHMENT B

Inspection Checklist

Aluminum Recycling Trentwood Site - Dross Removal Project

INSPECTION CHECKLIST

Checklist No.: ____________________

Date of Inspection: ____________________ **Weather Conditions:** ____________________

Inspected by (print name): ____________________

Signature of Inspector: ____________________

Inspection Feature	Photo. No.	Overall Condition **G/F/P**	Problem Severity **0/1/2**	Maintenance Required? **N/Y**	Notes and Comments
Ecological Cap (incl South Slope)					
Erosion					
Ponding					
Settlement					
Slope Failure					
Surface Water Facilities					
Berm					
North Ditch					
Overflow Channel					
Other 1[a]					
Other 2[a]					
Other 3[a]					
Security					
Site Entrance Gates & Locks					
Security Fencing					
Warning Signs					

Condition: G = Good F = Fair P = Poor

Severity: 0 = None or minor, feature appears stable 1 = Moderate, potential for future problems 2 = Major, function presently compromised

Indicate problem areas on attached map

(a) List

ATTACHMENT C

Maintenance Record

Aluminum Recycling Trentwood Site - Dross Removal Project
MAINTENANCE RECORD

Maintenance Record No.: ____________________

Date(s) of Maintenance: ______________________________

Weather Conditions: ____

Feature: ____

Cross-Reference Inspection Checklist No.: ____

Maintenance Contractor:

Name ____

Address ____

____

Phone ______________________

Maintenance Activities: (describe in detail, including any problems or unforeseen conditions; use additional sheets as necessary)

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Materials and Products: (list and describe all materials and products used for the maintenance activity, including supplier name and location; use additional sheets as necessary)

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Aluminum Recycling Trentwood Site - Dross Removal Project
MAINTENANCE RECORD

Maintenance Record No.: ____________________

Maintenance Documentation: (list all photos and / or drawings of maintenance activity, during and after completion of maintenance; attach photos and / or drawings to this record)

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Did Maintenance Require Changes from Recommended Procedures?

Yes ☐

No ☐

If yes, describe changes: (use additional sheets as necessary)

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Additional Maintenance Activities Required for this Feature?

Yes ☐

No ☐

If yes, describe changes: (use additional sheets as necessary)

____

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____

Maintenance Inspected by (print name): ____________________

Organization: ____________________

Signature of Maintenance Inspector: ____________________

Date: ____________________

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MEMBER OF WSP

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