Environment

Submitted to:
BNSF Railway Company
805 Great Northern Blvd, Ste. 105
Helena, Montana

Submitted by:
AECOM
Billings, Montana
60193807.620
September 2011

Final 2011 Work Plan for Additional Work

BNSF Former Tie Treatment Plant
Somers, Montana

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Prepared By Shelly Young

Reviewed By Ann Colpitts

List of Acronyms

µg/L	micrograms per liter
AECOM	AECOM Technical Services, Inc.
ARAR	Applicable or Relevant and Appropriate Requirements
BNSF	BNSF Railway Company
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGA	controlled groundwater area
COC	constituents of concern
CPAH	carcinogenic polycyclic aromatic hydrocarbons
CSM	conceptual site model
DNAPL	dense nonaqueous phase liquid
DPT	direct-push technology
DQA	Data Quality Assessment
DQO	Data Quality Objectives
EC	electrical conductivity
ESD	Explanation of Significant Differences
GPS	global positioning system
GWTS	Groundwater Treatment System
HASP	Health and Safety Plan
LNAPL	light nonaqueous phase liquid
MDEQ	Montana Department of Environmental Quality
MDNRC	Montana Department of Natural Resources & Conservation
mg/kg	milligrams per kilograms
NAPL	nonaqueous phase liquid
Pace	Pace Analytical Services, Inc.
PAH	polycyclic aromatic hydrocarbons
PID	photo ionization detector
POP	Project Operating Procedures
PPE	personal protective equipment
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RE	Response
ROD	Record of Decision
RPD	relative percent difference
RSL	Regional Screening Level
TarGOST®	Tar-specific Green Optical Screening Tool

TAT	turn-around time
THA	Task Hazard Analysis
TI	Technical Impracticability
TPAH	total polycyclic aromatic hydrocarbons
U.S.	United States
USC	United States Code
USEPA	United States Environmental Protection Agency
UV	ultraviolet
VOC	volatile organic compounds

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1.0 Introduction

AECOM Technical Services, Inc. (AECOM) has prepared this final work plan (Final 2011 Work Plan) on behalf of BNSF Railway Company (BNSF) in response to the United States (U.S.) Environmental Protection Agency (USEPA) request for "Additional Work" dated February 17, 2011 (USEPA 2011). USEPA's request for Additional Work was issued pursuant to Section III of Consent Decree No. CV-91-32-M-CCL (12/20/91). Although the Montana Department of Environmental Quality (MDEQ) is not a party to the Consent Decree, MDEQ also signed USEPA's request for Additional Work. USEPA and MDEQ are referred to collectively as the "Agencies."

USEPA has completed three independent 5-year reviews (1996, 2001, and 2006) to verify that the remedy selected by USEPA is operating and functioning as designed, and to evaluate whether the remedy remains protective of human health and the environment. The USEPA is in the process of preparing a fourth 5-year review.

1.1 Site Background

The Somers Site is located in northwestern Montana in the unincorporated town of Somers, Flathead County. BNSF and its predecessors operated a railroad tie treating plant from 1901 until its closure in 1986. Wood preservatives used at the site were creosote, zinc chloride, and for a short time, chromated zinc chloride. Wastewater generated during the treatment process was disposed of in two locations at the Site. During the operation of the Somers plant, BNSF discharged wastewater to the former Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) lagoon and overflow from this lagoon discharged through an open ditch into Flathead Lake. As discussed in the 1989 Remedial Investigation and Feasibility Study, the discharge of oily wastes was regulated under a permit issued by the Montana State Board of Health (RETEC 1989). In 1971, the CERCLA lagoon and ditch were abandoned, and in 1984, a recycling program was implemented to eliminate all wastewater discharges.

1.2 Previous Related Investigations

A series of investigations have been conducted on behalf of BNSF at the Somers Site since 1984, several of these within the area between the former CERCLA lagoon and monitoring wells S-91-2 and S-84-15. These investigations were conducted at the direction of USEPA. Investigations were conducted privately by property owners in 2009, without USEPA supervision, at the locations shown on **Figures 1-1A** and **1-1B**. **Figures 1-1A** and **1-1B** shows the location of wells, borings, and test pit locations installed during the following investigation.

- 1984 Phase I Investigation – installation of 16 groundwater monitoring wells, soil and waste sampling, groundwater sampling, and sampling and analysis of drinking water supplies.
- 1985 through 1987 Phase II Investigation – installation of 11 new groundwater monitoring wells and 3 borings, additional waste sampling and analysis, and 3 rounds of groundwater sampling.
- 1988 Phase III investigation – installation of 3 groundwater monitoring wells, 3 piezometers, and 11 test pits in the area of the former CERCLA lagoon, 3 rounds of groundwater sampling, and aquifer testing and groundwater modeling.
- 1991 remedial design study investigations – 13 soil borings, 9 piezometers, and 2 wells (designated with CB, CP, or CW, respectively) were installed downgradient of the CERCLA lagoon to a depth of 25 to 30 feet below ground surface.
- 1993 Phase I Groundwater Treatment System (GWTS) – 6 monitoring wells and 1 boring, 14 injection wells and 6 extraction wells were installed as part of the GWTS located in the former CERCLA lagoon.

- Additional Data Collection 2010 – Two monitoring well clusters (S-10-1 and S 10-2) were installed with three monitoring wells at each location: a shallow well screened across the water table, a deep well screened at the bottom of the boring, and an intermediate depth well installed midway between the shallow and the deep wells. Four existing wells were replaced as past zinc exceedances of the cleanup levels may be related to well construction with galvanized steel casing. Two wells that were dry during the interim monitoring period, including the background well, were replaced with deeper wells.
- 2011 Vapor Intrusion Investigation – In February 2011, vapor samples were collected at 5 residential properties (512, 520, 528, 536, and 544 Somers Road).

Figure 1-2 presents a summary of the soil analytical results obtained during the previous related investigations conducted within and near the area for soil investigation proposed by the Agencies in the February 2011 letter. Results for phenols, total polycyclic aromatic hydrocarbons (TPAH), and carcinogenic polycyclic aromatic hydrocarbons (CPAH) compounds are shown where available. Results exceeding 1989 Record of Decision (ROD) (USEPA 1989) excavation levels (1,875 milligrams per kilograms [mg/kg] for TPAH, 3.6 mg/kg for CPAH, and 3,000 mg/kg for phenols) have been bolded to show where ROD levels were exceeded during these previous investigations.

At the Somers Site, the dissolved creosote constituent groundwater plume was treated using a pump and treat GWTS located in the former CERCLA lagoon, which operated from 1994 through 2007. The groundwater remedy effectiveness at BNSF Somers was evaluated following 8 years of operation. Pursuant to CERCLA, 42 United States Code (USC) § 9621(d)(4), and USEPA's guidance on Technical Impracticability (TI) Evaluations (USEPA 1995, 1993), it was concluded that restoration of creosote impacted groundwater at the Somers Site to applicable or relevant and appropriate requirements is not technically practicable. Conclusions were presented in the Technical Impracticability Evaluation for Groundwater Restoration (TI Evaluation), which was revised in 2003 (RETEC 2003), which determined that full aquifer restoration (as defined in the ROD) cannot be achieved within a reasonable time frame, with the primary impediment to restoration of the aquifer being the inability to extract dense nonaqueous phase liquid or circulate nutrient-enriched water effectively. The TI Evaluation determined aquifer and creosote characteristics are the primary impediment to movement of dissolved creosote constituents, the Phase I GWTS is not a significant factor in the retardation of creosote constituents, and available groundwater treatment technologies are not able to meet the groundwater treatment goals in a reasonable time. USEPA approved the TI Evaluation report in 2003 but withheld a final decision on the TI waiver pending collection of additional data.

Consistent with the approved TI Evaluation, institutional controls were implemented at the Site to prevent use of the surficial aquifer and exposure to creosote impacted groundwater. A controlled groundwater area (CGA) designation was approved by the Montana Department of Natural Resources & Conservation in 2003 (MDNRC 2003). The CGA designation prohibits the installation of groundwater supply wells or the extraction of groundwater from the surficial aquifer for any purpose other than remediation. The area encompassed by the CGA is larger than the area of the TI Evaluation to minimize the risk that future groundwater pumping might cause the migration of dissolved creosote constituents in the surficial aquifer. BNSF also has adopted deed restrictions and land use controls pursuant to the Consent Decree (USA 1991).

BNSF requested termination of the GWTS in the Groundwater Treatment System Interim Shut-Down Plan (ENSR 2007) based on TI Evaluation and modeling results that indicated the GWTS provided only minimal creosote constituents removal and the unlikelihood for creosote-impacted groundwater from the Site to migrate to either the town well or Flathead Lake given the geologic conditions of the aquifer and the low mobility of the dissolved creosote constituents of concern (COCs) present onsite. Approval to shutdown GWTS operations for an interim period was granted in October 2007 (USEPA 2007). Since that time, BNSF has collected quarterly monitoring data in accordance with the GWTS Interim Monitoring Plan (ENSR 2009, revised AECOM 2011b) to evaluate the stability of the dissolved phase plume of COCs and to verify that the plume is naturally attenuating. Results have been reported in quarterly and annual interim monitoring reports (AECOM 2011a, 2010, 2009). **Figure 1-3** presents the groundwater flow vectors from the September 2009 through March 2011, gauging events. **Figure 1-4** shows the range of groundwater analytical results for phenols, TPAH, and CPAH collected over the interim monitoring period from January 2008 through March 2011, within the area of groundwater investigation proposed by the Agencies in the February 2011 letter. Results exceeding cleanup levels defined in the ROD or subsequent USEPA Explanation of Significant Differences (ESD) documents (USEPA 1998, 1992) (40 micrograms per liter [µg/L] for TPAH, 0.030 µg/L for CPAH, and 6,000 µg/L for phenols) have been bolded to show where ROD or ESD levels were exceeded during the interim monitoring period.

1.3 Data Quality Objectives

The Data Quality Objective (DQO) process is a series of planning steps that are designed to ensure that the type, quantity, and quality of environmental data used in decision-making are appropriate for the intended purpose. These DQOs also shall be the determinative factor for assessing the success or failure of the sampling. USEPA has issued guidelines to help data users develop site-specific DQOs (USEPA 2000). The seven steps of the DQO process are:

Step 1 – The Problem Statement;

Step 2 – Identifying the Decision;

Step 3 – Identifying the Decision Inputs;

Step 4 – Defining the Investigation Boundaries;

Step 5 – Developing a Decision Rule;

Step 6 – Defining Tolerance Limits on Decision Errors; and

Step 7 – Optimizing the Sample Design.

1.3.1 Project Objectives

USEPA's objective for the Additional Work is to characterize the vertical and horizontal extent of subsurface soil and groundwater contaminants associated with the Somers Site that exceed background levels or exceed USEPA 1989 ROD or ESD cleanup levels. The areas for additional characterization were depicted in Figure 2 attached to USEPA's request for Additional Work.

The response objectives for soil and groundwater identified in the 1989 ROD were also identified by the Agencies during the June 3, 2011, conference call as project objectives for this Final 2011 Work Plan. The ROD response objectives for soil remediation were to reduce exposure from direct contact to an acceptable level and to ensure migration of contaminants to groundwater was minimized. The ROD response objectives for groundwater remediation were to reduce, by treatment, potential exposures to groundwater ingestion and to ensure contaminants in groundwater do not adversely affect the quality of Flathead Lake. Potential vapor intrusion migration into homes was also expressed as a concern of the Agencies during a June 15, 2011, conference call with BNSF.

Data collected also will be used to:

1. Determine future groundwater well placement to define the CGA boundary,
2. Refine the existing conceptual site model (CSM) and groundwater flow model, and
3. Design treatability studies to evaluate technologies.

1.3.1.1 Step 1: Problem Statement

As described in Section 1.2, dissolved creosote constituents have been detected in groundwater at the Somers Site. Previous investigations indicate that creosote and/or dissolved phase constituents above the cleanup levels established in the 1989 ROD or subsequent ESDs are present in the subsurface beyond the proposed TI boundary and existing CGA.

1.3.1.2 Step 2: Identifying the Decision

The principal questions that must be addressed are the following:

- Confirm the nature and extent of the COCs within the study area identified in Figure 2 attached to USEPA's request for Additional Work.
- Confirm the relative groundwater flow directions in the shallow and deeper zones of the area.
- Refine the existing CSM.
- Use data resulting from investigation to assist in determining if the remedy selected by USEPA in the ROD and implemented by BNSF pursuant to the Consent Decree continues to protect human health and the environment.
- Examine the need for a treatability study based on data obtained from the investigation.

1.3.1.3 Step 3: Identifying the Inputs to the Decision

Potentiometric data and groundwater and soil samples will be collected. Samples will be analyzed for phenols, PAH, zinc, and volatile organic compounds (VOCs). Various sources of information that might be used include historical sampling and analysis and reports. The ROD or ESD levels will be used to define the decision values for determining if additional action may be required.

Potential samples include:

- Tar-specific Green Optical Screening Tool (TarGOST®) borings to identify the extent of nonaqueous phase liquid (NAPL) at the Site – 16 proposed and 17 tentative; and
- Direct-push technology (DPT) borings to identify the extent of the dissolved phase creosote at the Site – 19 proposed, 31 tentative.

Test Methods:

- EPA Method 8260B for VOCs;
- EPA Method 8270-SIM for PAH compounds;
- EPA Method 8270 for phenols; and
- EPA Method 6020 for zinc.

1.3.1.4 Step 4: Define the Investigation Boundaries

The study area was defined by USEPA on Figure 2 attached to the Agency's request for Additional Work and is shown in **Figure 2-1** of this Final 2011 Work Plan.

1.3.1.5 Step 5: Develop a Decision Rule

For this investigation, concentrations of COCs in soil and groundwater will be compared to the following criteria:

1. Are concentrations in soil samples above or below the ROD or ESD levels?
2. Are the concentrations in groundwater above or below the ROD or ESD cleanup levels?
3. Do TarGOST® results indicate creosote impacts?

4. Does the existing CSM and flow model need to be refined?
5. Does the data obtained indicate that the remedy selected by USEPA in the ROD and implemented by BNSF pursuant to the Consent Decree continues to protect human health and the environment?
6. In order to protect human health and the environment, should the TI boundary and CGA boundaries be modified to encompass additional areas where soil and groundwater exceed ROD or ESD cleanup levels using past and current contour maps for shallow and deep aquifers?

1.3.1.6 Step 6: Defining Tolerance Limits on Decision Errors

To mitigate the potential for false positive or false negative errors associated with the field sampling, sample collection procedures will be consistent with established Project Operating Procedures (POPs). A sufficient number of quality assurance/quality control (QA/QC) samples will be collected. The laboratory will follow the calibration and internal quality control procedures specified for the soil and groundwater methods of analyses. This includes initial and continuing laboratory calibration, use of method blanks, control samples and collection of blind duplicates to the lab (and subsequent comparison to primary samples using relative percent difference statistics, implementing decontamination procedures, and collection of field blanks.

1.3.1.7 Step 7: Optimizing the Sample Design

For this investigation work, the sample locations and the investigative approach were selected based on the results of previous sampling efforts at this site, discussions among the Agencies, BNSF, and existing data needs.

1.3.2 Measurement Performance Criteria

In order to meet the DQOs, persons generating the data (in both the field and the laboratory) must be aware of the objectives. Measurement performance criteria to meet the DQOs include performance criteria for obtaining the samples and performance criteria for the analytical laboratory. In addition, the persons generating the data must be properly certified and trained for the work and comply with the site health and safety requirements.

1.4 Scope of Work

This section presents the scope of work needed to meet the objectives, including data collection locations, discussion of the borings that will be installed, types of data that will be collected, field methods for collection, laboratory analytical methods, and data collection locations. Data collection activities will be conducted in a manner consistent with the procedures set forth in the POPs included in **Appendix A** of this Final 2011 Work Plan. The text procedures described in this Final 2011 Work Plan supersedes any POP text if the work plan and POP differ but are not intended to modify the Consent Decree. Field investigation activities will be conducted in a manner consistent with the procedures set forth in the Consent Decree and this Final 2011 Work Plan. The Site-specific Health and Safety Plan (HASP) and QA/QC Plan, referred to as a Quality Assurance Project Plan (QAPP), also will be followed while implementing the additional work outlined in this Final 2011 Work Plan.

1.4.1 Extent of Creosote and/or Dissolved Phase Constituents and Proposed TI Boundary Location

Additional activities are proposed to more fully characterize the extent of the creosote and/or dissolved phase constituents downgradient of the former CERCLA lagoon to fulfill the primary objective of this Final 2011 Work Plan. The data collected during implementation of this work plan and in future quarterly monitoring events will help evaluate the stability of the plume and the degree to which natural processes are present to aid in breaking down and/or inhibiting the migration of these constituents. The data also will help determine if the proposed TI and the existing CGA boundaries should be revised.

1.4.2 TarGOST® and Boring Investigation

TarGOST® will be used to determine the extent and distribution of NAPL near the former CERCLA lagoon in the vadose zone and below the water table and DPT borings will be used to evaluate the extent of creosote impacts (through evaluation of PAHs, phenols, zinc, and VOC concentrations) in the vadose zone and, where feasible, allow for collection of groundwater grab samples to assist in determining future groundwater well placement to define the CGA boundary. Tentative locations are presented on **Figure 2-1**, attached.

TarGOST® is designed for delineating NAPL found at creosote sites. Creosote NAPLs contain large amounts of naturally fluorescent PAHs and TarGOST® was specifically designed to precisely log the NAPL versus depth (Dakota Technologies 2011). A sample of water with emulsified creosote collected from the Somers Site on May 21, 2011 was sent to Dakota Technologies. Per Dakota Technologies, the NAPL responded well and TarGOST® will easily delineate the creosote providing that direct push conditions at the Site are amenable. Any response over 100 percent response (RE) is acceptable and over 500 percent RE is best. The sample provided from the site was greater than 2,000 percent RE and is in the "high confidence" category.

Different soil types will conduct electricity differently depending on particle size and mineralogy. For example, clays generally will have high conductivity while gravels will have low conductivity (Dakota Technologies 2011b). Electrical conductivity (EC) will be used in conjunction with TarGOST® to develop a model of NAPL and unconsolidated stratigraphy for use in predicting the mobility of the residual creosote at the Site.

At least three TarGOST® boring locations will be paired with DPT borings. The NAPL model and EC results obtained from the TarGOST® borings will be compared to the field observations of NAPL and lithology in the DPT borings. In addition, one TarGOST® boring will be installed next to nested monitoring well set S-10-1, where NAPL has been observed. The TarGOST® results will be compared to analytical data that has been obtained from the well to confirm TarGOST® results coincide with groundwater concentrations observed in the wells (i.e., a higher RE would be expected in the TarGOST® boring where higher groundwater impacts have been measured in the shallow well).

1.4.3 Conceptual Site Model and Groundwater Flow Model

Data collected during implementation of this Final 2011 Work Plan will be used in conjunction with historical data to update the existing CSM and groundwater flow model presented in the 2003 TI Evaluation (RETEC 2003).

1.4.4 Well Installation, Sampling, Development and Survey

Based on results of the TarGOST® investigation and observations in the DPT borings, an addendum to this Final 2011 Work Plan will identify locations for additional monitoring wells. Additional future work may include collection of fluids (groundwater and the NAPL emulsion present) for analysis of fluid interfacial tensions.

1.4.5 Data Collection to Support Treatability Study Design

Prior to preparing a work scope for additional treatability study design, the site conceptual model will be re-evaluated and the groundwater flow model validated and/or refined. Although a brief review of potentially applicable technologies is provided in the subsequent section, the decision to collect additional data to support treatability study design is unnecessary at this time. This initial technology review is primarily supported by extensive site knowledge of the site operation and sources of the contamination, the operation of a remediation system, and the former geologic and hydrogeologic characterization that has previously been conducted at the Site. An addendum to this Final 2011 Work Plan may identify soil core samples that may be collected to evaluate mobility of NAPL. Samples may be collected for the following analyses:

- NAPL core photography,
- Initial and residual pore fluid saturation,
- Grain-size analysis, and
- Soil chemical analysis on samples with and without NAPL.

Once the team understands the degree to which NAPL might be mobile at the site and the relative risks it might pose, additional technologies can be evaluated for feasibility of implementation to prevent such risks. No additional data collection is recommended at this time, pending TarGOST® results, to support treatability studies.

1.4.6 Treatability Study Work Plan

Upon determining the need for additional data collection, including those indicated above, a Treatability Study Work Plan or an addendum to this Final 2011 Work Plan will be prepared in order to identify the methods and materials necessary for collecting specific samples and to communicate how those data might be used to support technology treatability studies.

1.5 Work Plan Organization

This work plan is organized into the following sections.

- Chapter 1.0 provides an introduction to this plan.
- Chapter 2.0 provides a discussion of screening of treatment technologies.
- Chapter 3.0 provides the proposed treatability study approach.
- Chapter 4.0 provides a description of the field investigation and procedures.
- Chapter 5.0 provides a discussion of the focused feasibility study to evaluate technologies to achieve remedial action response objectives.
- Chapter 6.0 provides the quality assurance project plan.
- Chapter 7.0 provides the health and safety objectives.
- Chapter 8.0 provides report preparation.
- Chapter 9.0 provides the investigation schedule.
- Chapter 10.0 provides the references.
- **Appendix A** provides the Project Operating Procedures.

2.0 Screening of Treatment Technologies

A technical memorandum summarizing the work performed in the development and screening of alternatives and the results of each task described in the technical memorandum will be completed within 60 days of validation of all analytical results collected under this Work Plan.

This technical memorandum shall include, but is not limited to:

- A description of the treatment technology and the areas or volumes of contaminated media to which they apply;
- A description of the treatment technology types and process options applicable to each general soil and groundwater response objective identified in the ROD;
- The results of the initial screening of treatment technology types and process options;
- A description of the remedial alternatives;
- The results of the screening of alternatives based on effectiveness, implementability, and cost;
- Remedial alternatives selected for treatability studies; and
- A description of the alternatives that remain after screening and the action-specific State and Federal Applicable or Relevant and Appropriate Requirements (ARARs) that are specific for each alternative.

3.0 Proposed Treatability Study Approach

The Agencies will examine the need for treatability studies based on the data obtained from this investigation. If proposed, the treatability studies will be designed to provide sufficient data to allow treatment alternatives to be fully developed and evaluated and/or to reduce the cost and performance uncertainties for treatment alternatives to levels sufficient to allow the Agencies to make appropriate response action decisions. If required, BNSF shall refer to the “Guidance for Conducting Treatability Studies under CERCLA”, EPA No. 540/R-92/071A, OSWER Directive 9355.3-01/FS, October 1992.

3.1 Treatability Study Work Plan

If the Agencies, in consultation with BNSF, determine that treatability studies are necessary, a draft treatability studies are necessary, a draft treatability study work plan will be prepared. The treatability study work plan shall describe the type of treatability study to be performed (e.g., bench scale or pilot scale) and shall include:

- A discussion of background information;
- A list of key personnel and responsibilities;
- A description of the remedial technologies to be tested;
- DQOs for each test including measurements of performance;
- The experimental procedures for each test;
- A Sampling and Analysis Plan that describes the samples to be collected, sample collection procedures, sampling handling and tracking procedures, DQOs, a QAPP and analytical methods;
- A data management plan;
- A health and safety plan; and
- A plan for management of waste generated during the treatability study.

3.2 Treatability Study Report

Upon Agency approval of the treatability study work plan, BNSF shall implement the work plan. Following completion of the treatability study, BNSF shall analyze and interpret the study results in a technical report in accordance with the schedule contained in the final treatability study work plan. In the report, BNSF shall evaluate the effectiveness, implementability, and cost of each technology and compare test results with predicted results. BNSF shall also evaluate full-scale application of the technology including a sensitivity analysis identifying key parameters affecting full-scale operation.

4.0 Field Investigations and Procedures

4.1 TarGOST® Boring Locations

AECOM will perform site-wide screening using TarGOST® installed on a Geoprobe direct push platform to provide real-time delineation of subsurface tar impacts. TarGOST® uses pulsed ultraviolet (UV) light from a laser to excite the fluorescence of PAHs found in NAPL. Aromatic hydrocarbons fluoresce at characteristic wavelengths. Low molecular weight aromatic hydrocarbons such as benzene fluoresce at shorter wavelengths whereas high molecular weight aromatic hydrocarbons fluoresce at longer wavelengths. Consequently, the composition of Dense NAPL (DNAPL) or Light NAPL (LNAPL) can be estimated by measuring the wavelengths over which it fluoresces. TarGOST® measures the wavelengths and relative intensity of the NAPL fluorescence in soil, making it possible to qualitatively identify NAPL type. Since the fluorescence intensity of NAPL measured by TarGOST® can be proportional to the NAPL concentration in soil, it is also possible to calibrate TarGOST® fluorescence measurements to in-situ NAPL soil saturations if detailed lithology data is available.

BNSF proposes sixteen TarGOST® borings around the former CERCLA lagoon (including 1 boring inside the lagoon) and an additional 17 locations are tentatively proposed down gradient from the former CERCLA lagoon. Criteria from initial borings, including fluorescence response, boring refusal, and site logistics, will be analyzed and will guide the completion of remaining borings. The initial proposed and tentative TarGOST® locations are shown on **Figure 2-1.** Borings will be discontinued vertically or laterally if evidence of creosote impacts is no longer observed. TarGOST® borings will be performed to a depth of 50 to 75 feet if the equipment can achieve those depths given the tight formation at the Somers Site (**Figure 2-1**). In addition, final placement of the borings may be limited by property owner permissions and physical obstructions in the field including utilities and structures. The 16 proposed and 17 tentative TarGOST® borings does not include duplicate locations, which are needed for QA/QC.

A TarGOST® boring will be installed in a location where no groundwater impacts have been observed to evaluate background fluorescence effects (i.e., non-contaminant based fluorescence including minerals organic rich debris).

Proposed boring locations will be demarcated in the field by using a hand-held global positioning system (GPS) unit that has the AutoCAD coordinated entered into it. Final locations may be moved based on overhead and underground utilities, surface obstructions, and landowner requests.

During the implementation of the TarGOST® field activities, AECOM will provide daily communication between the field staff and the technical and management team. AECOM will work with TarGOST® data as it is generated to maximize the utility of subsequent data points. Additional locations may also be proposed at Agencies' discretion.

4.1.1 TarGOST® Borings Installation and Sampling Methods

- TarGOST® borings will be installed using a track mounted Geoprobe® Rig using push-probe sampling methods (Dakota Technologies SOP in **Appendix A**).
  - Each TarGOST® boring will be logged continuously by Dakota Technologies representatives. An AECOM representative will provide oversight at each of the boring locations.
  - All pushes should be completed to a minimum of 5 feet below significant NAPL TarGOST® intensities or to refusal. Significant response depends on site specific contaminants properties and delineation goals, however generally responses above 10 to 25 percent that are greater than 0.5 feet in thickness represent zones that need further delineation vertically and laterally.

  - All TarGOST® data will be recorded electronically; in addition, a hard copy of the data from each boring will be generated.
  - EC also will be measured in the TarGOST® borings and will provide information on the soil types. For example, clays generally have a higher conductivity than gravels.
- The TarGOST® probe will be decontaminated and re-calibrated between each boring location;
- TarGOST® Borings will be abandoned following sample collection. Boring abandonment activities will be conducted in accordance with Montana Administrative Code 36.21.670. The boring will be filled with sealing material (bentonite) to within 3 feet of the surface to prevent vertical movement of groundwater in the bore hole. Any remaining hole will be filled with unimpacted or clean naturally occurring soils.

4.2 Geoprobe® Boring Locations

BNSF proposes 19 DPT borings with groundwater grab sample collection, where feasible, around the former CERCLA lagoon (including one inside the lagoon) (**Figure 2-1**). An additional 31 DPT borings are tentatively proposed upgradient and downgradient from the lagoon. The boring locations include those requested by USEPA's May 23 and June 17, 2011 emails and the comments provided by the Agencies in an August 9, 2011 letter (USEPA 2011). **Table 4-1** presents the rationale for each of the soil boring locations.

Soil borings will be completed to depths of 50 to 75 feet if possible. Borings will be discontinued vertically or laterally if groundwater concentrations from all sampled intervals are below the 1989 ROD or subsequent ESD levels, or the USEPA tap water levels for VOC or PAH compounds without assigned ROD/ESD levels. Boring observations may also determine if another boring is necessary if evidence of creosote impacts (which may include staining, odor, or high photo ionization detector [PID] readings) is no longer observed. Heaving sands could affect boring installation, sample collection, or sample quality (it may be necessary to add water to counter the heaving sands). Final placement of the borings may be limited by property owner permissions and physical obstructions in the field including utilities and structures.

4.2.1 Geoprobe® Borings Installation and Sampling Methods

- Borings will be installed using a Geoprobe® Rig using Geoprobe's DT 22 Dual-Tube Soil Sampling System (DT22). The DT22 system is a continuous core soil sampler. The DT22 system consists of an outer casing and core catcher, which is designed to keep the borehole open throughout the probing process (similar to the augers used on a hollow stem auger drill rig). The DT22 system also consists of an inner rod and 1.3 inch diameter acetate liner which is used to retrieve soil samples.
- Each continuous core will be logged by a field scientist/engineer and recorded in the field logbook and Boring Log (POP 120, 210, and 212).
  - PID readings will be collected from each 2-foot interval (if many soil types are present) or from zones of different soil types (if zone thicknesses are greater than two feet) (POP 310).
  - A sheen test will be conducted at each 2-foot interval within the headspace bags. (POP 225).
  - A plastic tarp or similar barrier will be placed on the ground around the borehole and soil cuttings will be containerized (POP 006). Any drilling mud or well development/purge liquid collected also will be properly contained and disposed of (POP 006). Soils and liquid will be managed as indicated in Section 7.2.
- Soil samples will be collected in the unsaturated zone of each boring up to the depth of the groundwater table if evidence of creosote impacts (i.e., dark staining, hydrocarbon odors, or high PID readings) is encountered above the groundwater table, if no impacts are observed, a soil

sample will be collected directly above the water table. The interval from which samples are collected will be recorded in the field logbook, and photos will be taken of the soil cores as appropriate POP 210.

- Soil samples will be sent to Pace Analytical Services, Inc. (Pace) in Minneapolis, Minnesota, and will be analyzed for TPAH and CPAH by USEPA Method 8270-SIM, phenols by USEPA Method 8270, and VOCs by USEPA Method 8260B. Analytical results will be compared to the 1989 ROD or subsequent ESD levels, or to USEPA residential soil to groundwater Regional Screening Levels (RSLs) if ROD/ESD levels are not assigned.
- Proper packaging methods and shipment of samples to minimize the potential for sample breakage, leakage, or cross-contamination and to provide a clear record of sample custody from collection to analysis is provided in POP 110.
- Split samples will be made available to the Agencies and/or property owners upon request provided a sufficient volume of soil can be collected. The Agencies will follow proper methods established in POP 110 and POP 210 if split samples are taken.

• Groundwater sample collection will be attempted from all of the borings at locations of historical impacts and if a sufficient volume of water is present (POP 210 and POP 230).

  - Groundwater samples will be collected from a maximum of three depths; at first encountered groundwater, at depth of 20 to 40 feet below ground surface, and at terminal depth of boring (50+ feet below ground surface).
  - Once the direct push rods have reached the appropriate depth, a reusable, discrete stainless steel sampler will be inserted into the outer rods.
  - Water levels will be measured from inside the discrete sampler and will be recorded on a fluid level log (POP 231) and on the groundwater sampling form (POP 230).Groundwater samples will either be collected using a disposable polyethylene micro-bailer or polyethylene tubing connected to a peristaltic pump, depending upon groundwater levels below ground surface.
  - Provided a sufficient volume of water can be obtained in a reasonable amount of time, samples will be collected in the following order (based on the mobility of the compounds in groundwater) and will be sent to Pace.
    1. VOC by EPA Method 8260B;
    2. Phenols by EPA Method 8270; and
    3. PAH by EPA Method 8270-SIM (lab to report all compounds included in the 8270-SIM method including Dibenzofuran, 1-Methylnapthalene, and 2-Methylnapthalene).
  - Proper packaging methods and shipment of samples to minimize the potential for sample breakage, leakage, or cross-contamination and to provide a clear record of sample custody from collection to analysis is provided in POP 110.
  - Groundwater sampling logs will be completed and/or notes will be added to the field logbook and presented in the 2011 Completion Report (POP 230).
  - Split samples will be made available to the Agencies and property owners upon request provided a sufficient volume of water can be collected from the installed boring.
  - Soil and groundwater samples will be shipped overnight to Pace Analytical in Minneapolis, MN for a 2 day turn-around time (TAT). Pace Analytical cannot provide a 24-TAT based upon extraction methods.
  - If the groundwater concentrations exceed the ROD or ESD levels, or USEPA tap water levels for VOC or PAH compounds not included in the ROD/ESDs, a Geoprobe® boring downgradient of the sampled boring will be completed.

- At the downgradient boring, a groundwater sample will only be collected at the same sampling interval as the boring containing the groundwater exceedance. For example, if the shallow groundwater sample collected from the initial boring presented exceedances and the intermediate and deep groundwater samples were clean, only a shallow groundwater sample will be collected from the downgradient boring.
- If groundwater samples collected from the proposed or tentative boring do not exceed the ROD or ESD levels, or USEPA tap water levels for compounds not included in the ROD/ESDs, a downgradient boring will be not be completed.

- Borings will be abandoned following sample collection. Boring abandonment activities will be conducted in accordance with Montana Administrative Code 36.21.670. The boring will be filled with sealing material (bentonite) to within 3 feet of the surface to prevent vertical movement of groundwater in the bore hole. Any remaining hole will be filled with unimpacted or clean naturally occurring soils.

4.3 Boring Survey

All boring locations will be surveyed by a licensed surveyor within 60 days of completion. Surveying will be provided by Montana licensed professional land surveyor. Surveying will be based on the horizontal datum of NAD 83 Montana State Plane Feet and the vertical datum of NGVD 29 to be consistent with information gathered during previous survey events. Positional accuracy of the survey will meet the Accuracy Standards for ALTA/ACSM Land Title Surveys, as adopted by the American Land Title Association and the National Society of Professional Surveyors.

5.0 Focused Feasibility Study to Evaluate Technologies to Achieve Remedial Action Response Objectives

If the Development and Screening of Alternatives Technical Memorandum (Memorandum) described in Section 2.0 of this Work Plan is deemed necessary, upon Agency approval of the Memorandum, BNSF shall perform a focused feasibility study of the remaining remedial alternatives to achieve response action objectives identified in the ROD. The detailed analysis shall be sufficient to allow the Agencies to adequately compare the alternatives; select an appropriate treatment technology or range of technologies and demonstrate satisfaction of the CERCLA statutory remedy selection requirements pursuant to Section 121(b)(1)(A).

Each alternative will be assessed against the following seven of the nine evaluation criteria contained in the National Contingency Plan, 40 Code of Federal Regulations (CFR) Part 300.430(e) (9) (iii):

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long term effectiveness and permanence
4. Reduction of toxicity, mobility, and volume
5. Short-term effectiveness
6. Implementability
7. Capital and Operating and Maintenance Costs

A detailed analysis of alternatives will be conducted by evaluating each alternative against the seven evaluation criteria above and then performing a comparative analysis between remedial alternatives. The major objective of this activity is to evaluate the relative performance of each alternative with respect to each criteria and consider the tradeoffs of each in order to select one, or a combination of several alternatives, as a proposed alternative treatment. This also helps ensure that the advantages and disadvantages of each alternative are clearly understood.

6.0 Quality Assurance Project Plan

6.1 Field Documentation

All field observations will be recorded in a field book designated for the BNSF Somers Project. Geologic information while drilling will be recorded on AECOM's Soil Boring and Well Construction Logs. Groundwater sampling information, from the soil borings, will be recorded on AECOM's Groundwater Sampling Forms.

6.2 Decontamination

All sampling equipment will be subject to appropriate decontamination protocol (POP 110, POP 120). To assess the adequacy of decontamination procedures, 1 rinsate or equipment blanks per 20 samples will be collected and analyzed for the same parameters as the field samples.

6.3 Data Quality Assessment

Information obtained through the implementation of this Final 2011 Work Plan will be evaluated through the Data Quality Assessment (DQA) process to determine if the data obtained are of adequate quality and quantity to support their intended use. The DQA process consists of five steps, as summarized below (USEPA 2000):

1. Review the DQOs and Sampling Design: DQO outputs will be reviewed to ensure that they are still applicable. The sampling analysis and data collection documentation also will be reviewed for completeness and consistency with DQOs.
2. Conduct a Preliminary Data Review: Data validation reports will be reviewed to identify any limitations associated with the analytical data. Basic statistics will be utilized by the laboratory where applicable and meaningful graphs of the data will be prepared. This information will be used to learn about the structure of the data and to identify patterns, relationships, or potential anomalies/outliers.
3. Select the Statistical Method: Select the appropriate procedures for summarizing and analyzing the data, based on the review of the performance and acceptance criteria associated with the project objectives, the sampling design, and the preliminary data review. Identify the key underlying assumptions associated with the statistical tests.
4. Verify the Assumptions of the Statistical Method: Evaluate whether the underlying assumptions hold, or whether departures are acceptable, given the actual data and other information about the study.
5. Draw Conclusion from the Data: Perform the calculations necessary to draw reasonable conclusions from the data. If the design is to be used again, evaluate the performance of the sampling design.

Uncertainty of validated data will be identified in the report and evaluated by the Site team to determine if the DQOs were met. In the event that the DQOs were not met, they will be reviewed to determine if they are achievable and may be revised if necessary, and the data may be further evaluated to determine the impact to the project. Data usability and limitations will be evaluated by the Site team.

6.4 Quality Control Samples and Collection Procedures

QA/QC field samples are collected to provide assurance that sample results are representative of actual conditions and that no contamination has inadvertently been introduced into the samples. One blind field duplicate sample will be collected for every 20 soil samples and for every 10 groundwater samples (with a minimum of 1 sample per media) to test the precision of the sampling process and the laboratory analysis. For soil analysis, sample material for the primary and blind duplicate samples will be thoroughly composited in a stainless steel bowl or plastic bag to ensure both samples are representative of the same conditions. Soil samples collected for VOC analysis will be collected directly from the acetate sleeve and not the stainless steel bowl or plastic bag. Groundwater duplicate samples will be collected from the same boring by using the same sampling equipment. Blind duplicates will be collected and analyzed for the same list as the primary sample. For TarGOST® borings, additional borings are installed next to "parent" borings to perform QA/QC checks.

The relative percent difference (RPD) parameter will be calculated to define the precision between duplicate analyses; see below for a detailed description of this calculation. The acceptable limits for field duplicate RPD will be 0 to 50 percent for soil samples.

Precision is a measure of the mutual agreement among individual measurements of the same parameter, usually under prescribed similar conditions. The RPD parameter will be calculated to define the precision between duplicate analyses.

The RPD for each component is calculated using the following equation:

$$RPD = \{|D1-D2| / [0.5 \times (D1+D2)]\} \times 100$$

where:

RPD = relative percent difference

D1 = first sample value

D2 = second sample value (duplicate)

Precision is determined through analyses of field and laboratory duplicate samples. Duplicate samples will be collected at a 5 percent frequency during field sampling. For all analyses, the laboratory(s) also will perform duplicate analysis on 5 percent of the samples submitted. Duplicates will be collected from all media; including impacted media, if the media can be identified as impacted while field sampling. Field duplicates will be sampled weekly. For duplicate samples, the calculated RPD will be summarized. The RPD data will be used to evaluate the long-term precision of the analytical method. The acceptable limits for field duplicate RPD will be 0 to 50 percent for soil samples. The acceptable limits for laboratory RPD will be 0 to 20 percent for all media as referenced in the National Functional Guidelines (USEPA 2010, 2008). If field or laboratory RPDs exceeds these limits, corrective action will be taken. The corrective action will consist of reanalysis, or flagging the result as an estimate for the specific analyte if sample heterogeneity is confirmed.

Equipment rinse blank or field blank samples will be collected during groundwater and soil sampling to assess accuracy of field sampling and decontamination procedures. Equipment rinse blank samples will be obtained by pouring deionized water over the decontaminated sampling equipment. One equipment rinsate blank will be collected per every 20 field samples or 1 for each day that sampling equipment is decontaminated in the field. The rinsate blanks that are collected will be analyzed for the same compounds as the samples that were taken with the equipment.

In the event equipment, which does not require decontamination, is utilized for sample collection (such as disposable trowels), then field blanks shall be collected in lieu of equipment rinse blank samples. Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling due to contamination from sample containers. Field blank samples will be obtained by pouring deionized water into a sampling container at the sampling point. One field blank sample shall be collected per every 20 field samples. The field blank samples collected will be analyzed for same compounds as the sample taken from that location.

The equipment rinsate blank or field blank samples will be preserved, packaged, and sealed in the manner described for the environmental samples. A separate sample number and station number will be assigned to each sample, and it will be submitted blind to the laboratory.

6.5 Sampling Handling Procedures

6.5.1 Soil and Groundwater Sampling Documentation

The soil and groundwater samples submitted for laboratory analysis will include the name of the sample, the date and time of collection, and the approximate depth below the original ground surface. Collection details of all samples will be recorded in site field books including samplers name, date, time, who was present onsite, field instrument information, purge start and end time, weather, etc.

6.5.2 Quality Assurance/Quality Control Field Documentation

The collection of the blind duplicate sample will be documented in the field notebook so that the correct QA/QC sample data can be later matched with the appropriate primary sample. For the blind duplicate sample, this information will include the name, collection date, and collection time, of both the primary sample and the associated duplicate.

6.5.3 Chain of Custody

Sample custody procedures are documented in the HASP and will be followed for all samples submitted for laboratory analysis. A copy of each chain-of-custody will be sent to the AECOM project manager and retained in the project file. Samples will be in the custody of the sampler and within their sight until shipped to the laboratory in a sealed cooler that contains a copy of the chain-of-custody in a Ziploc® bag taped to the inside cover. The laboratory will keep a copy of the chain-of-custody and shipping invoice as proof of custody.

7.0 Health and Safety

A HASP has been developed for the Somers Site. The HASP is reviewed annually and updated as needed. The HASP contains emergency contact information and directions to the hospital, as well as information on hazards generally present on AECOM field sites. A copy of the HASP will remain on-site in the treatment building office throughout the data collection activities; all personnel working on-site must review and sign the HASP.

Safety equipment is available on site and personnel involved in the work activities need to be familiar with its proper use and location. Equipment includes the safety shower eyewash station and fire extinguishers. Minimum personal protective equipment (PPE) requirements include safety glasses with side shields, hard hats, and steel-toed boots. Gloves shall be worn when handling equipment and materials. Nitrile or other chemically impervious gloves shall be worn when working with contaminated liquids or sludges. Orange vests also will be worn when working around moving vehicles or near public roads.

Below is a list of general safety guidelines that will be followed during the additional data collection activities.

- All contractors will have completed the BNSF Contractor Orientation Training prior to conducting work on site. Annual certification is required.
- All manufacturers' recommended safety precautions for all chemicals will be followed. Refer to the Material Safety Data Sheets located in the HASP.
- A task or job hazard analysis will be conducted prior to performing interim monitoring tasks. If a Task Hazard Analysis (THA) already exists for the activity, it will be reviewed by all personnel involved in the task. New THAs will be filed in the HASP.
- All required PPE shall be worn while conducting work on site.
- Special precautions will be taken with moving liquids. This requires the use of appropriate PPE and maintaining a safe distance.
- When installing borings outside of the fenced Site, exclusion zones will be established around working areas to protect untrained and unqualified individuals. Traffic control will be implemented is work is conducted near public or private roadways.
- Utility locates will be conducted prior to borings.
- All personnel are empowered to stop work activities if a deviation from planned activities occurs or if an unsafe condition is present.

7.1 Access Agreements

Owners of the property where borings may be located will be contacted upon Agency approval of the Final 2011 Work Plan for obtaining access. BNSF shall make best efforts to locate borings away from structures and utilities. BNSF shall also use best efforts to obtain written access agreements to such property. Such agreements shall ensure access for the USEPA and it authorized representatives. If BNSF is unable to obtain access prior to the planned dates of field work, BNSF shall notify USEPA of the failure to obtain access, and the efforts made to obtain it.

If BNSF is unable to obtain access where USEPA has determined it to be necessary for carrying out the work under this Final 2011 Work Plan, USEPA may then assist BNSF in gaining access, to the extent necessary to effectuate the investigations described in this Work Plan, using such means as USEPA deems appropriate. USEPA may at its discretion also consider alternate locations, including but not limited to existing County rights-of-way on the property, as appropriate. If USEPA determines that placing monitoring wells in a County right-of-way is acceptable (in the event a property owner refuses access), BNSF agrees it will make best efforts to obtain access for such placement from the County. Nothing in Section 4.1 is intended to modify the Consent Decree.

No personnel or individuals shall be allowed within the work area without prior approval. Property owners will be notified of the work activities and health and safety concerns. Access to the work area will be controlled with barricades, temporary fencing, or other means to limit entry. The AECOM field manager will be responsible for ensuring unauthorized access to the work area is prevented.

If a monitoring well is installed off of BNSF owned property, an access agreement will be drafted with which the property owner will grant BNSF and the Agencies access to the well for future monitoring and operation and maintenance.

7.2 Data Collection-Derived Waste Management

Waste material including but not limited to soils and liquids generated during the field work will be containerized and stored within the fenced area of the Somers Site until appropriate disposal can be arranged. “Waste Material” shall mean: 1) any “hazardous substance” under Section 101(14) of CERCLA, 42 USC § 9601(14); 2) any pollutant or contaminant under Section 101(33) of CERCLA, 42 USC § 9601(33); 3) any “solid waste” under Section 1004(27) of Resource Conservation and Recovery Act, 42 USC § 6903(27); and 4) any “hazardous waste” under State law.

7.2.1 Soils

A composite sample will be collected from the containerized soil and will be analyzed for TPAH by USEPA Method 8270-SIM and will be compared to the Resource Conservation and Recovery Act (RCRA) treatment standards for hazardous waste (specifically, listed waste F034). Soil cuttings that are non-hazardous will be spread on the ground surface within the fenced area of the Site. If soil cuttings are determined to be hazardous waste (F034), they will be sent off-site for disposal at an appropriate hazardous waste disposal facility.

7.2.2 Liquids

Liquid produced during decontamination activities will be collected, drummed, and analyzed for TPAH by USEPA Method 8270-SIM. Liquid that is not determined to be hazardous waste (F034) will be poured onto the ground surface within the fenced area of the Site. If collected liquid is determined to be hazardous waste (F034), the drums will be sent off-site for disposal at an appropriate hazardous waste disposal facility.

8.0 Report Preparation

A 2011 Completion Report shall be prepared and submitted to the Agencies for review and approval. The draft report including data summaries (in text, table and figure format), Updated Conceptual Site Model, Updated Groundwater Flow Model, and, if appropriate, a work plan for a treatability study(s) will be prepared within 60 days of validation of all analytical data.

The draft report will include the following information:

- Description of all activities conducted under this Final 2011 Work Plan;
- Deviations to the planned work;
- Access agreements;
- Evaluation of data quality;
- Boring logs;
- Analytical results for both soils and groundwater, in summary table format, including comparison to the cleanup levels in the ROD or ESDs;
- Water levels measured;
- Cross sections and lithology diagrams;
- Copies of field logbooks and photos taken;
- Field data; and
- COC concentration contour diagrams.

9.0 Schedule

The schedule for the scope of work included in his Work Plan is as follows:

- Annotated outline of the Work Plan for Additional Work.
- Final Work Plan for Additional Work – Within 30 days of receipt of Agencies' comments.
- Field Activities – Mobilize to the site for a start date of September 12, 2011, assuming Agency approval of this Final 2011 Work Plan is received prior to September 6, 2011, and assuming property access agreements and subcontractor availability can be obtained within 5 days following Agency approval of the Final 2011 Work Plan.
- Field Activities – Field activities will take approximately 21 to 28 days to complete for the TarGOST® and DPT borings. Well installations and soil core sample collection to be completed as an addendum to this Final 2011 Work Plan after review of data collected and in consultation with the Agencies.
- Laboratory Data – Final data is expected to be received 10 days following laboratory receipt of samples.
- Determine if additional boring or groundwater well installation is necessary following review of data and submit a work plan addendum if necessary – within 30 days of receipt of validated analytical data.
- Draft Technical Memorandum summarizing the work performed in the development and screening of alternatives – within 60 days of validation of all analytical results collected as part of the 2011 investigation.
- Final Technical Memorandum – within 14 days after receipt of Agency comments.
- Draft 2011 Completion Report – within 60 days of validation of all analytical data.
- Draft Treatability Study Work Plan, if deemed necessary following review of data results – within 60 days of approval of the Final Technical Memorandum.
- Final 2011 Completion Report and Treatability Study Work Plan, if necessary – Within 14 days after receipt of Agencies' comments.
- Treatability Study Report, if Treatability Study is performed – within 60 days of completion of the Treatability Study (including the receipt of validated data).
- Determine if a feasibility study is needed based upon the presence of soil and groundwater COCs above ROD cleanup levels and in consultation with the Agencies – complete within 60 days of completion of the Treatability Study (including the receipt of validated data).

10.0 References

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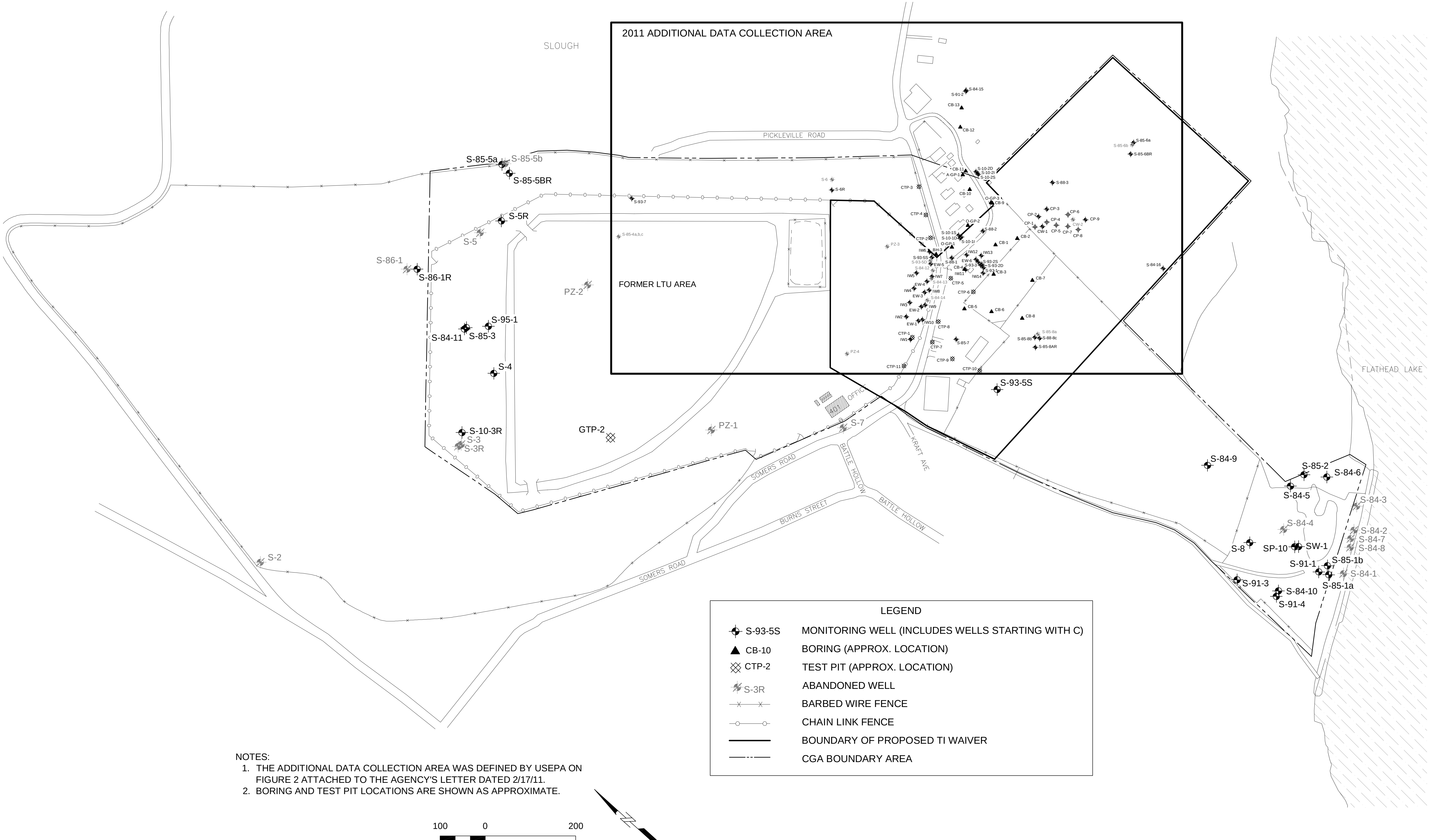
Tables

Table 4-1 Rationale for Geoprobe Locatons

Boring Number	Proposed or Tentative Boring	Rationale
1	Proposed	Characterize the source area
2	Proposed	Upgradient of the former CERCLA lagoon
3	Proposed	Confirm impacts downradient of the former CERCLA lagoon
4	Tentative	Possible location if Geoprobe location #3 exceeds ROD levels
5	Proposed	Confirm impacts downgradient of former CERCLA lagoon
6	Proposed	Confirm impacts downgradient of S-88-2 and S-10-1 nested wells
7	Proposed	Confirm impcacts downgradient of former CERCLA lagoon
8	Tentative	Possible location if Geoprobe location #7 exceeds ROD levels
9	Proposed	Confirm impacts downgradient of former CERCLA lagoon
10	Tentative	Possible location if Geoprobe location #9 exceeds ROD levels
11	Proposed	Confirm impacts between injection and extraction wells.
12	Tentative	Possible location if Geoprobe location #2 exceeds ROD levels
13	Proposed	Confirm impacts downgradient of S-6R
14	Proposed	Confirm impacts downgradient of S-6R
15	Proposed	Confirm impacts on Hayes Property
16	Proposed	Confirm impacts downgradient of S-6R and source area
17	Proposed	Confirm impacts downgradient of S-10-2
18	Proposed	Confirm impacts downgradient of S-10-2
19	Proposed	Confirm impacts downgradient of S-10-1 and upgradient of S-91-2 and S-84-15.
20	Proposed	Confirm impacts upgradient of S-91-2 and S-84-15
21	Proposed	Confirm impacts downgradient of S-91-2 and S-84-15
22	Proposed	Confirm impacts downgradient of S-91-2 and S-84-15
23	Tentative	Possible location to confirm impacts downgradient of S-88-3
24	Tentative	Possible location to confirm impacts downgradient of S-88-3
25	Tentative	Possible location to confirm impacts downgradient of S-88-3
26	Tentative	Possible location if Geoprobe locations #24 or #25 exceeds ROD levels
27	Tentative	Possible location if Geoprobe location #23 exceeds ROD levels
28	Tentative	Possible location if Geoprobe location #23 exceeds ROD levels
29	Tentative	Possible location if Geoprobe location #17 exceeds ROD levels
30	Tentative	Possible location if Geoprobe location #6 exceeds ROD levels
31	Tentative	Possible location if Geoprobe location #6 exceeds ROD levels
32	Tentative	Possible location if Geoprobe location #6 exceeds ROD levels
33	Tentative	Possible location if Geoprobe location #11 exceeds ROD levels
34	Tentative	Possible location if Geoprobe location #3 exceeds ROD levels
35	Tentative	Possible location if Geoprobe location #3 exceeds ROD levels
36	Tentative	Possible location if Geoprobe location #3 exceeds ROD levels
37	Tentative	Possible location if Geoprobe locations #9 or #2 exceeds ROD levels
38	Tentative	Possible location if Geoprobe locations #13 or 14 exceeds ROD levels
39	Tentative	Possible location if Geoprobe locations #15 or #16 exceeds ROD levels
40	Tentative	Possible location if Geoprobe locations #19 or #20 exceeds ROD levels
41	Tentative	Possible location if Geoprobe locations #18 or #19 exceeds ROD levels
42	Tentative	Possible location if Geoprobe locations #17 or #18 exceeds ROD levels
43	Tentative	Possible location if Geoprobe location #22 exceeds ROD levels
44	Tentative	Possible location if Geoprobe locations #21 or #22 exceeds ROD levels
45	Tentative	Possible location if Geoprobe location #21 exceeds ROD levels
46	Tentative	Possible location if Geoprobe locations #16 or #39 exceeds ROD levels
47	Tentative	Possible location if Geoprobe locations #16 or #38 exceeds ROD levels
48	Tentative	Possible location if Geoprobe location #5 exceeds ROD levels
49	Tentative	Possible location if Geoprobe location #25 exceeds ROD levels
50	Proposed	Confirm impacts downgradient of the CERCLA Lagoon.

Figures



NOTES:

1. THE ADDITIONAL DATA COLLECTION AREA WAS DEFINED BY USEPA ON FIGURE 2 ATTACHED TO THE AGENCY'S LETTER DATED 2/17/11.
2. BORING AND TEST PIT LOCATIONS ARE SHOWN AS APPROXIMATE.

AECOM

2011 Work Plan for Additional Data Collection

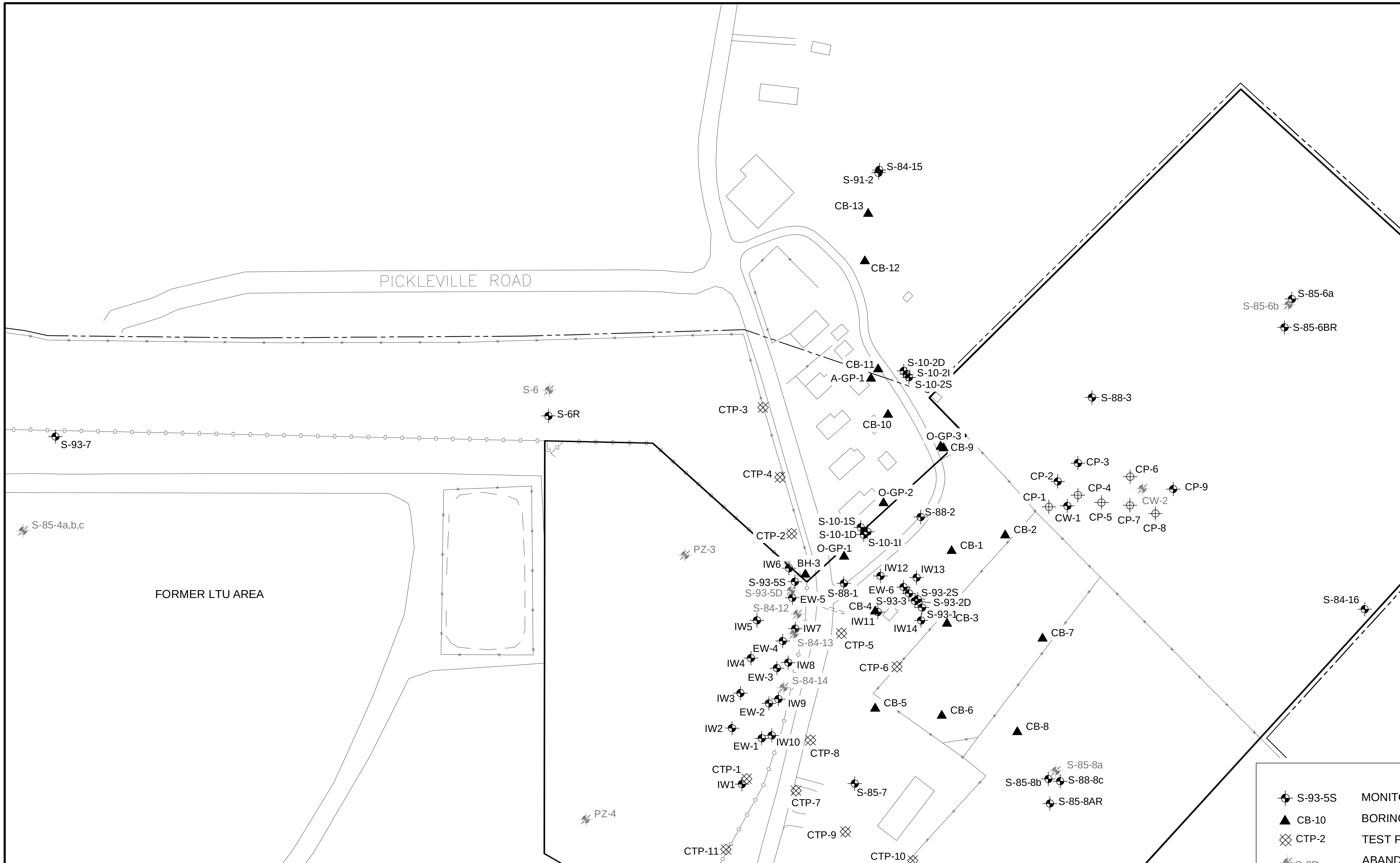
BNSF Railway Company, Somers, Montana (60193807-620)

DATE: 08/26/11 DRWN: E.S.S./DEN

SITE MAP

FIGURE 1-1A

File: M:\BNSFSecure\BNSF Somers\BNSF-Som – Add Data Coll 2011_1-1A-B_Site Map.dwg Layout: FIGURE 1-1A User: schwartze Plotted: Aug 26, 2011 – 2:38pm Xref's:



LEGEND

S-93-5S	MONITORING WELL
CB-10	BORING (APPROX. LOCATION)
CTP-2	TEST PIT (APPROX. LOCATION)
S-3R	ABANDONED WELL
	BARBED WIRE FENCE
	CHAIN LINK FENCE
	BOUNDARY OF PROPOSED TI WAIVER
	CGA BOUNDARY AREA

NOTES:
1. THE ADDITIONAL DATA COLLECTION AREA WAS DEFINED BY USEPA ON FIGURE 2 ATTACHED TO THE AGENCY'S LETTER DATED 2/17/11.
2. BORING AND TEST PIT LOCATIONS ARE SHOWN AS APPROXIMATE.

AECOM

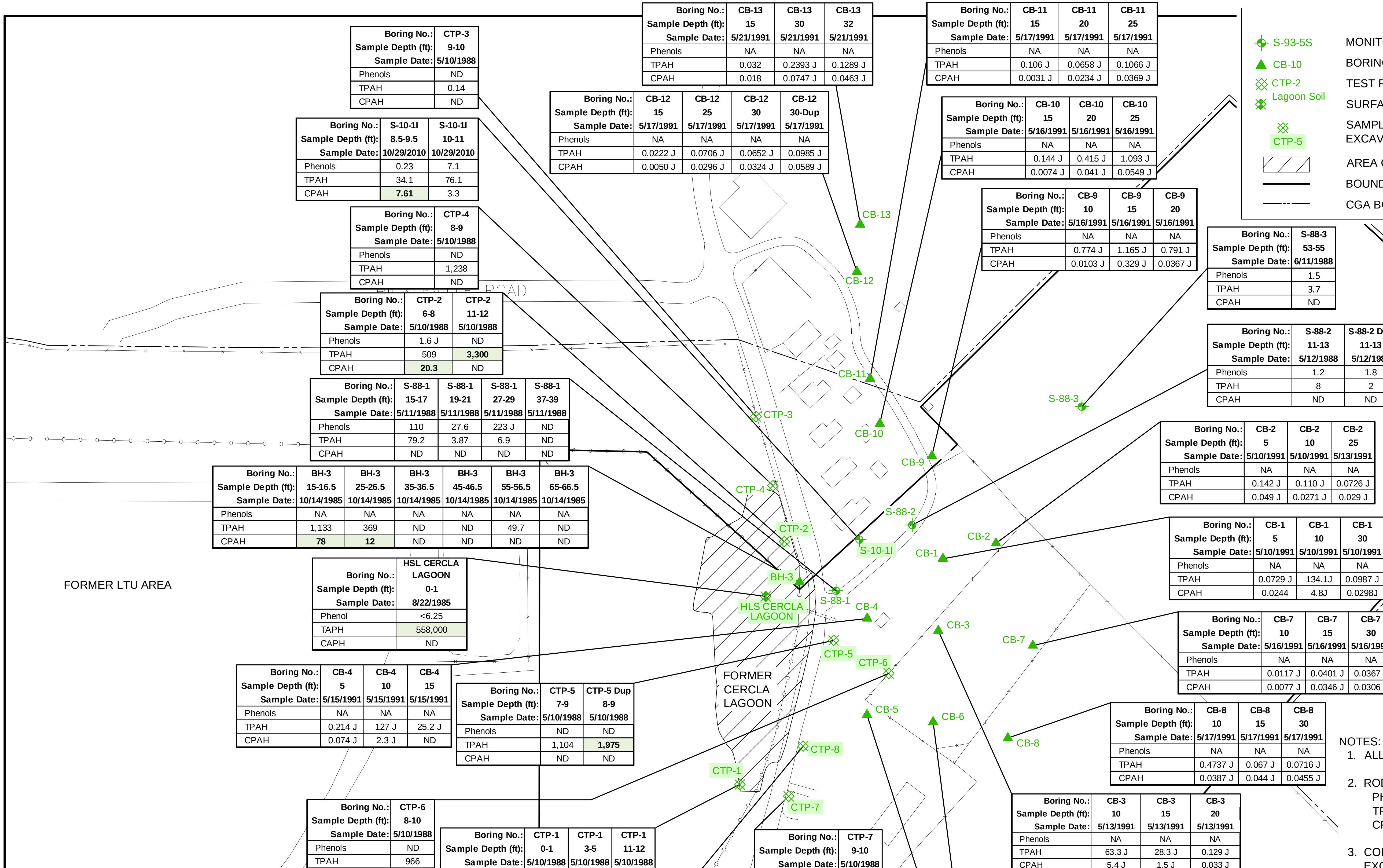
2011 Work Plan for Additional Data Collection

BNSF Railway Company, Somers, Montana (60193807-620)

DATE: 08/26/11 DRWN: E.S.S./DEN

2011 ADDITIONAL DATA COLLECTION AREA

FIGURE 1-1B



Boring No.:	CTP-3
Sample Depth (ft):	9-10
Sample Date:	5/10/1988
Phenols	ND
TPAH	0.14
CPAH	ND

Boring No.:	CB-13	CB-13	CB-13
Sample Depth (ft):	15	30	32
Sample Date:	5/21/1991	5/21/1991	5/21/1991
Phenols	NA	NA	NA
TPAH	0.032	0.2393 J	0.1289 J
CPAH	0.018	0.0747 J	0.0463 J

Boring No.:	CB-11	CB-11	CB-11
Sample Depth (ft):	15	20	25
Sample Date:	5/17/1991	5/17/1991	5/17/1991
Phenols	NA	NA	NA
TPAH	0.106 J	0.0658 J	0.1066 J
CPAH	0.0031 J	0.0234 J	0.0369 J

Boring No.:	CB-12	CB-12	CB-12	CB-12
Sample Depth (ft):	15	25	30	30-Dup
Sample Date:	5/17/1991	5/17/1991	5/17/1991	5/17/1991
Phenols	NA	NA	NA	NA
TPAH	0.0222 J	0.0706 J	0.0652 J	0.0985 J
CPAH	0.0050 J	0.0296 J	0.0324 J	0.0589 J

Boring No.:	CB-10	CB-10	CB-10
Sample Depth (ft):	15	20	25
Sample Date:	5/16/1991	5/16/1991	5/16/1991
Phenols	NA	NA	NA
TPAH	0.144 J	0.415 J	1.093 J
CPAH	0.0074 J	0.041 J	0.0549 J

Boring No.:	S-10-1I	S-10-1I
Sample Depth (ft):	8.5-9.5	10-11
Sample Date:	10/29/2010	10/29/2010
Phenols	0.23	7.1
TPAH	34.1	76.1
CPAH	**7.61**	3.3

Boring No.:	CB-9	CB-9	CB-9
Sample Depth (ft):	10	15	20
Sample Date:	5/16/1991	5/16/1991	5/16/1991
Phenols	NA	NA	NA
TPAH	0.774 J	1.165 J	0.791 J
CPAH	0.0103 J	0.329 J	0.0367 J

Boring No.:	CTP-4
Sample Depth (ft):	8-9
Sample Date:	5/10/1988
Phenols	ND
TPAH	1,238
CPAH	ND

Boring No.:	S-88-3
Sample Depth (ft):	53-55
Sample Date:	6/11/1988
Phenols	1.5
TPAH	3.7
CPAH	ND

Boring No.:	CTP-2	CTP-2
Sample Depth (ft):	6-8	11-12
Sample Date:	5/10/1988	5/10/1988
Phenols	1.6 J	ND
TPAH	509	**3,300**
CPAH	**20.3**	ND

Boring No.:	S-88-2	S-88-2 Dup	S-88-2	S-88-2	S-88-2	S-88-2
Sample Depth (ft):	11-13	11-13	15-17	23-25	33-35	37-39
Sample Date:	5/12/1988	5/12/1988	5/12/1988	5/12/1988	5/12/1988	5/12/1988
Phenols	1.2	1.8	ND	ND	0.75 J	ND
TPAH	8	2	ND	0.47	1	ND
CPAH	ND	ND	ND	ND	ND	ND

Boring No.:	S-88-1	S-88-1	S-88-1	S-88-1
Sample Depth (ft):	15-17	19-21	27-29	37-39
Sample Date:	5/11/1988	5/11/1988	5/11/1988	5/11/1988
Phenols	110	27.6	223 J	ND
TPAH	79.2	3.87	6.9	ND
CPAH	ND	ND	ND	ND

Boring No.:	CB-2	CB-2	CB-2
Sample Depth (ft):	5	10	25
Sample Date:	5/10/1991	5/10/1991	5/13/1991
Phenols	NA	NA	NA
TPAH	0.142 J	0.110 J	0.0726 J
CPAH	0.049 J	0.0271 J	0.029 J

Boring No.:	BH-3	BH-3	BH-3	BH-3	BH-3	BH-3
Sample Depth (ft):	15-16.5	25-26.5	35-36.5	45-46.5	55-56.5	65-66.5
Sample Date:	10/14/1985	10/14/1985	10/14/1985	10/14/1985	10/14/1985	10/14/1985
Phenols	NA	NA	NA	NA	NA	NA
TPAH	1,133	369	ND	ND	49.7	ND
CPAH	**78**	**12**	ND	ND	ND	ND

Boring No.:	CB-1	CB-1	CB-1
Sample Depth (ft):	5	10	30
Sample Date:	5/10/1991	5/10/1991	5/10/1991
Phenols	NA	NA	NA
TPAH	0.0729 J	134.1J	0.0987 J
CPAH	0.0244	4.8J	0.0298J

Boring No.:	HSL CERCLA LAGOON
Sample Depth (ft):	0-1
Sample Date:	8/22/1985
Phenol	<6.25
TAPH	558,000
CAPH	ND

Boring No.:	CB-7	CB-7	CB-7
Sample Depth (ft):	10	15	30
Sample Date:	5/16/1991	5/16/1991	5/16/1991
Phenols	NA	NA	NA
TPAH	0.0117 J	0.0401 J	0.0367 J
CPAH	0.0077 J	0.0346 J	0.0306 J

Boring No.:	CB-4	CB-4	CB-4
Sample Depth (ft):	5	10	15
Sample Date:	5/15/1991	5/15/1991	5/15/1991
Phenols	NA	NA	NA
TPAH	0.214 J	127 J	25.2 J
CPAH	0.074 J	2.3 J	ND

Boring No.:	CTP-5	CTP-5 Dup
Sample Depth (ft):	7-9	8-9
Sample Date:	5/10/1988	5/10/1988
Phenols	ND	ND
TPAH	1,104	**1,975**
CPAH	ND	ND

Boring No.:	CB-8	CB-8	CB-8
Sample Depth (ft):	10	15	30
Sample Date:	5/17/1991	5/17/1991	5/17/1991
Phenols	NA	NA	NA
TPAH	0.4737 J	0.067 J	0.0716 J
CPAH	0.0387 J	0.044 J	0.0455 J

Boring No.:	CTP-6
Sample Depth (ft):	8-10
Sample Date:	5/10/1988
Phenols	ND
TPAH	966
CPAH	**24**

Boring No.:	CB-3	CB-3	CB-3
Sample Depth (ft):	10	15	20
Sample Date:	5/13/1991	5/13/1991	5/13/1991
Phenols	NA	NA	NA
TPAH	63.3 J	28.3 J	0.129 J
CPAH	5.4 J	1.5 J	0.033 J

Boring No.:	CTP-1	CTP-1	CTP-1
Sample Depth (ft):	0-1	3-5	11-12
Sample Date:	5/10/1988	5/10/1988	5/10/1988
Phenols	ND	ND	ND
TPAH	28.2	0.207	33.8
CPAH	**13.99**	ND	ND

Boring No.:	CTP-7
Sample Depth (ft):	9-10
Sample Date:	5/10/1988
Phenols	ND
TPAH	1,172
CPAH	**61**

Boring No.:	CB-6	CB-6	CB-6
Sample Depth (ft):	10	15	20
Sample Date:	5/15/1991	5/15/1991	5/15/1991
Phenols	NA	NA	NA
TPAH	4.29 J	4.74 J	0.071 J
CPAH	ND	0.404	0.039

Boring No.:	CTP-8	CTP-8
Sample Depth (ft):	0-1	8-9
Sample Date:	5/10/1988	5/10/1988
Phenols	ND	ND
TPAH	1.49	**1,516**
CPAH	0.68	ND

Boring No.:	CB-5	CB-5	CB-5	CB-5 Dup
Sample Depth (ft):	10	15	20	20
Sample Date:	5/15/1991	5/15/1991	5/15/1991	5/15/1991
Phenols	NA	NA	NA	NA
TPAH	126 J	30.59J	0.138 J	0.199 J
CPAH	5.4 J	1.5	0.033 J	0.0437 J

LEGEND

- S-93-5S — MONITORING WELL
- CB-10 — BORING (APPROX. LOCATION)
- CTP-2 — TEST PIT (APPROX. LOCATION)
- Lagoon Soil — SURFACE SOIL (APPROX. LOCATION)
- CTP-5 — SAMPLE LOCATION EXCEEDS ROD EXCAVATION LEVELS
- AREA OF PREVIOUS SOURCE REMOVAL
- BOUNDARY OF PROPOSED TI WAIVER
- CGA BOUNDARY AREA

NOTES:

1. ALL CONCENTRATIONS SHOWN IN mg/kg
2. ROD SOIL EXCAVATION LEVELS:
   PHENOLS = 3,000 mg/kg
   TPAH = 1,500 mg/kg
   CPAH = 5.7 mg/kg
3. CONCENTRATIONS EXCEEDING THE ROD EXCAVATION LEVEL SHOWN IN **BOLD**
4. J = ESTIMATED VALUE
   NA = NOT ANALYZED
   ND = NOT DETECTED
5. BORING AND TEST PIT LOCATIONS ARE SHOWN AS APPROXIMATE.

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2011 Work Plan for Additional Data Collection

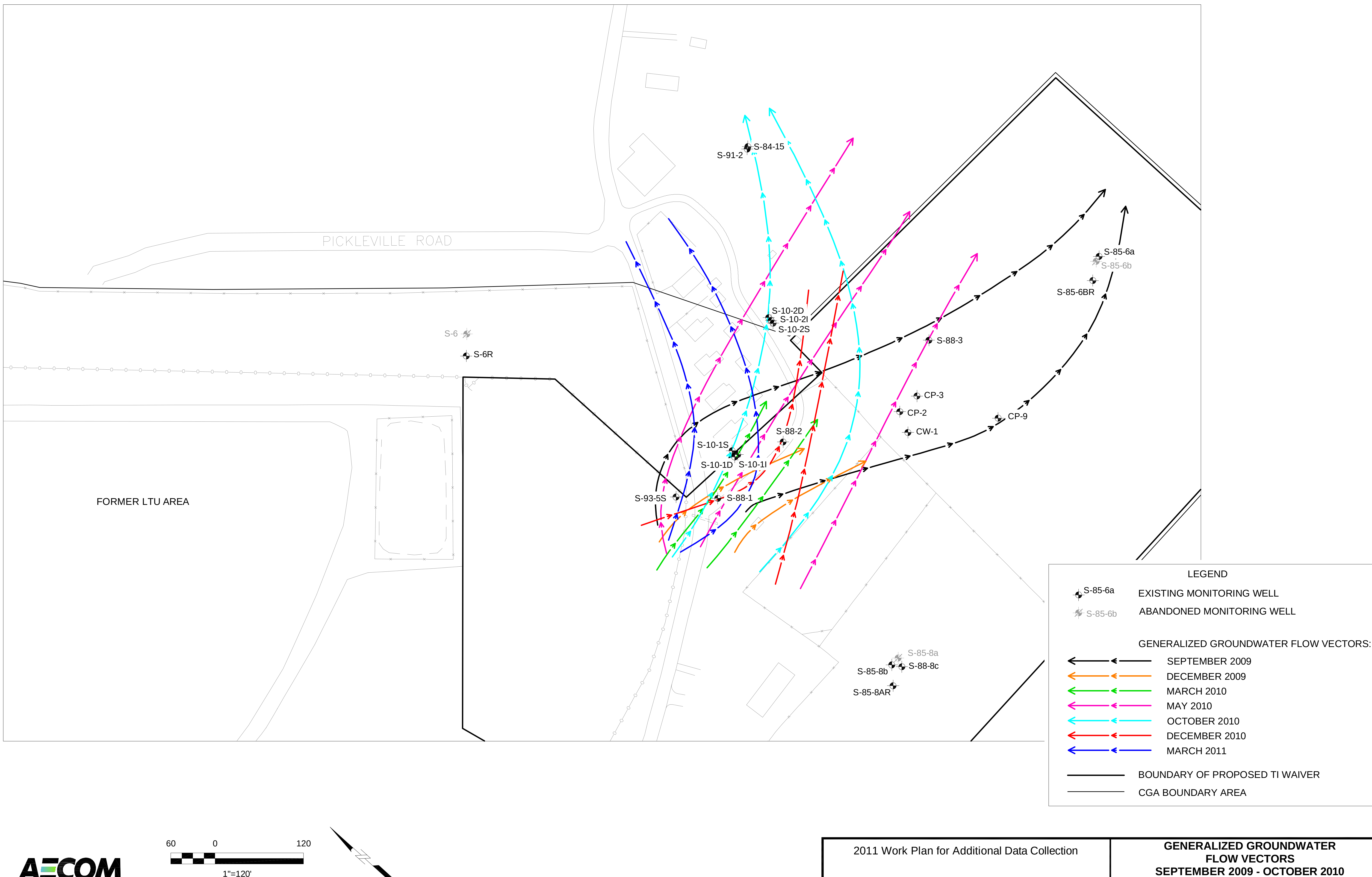
BNSF Railway Company, Somers, Montana (60193807-620)

2011 ADDITIONAL DATA COLLECTION AREA SOIL RESULTS

DATE: 08/26/11 | DRWN: E.S.S./DEN

FIGURE 1-2

File: M:\BNSFSecure\BNSF Somers\BNSF-Som - Add Data Coll 2011_1-2_Soil Results.dwg Layout: FIGURE 1-2 User: schwartze Plotted: Aug 29, 2011 - 3:04pm Xref's:



2011 Work Plan for Additional Data Collection

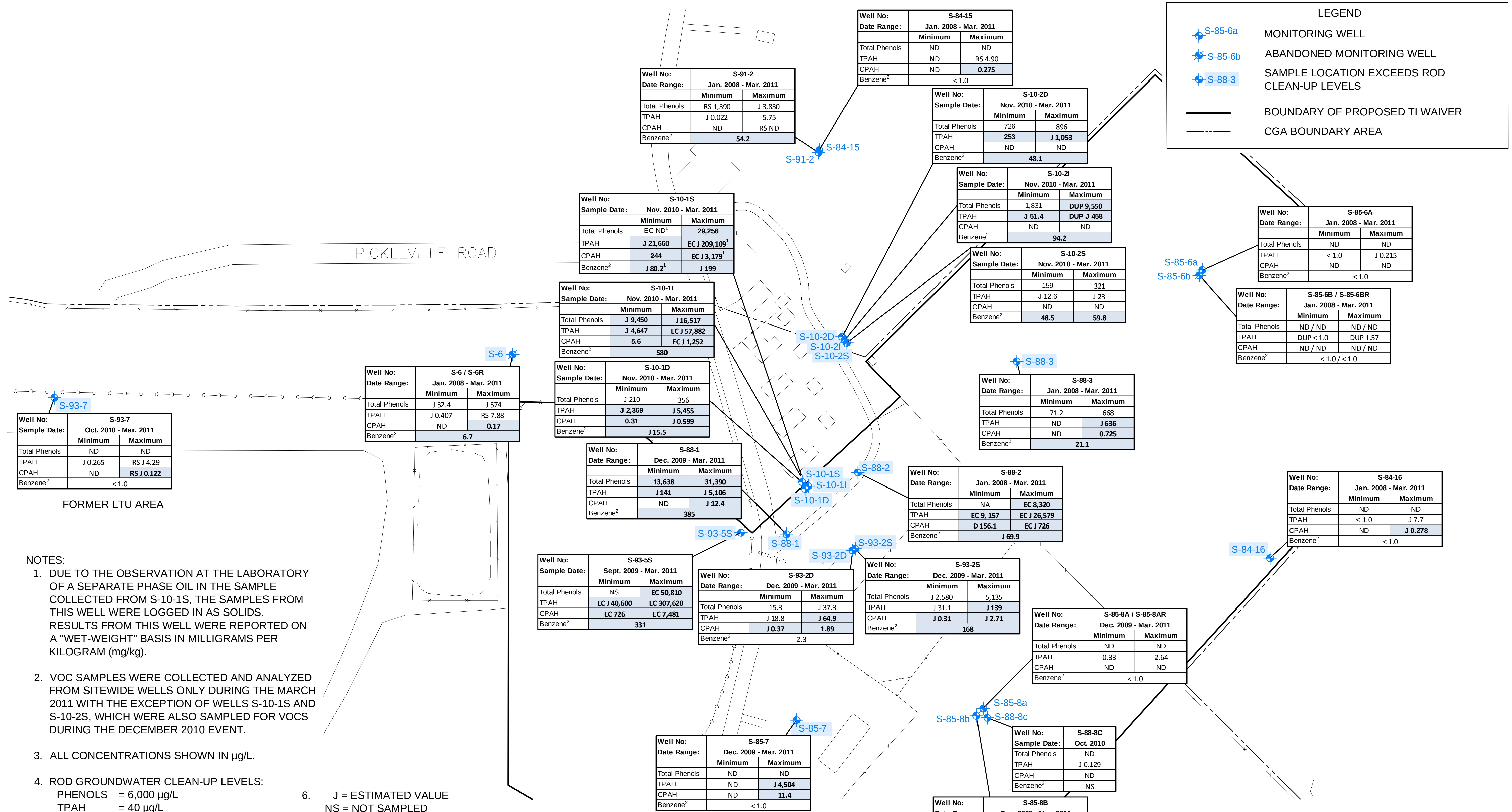
BNSF Railway Company, Somers, Montana (60193807-620)

GENERALIZED GROUNDWATER FLOW VECTORS SEPTEMBER 2009 - OCTOBER 2010

DATE: 08/26/11 DRWN: E.S.S./GOL

FIGURE 1-3

File: M:\BNSFSecure\BNSF Somers\BNSF-Som - Add Data Coll 2011_1-3_GW Flow.dwg Layout: FIGURE 1-3 User: schwartze Plotted: Aug 26, 2011 - 2:38pm Xref's:



Well No:	S-84-15	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND	ND
TPAH	ND	RS 4.90
CPAH	ND	**0.275**
Benzene[2]	< 1.0	

Well No:	S-91-2	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	RS 1,390	J 3,830
TPAH	J 0.022	5.75
CPAH	ND	RS ND
Benzene[2]	**54.2**	

Well No:	S-10-2D	
Sample Date:	Nov. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	726	896
TPAH	**253**	**J 1,053**
CPAH	ND	ND
Benzene[2]	**48.1**	

Well No:	S-10-2I	
Sample Date:	Nov. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	1,831	**DUP 9,550**
TPAH	**J 51.4**	**DUP J 458**
CPAH	ND	ND
Benzene[2]	**94.2**	

Well No:	S-10-1S	
Sample Date:	Nov. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	EC ND[1]	**29,256**
TPAH	**J 21,660**	**EC J 209,109[1]**
CPAH	**244**	**EC J 3,179[1]**
Benzene[2]	**J 80.2[1]**	**J 199**

Well No:	S-10-2S	
Sample Date:	Nov. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	159	321
TPAH	J 12.6	J 23
CPAH	ND	ND
Benzene[2]	**48.5**	**59.8**

Well No:	S-85-6A	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND	ND
TPAH	< 1.0	J 0.215
CPAH	ND	ND
Benzene[2]	< 1.0	

Well No:	S-10-1I	
Sample Date:	Nov. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	**J 9,450**	**J 16,517**
TPAH	**J 4,647**	**EC J 57,882**
CPAH	**5.6**	**EC J 1,252**
Benzene[2]	**580**	

Well No:	S-85-6B / S-85-6BR	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND / ND	ND / ND
TPAH	DUP < 1.0	DUP 1.57
CPAH	ND / ND	ND / ND
Benzene[2]	< 1.0 / < 1.0	

Well No:	S-6 / S-6R	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	J 32.4	J 574
TPAH	J 0.407	RS 7.88
CPAH	ND	**0.17**
Benzene[2]	**6.7**	

Well No:	S-10-1D	
Sample Date:	Nov. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	J 210	356
TPAH	**J 2,369**	**J 5,455**
CPAH	**0.31**	**J 0.599**
Benzene[2]	**J 15.5**	

Well No:	S-88-3	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	71.2	668
TPAH	ND	**J 636**
CPAH	ND	**0.725**
Benzene[2]	**21.1**	

Well No:	S-93-7	
Sample Date:	Oct. 2010 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND	ND
TPAH	J 0.265	RS J 4.29
CPAH	ND	**RS J 0.122**
Benzene[2]	< 1.0	

Well No:	S-88-1	
Date Range:	Dec. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	**13,638**	**31,390**
TPAH	**J 141**	**J 5,106**
CPAH	ND	**J 12.4**
Benzene[2]	**385**	

Well No:	S-88-2	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	NA	**EC 8,320**
TPAH	**EC 9, 157**	**EC J 26,579**
CPAH	**D 156.1**	**EC J 726**
Benzene[2]	**J 69.9**	

Well No:	S-84-16	
Date Range:	Jan. 2008 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND	ND
TPAH	< 1.0	J 7.7
CPAH	ND	**J 0.278**
Benzene[2]	< 1.0	

Well No:	S-93-5S	
Sample Date:	Sept. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	NS	**EC 50,810**
TPAH	**EC J 40,600**	**EC 307,620**
CPAH	**EC 726**	**EC 7,481**
Benzene[2]	**331**	

Well No:	S-93-2D	
Date Range:	Dec. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	15.3	J 37.3
TPAH	J 18.8	**J 64.9**
CPAH	**J 0.37**	**1.89**
Benzene[2]	2.3	

Well No:	S-93-2S	
Date Range:	Dec. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	J 2,580	5,135
TPAH	J 31.1	**J 139**
CPAH	**J 0.31**	**J 2.71**
Benzene[2]	**168**	

Well No:	S-85-8A / S-85-8AR	
Date Range:	Dec. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND	ND
TPAH	0.33	2.64
CPAH	ND	ND
Benzene[2]	< 1.0	

Well No:	S-85-7	
Date Range:	Dec. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND	ND
TPAH	ND	**J 4,504**
CPAH	ND	**11.4**
Benzene[2]	< 1.0	

Well No:	S-88-8C
Sample Date:	Oct. 2010
Total Phenols	ND
TPAH	J 0.129
CPAH	ND
Benzene[2]	NS

Well No:	S-85-8B	
Date Range:	Dec. 2009 - Mar. 2011	
	Minimum	Maximum
Total Phenols	ND / ND	ND / ND
TPAH	ND / ND	DUP 0.021
CPAH	ND / ND	ND / ND
Benzene[2]	< 1.0 / < 1.0	

NOTES:

1. DUE TO THE OBSERVATION AT THE LABORATORY OF A SEPARATE PHASE OIL IN THE SAMPLE COLLECTED FROM S-10-1S, THE SAMPLES FROM THIS WELL WERE LOGGED IN AS SOLIDS. RESULTS FROM THIS WELL WERE REPORTED ON A "WET-WEIGHT" BASIS IN MILLIGRAMS PER KILOGRAM (mg/kg).
2. VOC SAMPLES WERE COLLECTED AND ANALYZED FROM SITEWIDE WELLS ONLY DURING THE MARCH 2011 WITH THE EXCEPTION OF WELLS S-10-1S AND S-10-2S, WHICH WERE ALSO SAMPLED FOR VOCS DURING THE DECEMBER 2010 EVENT.
3. ALL CONCENTRATIONS SHOWN IN µg/L.
4. ROD GROUNDWATER CLEAN-UP LEVELS:
   - PHENOLS = 6,000 µg/L
   - TPAH = 40 µg/L
   - CPAH = 0.030 µg/L
   - BENZENE = 5 µg/L
5. CONCENTRATIONS EXCEEDING THE ROD CLEAN-UP LEVEL SHOWN IN **BOLD**
6. J = ESTIMATED VALUE
   NS = NOT SAMPLED
   ND = NOT DETECTED
   NA = NOT ANALYZED
   RS = WELL RESAMPLED DUE TO EXCEEDANCE OF CONTINGENCY CONCENTRATION (50% OF TARGET CLEANUP LEVEL AT SELECT WELLS). RESAMPLED RESULT IS SHOWN.
   EC = SAMPLED COLLECTED FROM WELLS WITH EMULSIFIED CREOSOTE.
   DRY = WELL HAD INSUFFICIENT WATER FOR SAMPLE COLLECTION
   DUP = DUPLICATE SAMPLE TAKEN, HIGHEST CONCENTRATION REPORTED.

60 0 120

1"=120'

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2011 Work Plan for Additional Data Collection

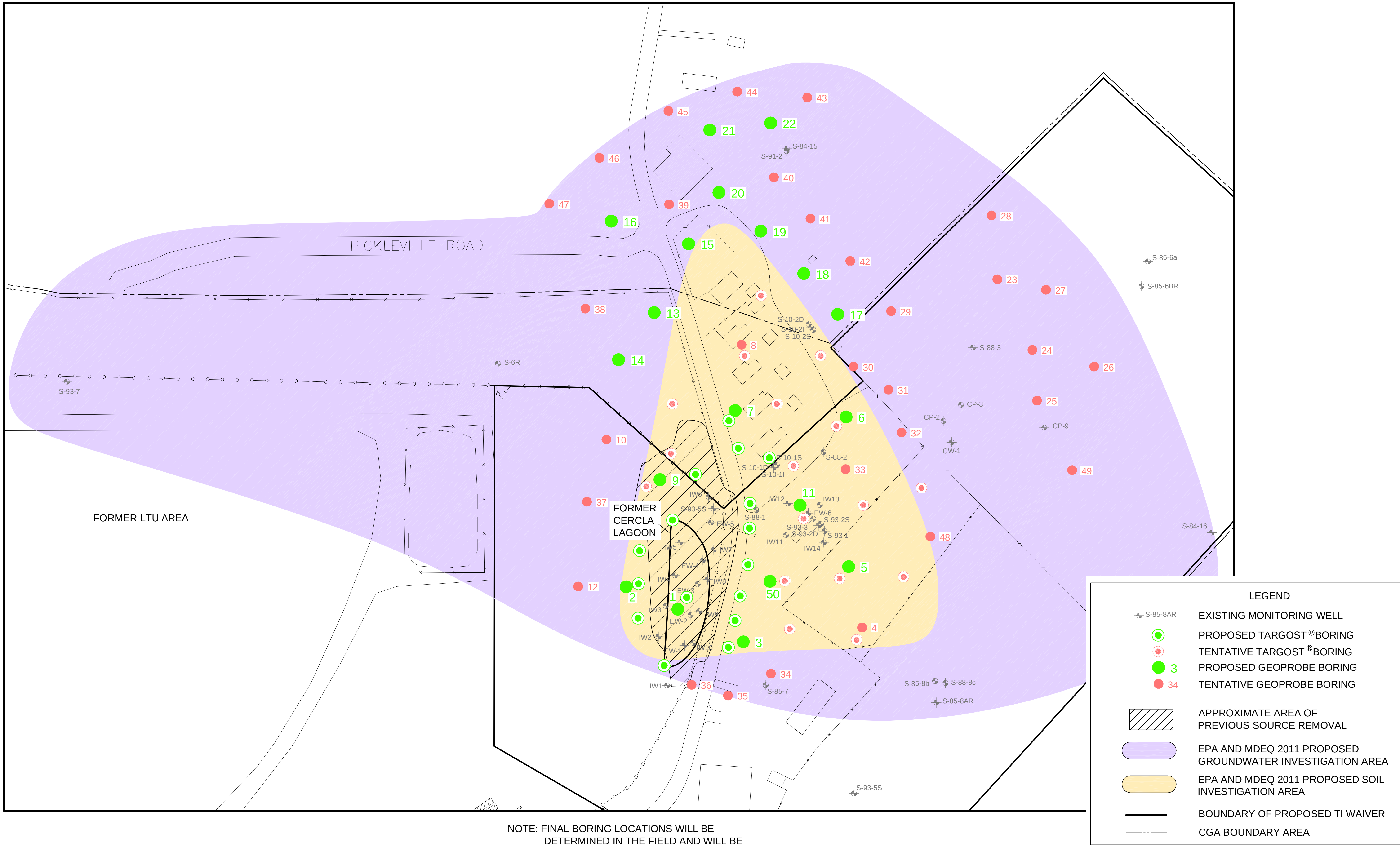
BNSF Railway Company, Somers, Montana (60193807-620)

DATE: 08/26/11 DRWN: E.S.S./DEN

2011 ADDITIONAL DATA COLLECTION AREA GROUNDWATER RESULTS

FIGURE 1-4

File: M:\BNSFSecure\BNSF Somers\BNSF-Som - Add Data Coll 2011_1-4_Water Results.dwg Layout: FIGURE 1-4 User: schwartze Plotted: Aug 26, 2011 - 2:39pm Xref's:



NOTE: FINAL BORING LOCATIONS WILL BE DETERMINED IN THE FIELD AND WILL BE DEPENDENT ON OBSERVED IMPACTS TO SOIL AND OBSTRUCTIONS. IDENTIFICATION NUMBERING WILL BE FINALIZED IN THE FIELD.

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70 0 140
1"=140'

2011 Work Plan for Additional Data Collection

BNSF Railway Company, Somers, Montana (60193807-620)

DATE: 08/26/11 DRWN: E.S.S./GOL

PROPOSED SOIL BORING AND TARGOST LOCATIONS

FIGURE 2-1

File: M:\BNSFSecure\BNSF Somers\BNSF-Som - Add Data Coll 2011_2-1_Proposed Borings.dwg Layout: FIGURE 2-1 User: schwartze Plotted: Aug 26, 2011 - 2:39pm Xref's:

Appendix A

Project Operation Procedures

1.0 Scope and applicability

1.1 Purpose and Applicability

1.1.1 This Project Operating Procedure (POP) provides guidance for installing groundwater monitoring wells. Monitoring wells are installed to monitor the depth to groundwater, to measure aquifer properties, and to obtain samples of groundwater for chemical analysis.

1.1.2 This POP is applicable to installation of single monitoring wells within a borehole. The construction and installation of nested, multilevel or other special well designs are not covered within this POP as these type of wells are not frequently constructed. This POP applies to both overburden and bedrock monitoring wells.

1.1.3 Some states and United States Environmental Agency (USEPA) Regions have promulgated comprehensive guidelines for monitoring well construction and for subsurface investigation procedures. Deviations from this POP to accommodate other regulatory requirements should be reviewed in advance of the field program and must be documented in the field project notebook when they occur.

1.2 General Principles

1.2.1 Monitoring well construction and installation generally involves drilling a borehole using conventional drilling equipment, installing commercially available well construction and filter/sealing materials, and development of the well prior to sampling. This POP covers well construction and installation methods only.

2.0 Health and safety considerations

2.1 Monitoring well installation may involve chemical hazards associated with materials in the soil or groundwater being investigated; and always involves physical hazards associated with drilling equipment and well construction methods. When wells are to be installed in locations where the aquifer and/or overlying materials may contain chemical hazards, a Health and Safety Plan (HASP) must be prepared and approved by the Health and Safety Officer before field work commences. This plan must be distributed to all field personnel and must be adhered to as field activities are performed.

3.0 Interferences

Not Applicable

4.0 Equipment and materials

4.1 Well Construction Materials

4.1.1 Well construction materials are usually provided by the drilling subcontractor and most often consist of commercially available flush-threaded well screen and riser pipe constructed of PVC or stainless steel with a minimum 2-inch inside diameter. The length of the screen and the size of the screen slots should be specified in the project-specific work plan.

4.2 Well Completion Materials

4.2.1 Well completion materials include silica sand, bentonite, cement, protective casings and locks. Completion materials are generally provided by the drilling subcontractor.

4.3 Other required materials include the following:

- Potable water supply
- Fiberglass or steel measuring tape
- Water level indicator
- Well completion log (Figure 1)
- Waterproof marker or paint (to label wells)
- Health and Safety supplies
- Equipment decontamination materials
- Field project notebook/pen

5.0 Procedures

5.1 General Preparation

5.1.1 Borehole Preparation

- Standard drilling methods should be used to achieve the desired drilling/well installation depths specified in the project-specific work plan.
- Rotary drilling methods requiring bentonite-based drilling fluids, if selected, should be used with caution to drill boreholes that will be used for monitoring well installation. The bentonite mud builds up on the borehole walls as a filter cake and permeates the adjacent formation, potentially reducing the permeability of the material adjacent to the well screen.
- An attempt should be made to recover the quantity of fluid or water that was introduced, either by flushing the borehole prior to well installation and/or by overpumping the well during development.

5.1.2 Well Material Decontamination

- Although new well materials (well screen and riser pipe) generally arrive at the site boxed and sealed within plastic bags, it is sometimes necessary to decontaminate the materials prior to their use. Well materials should be inspected by the project geologist/engineer upon delivery to check cleanliness. If the well materials appear dirty, or if local or regional regulatory guidance requires decontamination, then well material decontamination should be performed by the drilling subcontractor.

5.2 Well Construction Procedure

5.2.1 Depth Measurement

- Once the target drilling depth has been reached, the drilling subcontractor will measure the total open depth of the borehole with a weighted, calibrated tape measure. Adjustments of borehole depth can be made at this time by drilling further or installing a small amount of sand filter material to achieve the desired depth. If drilling fluids were used during the drilling process, the borehole should be flushed at this time using potable water. The water table depth may also be checked with a water level indicator if this measurement cannot be obtained with the calibrated tape.

5.2.2 Centralizers

- To install a well centered within the borehole, it is recommended that centralizers be used. Centralizers are especially helpful for deep well installations where it may be difficult to position the well by hand. Centralizers may not be necessary on shallow water table well installations where the well completion depth is within 25 feet of the ground surface.

5.2.3 Well Construction

- The well screen and riser pipe generally are assembled by hand as they are lowered into the borehole. Before the well screen is inserted into the borehole, the full length of the slotted portion of the well screen as well as the unslotted portion of the bottom of the screen should be measured with the measuring tape. These measurements should be recorded on the well construction diagram.
- After the above measurement has been taken, the drilling subcontractor may begin assembling the well. As the assembled well is lowered, care should be taken to ensure that it is centered in the hole if centralizers are not used. The well should be temporarily capped before filter sand and other annular materials are installed.

5.2.4 Filter Sand Installation

- The drilling contractor shall fill the annular space surrounding the screened section of the monitoring well with the filter pack material to at least two feet above the top of the screen. Furthermore, a tremie pipe will be used for filter pack installation regardless of well depth. In general, the filter pack should not extend more than 3 feet above the top of the screen to limit the thickness of the monitoring zone. If coarse filter materials are used, an additional 1-foot thick layer of fine sand should be placed immediately above the filter pack to prevent the infiltration of sealing components (bentonite or grout) into the filter pack. As the filter pack is placed, a weighted tape should be lowered in the annular space to verify the depth to the top of the layer. Depending upon depth, some time may be required for these materials to settle.

5.2.5 Bentonite Seal Installation

- A minimum 2-foot thick layer of bentonite pellets or slurry seal will be installed by the drilling subcontractor immediately above the well screen filter pack in all monitoring wells. The purpose of the seal is to provide a barrier to vertical flow of water in the annular space between the borehole and the well casing. Bentonite is used because it swells significantly upon contact with water. Pellets generally can be installed in shallow boreholes by pouring them very slowly from the surface. If they are poured too quickly, they may bridge at some shallow, undesired depth. As an option, powdered bentonite may be mixed with water into a very thick slurry and a tremie pipe used to inject the seal to the desired depth.

5.2.6 Annular Grout Seal Installation

- This grout seal should consist of a bentonite/cement mix with a ratio of bentonite to cement of between 1:5 and 1:20. The grout ratio should be chosen based on site conditions with a higher percentage of bentonite generally used for formations with higher porosity. Grout slurry should be pumped into the annular space using a side discharging tremie pipe located about 2 feet above the sand pack. Side discharge will help preserve the integrity of the sand pack. If pellets or chips are used, they will be allowed to hydrate following manufacture's recommendations prior to grout installation, typical of industry practice. If a slurry seal is used; it shall consist of a high-solids bentonite grout that is specifically designed for monitoring well installation. The bentonite/cement grout shall be mixed in accordance with the guidance provided by the manufacturer to the recommended density. The density shall be measured with a mud scale and recorded by the drilling contractor.
- In situations where the monitoring well screen straddles the water table, the seal will be in the unsaturated zone and pure bentonites (pellets or powder) will not work effectively as seals without hydration. Dry bentonite may be used if sufficient time to hydrate the seal is allowed. Seal hydration requires the periodic addition of clean water. Optionally, seals in this situation may be a cement/bentonite mixture containing up to 10 percent bentonite by weight. This type of mixture shall be tremied to the desired depth in the borehole.
- The borehole annulus will be grouted with seal materials to within 3 feet of the ground surface. Drill cuttings, even those known not to be contaminated, will not be used as backfill material.

5.2.7 Well Completion

- The drilling subcontractor will cut the top of the well to the desired height and install a vented (if possible), locking cap. The upper portion of the well casing can optionally be drilled to allow venting. Well casings are usually cut to be a certain height above ground surface (typically 2.5 to 3 feet) or are cut to be flush with the ground surface.

5.2.8 Protective Casing/Concrete Pad Installation

- The drilling subcontractor will install a steel guard pipe on the well as a protective casing. The borehole around the guard pipe will be dug out to an approximate 2 to 3-foot radius to a minimum depth of 1 foot at the center and 6 inches at the edges. After installing the protective casing, the excavation will be filled with a concrete/sand mix. The surface of the concrete pad will be sloped so that drainage occurs away from the well. Flush-mount protective casings may not require an extensive concrete pad and should be completed such that they are slightly mounded above the surrounding surface to prevent surface water from running over or ponding on top of the casing. It should be noted, however, that in areas subject to snowfall, flush-mount casings may have to be installed so that they are entirely flush with the ground surface as they may be damaged by snow plows.

- Above-ground protective casings should also be vented or should have non-air tight caps. Road box installations should not be vented. Installation of additional guard pipes may be necessary around above-ground well completions in traffic areas. Protective casings should be lockable to prevent unauthorized access.

5.2.9 Well Numbering

- The project geologist/engineer will number each well casing with an indelible marker or paint to identify the well. This is particularly important with nested or paired wells to distinguish between shallow and deep wells. The well should be labeled on both the outside of the protective casing and inside beneath the protective casing lid.

5.2.10 Measuring Point Identification

- The project geologist/engineer will mark the measuring point from which water level measurements will be made at a specific location along the upper edge of the well casing. PVC wells can easily be notched with a pocket knife or saw. Stainless steel wells (or PVC wells) can be marked with a waterproof marker on the outside of the well casing with an arrow pointing to the measuring point location. The measuring point is the point which will require surveying during the well elevation survey task.

5.2.11 Well Measurements

- Upon completion, the following well measurements should be taken by the project geologist/engineer and recorded on the well construction diagram (Figure 1):
    - Depth to static water level if water level has stabilized,
    - Total length of well measured from top-of-well casing,
    - Height of well casing above ground surface,
    - Height of protective casing above ground surface,
    - Depth of bottom of protective casing below ground surface (may be estimated).
- Well screen filter pack, bentonite seal and annular seal thicknesses and depths should also be recorded on the well construction diagram.

5.2.12 Disposal of Drilling Wastes

- Drill cuttings and other investigation-derived wastes such as drilling mud or well development/purge water must be properly contained and disposed of. Site-specific requirements for collection and removal of these waste materials should be outlined within the project-specific work plan. Containment of these materials should be performed by the drilling subcontractor.

5.2.13 Well Development

- At some point after installation of a well and prior to use of the well for water-level measurements or collection of water quality samples, development of the well shall be undertaken in accordance with POP 007 (Monitoring Well Development). Well development may be performed by the drilling subcontractor if contracted to do so, or by the project geologist/engineer or other project staff.

5.2.14 Well Elevation Survey

- At the completion of the well installation program, all monitoring wells are usually surveyed to provide, at a minimum, the top-of-casing measuring point elevation for water level monitoring purposes. Other surveyed points may include: ground surface elevation, top of protective casing elevation, and well coordinate position. Well elevation surveys are usually conducted by a surveying subcontractor.

6.0 Quality assurance / quality control

6.1 Field personnel should follow specific quality assurance guidelines as outlined in the site-specific QAPP. The following aspects of monitoring well design and installation procedures depend on project-specific objectives which maybe addressed in the QAPP or in the project-specific work plan:

- Borehole drilling method and diameter,
- Type of construction materials for well screen, riser, filter pack and seals,
- Diameter of well materials,
- Length of well screen,
- Location, thickness, and composition of annular seals, and
- Well completion and surface protection requirements.

6.2 Certain quality control measures should be taken to ensure proper well completion.

6.3 The borehole will be checked for total open depth, and extended by further drilling or shortened by backfilling, if necessary, before any well construction materials are placed.

6.4 Water level and non-aqueous phase liquid (NAPL) presence will be checked during well installation to ensure that the positions of well screen, sand pack, and seal, relative to water level, conform to project requirements.

6.5 The depth to the top of each layer of packing (i.e., sand, bentonite, grout, etc.) will be verified and adjusted if necessary to conform to project requirements before the next layer is placed.

6.6 If water or other drilling fluids have been introduced into the boring during drilling or well installation, samples of these fluids may be required for analysis of chemical constituents of interest at the site.

7.0 Data and records management

7.1 All well construction data will be recorded on the Well Completion Log (Figure 1). All wells will be referenced onto the appropriate site map. A field notebook and/or boring log will be used as additional means of recording data. In no case will the notebook or boring log take the place of the well construction diagram.

8.0 Personnel qualifications and training

8.1 Well construction and installation requires a moderate degree of training and experience as numerous drilling situations may occur which will require field decisions to be made. It is recommended that inexperienced personnel be supervised for several well installations before working on their own. Experienced drillers are also of great assistance with problem resolution in the field. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

8.2 Drilling Subcontractor

- Any well drilling services or pump installation/repair services will be performed by an Iowa Department of Natural Resources licensed drilling contractor. It is the responsibility of the drilling subcontractor to provide the necessary equipment for well construction and installation. Well construction materials should be consistent with project requirements.

8.3 Surveying Subcontractor

- It is the responsibility of the surveying subcontractor to provide one or more of the following well measurements: ground surface elevation, horizontal well coordinates, top of well casing elevation (i.e., top-of-casing, or measuring point elevation), and/or top of protective casing elevation.

8.4 Project Geologist/Engineer

- It is the responsibility of the Project Geologist/Engineer to directly oversee the construction and installation of the monitoring well by the drilling subcontractor to ensure that the well-installation specifications defined in the project-specific work plan are adhered to, and that all pertinent data are recorded on the appropriate forms.

8.5 Project Manager

- It is the responsibility of the Project Manager to ensure that each project involving monitoring well installation is properly planned and executed.

9.0 References

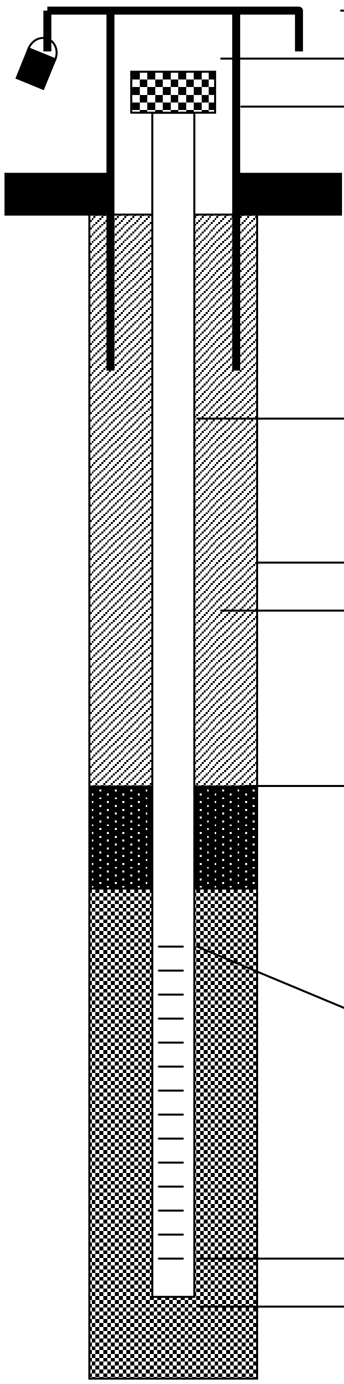
Standard References for Monitoring Wells, Massachusetts Department of Environmental Protection, WSC-310-91, 1991.

10.0 Revision history

Revision	Date	Changes
1	May 2010	Version 1

Well Completion Log

Date of Installation____________________ Monitoring Well No.____________________
Drilling Company____________________
Field Engineer____________________



Elevation of Top of Protective Casing____________
Elevation of Top of Riser Pipe________________
I.D. of Protective Casing____________________
Type of Protective Casing____________________
Ground Surface Elevation____________________

I.D. of Riser Pipe____________________________
Type of Riser Pipe___________________________
____

Diameter of Borehole________________________
Type of Backfill______________________________
____

Grout Ratio__________________________________

Depth to Top of Seal_________________________
Type of Seal_________________________________
____

Depth to Top of Sandpack____________________
Type of Sandpack____________________________
____

Depth to Top of Screen______________________
I.D. of Well Screen___________________________
Type of Well Screen__________________________
____

Depth to Bottom of Screen___________________
Depth to Bottom of Sediment Trap_____________
Depth to Bottom of Borehole_________________

Groundwater Levels
Initial During Drilling____________
Upon Completion of Well________

Figure 1

BNSF Somers Project Operating Procedure (POP) 110 Packing and Shipping Samples

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) Somers Project POP 110 describes proper packaging methods and shipment of samples to minimize the potential for sample breakage, leakage, or cross-contamination, and provide a clear record of sample custody from collection to analysis. Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Job Hazard Analysis (JHA), Safety Task Analysis Review (STAR), or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

The Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (1976) (RCRA) regulations (40 CFR Section 261.4 (d)) specify that samples of solid waste, water, soil, or air collected for the purpose of testing are exempt from regulation when any of the following conditions apply:

- Samples are being transported to a laboratory for analysis
- Samples are being transported to the collector from the laboratory after analysis
- Samples are being stored:
  - By the collector prior to shipment for analysis
  - By the analytical laboratory prior to analysis
  - By the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case

Samples collected by AECOM are generally qualified for these exemptions. BNSF Somers POP 110 deals only with these sample types. If you have any additional questions about shipping requirements contact the AECOM Environment, Health and Safety (EHS) Department.

2.0 Responsibilities

The field sampling coordinator is responsible for the enactment and completion of the chain-of- custody and the packaging and shipping requirements outlined here and in project-specific sampling plans.

3.0 Health and Safety

This section presents the generic hazards associated with packing and shipping samples and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific HASP and THAs will address additional requirements and will take precedence over this document. Note that packing and shipping samples usually requires Level D personal protection unless there is a potential for airborne exposure to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or EHS Coordinator.

Health and safety hazards with packing and shipping of samples include the following:

- Exposure to sample preservatives – Know the types of sample preservatives sent to you by the analytical laboratory. Understand the potential exposures (inhalation, ingestion skin contact) and use chemically impervious gloves to protect your hands from acids in particular.

- Anticipate the potential for spills – Glass containers are subject to breakage and if dropped on the floor will create a spill. Know how to contain the spill, have spill response materials available, and understand the proper disposal methods for spilled materials. Wear personal protective equipment (PPE) to clean up the spill as appropriate (Level C or D).

- Broken glass – Be aware of the possibility for broken glass in previously used coolers. Inspect the cooler before you place samples in it and clean out any broken glass safely (i.e. with a small brush).

- Coolers can be heavy – Use proper lifting techniques to pick up loaded coolers. Bend your legs and lift with a straight back to avoid a back injury.

- Do not use your teeth to cut tape to size, use a tape dispenser.

4.0 Supporting Materials

The following materials must be on hand and in sufficient quantity to ensure that proper packing and shipping methods and procedures may be followed:

- Chain-of-custody forms and tape

- Sample container labels
- Coolers or similar shipping containers
- Duct tape or transparent packaging tape
- Zip-lock type bags
- Protective wrapping and packaging materials
- Ice
- Shipping labels for the exterior of the ice chest
- Transportation carrier forms (Federal Express, Airborne, etc.)
- PPE as specified in the Site-Specific HASP
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants (including sample preservatives)
- A copy of the Site-Specific HASP

5.0 Methods and Procedures

All samples must be packaged so they do not leak, break, vaporize, or cause cross-contamination of other samples. Waste samples and environmental samples (e.g., groundwater, soil, etc.) should not be placed in the same shipping container. Each individual sample must be properly labeled and identified. A chain-of-custody record must accompany each shipping container. When refrigeration is required for sample preservation, samples must be kept cool during the time between collection and final packaging.

All samples must be clearly identified immediately upon collection. Each sample bottle label (Figure 1) will include the following information:

- Client or project name, or unique identifier, if confidential
- A unique sample description
- Sample collection date and time
- Sampler's name or initials
- Indication of filtering or addition of preservative, if applicable
- Analyses to be performed

After collection, identification, and preservation (if necessary), the samples will be maintained under chain-of-custody procedures as described below.

5.1 Chain-Of-Custody

A sample is considered to be under custody if it is in one's possession, view, or in a designated secure area. Transfers of sample custody must be documented by chain-of-custody forms (Figure 2). The chain-of-custody record will include, at a minimum, the following information:

- Client or project name, or unique identifier, if confidential
- Sample collector's name
- AECOM's mailing address and telephone number
- Designated recipient of data (name and telephone number)
- Analytical laboratory's name and city
- Description of each sample (i.e., unique identifier and matrix)
- Date and time of collection
- Quantity of each sample or number of containers
- Type of analysis required
- Date and method of shipment

Additional information may include type of sample containers, shipping identification air bill numbers, etc.

When transferring custody, both the individual(s) relinquishing custody of samples and the individual(s) receiving custody of samples will sign, date, and note the time on the form. If samples are to leave the collector's possession for shipment to the laboratory, the subsequent packaging procedures will be followed.

5.2 Packing for Shipment

To prepare a cooler for shipment, the sample bottles should be inventoried and logged on the chain-of-custody form. At least one layer of sorbent protective material should be placed in the bottom of the container. Be careful for any broken glass. A heavy-duty plastic bag, if available, should be placed in the shipping container to act as an inner container. As each sample bottle is logged on the chain-of-custody form, it should be wrapped with protective material (e.g., bubble wrap, matting, plastic gridding, or similar material) to prevent breakage. The protective material should be secured with tape. The sample should then be placed in a zip-lock type bag. Each sample bottle should be placed upright in the heavy-duty plastic bag inside the shipping container. Each sample bottle cap should be checked during wrapping and tightened, if needed. Avoid over tightening, which may cause bottle cap to crack and allow leakage. Additional packaging material, such as bubble wrap, should be spread throughout the voids between the sample bottles.

Most samples require refrigeration as a minimum preservative. To ensure that samples are received by the laboratory within required temperature limits, place cubed ice directly over packed samples, making sure that ice is present on all sides of each sample (a 2-inch layer of ice should be present on top of the samples prior to shipment).

If applicable, secure the inner heavy-duty bag with clear packing tape. This will prevent water from leaking out of the package, thus stopping shipment (package handling companies will not ship a leaking package).

Place the original completed chain-of-custody record in a zip-lock type plastic bag and place the bag on the top of the contents within the cooler or shipping container. Alternatively, the bag may be taped to the underside of the container lid. Retain a copy of the chain-of-custody record with the field records.

Close the top or lid of the cooler or shipping container and rotate/shake the container to verify that the contents are packed so that they do not move. Add additional packaging if needed and reclose. Place signed and dated chain-of-custody seal (Figure 3) at two different locations (front and back) on the cooler or container lid and overlap with transparent packaging tape. The chain-of-custody seal should be placed on the container in such a way that opening the container will destroy the tape. Packaging tape should encircle each end of the cooler at the hinges. Use proper lifting techniques when picking up the cooler.

Sample shipment should be sent via an overnight express service that can guarantee 24-hour delivery. Retain copies of all shipment records as provided by the shipper.

6.0 Quality Assurance/Quality Control

Recipient of sample container should advise shipper and/or transporter immediately of any damage to the container, breakage of contents, or evidence of tampering.

7.0 Documentation

The documentation for support of proper packaging and shipment will include AECOM or the laboratory chain-of-custody records and transportation carrier’s airbill or delivery invoice. All documentation will be retained in the project files.

Figure 1 Sample Label

Sample Label

Sample I.D. ______________________________

Location ______________________________

Date ______________ Time ________ Sampled By ________

Test(s) ______________________________

Pres ______________________________

Figure 1

Figure 2 Chain-of-Custody Record

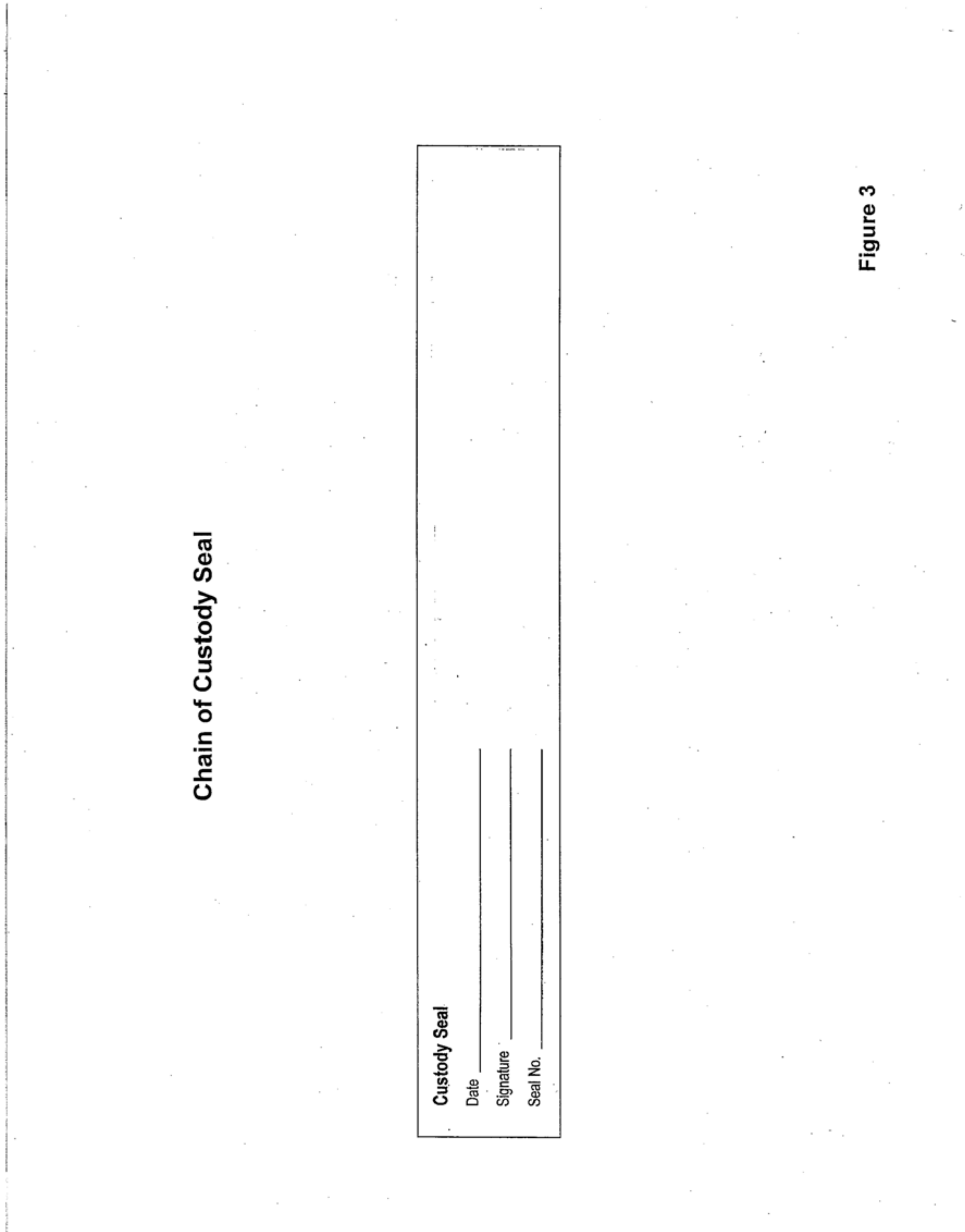
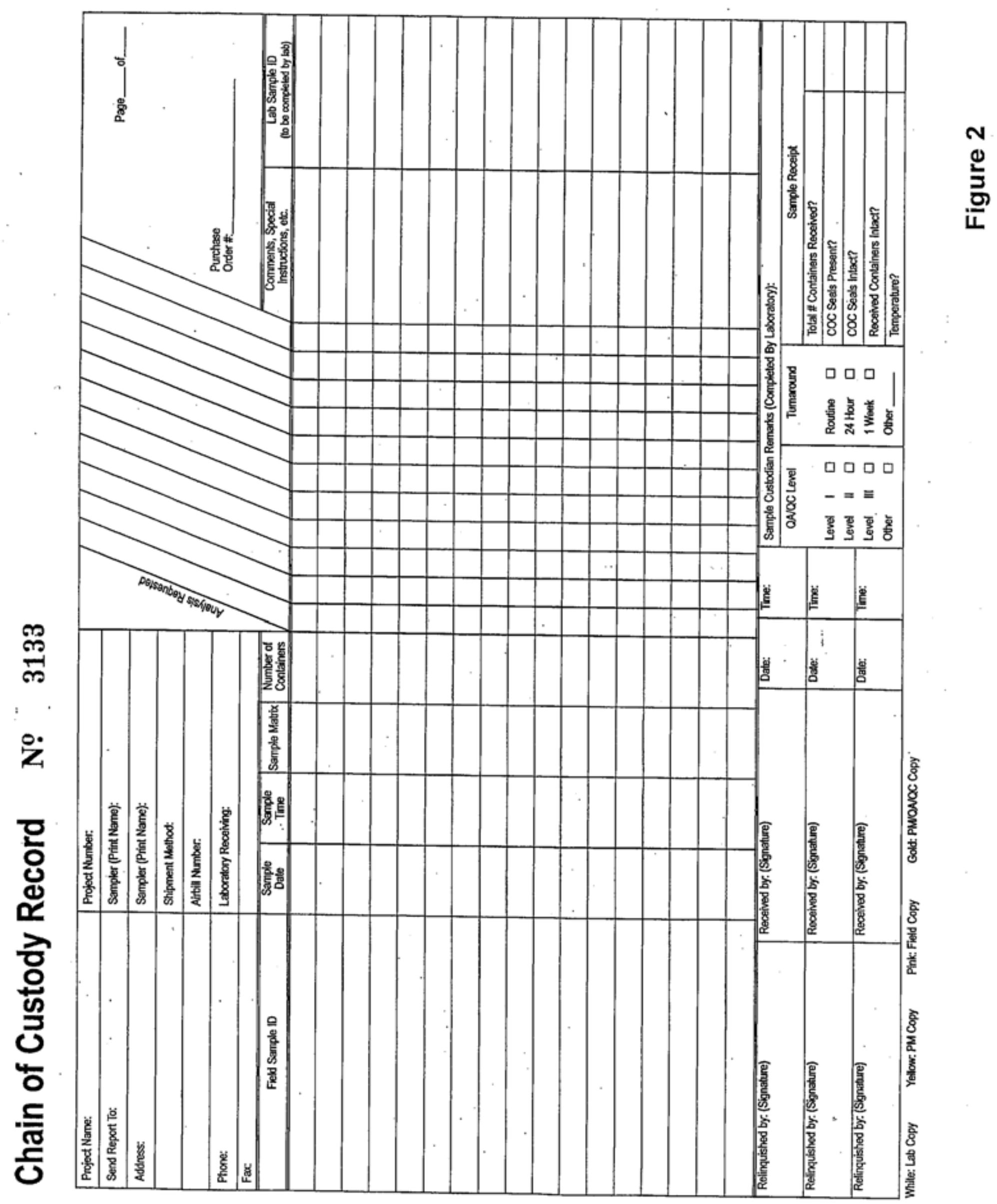


Figure 3 Chain-of-Custody Seal



Chain of Custody Record Nº 3133

Project Name:
Send Report To:
Address:
Phone:
Fax:
Project Number:
Sampler (Print Name):
Sampler (Print Name):
Shipment Method:
Airbill Number:
Laboratory Receiving:
Analysis Requested
Page ___ of ___
Purchase Order #: ___

Field Sample ID	Sample Date	Sample Time	Sample Matrix	Number of Containers												Comments, Special Instructions, etc.	Lab Sample ID (to be completed by lab)

Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:	Sample Custodian Remarks (Completed By Laboratory):
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:	
Relinquished by: (Signature)	Received by: (Signature)	Date:	Time:	

QA/QC Level: Level I ☐; Level II ☐; Level III ☐; Other ☐

Turnaround: Routine ☐; 24 Hour ☐; 1 Week ☐; Other ___

Sample Receipt: Total # Containers Received?; COC Seals Present?; COC Seals Intact?; Received Containers Intact?; Temperature?

White: Lab Copy Yellow: PM Copy Pink: Field Copy Gold: PM/QA/QC Copy

Figure 2

BNSF Somers Project Operating Procedure (POP) 120 Decontamination

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) Project POP 120 describes the methods to be used for the decontamination of items that may become contaminated during field operations. Decontamination is performed as a quality assurance measure, and as a safety and health precaution. It prevents cross-contamination between samples and also helps maintain a clean working environment. Equipment requiring decontamination may include hand tools, monitoring and testing equipment, personal protective equipment (PPE), or heavy equipment (e.g., loaders, backhoes, drill rigs, etc.).

Decontamination is achieved mainly by rinsing with liquids, which may include soap and/or detergent solutions, tap water, distilled water, and methanol or isopropyl alcohol. Equipment may be allowed to air dry after being cleaned or may be wiped dry with paper towels or chemical-free cloths.

All sampling equipment will be decontaminated prior to use and between each sample collection point. Waste products produced by the decontamination procedures, such as rinse liquids, solids, rags, gloves, etc., will be collected and disposed of properly, based on the nature of contamination and site protocols. Any materials and equipment that will be reused must be decontaminated or properly protected before being taken off site.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, AECOM Safety, Health, and Environment (SHE) Manual, Task Hazard Analysis (THA), or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

It is the responsibility of the field sampling coordinator to ensure that proper decontamination procedures are followed and that all waste materials produced by decontamination are properly managed. It is the responsibility of any subcontractors (e.g., drilling or sampling contractors) to follow the designated decontamination procedures that are stated in their contracts and outlined in the project HASP. It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and to ensure that no contaminants are inadvertently introduced into the environment, tracked out of the contamination reduction zone (CRZ), or passed from one sample point to another.

3.0 Health and Safety

This section presents the generic hazards associated with decontamination and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific HASP and THAs will address additional requirements and will take precedence over this document. Note that decontamination usually requires Level D personal protection unless there is a potential for airborne exposures to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or SHE Coordinator.

Health and safety hazards potentially involved decontamination include the following:

- Skin contact with decontamination solvents. Wear solvent impervious gloves when decontaminating equipment. Methanol and isopropanol are approved but use the solvents sparingly and dispense only from pre-labeled polypropylene solvent wash bottles. Whenever possible use an aqueous based non-toxic cleaning agents in lieu of solvents. **Hexane is prohibited from use for decontamination.**

- Avoid contact with site contaminants. Exposure to contaminated media is possible when either removing contaminated personal protective equipment (PPE) or decontaminating heavy equipment. Take care to prevent slips and falls when scrubbing over boots in the CRZ and remove PPE using proper “inside-out” techniques to minimize airborne exposure to potentially contaminated particulate. In addition to Level D PPE, wear a face shield when brushing off heavy equipment or using a pressure washer. Consult the Corporate EHS Manual for additional precautions.

- Decontamination pad liquids. If large volumes of rinsates are generated, wash water must be properly characterized prior to disposal. Avoid contact and wear PPE during liquids transfer.

4.0 Supporting Materials

The following materials should be on hand in sufficient quantity to ensure that proper decontamination methods and procedures are followed:

- Cleaning liquids and dispensers (phosphate-free soap and/or detergent solutions, tap water, distilled water, deionized water, reagent grade methanol or isopropyl, etc.)

- PPE, as defined in the project HASP

- Paper towels or chemical-free cloths
- Disposable chemically impervious gloves
- Waste-storage containers (e.g., drums, boxes, plastic bags)
- Drum labels, if necessary
- Cleaning containers (e.g., plastic and/or galvanized steel pans or buckets)
- Cleaning brushes
- Plastic sheeting
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants and decontamination solvents
- A copy of the Site-Specific HASP (consult for heavy equipment decontamination)

5.0 Methods and Procedures

The extent of known contamination will determine the degree of decontamination required. When the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated.

Standard operating procedures listed below describe the method for full field decontamination. If different technical procedures are required for a specific project, they will be spelled out in the project plans.

Such variations in decontamination may include all or an expanded scope of these decontamination procedures:

- Remove gross contamination from the equipment by brushing and then rinse with tap water.
- Wash with detergent or soap solution (e.g., Alconox and tap water).
- Rinse with tap water or distilled water.
- Rinse with reagent grade methanol or isopropyl alcohol.
- Rinse with deionized water (distilled water is an acceptable substitute if deionized water is unavailable).
- Repeat entire procedure or any parts of the procedure as necessary.

- After decontamination procedure is completed, avoid placing equipment directly on ground surface to avoid re-contamination.

Downhole drilling equipment, such as augers and split spoons, will be decontaminated with pressurized hot water or steam wash, followed by a fresh water rinse. No additional decontamination procedures will be required if the equipment appears to be visually clean. If contamination is visible after hot water/steam cleaning, then a detergent wash solution with brushes (if necessary) will be used. Items heavily contaminated with product may require more aggressive decontamination techniques. If the items cannot be discarded, consult your EHS coordinator to obtain guidance in this regard.

6.0 Quality Assurance/Quality Control

To assess the adequacy of decontamination procedures, rinsate blanks should be collected and analyzed for the same parameters as the field samples. Specific number of blanks will be defined in the project-specific sampling plan. In general, one rinsate blank will be collected per 20 samples.

7.0 Documentation

Field notes describing procedures used to decontaminate equipment/personnel and for collection of the rinsate blanks will be documented by on-site personnel. Field notes will be retained in the project files.

BNSF Somers Project Operating Procedure (POP) 210

Soil Sample Collection

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) Somers Project POP 210 describes methods used to obtain soil samples for physical testing, stratigraphic correlations, and chemical analysis. Soil samples may be obtained in conjunction with surface sampling, test pit excavation, soil boring, and monitoring well installation programs. These procedures provide specific information for determining the physical makeup of the surface and subsurface environment, as well as how to estimate the extent and magnitude of soil contamination, if present. BNSF Somers Project POP 210 will discuss sampling of the subsurface material by augers and split spoons, and within test pits by backhoes and hand tools.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Job Hazard Analysis, Safety Task Analysis Review, or Site-Specific Health & Safety Plan will take precedence over the procedures described in this document.

2.0 Responsibilities

The project geologist/engineer will be responsible for the proper use and maintenance of all types of equipment used for obtaining soil samples. The geologist/engineer will determine the location, total depth, and overall size of each surface sample collection point and test pit, and the location and depth of all subsurface borings based on the project specific sampling plan. The project geologist/engineer will be responsible for locating any subsurface utilities or structures, and disseminating this information to the contractor prior to commencing the sampling program. The location of overhead utilities and obstructions relative to the sampling locations will also be noted. In addition, a Task Hazard Analysis will be conducted to assess any other potential health and safety hazards associated with soil sample collection.

It shall be the responsibility of the project geologist/engineer to observe all activities pertaining to soil sampling and subsurface investigations to ensure that all the standard procedures are followed properly, and to record all pertinent data on a field log or field book. The collection, handling, and storage of all samples will be the responsibility of the geologist/engineer.

It is the responsibility of the contractor to provide safe and well-maintained equipment for obtaining subsurface samples in borings and for decontamination of the equipment. Test pit construction, split-spoon sampling, and subsurface augering will be conducted by the contractor. In addition, the contractor will be responsible for containment of cuttings, if required.

3.0 Health and Safety

This section presents the generic hazards associated with soil sampling techniques and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific Health & Safety Plan, and Task Hazard Analyses will address additional requirements and will take precedence over this document. Note that sample collection usually requires Level D personal protection unless there is a potential for airborne exposures to site contaminants.

Health and safety hazards include but are not limited to the following:

Hollow Stem Auger Drilling

- Heavy equipment operation
- Pinch points
- Rotating parts
- Loose clothing
- Heavy lifting
- Air quality (i.e., chemical, dust, explosive conditions)
- Hazardous materials (exposure and release)
- Pressurized lines
- High noise levels
- Utilities (underground or overhead)
- Hoisting
- Overhead hazards
- Hand hazards

Rotary Drilling (Mud/Air)

- Same as above
- Increased noise hazard
- Increased dust hazard (air rotary)
- Cyclones/Diverters (pressurized lines should be anchored with whip-stops)
- Investigation derived waste containment
- Blow protect inspection/replacement
- Sample collection (i.e., there are increased hazards when taking samples from air rotary rigs resulting from overhead hazards (cyclones), pressurized lines, increased noise, and air quality at sample collection outlets. Field personnel must be aware of these hazards and initiate engineered controls to limit these hazards.)

Rotosonic Drilling

- Same as above
- Elevated work platform
- Maneuvering rig and support truck

If site/project conditions warrant the use of other drilling techniques, hazards associated with these techniques will be evaluated by amendment in the site-specific Health & Safety Plan, Job Hazard Analyses, or Safety Task Analysis Reviews. Drill rig inspections, if applicable, will be completed prior to initiating soil sampling.

4.0 Supporting Materials

In addition to materials provided by the contractor, the geologist/engineer will provide:

- Sample bottles/containers and labels
- Boring or test pit logs
- Field notebook
- Chain-of-custody forms
- Depth-measurement device
- Stakes and fluorescent flagging tape
- Decontamination solution
- Camera for photographing sections
- Sampling equipment (e.g., knives, trowels, shovels, hand augers, aluminum foil, etc.)
- Plastic garbage bags
- Material Safety Data Sheets (MSDSs) for any chemicals or site specific contaminants
- A copy of the site-specific Health and Safety Plan

5.0 Methods and Procedures

Specific sampling equipment and methodology will be dictated by characteristics of the soil to be sampled, type of soil samples required, and by the analytical procedures to be employed.

There are two types of samples that may be required by the project sampling plan, grab or composite. A grab sample is collected from a specific location or depth and placing it in the appropriate sample container. A composite sample consists of several discrete locations (or depths) mixed to provide a homogeneous, representative sample. To ensure that the sample is representative, the soil volume and collection method from each discrete location should be as identical as possible. It should be noted that samples analyzed for volatile organic compounds cannot be composited since it is necessary to expose the soil to the atmosphere prior to transfer into the sample container.

The sampling depth interval in borings is typically one sample for every five feet with additional samples taken at the discretion of the project geologist/engineer when significant color, textural, or odor changes are encountered. Deviations in the standard operating procedure will be covered in the project specific sampling plans.

Most subsurface explorations by AECOM will be on privately owned land, often an industrial facility. Prior to commencing subsurface exploration, AECOM will work with the facility manager to locate any subsurface utilities or structures and discuss any pertinent health and safety issues. Utility companies, (electric, gas, water, phone, sewer, etc.) who may have equipment or transmission lines buried in the vicinity, will also be notified. Many regions have organizations, which represent all utilities for these notification purposes. Allow enough time after notification (typically three working days) for the utilities to respond and provide locations of any equipment, which may be buried on site. Overhead lines must also be kept in consideration when a drilling rig is used. As a rule of thumb, the rig and derrick should be at least 25 feet away from overhead lines unless special shielding and grounding are provided. In addition, consult the site-specific health and safety documentation.

5.1 General Applications

General locations shall be mapped by the field geologist/engineer using a stationary structure as the reference point. Specific locations for test pits and sampling locations will be documented by survey or by using topographic maps and/or plans. A preliminary log of the test pit, or boring shall be prepared in the field by the field geologist/engineer. A sketch of the test pit may be necessary to depict the strata encountered. Before measuring the depth to groundwater, if encountered, the field geologist/engineer will allow sufficient time for stabilization of the water table in the excavation or boring. All information shall be recorded on the field log or the field book.

5.2 Subsurface Sampling

Note: AECOM employees conducting these operations must have completed a drilling safety course.

The casing shall be of the flush-joint or flush-couple type and of sufficient size to allow for soil sampling, coring, and/or well installation. All casing sections shall be straight and free of any obstructions. Hollow-stem augers or solid-flight augers with casing may be used according to specific project requirements.

Generally subsurface soil samples shall be obtained using a split-tube type sampler (split spoon), however, other devices (Shelby tubes, continuous samples, core, etc.) may be used as specified in the project specific sampling plan. Split-spoons come in a variety of sizes with the most standard having a 2-inch OD, a 1 3/8-inch ID and a 24-inch long barrel with an 18-inch sample capacity. Split spoons shall be equipped with a check valve at the top and a flap valve or basket-type retainer at the bottom. Samples shall be obtained using the standard penetration test (SPT), which allows for qualitative determination of mechanical properties and aids in identification of material type. The number of hammer blows shall be recorded on the boring log for each six-inch drive distance.

The soil sampler shall be opened immediately upon removal from the casing. If the recovery is inadequate (i.e., most of the penetrated material was not retained inside the soil sampler), a note will be made on the boring log stating that “no recovery” was possible at that depth. In the event that gravels or other material prevent penetration by the split spoon, samples may be collected from the auger flights. Slowly remove the auger and collect the sample at the point corresponding to the required depth. Samples collected in this manner must be documented on the boring log.

Subsurface groundwater samples may be obtained from the borings. Groundwater samples may be collected using a peristaltic pump lowered into hollow-stem augers, through a power punch sampling technique, or through a packer assembly.

Depth discrete samples would be best collected through use of the power punch or packer techniques. Samples collected using a power punch would be collected by driving the sampler to the desired depth, pulling back on the sampler to expose the screen, and withdrawing the tool after a sufficient collection time has elapsed. Alternatively, a sample may be collected from the exposed screen by using a small diameter bailer or a peristaltic pump to collect the groundwater entering the screen. Samples collected using a packer assembly would be collected from a stainless screen attached to a two inch diameter black pipe; the packer would be inflated to isolate the desired depth interval and a bailer or peristaltic pump would be used to collect the sample.

Photographs of specific geologic features or sample location may be required for documentation purposes. A scale or item providing a size perspective should be placed in each photograph. The frame number and picture location shall also be documented in the field book. All equipment will be decontaminated following BNSF Somers Project POP 120 between sample locations and sample depths unless otherwise specified in the project specific sampling plan.

Upon completion of the boring, backfill may be required. The backfill may consist of native material, hydrated bentonite chips/pellets, Portland cement/bentonite grout, or other low permeability material as specified in the project specific sampling plan. All applicable state/federal regulations concerning plugging of boreholes should be reviewed prior to the commencement of field activities.

5.3 Sample Logging

To ensure consistent descriptions of soil or rock material, the following criteria should be included on the sampling logs:

- Soil or rock type
- Depth ranges, recorded in feet
- Grain size
- Roundness
- Sorting
- Moisture
- Color
- Degree of oil contamination
- Remarks

Examples of soil types would be gravel, sand, silt, or clay. Soil types should be based on the Unified Soil Classification System (USCS). Examples of rock types include limestone, shale, claystone, siltstone, and sandstone. Soil/rock classifications determined in the field may be subject to change based upon laboratory tests. Factors to consider before changing a field determination include the expertise of the field geologist/engineer and laboratory personnel, representative character of the tested sampling, labeling errors, etc. Any changes made after this consideration shall be discussed and incorporated in the project report.

Grain size, roundness, and degree of sorting should also be included on the log if they are discernable. In addition to composition, blow counts and the length of the sample recovered should also be recorded on the sampling log. The degree of sample moisture should be described as dry, moist, and wet.

The color(s) or range of color(s) of the soil or rock type should be defined. If a Munsell color chart is used, the number designation of the color will also be recorded in the description. A notation of the degree of oil contamination should be included on the sample log. The contamination should be noted as high (30 %), medium (10-30 %), low (1-10 %), or none. Other classifiers may include odor (low to high) and mottling (low to high).

Remarks should include anything pertinent to the sample description or sample collection that is not described above. Other information to be placed on the logs as appropriate is:

- PID readings (with associated calibration information)
- Appearance of contamination (consistency)
- Degree of fracturing or cementation in the rock
- Drilling equipment used (rod size, bit type, pump type, rig manufacturer and model, etc.)
- Special problems and their resolution (hole caving, recurring problems at a particular depth, sudden tool drops, excessive grout takes, drilling fluid losses, lost casing, etc.)
- Dates for start and completion of borings
- Depth of first encountered free water

- Definitions of special abbreviations used on log

5.4 Sample Handling

Specific procedures pertaining to the handling and shipment of samples shall be in accordance with BNSF Somers Project POP 110. A clean pair of gloves and decontaminated sampling tools will be used when handling the samples during collection to prevent cross contamination. A representative sample will be placed in the sampling container. Sample containers (jars or bags) shall be labeled with the following information:

- Client or project name, or unique identifier, if confidential
- Unique sample description (i.e., test pit, boring, or sampling point number and horizontal/vertical location)
- Sample collection date and time
- Sampler's name or initials
- Analyses to be performed

These data shall be recorded on the field logs and/or field book. Larger bulk samples shall be placed in cloth bags with plastic liners or plastic five-gallon buckets. Sample bags shall be marked with the information listed above.

6.0 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) requirements include, but are not limited to, blind field duplicates, blind rinsate blanks, and blind field blanks. These samples will be collected on a frequency of one QA/QC sample per 20 field samples or a minimum of one QA/QC sample per day unless otherwise specified in the project specific sampling plan.

7.0 Documentation

Documentation may consist of all or part of the following:

- Test pit or boring log
- Sample log sheets
- Field log book
- Chain-of-custody forms
- Shipping receipts
- Health & Safety forms (Job Hazard Analysis, Safety Task Analysis Review, and/or Site Specific Health & Safety Plan amendments)
- PID calibration records

All documentation shall be placed in the project files and retained following completion of the project.

8.0 References

Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, EPA/600/4-89/034, published by National Water Well Association, 1991.

RCRA Ground Water Monitoring Technical Enforcement Guidance Document, published by National Water Well Association, 1986.

A Compendium of Superfund Field Operations, EPA 540/P-87/001, published by the Office of Emergency and Remedial Response, Office of Waste Programs Enforcement, US EPA, 1987.

Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies, EPA/600/R-92/128, published by the Environmental Research Center, 1992.

AECOM

Boring and Well Construction Log

Project:	Contractor: .	Location: Somers, MT
Project #:	Operator:	Northing: Easting:
Client:	Drill Rig Type:	Surface Elevation (ft AMSL):
Start Date & Time:	Method:	Total Depth (ft):
Finish Date & Time:	Boring ID:	Logged By:

Sample						Depth (ft.)	Lithology	USCS Symbol	Soil and Rock Description	Well Diagram
Analytical Sample	Sample Type	Blows/ 6 inch	% Rec	PID (ppm)	Sheen Test					
						0				
						5				
						10				
						15				
						20				
						25				

Remarks and Datum Used:

AECOM
1601 Prospect Parkway
Fort Collins, CO 80525
Phone: (970) 493-8878
Fax: (970) 493-0213

Depth to Water Table (ft):

BNSF Somers Project Operating Procedure (POP) 225 Hydrocarbon Field Screening by Sheen Test

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) Project POP 225 describes a procedure to visually estimate areas of possible hydrocarbon impacts in soil or sediment. In addition, screening results can be used to aid in the selection of soil/sediment samples for chemical analysis. The field screening method includes:

- Visual examination
- Water sheen screening

Visual screening consists of inspecting the soil/sediment for stains, nonaqueous-phase liquids (NAPL), and/or sheens indicative of residual hydrocarbons. Visual screening is most effective at detecting heavy hydrocarbons, such as creosote, or high hydrocarbon concentrations. Water sheen screening from a representative soil sample is a more sensitive method at detecting the presence of hydrocarbons.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Task Hazard Analysis (THA), AECOM Safety, Health, and Environment (SHE) Manual, or Site-specific Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The project manager is responsible for ensuring that a properly designed sampling program is prepared prior to any sample collection. The field sampling coordinator will have the responsibility to oversee and ensure that all sampling is performed in accordance with the project-specific sampling program and this POP. In addition, the field sampling coordinator must ensure that all field workers are fully apprised of this POP.

3.0 Health and Safety

This section presents the potential hazards associated with this technique. The site-specific HASP, JHA, and STAR will address additional requirements and will take precedence over this document. Note that sample collection usually requires Level D personal protection unless there is a potential for airborne or dermal exposures to site contaminants.

Health and safety hazards include but are not limited to the following:

- Dermal exposure to potentially contaminated media: Ensure that proper personal protective equipment (PPE) is used to mitigate dermal contact including the impact of splashes of water or media to skin and/or eyes

- Inhalation exposure when handling impacted media. Respiratory protection should follow the procedures outlined in the project Site-Specific HASP

- Broken glass, in the event that a glass jar is used: Use care when handling glassware

4.0 Supporting Materials

The following materials must be on hand in sufficient quantity to ensure that proper screening procedures may be followed.

- Approximately one cubic-inch of media to be screened
- Two or four oz. wide-mouth glass jar (some field situations may require the use of a plastic baggy)
- Stirring devise (i.e. spoon)
- Squirt bottle
- Supply of distilled water

5.0 Methods and Procedures

The strategy used to collect soil/sediment samples in the field for sheen testing will depend on the nature/grain size of the material and the type of hydrocarbon. Discrete samples may be collected from specific depths where NAPL is likely to occur. When lithology is course-grained material over fine-grained material, then a sample should be collected just above this interface where NAPL may be pooling above the “aquitard”. Similarly, where fine-grained material overlies a coarse-grained layer with suspected impacts, the sample should be collected just below the contact. When lithology is fine-grained, then a sample should be collect near the contact with the coarse-grained layer.

Alternatively, when lithology is finely bedded (< 1-inch thick), then homogenized samples may be collected over a larger depth interval to gain an “average” observation. Use a spoon to scrap material across the surface of the depth interval of interest, and place into sample jars for further observation. Once the sample is collected (approximately 2 to 4 oz depending upon grain size) the sample is examined and tested as described below.

5.1 Visual Examination

In the field, observe sediment core tubes or soil samples for evidence of NAPL. Look at the material and note color and type/nature of occurrence. Observe the sidewalls of the sampling container for signs of staining. If wet, observe the nature of liquid. Among gravels, observe the surface of the gravel for signs of sheen and/or NAPL.

Naturally-occurring sheen is often found in the field. Naturally-occurring sheen can be similar in color to hydrocarbon sheens and can range in color from a milky white to a metallic blue. It can be discerned from hydrocarbon sheen due to its ability to break up when disturbed by touch.

5.2 Water Sheen Test

Water sheen screening involves placing soil/sediment in a clear glass jar or a black plastic pan partially filled with water, and observing the water surface for signs of a sheen. The volume of soil/sediment required for observation is approximately one cubic inch, or 10 mls, or about one tablespoon of media. For practical application in the field or lab, place about one cubic inch of soil/sediment in a 2 or 4 oz jar filled ¼-full with water. For larger volumes, use about 2 oz of material in an 8 oz wide-mouth glass jar filled ¼-full with water. Even larger volumes are needed for gravel. A plastic baggy may be substitute for a glass jar if field conditions require. Crush the material in the jar using a stirring devise (i.e., spoon), and shake the sealed jar vigorously for 30 seconds and allow the material to settle. Observe the water surface and sidewalls of the jar for signs of sheen, LNAPL, and DNAPL. Naturally occurring sheen can be discerned from hydrocarbon sheen by its ability to dissolve or break-up upon agitation. Quantify the amount of sheen and blebs in the water surface using the following sheen classification:

No Sheen	No visible sheen on water surface;
Slight Sheen	Light, colorless, dull sheen; spread is irregular, not rapid; sheen dissipates rapidly;
Moderate Sheen	Light to heavy sheen, may have some color/iridescence; spread is irregular to flowing, may be rapid; few remaining areas without sheen on water surface;
Heavy Sheen	Heavy sheen with color/iridescence; spread is rapid; entire water surface may be covered with sheen; visible droplets of immiscible liquids (i.e., NAPL).

Quantify the spatial coverage of sheen, size/diameter NAPL blebs if observed, and color. Visual descriptions and percent coverage are provided in the table below.

Sheen Test- % coverage		**Sheen Test- Visual Description**	
none, trace	<2	rainbow	multicolored
slight sheen	2-15	metallic	metallic gray-colored
moderate sheen	15-40	florets	semi-circular and multicolored
moderate to heavy	40-70	blebs	semi-circular and black/brown
heavy	>70	streaks	long and flowing shape

Observe the sidewalls of the jar and estimate the thickness of LNAPL on the water surface and the thickness of DNAPL accumulated at the bottom of the jar. Record visual signs of staining on jar sidewalls and stirring devise.

Field screening results will be recorded on the field logs forms or in a field notebook. Field screening results are site-specific and location-specific. Factors that may affect the performance of this method include: operator experience (experimentation may be required before routine screening is started) ambient air temperature, soil type, soil moisture, organic content, and type of hydrocarbon. Headspace screening may be collected to help correlate results and observations.

6.0 Quality Assurance/Quality Control

Not applicable.

7.0 Documentation

Documentation may consist of all or part of the following:

- Field sampling forms
- Field log book
- Chain-of-custody forms

Field records should contain sufficient detail to provide a clear understanding of how and where samples were collected. All documentation shall be placed in the project files and retained following completion of the project.

BNSF Somers Project Operating Procedure (POP) 230 Groundwater Sampling

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) Somers Project POP 230 describes methods used to obtain the collection of valid and representative groundwater samples from monitoring wells. Specific project requirements as described in an approved Work Plan, Task Hazard Analysis (THA), or Site-Specific Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The field sampling coordinator will have the responsibility to ensure that all groundwater sampling is performed in accordance with the project-specific sampling program and this POP. In addition, the field sampling coordinator must ensure that all field workers responsible for conducting groundwater sampling activities are fully apprised of this POP and other pertinent project documents.

3.0 Health and Safety

This section presents the generic hazards associated with low flow groundwater sampling and is intended to provide general guidance in preparing site-specific health and safety documents. The site-specific HASP and THA will address additional requirements and will take precedence over this document. Note that low flow groundwater sampling usually requires Level D personal protection unless there is a potential for exposure to airborne site contaminants.

Health and safety hazards include but are not limited to the following:

- Slip, trips, and falls in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure there is a safe means of access/egress to the wellhead.
- Dermal exposure to potentially contaminated groundwater. Ensure that proper personal protective equipment (PPE) is used to mitigate the impact of splashes of groundwater to skin and/or eyes.

- Exposure to site contaminants. If there is product in the well, take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.
- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.

4.0 Supporting Materials

The following section includes basic types of materials and equipment necessary to complete groundwater sampling activities. Project specific equipment will be selected based upon project objectives and site conditions (e.g., the depth to groundwater, purge volumes, analytical parameters, well construction, and physical/chemical properties of the analytes).

4.1 Project Documentation and Set-Up

- Work Plan
- Sampling Plan
- Quality Assurance Project Plan
- POP 231
- HASP
- Project Contact List
- Laboratory, and other subcontractor, work orders (signed)

4.2 Purging/Sample Collection

The following equipment will be used to purge monitoring wells and collect groundwater samples:

- Low flow peristaltic sampling pump
- Teflon and polyethylene tubing
- Water level measurement equipment
- In-line water quality meter (e.g., flow-through cell) with individual temperature, pH, specific conductance, dissolved oxygen (DO), salinity, and oxidation-reduction potential (ORP) probes
- Turbidity meter

- Sample containers, labels and preservation solutions (if necessary)
- Coolers and ice
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- Field data sheets and log book
- Decontamination equipment
- Paper towels
- Well keys
- Disposable gloves
- Tubing cutters
- Plastic sheeting
- Personal protective equipment
- Cloth towel(s) or other suitable insulating material to insulate the flow-through cell
- Buckets and intermediate containers

5.0 Methods and Procedures

The following sections describe the methods and procedures required to collect representative groundwater samples.

5.1 Water-Level Measurement

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. A static-water level will be measured in the well prior to purging and sample collection. The water level is needed for estimating the purge volume and also may be used for mapping the potentiometric surface of the groundwater. Whenever possible, water level measurements will be collected at all of the wells on-site within 24 hours of each other, or a period reasonable to site conditions. Water-level measurements will be collected using an electronic or mechanical device following the methods described in POP 231.

The location of the measurement point for water level measurements for each well should be clearly marked on the outermost casing or identified in previous sample collection records. This point usually is established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If the measuring point from previous investigations is not marked, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form. The location should be described on the groundwater sampling form.

After opening the well, the field sampler will check for indications of an airtight seal resulting in a pressure difference within the well compared to ambient conditions. If this is the case, the field sampler will allow a minimum of 5 minutes for the water level to stabilize before collecting a down-hole measurement. To obtain a water level measurement, the field sampler should lower a decontaminated mechanical or an electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time, the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement. The water-level measurement should be entered on the groundwater sampling form. The water-level measurement device shall be decontaminated immediately after use following the procedures outlined in POP 120.

5.2 Purging and Sample Collection Procedures

Wells may be purged and sampled using low-flow sampling techniques.

Purging must be performed for all wells prior to sample collection. The volume of water present in each well must be computed using two measurable lengths: length of water the water column and monitoring well inside diameter. The following data can be used in this field calculation:

Inside Diameter of casing (inches)	Gallons/foot
1 1/4	0.077
1 1/2	0.10
2	0.16
3	0.37
4	0.65
6	1.64

A low flow, electric driven pump (e.g., peristaltic pump) may be used to purge water. The inlet of the peristaltic pump tubing will be lowered into the well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer, or 1 to 2 feet below the water level in the well, whichever is greater. A depth-to-water measurement device will be lowered into the well to monitor drawdown. The pump will be turned on at a flow rate of about 0.1 liter per minute (L/min). The flow rate will be adjusted up or down to maximize flow, yet ensure minimum drawdown. Efforts will be made to limit drawdown to 0.5 foot. If the well recharge is not adequate enough to maintain proper water levels, the well will be pumped dry. The well will be sampled after water level in the well has recovered.

If the well being sampled is newly installed and developed or has been redeveloped, sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new well. Wells developed with stressful measures (e.g., backwashing, jetting, compressed air, etc.) may require as long as a 7-day interval before sampling.

Groundwater will be pumped from the well into a sealed and insulated flow-through assembly containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a Water Quality Meter.

The flow-through assembly must be placed as close as possible to the well to be sampled. The tubing that connects the well discharge to the flow-through cell must be as short as possible. The flow-through assembly must be insulated with a cloth towel or other suitable insulating material to minimize fluctuations in the water quality readings.

It is essential to properly calibrate the Water Quality Meter for the specific parameters being monitored, according to the procedures identified in the instrument manual. Calibration procedures and results must be documented in the site field notebook.

Field parameters values will be recorded on the Groundwater Sampling Form (attached) or in the site field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the container is full, the water will be properly disposed following Site protocols.

Groundwater samples will be collected for laboratory analysis when the groundwater has stabilized; and the change between successive readings of temperature, pH and conductivity are less than 10 percent. This may occur prior to removal of three well volumes. Stabilization of groundwater measurements is considered indicative of sampling fresh formation water and is a more reliable indicator of purging than removal of a standard volume of water.

Each sample container will be slowly filled by pouring sample water gently down the inside of the container with minimal turbulence. During sample collection, the tubing will not be allowed to contact the sample containers.

Sample labels and chain of custody will be filled out and include the following information at a minimum: sample location, sample name, sampler name or initials, requested analysis, preservative, date and time. Proper packaging and shipment of samples will minimize the potential for sample breakage, leakage, or cross contamination and will provide a clear record of sample custody from collection to analysis.

Non-dedicated equipment will be decontaminated between each well. Note that the peristaltic pump does not require decontamination because it does not contact the groundwater.

5.3 Field Parameter Monitoring

Field personnel should familiarize themselves with the field parameters to be monitored. Certain field parameters such as DO and ORP should correlate to each other. If available, historical sampling forms should be reviewed prior to sampling for an initial understanding of the range of values previously obtained at each sample location. Often it is useful to photocopy the past sampling forms and have them available in the field for comparison purposes. Understanding the past results and current conditions can indicate well damaged or if meters are working properly.

5.4 Sample Preparation and Filtration

Prior to transport or shipment, groundwater samples may require preparation and/or preservation. Field preparation includes preservation in the form of chemical additives and temperature control. Specific handling and preservation requirements will be in accordance with POP 110 and the project-specific sampling plans. A clean pair of gloves and decontaminated sampling tools will be used when handling the samples during collection to prevent cross contamination.

In general, groundwater samples will need to be placed on ice and inside coolers to protect the samples from the sun and to decrease their temperature to or below 4 degrees Celcius.

Field personnel should contact the laboratory prior to going out into the field to ensure necessary lab containers are available and sample preservation procedures are followed. Items such as preservative safety and clear versus opaque jars are examples of items that should be discussed with the laboratory. Sample receiving dates also should be discussed with the laboratory.

6.0 Field Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) requirements dictated by the project specific sampling plans include, but are not limited to, blind field duplicates, equipment rinse blanks (ERB), and field blanks. These samples will be collected at the following frequencies:

- Duplicate – 1 per 10 samples
- ERB – 1 per day of sample collection activities or per type of field equipment used to collect samples only when non-dedicated sampling methods are used
- Field Blank – as determined for the project
- Trip Blanks – shall be included with all VOCs, methane and other samples that consist of dissolved gas phase compounds.

7.0 Documentation

Various documents will be completed and maintained as a part of groundwater sample collection. These documents will provide a summary of the sample collection procedures and conditions, shipment method, analyses requested, and the custody history. These documents may include:

- Field book
- Groundwater sampling forms
- Sample labels
- Chain of custody
- Shipping receipts
- Sample nomenclature protocol

All documentation will be stored in the project files. Sample nomenclature protocol should be discussed with the project data management personnel to ensure consistency between sampling events.

Fluid-Level Monitoring Log

Site Location:	**Project Name:**
Personnel:	**Project No.:**
Gauging Instrument:	**Date(s):**

Well Number	Date	Time	Total Depth (A)	Depth to Water (A)	Remarks

Figure 1

BNSF Somers Project Operating Procedure (POP) 231 Water-Level Measurements

1.0 Purpose and Applicability

BNSF Railway Company (BNSF) Somers Project POP 231 describes the measurement of water levels in groundwater monitoring wells or piezometers. Water-level measurements are fundamental to groundwater and solute transport studies. Water-level data are used to indicate the directions of groundwater flow and areas of recharge and discharge, to evaluate the effects of manmade and natural stresses on the groundwater system, to define the hydraulic characteristics of aquifers, and to evaluate stream-aquifer relations. Measurements of the static-water level are also needed to estimate the amount of water to be purged from a well prior to sample collection.

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Task Hazardous Analysis (THA), or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The field sampling coordinator will have the responsibility to oversee and ensure that all procedures are performed in accordance with the project-specific sampling program and this POP.

3.0 Health and Safety

This section presents the generic hazards associated with the collection of water-level measurements. The site-specific HASP, and THA will address additional requirements and will take precedence over this document. Appropriate personal protective equipment (PPE) must be worn as determined in the Site-Specific HASP, which typically consists of Level D protection. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or Environment, Health, and Safety (EHS) Coordinator.

Health and safety hazards during groundwater level measurements may involve:

- Slip, trips, and falls in tall grasses over obstacles and berms near well locations. Review terrain hazards prior to conducting these operations. Ensure that you have safe means of access/egress to the wellhead.

- Exposure to site contaminants. If there is product in the well (especially gasoline) take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.

- Ergonomics. Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.

If the well is suspected of being contaminated, or has a history of contamination, the static water-level measurements should be made while wearing appropriate personal protective equipment (PPE). The air in the wellhead may also be sampled for organic vapors using a Photo Ionization Detector (PID). The results shall be recorded in the Fluid-Level Monitoring Log or the project field book. This would be the first indication of the presence of a non-aqueous phase liquid (NAPL). If the potential for fire or explosion exists, use of the probe ground wire is required.

4.0 Supporting Materials

This section identifies the types of equipment that may be used for measurement of groundwater levels. Based on project objectives, observed or probable well contamination, and well construction, a project-specific equipment list will be determined from the following equipment:

- Water-level and/or product-level measuring device
- Distilled water dispenser bottle
- Methanol or isopropyl in properly labeled dispenser bottles
- Plastic sheeting
- PPE as specified in the Site-Specific HASP
- Fluid-level monitoring logs and field book
- Paper towels or chemical-free cloths
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP

5.0 Methods and Procedures

When taking a series of fluid-level measurements at a number of monitoring wells, it is generally good practice to go in order from the least- to the most contaminated well. Additionally, the measurement of all site wells should be done consecutively and before any sampling activities begin. This will ensure the data are representative of aquifer conditions. All pertinent data should be entered in the Fluid-Level Monitoring Log or the project field book.

5.1 Well Evaluation

Upon arrival at a monitoring well, the surface seal and well protective casing should be examined for any evidence of frost heaving, cracking, or vandalism. All observations should be recorded in the fluid-level monitoring log or the project field book.

The area around the well should be cleared of weeds and other materials prior to measuring the static-water level (avoid contact with poison ivy or other allergenic plants). A drop cloth or other material (e.g., plastic garbage bag) should be placed on the ground around the well, especially if the ground is disturbed or potentially contaminated. This will save time and work for cleaning equipment or tubing if it falls on the ground during preparation or operation. The well protective casing should then be unlocked and the cap removed.

5.2 Measuring Point Location

The measuring point location for the well should be clearly marked on the outermost casing or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If not marked from previous investigations, the water-level measuring point should be marked on the north side of the well casing and noted in the Fluid-Level Monitoring Log or the project field book. Monitoring well measurements for total depth and water level should be consistently measured from one reference point so that these data can be used for assessing trends in the groundwater.

5.3 Water-Level Measurement

Water-level measurements shall be made using an electronic or mechanical device. Several methods for water-level measurement are described below. The specific method to be used will be defined in the project-specific sampling plan.

5.3.1 Graduated Steel Tape

The graduated steel-tape method is considered an accurate method for measuring the water level in nonflowing wells. Steel surveying tapes in lengths of 100, 200, 300, 500, and 1,000 feet are commonly used; a black tape is better than a chromium-plated tape. The tapes are mounted on hand-cranked reels up to 500-foot lengths; for greater depth, a motor-driven tape drive is usually required. A slender weight is attached to the ring at the end of the tape to ensure plumbness and to permit some feel for obstructions.

The lower few feet of tape is chalked by pulling the tape across a piece of blue carpenter's chalk. The wet chalk mark identifies the portion of the tape that was submerged. Lower the graduated steel-tape from the measuring point at the top of the well until a short length of the tape is submerged. The weight and tape should be lowered into the water slowly to prevent splashing. Submergence of the weight and tape may temporarily cause the water level to rise in wells or piezometers having very small diameters. This effect can be significant if the well is in materials of very low hydraulic conductivity.

Under dry surface conditions, it may be desirable to pull the tape from the well by hand, being careful not to allow it to become kinked, and reading the water mark before rewinding the tape onto the reel. In this way, the watermark on the chalked part of the tape is rapidly brought to the surface before the wetted part of the tape dries. In cold regions, rapid withdrawal of the tape from the well is necessary before the wet part freezes and becomes difficult to read. Read the tape at the measuring point, and then read the watermark on the tape. The difference between these two readings is the depth to water below the measuring point. Errors resulting from the effects of thermal expansion of tapes and of stretch due to the suspended weight of the tape and plumb weight can become significant at high temperatures and for measured depths in excess of 1,000 feet.

The observer should make two measurements. If two measurements of static-water level made within a few minutes do not agree within 0.01 or 0.02 foot in observation wells having a depth to water of less than a couple hundred feet, continue to measure until the reason for the lack of agreement is determined or until the results are shown to be reliable. Where water is dripping into the well or covering the well casing wall, it may be impossible to get a good watermark on the chalked tape.

Water-level measurement should be entered in the fluid-level monitoring log or the project field book. The water-level measurement device shall be decontaminated immediately after use.

5.3.2 Electrical Methods

Many types of electrical instruments are available for water-level measurement; most operate on the principle that a circuit is completed when two electrodes are immersed in water. Electrodes are generally contained in a weighted probe that keeps the tape taut while providing some shielding of the electrodes against false indications as the probe is being lowered into the well. Before lowering the probe into the well, the circuitry can be checked by dipping the probe in water and observing the indicator (a light, sound, and/or meter).

To obtain a water-level measurement, slowly lower the decontaminated probe into the monitoring well until the indicator (light, sound, and/or meter) shows water contact. At this time, the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement.

In wells having a layer of NAPL floating on the water, the electric tape will not respond to the oil surface and, thus, the fluid level determined will be different than would be determined by a steel tape. The difference depends on how much NAPL is floating on the water. Dual media tapes are recommended in that instance to measure both NAPL and water levels using the same measuring device. The procedure is discussed in Section 5.4.

Water-level measurement should be entered in the fluid-level monitoring log or the project field book. The water-level measurement device shall be decontaminated immediately after use.

5.3.3 Airline

The airline method is especially useful in pumped wells where water turbulence may preclude using more precise methods. A small diameter air-type tube of known length is installed from the surface to a depth below the lowest water level expected. Compressed air is used to purge the water from the tube. The pressure, in pounds per square inch (psi), needed to purge the water from the airline multiplied by 2.31 (feet of water for one psi) equals the length in feet of submerged airline. The depth to water below the center of the pressure gage can be easily calculated by subtracting the length of airline below the water surface from the total length of airline (assuming the air line is essentially straight).

Accuracy depends on the precision to which the pressure can be read. The accuracy of an airline or pressure gage measurement depends primarily on the accuracy and condition of the gage. It is normally within 1 foot of the true level as determined by means of a steel-tape measurement. The airlines themselves, however, have been known to become clogged with mineral deposits or bacterial growth, or to develop leaks and consequently yield false information. A series of airline measurements should be checked periodically by the use of a steel tape or an electric water-level indicator.

The airline and any connections to it must be airtight throughout the entire length. A long-term increase in airline pressure may indicate gradual clogging of the airline. A relatively sudden decrease in airline pressure may indicate a leak or break in the airline. Airline pressures that never go above a constant low value may indicate that the water level has dropped below the outlet orifice of the airline. To minimize the effect of turbulence, the lower end of the airline should be at least 5 feet above or below the pump intake. Corrections should be made for fluid temperatures much different from 20° C and for vertical differences in air density in the well column for cases where the depth to water is very large.

5.4 Procedures for Immiscible Fluids

At those facilities where monitoring to determine the presence or extent of immiscible fluids is required, the sampler will need to use special procedures for the measurement of fluid levels. The procedures required will depend on whether light NAPL (LNAPL) that form lenses floating on top of the water table or dense NAPL (DNAPL) that sink through the aquifer and form lenses over lower permeability layers are present.

In the case of LNAPL, measurements of immiscible fluid and water level usually cannot be accomplished by using normal techniques. For example, a chalked steel-tape measurement will only indicate the depth to the immiscible fluid (not the depth to water) and a conventional electric water-level probe will not generally respond to nonconducting immiscible fluids.

To circumvent these problems, the use of special techniques and equipment can be specified. These techniques have been specially developed to measure fluid levels in wells containing LNAPL or DNAPL, particularly petroleum products. One method is similar to the chalked steel-tape method. The difference is the use of a special paste or gel rather than ordinary carpenters chalk. Such indicator pastes, when applied to the end of the steel tape and submerged in the well, will show the top of the oil as a wet line and the top of the water as a distinct color change. Another method, similar to the electric-tape method, uses a dual purpose probe and indicator system. The probe can detect the presence of any fluid (through the wetting effect) and can also detect fluids that conduct electricity. Thus, if a well is contaminated with low density, nonconducting LNAPL such as gasoline, the probe will first detect the surface of the gasoline, but it will not register electrical conduction. However, when the probe is lowered deeper to contact water, electrical conduction will be detected. The detection of a DNAPL would be similar.

5.5 Measurement of Total Depth

During water-level measurement, the total depth of the well may also be measured. This measurement gives an indication of possible sediment buildup within the well that may significantly reduce the screened depth. The same methods used for measuring water levels (e.g., steel tape or electrical probes) may be used to measure the total well depth. The most convenient time to measure the total well depth is immediately following measurement of the water level and prior to removing the measurement device completely from the well. The measurement device (steel tape or electrical probe) is lowered down the well until the measurement tape becomes slack indicating the weighted end of the tape or probe has reached the bottom of the well. While the probe remains touching the bottom and the tape pulled taut, the total well depth shall be recorded into the field book.

6.0 Quality Assurance/Quality Control

To ensure that accurate data are collected, repeated measurements of the fluid depths should be made. The readings should be within 0.01 to 0.02 feet of each other. A secondary check, if data are available, is to compare previous readings collected under similar conditions (e.g., summer months, wells pumping, etc.).

7.0 Documentation

Data will be recorded into the fluid-level monitoring log form, the project field book, or, if groundwater sampling, the groundwater sample collection record. Additional comments, observations, or details will also be noted. These documents will provide a summary of the water-level measurement procedures and conditions and will be kept the in project files.

BNSF Somers Project Operating Procedure (POP) 310 Headspace Screening

1.0 Purpose and Applicability

BNSF Somers Project POP 310 describes the basic techniques for using headspace analysis to screen for volatile organics in contaminated soils using a portable Photo Ionization Detector (PID) or Flame Ionization Detector (FID).

Specific project requirements as described in an approved Work Plan, Sampling Plan, Quality Assurance Project Plan, Task Hazard Analysis (THA), or Site-Specific Health and Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Responsibilities

The project manager/task manager is responsible for overseeing work activities to ensure that field screening is performed and documented in accordance with the methods described here and in the project-specific sampling plan. In addition, a THA will be conducted to assess any potential hazards associated with headspace screening. Copies of THA forms are available in the Site-Specific HASP.

3.0 Health and Safety

This section presents the generic hazards associated with headspace screening and is intended to provide general guidance in preparing site-specific health and safety documents. The Site-Specific HASP and THA will address additional requirements and will take precedence over this document. Note that headspace screening usually requires Level D personal protection unless there is a potential for airborne exposure to site contaminants. Under circumstances where potential airborne exposure is possible respiratory protective equipment may be required based on personal air monitoring results. Upgrades to Level C will be coordinated with your Site Safety and Health Officer (SSHO) or Environment, Health, and Safety (EHS) Coordinator.

Health and safety hazards and corresponding precautions include, but are not limited to, the following:

- Dermal contact with contaminated soil. Personnel should treat all soil as potentially contaminated and wear chemically impervious gloves. Minimize skin contact with soil by using sampling instruments such as stainless steel spades or spoons. Do not touch any exposed skin with contaminated gloves.

- Inhalation hazards. Appropriate air monitoring should be conducted to ensure that organic vapor concentrations in the breathing zone do not exceed action levels as specified in the Site-Specific HASP. When ambient temperatures are low enough to require warming samples using the vehicle heater, the vehicle's windows should be opened enough to prevent the build-up of any organic vapors. Use the PID or FID to verify the airborne concentrations in the vehicle remain below applicable action levels. Note that many volatile organic compounds (VOCs) are flammable and all precautions must be observed to eliminate any potential ignition sources.

- Shipping limitations. Follow applicable regulations when shipping FID/PID equipment. When shipping an FID by air, the hydrogen tank must be bled dry. Calibration gas canisters are considered dangerous goods and must be shipped according to IATA and DOT regulations. Consult your EHS Coordinator and check with your shipping company to determine the correct shipping procedures.

4.0 Supporting Materials

The following materials must be on hand in good operating condition and/or in sufficient quantity to ensure that proper field analysis procedures may be followed.

- Calibrated PID/FID instrument
- Top-sealing "Zip-Loc" type plastic bags – *or* – 16 ounces of soil or "mason-" type glass jars and aluminum foil
- Project field book and/or boring logs
- PPE as specified in the Site-Specific HASP
- Material Safety Data Sheets (MSDSs) for any chemicals or site-specific contaminants
- A copy of the Site-Specific HASP

5.0 Methods and Procedures

5.1 Preparation

Review available project information to determine the types of organic vapors that will likely be encountered to select the right instrument. The two basic types of instruments are FIDs and PIDs.

FIDs work well with organic compounds that have relatively lightweight molecules, but may have problems detecting halogenated compounds or heavier organic compounds; FIDs can detect methane for example. Since the FID uses a flame to measure organic compounds, ensure that work is conducted in an atmosphere, which is free of combustible vapors. If ambient temperatures are below 40°F, the flame of the FID may be difficult to light.

When using a PID, select an instrument that can measure the ionization potential of the anticipated contaminants of concern. PIDs work well with a range of organic compounds and can detect some halogenated hydrocarbons; PIDs cannot detect methane. The correct ultraviolet (UV) light bulb must be selected according to the types of organic vapors that will likely be encountered. The energy of the UV light must equal or exceed the ionization potential of the organic molecules that the PID will measure. The NIOSH *Pocket Guide to Chemical Hazards* is one source for determining ionization potentials for different chemicals. Bulbs available for PIDs include 9.4 eV, 10.6 (or 10.2) eV, and 11.7 eV bulbs. The 10.6 eV bulb is most commonly used as it detects a fairly large range of organic molecules and does not burn out as easily as the 11.7 eV bulb. The 9.4 eV bulb is the most rugged, but detects only a limited range of compounds. Under very humid or very cold ambient conditions, the window covering the UV light may fog up, causing inaccurate readings. Ask your EHS coordinator about correction factors when high humidity conditions exist.

After selecting the correct instrument, calibrate the PID/FID according to the manufacturer's instructions. Record background/ambient levels of organic vapors measured on the PID/FID after calibration and make sure to subtract the background concentration (if any) from your readings. Check the PID/FID readings against the calibration standard every 20 readings or at any time when readings are suspected to be inaccurate, and recalibrate, if necessary. Be aware that, after measuring highly contaminated soil samples, the PID/FID may give artificially high readings for a time.

5.2 Top-Sealing Plastic Bag

Place a quantity of soil in a top-sealing plastic bag and seal the bag immediately. The volume of soil to be used should be determined by the project manager or field task manager. The volume of soil may vary between projects but should be consistent for all samples collected for one project. Ideally, the bag should be at least 1/10th-filled with soil and no more than half-filled with soil. Once the bag is sealed, shake the bag to distribute the soil evenly. If the soil is hard or clumpy, use your fingers to gently work the soil (through the bag) to break up the clumps. Do not use a sampling instrument or a rock hammer since this may create small holes in the plastic bag and allow organic vapors to escape. Alternatively, the sample may be broken up before it is placed in the bag. Use a permanent marker to record the following information on the outside of the bag:

- Site identification information (i.e., borehole number)
- Depth interval
- Time the sample was collected
- For example: "SS-12, 2-4 ft, @1425"

Headspace should be allowed to develop before organic vapors are measured with a PID/FID. The amount of time required for sufficient headspace development will be determined by the project-specific sampling plan and the ambient temperature. Equilibration time should be the same for all samples to allow an accurate comparison of organic vapor levels between samples. However, adjustments to equilibration times may be necessary when there are large variations in ambient temperature from day to day. When ambient temperatures are below 32°F, headspace development should be within a heated building or vehicle. When heating samples, be sure there is adequate ventilation to prevent the build-up or organic vapors above action levels.

Following headspace development, open a small opening in the seal of the plastic bag. Insert the probe of a PID/FID and seal the bag back up around the probe as tightly as possible. Alternatively, the probe can be inserted through the bag to avoid loss of volatiles. Since PIDs and FIDs are sensitive to moisture, avoid touching the probe to the soil or any condensation that has accumulated inside of the bag. Since the PID/FID consumes organic vapors, gently agitate the soil sample during the reading to release fresh organic vapors from the sample. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted. Record the highest reading on the field form or in the field notebook as described in Section 7.

5.3 Jar and Aluminum Foil (Alternate Method)

Half-fill a clean glass jar with the soil sample to be screened. Quickly cover the jar's opening with one to two sheets of clean aluminum foil and apply the screw cap to tightly seal the jar. Allow headspace development for at least ten minutes. Vigorously shake the jar for 15 seconds, both at the beginning and at the end of the headspace development period. Where ambient temperatures are below 32°F (0°C), headspace development should be within a heated area. When heating samples be sure there is adequate ventilation to prevent the build-up of organic vapors above action levels.

Subsequent to headspace development, remove the jar lid and expose the foil seal. Quickly puncture the foil seal with the instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates. As an alternative, use a syringe to withdraw a headspace sample, and then inject the sample into the instrument probe or septum-fitted inlet. This method is acceptable contingent upon verification of methodology accuracy using a test gas standard. Following probe insertion through the foil seal or sample injection to probe, record the highest meter response on the field form or in the field notebook. Using foil seal/probe insertion method, maximum response should occur between two and five seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case, headspace data should be discounted.

6.0 Quality Assurance/Quality Control

Quality Assurance/Quality Control (QA/QC) will include the collection of duplicate samples. In general, one duplicate will be collected per 20 samples. Organic vapor concentrations measured in the primary and duplicate samples should be similar within plus or minus 20 percent. The frequency of headspace duplicate collection will be determined by the project manager/task manager. The PID/FID instrument must be calibrated according to the manufacturer's instructions before beginning screening, and checked or recalibrated every 20 analyses or when readings are suspected to be inaccurate. Record ambient organic vapor levels in the field notebook and on the field form. Periodically check ambient organic vapor levels. If ambient levels have changed more than 20 percent, recalibrate the PID/FID. Make sure readings are not collected near a vehicle exhaust or downwind of the drill rig exhaust. If grossly contaminated soil is encountered, decontaminate sampling instruments between samples and/or change contaminated gloves to avoid cross contaminating less contaminated samples.

7.0 Documentation

All data generated (results and duplicate comparisons) will be recorded in the field notebook and/or on the field form. Any deviation from the outlined procedure will also be noted. Field conditions (ambient temperature, wind, etc.) should also be recorded in the field notebook.

Readings may be recorded in a field notebook, on a boring log, or on an appropriate form specific to the project. The form should include the following information:

- When the PID/FID was calibrated (date/time) and calibration standard used
- Background/ambient concentrations measured after PID/FID calibration
- Location of sample (i.e., bore-hole number)
- Depth interval of sample measured
- Lithology of material measured
- PID/FID reading and units of measure

Note that if PID/FID measurements are recorded on a boring log, it is not necessary to duplicate information in the column where the PID/FID readings are recorded (e.g., borehole number, depth interval, lithology type).

All documentation will be stored in the project files and retained following completion of the project.

Tar-specific Green Optical Screening Tool (TarGOST®)

The Tar-specific Green Optical Screening Tool (TarGOST®) is a laser-induced fluorescence (LIF) screening tool that is specifically designed to detect non-aqueous phase liquid (NAPL) in the subsurface. It responds almost exclusively to the NAPL found at former manufactured gas plants (MGPs) and creosote/pentachlorophenol sites. It does this by sensing the fluorescence of polycyclic aromatic hydrocarbons (PAHs) found in MGP and creosote NAPLs. TarGOST is a modification of the Ultra-Violet Optical Screening Tool (UVOST®). Dakota developed the UVOST early in the 1990's with U.S. Air Force funding. The UVOST platform is a mature technology that has been applied at hundreds of petroleum, oil, and lubricant (POL) contaminated sites in the U.S., Europe, and Japan since 1994. TarGOST has been in commercial use since March 2003.

Standard Operating Procedure

Power Up/Down

To power up the TARGOST, simply switch the power on using the power switch on the front of TARGOST's e-deck. All peripheral devices are powered through the cabling – minimizing tangles and trip hazards. The laser takes several minutes of warm-up. If powering up from cold conditions (overnight, etc.), make sure you have laser running at least 10-15 minutes prior to attempting your first Reference Emitter (RE) calibration. We recommend running heaters overnight if in sub-freezing conditions to minimize warm-up times in the morning. Extremely high or low temperatures negatively affect laser power. If used in extreme conditions one should attempt to house/store the TARGOST system in a warmer/cooler environment to assure proper operation. There are no hard/fast rules for this – since case temperatures/heaters can assist but a lot depends on winds, ventilation, direct sun, etc.

To power down the TARGOST, switch off the power button.

Boot PC and Check Software Function

Make sure all drivers are loaded and ready. Start the OST system software. Indicators in the software will assist in alerting you to problem connections and general status of the components (Hardware Tab). See software manual for specifics on OST software.

Proper System Function

Once the software is started and functional you can proceed to check the depth encoding and associated peripheral functions. Actuating the probe (or hand advancing the string pot) should show Current Depth changing on the OST software (Depth tab). The Remote Display should be functional and show status. Activate Info tab and make sure your job information is updated for storage with each LIF log.

SPOC Setup

A detailed discussion is available under **SPOC Assembly** section. Carefully examine mirror and window for ANY trace grease, lint, and moisture. They must be very clean. Assure that all o-rings, seals, and adapters are in correct order – including Teflon tape, and associated hardware. With SPOC tip left off of SPOC, dry the air inside the SPOC, and quickly screw in window. You can check for moisture condensing inside window using an ice cube. If there is condensation you must dry the SPOC air better. Slightly tighten the mirror and fiber optic Swagelok seals (just snug). Adjust fiber terminator up/down to achieve proper distance from mirror to collimate the laser beam (use white paper – you may have to "up" energy for this).

Place RE in front of window and adjust laser energy (Fiber I/O block screw) to achieve approximately ¾ scale with oscilloscope's CH2 on 20 mV/div. Adjust the mirror (using window pick/hook) to image only the sapphire window – not epoxy or SPOC barrel (no clipping – full circle image on paper). This occurs approximately 1/3 of the way down from top of window.

Clean/polish window and then make sure that background does not exceed ~2.5mV peak signals. If background is high, carefully inspect for imaging of sides/epoxy or contamination (lint, cotton fibers, fuel, moisture, grease, etc.) An unacceptably high background can make interpretation extremely difficult.

Once you're certain the mirror/fiber/window system is achieving proper results you can tighten the Swageloks securely. Use ONLY the supplied wrenches to hold the SPOC securely during tightening. This is most readily assured by laying SPOC down and only handling wrenches. Use the mirror pick/hook to hold the mirror firmly in place during tightening to prevent rotation. Make sure laser beam stays in centered in the window (side to side) and 1/3 down from the top (toward first rod).

With window/mirror/fiber terminator all secured, proceed with attaching drive tip, adapter, extension rod, and tighten extremely well with 2 pipe wrenches or pipe wrench and vice. Teflon tape helps reduce loosening from rattling/vibration.

Background

Wipe window clean and acquire a Background (blank) waveform with the Acq BckG command. A perfect system would yield no waveform in the last 3 channels– only white noise. The first channel (scatter channel) should not exceed full screen on the 2mV/division scale on the oscilloscope while in clean soil. Try to achieve <2mV peak signal in the last 3 channels. You simply want it as small as you can get it. A background waveform that looks like your current contaminant of interest suggests leakage and contamination of the internal SPOC mirror/window OR simply a dirty window. Clean with methanol or solvent if soap/water doesn't work.

RE Calibration

Calibration should be done just before each TARGOST logging event. Note: do NOT calibrate with RE, then spend time messing around with push rig, etc; wait until the direct push rig is ready to go before doing the calibration. Pre-push with dummy tip if obstructions are likely or getting a "straight hole going" is difficult. Place RE on window (making sure window is very clean). Immediately acquire RE with Acq RE command. Extended exposure to laser light can form excimers and photodegradation – causing a morph in waveform shape/intensity. If you have changed fiber optic lengths the software may correct the delay time to achieve proper position in window. Make sure the RE signal level exceeds a 3,000 pVs minimum but does not exceed 12,000 pVs with 6,000-9,000 pVs about optimum. Try to be consistent (± 500 pVs) – especially when on the same project/site. Make sure the RE waveform shape "looks right". Extremely noisy/jagged REs, misshapen REs, and missing/low channel contributions indicate damaged or loose fiber optics/filters/detector. Attain an 8:1 (+/- 1) ratio of fluorescence to scatter.

Logging

Follow these steps to acquire a TARGOST log:

Step 1. With proper RE and background acquired, pertinent log information recorded, and probe in position (window just below (~1 inch) ground surface), activate the Record command.

Step 2. If you failed to acquire a recent RE the OST software will alert you that it's not recent (at least one log event old). Proceed with you recent (perhaps you just aborted a "false start"/crooked log) – or cancel out and acquire the RE you forgot to acquire. You can "rescue" an RE if it's for a rational purpose (such as an accidentally aborted log and you want to continue logging and probe is under ground, under water during a barge project, etc.) DO NOT purposefully continue logging without a new RE for each and every log if you're having problems acquiring a new RE due to a problem. FIX the problem, acquire a good RE, and then proceed. Failure to acquire a new RE for each log will generate inaccurate data.

Step 3. Choose a directory and name for your log. TARGOST auto-suggests the name sequentially in an attempt to reduce typing. In order to absolutely avoid accidental overwrite of any OST file, the OST software creates a unique time/date name and uses that name in place of overwrites (even though you said "OK" to the overwrite. If you want to risk it, you can always delete a file from the Save File dialog after you click on it once, but before hitting OK. That prevents the Windows software from reporting an overwrite to the OST and cueing the unique filename routine. The safest method is to choose OK to overwrite – and rename files later.

Step 4. Once the name is chosen you are asked to choose whether or not to "zero" the depth. For normal logs you always choose Yes and zero out depth. If you're continuing an aborted log that you want to continue (accidental termination) – choose No. Log should continue at depth where you left off.

Step 5. As the log progresses, it is your responsibility to make sure the system is operating properly. Observe the oscilloscope or OST display to watch for unusual events such as:

A. Try to keep the probe advancing at approximately 0.75 inch/sec – your company may choose less – but we do not recommend faster

B. Strange background drifts several feet under (possible fogging), etc.

C. Broken depth cable or poor connection will result in jumps in depth or a loss of depth increase – even though the operator is advancing the probe

D. Incorrect depths would indicate a possible rod length or string pot cal factor mismatch

E. Sudden loss of waveform (flatline) indicates possible fiber optic break due to broken probe

F. Depth is advancing – but no new waveform updates aren't showing up – this indicates poor triggering – is Trig'd showing up on oscilloscope every second or so? If not – hit Trigger 50% button on scope or look for other cause such as Stop button on laser being accidentally pushed.

Step 6. Once refusal is reached – or target depth is reached – activate the End command. All pertinent data is stored and the oscilloscope scale is automatically returned to the default 20mV/div scale in preparation for next RE.

Step 7. Inspect the probe, window, etc. for leaks, breaks, and loose parts in preparation for next the next logging event (push).

Printing/Exporting LIF Logs

Once the push is complete the log can be viewed (a log can be also opened from file and viewed with the OST software) it is necessary to print the log to paper or export it to an electronic image (JPG file). Prior to print/export it is most often desirable to select callout waveforms. Select single waveforms by clicking the log at any depth – which creates a stats bar. Transfer single logs by dragging/dropping the stats bar or with the < bar next to each callout box. Select the average of a region of waveforms along a log by clicking the log, holding down, and then releasing at a second depth along the log. Transfer average zone waveforms by dragging/dropping the bottom stats bar or with the < bar next to each callout box. Reasons to select certain depths/regions include:

- Bracketing what appear to be continually affected zones - this helps the client/consultant "summarize" the general NAPL zones and easily jot down depths for future validation sampling, project design, discussion with site owner, etc.
- It's best to bracket large zones of homogenous NAPL - do not span different products
- Highlighting unusual signatures – perhaps to suggest sampling there or to "flag" things the client needs to investigate or discount
- Maybe a background here/there to remind viewer what "clean" looks like
- Any potential "false positives" such as mineral/plant/urban background/highly degraded NAPL – the different waveform should help client understand that "it's nothing to worry about"
- Use caution when highlighting single waveforms from the rising edge of NAPL hits – the waveforms in these area are usually saturated because the oscilloscope scaling wasn't able to fully respond – they are morphed and ugly and cause unnecessary confusion and alarm
- You do not have to start with top and work down – pick a callout "straight across" for neater appearance
- Avoid "crossing" of the depths of multiple callouts as this looks messy/confusing

It is best that the TARGOST operator and the client discuss depth/RE scales, depths of interest, etc. ahead of time to hopefully avoid lots of "reprints".

It is suggested that you annotate the callouts (text box under each waveform) in order to guide the client. If it's the usual product you expect then leave it blank – but if it's unusual, significant, or out of the ordinary, guide the viewer with a brief description.

Each time you print/export the settings are saved in a lif.plt (plot) file. That way the same callouts and depths are available later. The OST software (and we) suggests that the very first print/export a log in the filed you save it as field. That way you always know what the client received originally. Subsequent print schemes are saved as well. Later, upon opening, you can choose which of the various schemes to open the file with.

SPOC Assembly

Figure 1. Parts and tools for SPOC assembly

Figure 2 shows all the parts necessary to properly assemble a SPOC. Prior to assembling the SPOC make sure you have the fibers properly threaded through all your rods - and your adapter and lead rod are in place! If necessary you can sometimes thread fibers through with SMA ends leading.

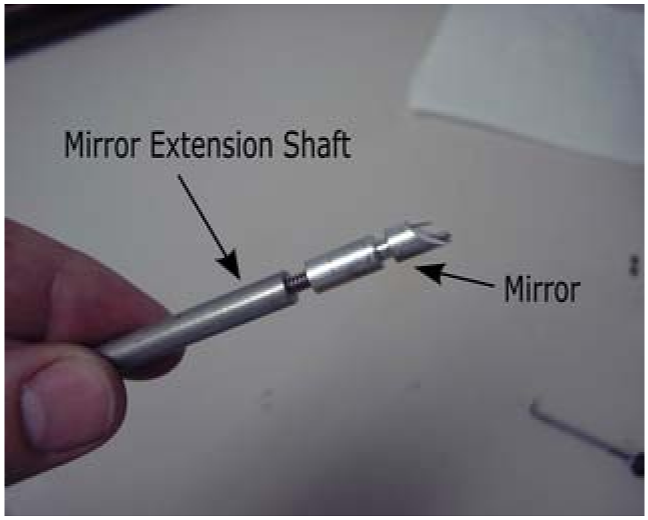


Figure 2. Attaching mirror to mirror extension shaft

First, securely fashion the mirror to the mirror extension shaft **without touching the mirror surface**. Tighten securely with pliers. Do not gouge/scar shafts too badly.

Figure 3. O-ring placement on mirror

Lubricate o-ring very sparingly with supplied silicone vacuum grease. The idea is to fill any micro-voids. Just a light coating – do not leave any 'gobs' or visual amounts other than sheen/glistening appearance. Slide o-ring into groove on mirror FROM THE BACK of the extension shaft so as not to grease up mirror. If the mirror is contaminated with dust, lint, or debris; clean it by blowing canned air (ALWAYS hold can upright – liquid refrigerant will haze/ruin the mirror!) at the mirror at a glancing angle. The mirror surface is delicate – once damaged it is permanent. If necessary, extremely gentle scrubbing with cotton swab and dilute Alconox soap/water followed by copious water rinse and blow dry is recommended. Methanol is also useful for final rinse or to dissolve non-water-soluble stains.

Figure 4. Swagelok nut and nylon ferrule (Note: ferrule is misspelled in photo)

Figure 5. Properly constructed SPOC mirror assembly

The ferrules and Swagelok fittings are attached to each SPOC when delivered. Remove them, slide them onto mirror shaft, and then insert mirror into the TOP end as shown in Figure 2 (the end that the window hole is closest to). If you forget proper orientation of the ferrules, look at how they are arranged on the plastic spare ferrule shaft in the spares kit.

At this point you just want to temporarily arrange the mirrored surface to be in center of window hole and basically aligned with the window – centered side-to-side and tip-top of mirror just a tad down from the uphole edge of the brass hole (opposite end that mirror is inserted into) as shown in figures 14 and 15. Tighten lightly with the wrenches. CAUTION: THE BRASS "GUTS" OF THE SPOC CAN TURN LOOSE OF THE EXTERIOR PIPE – RUINING THE SHOCK ABSORBING RUBBER SEAL OF THE SPOC. To prevent this, **never ever** hold the outer pipe of the SPOC when you tighten or loosen the Swage fittings. The wrenches are designed to allow you to tighten or loosen the Swage with shorter (6pt) wrench while holding the Swage that is permanently attached to SPOC with the longer (12 pt) wrench. See photo below. One must always use the provided wrenches to isolate the outer SPOC from any torque that you are applying to the Swage fittings. This is most easily assured by laying the SPOC down (allowing it to freely rotate) and tightening or loosening while holding ONLY the two wrenches. Do not tighten the Swage too much on the mirror at this point – just enough to hold the mirror at center of hole and aligned to send light out the center of the brass hole. Keep in mind you will need to rotate the Swage nut to align with the "Bottom" (inner) Swage fitting's nut - so that the inner wrench can be removed. There are actually two distinct orientations of the Swage nut at which the inner wrench can slip past – since it is a 12 point wrench.

Figure 6. Proper wrench technique

This photo shows technician LIGHTLY holding onto the SPOC and preparing to tighten the mirror by turning the top wrench – technician must NOT hold SPOC firmly once he starts applying torque to the either wrench.

Figure 7. Holding the mirror shaft with pick to rotate (or hold) mirror.

When tightening mirror it will want to rotate. Use the 90 degree pick tool to hold the mirror and prevent it from rotating. This is especially important when making final tightening later in the process.

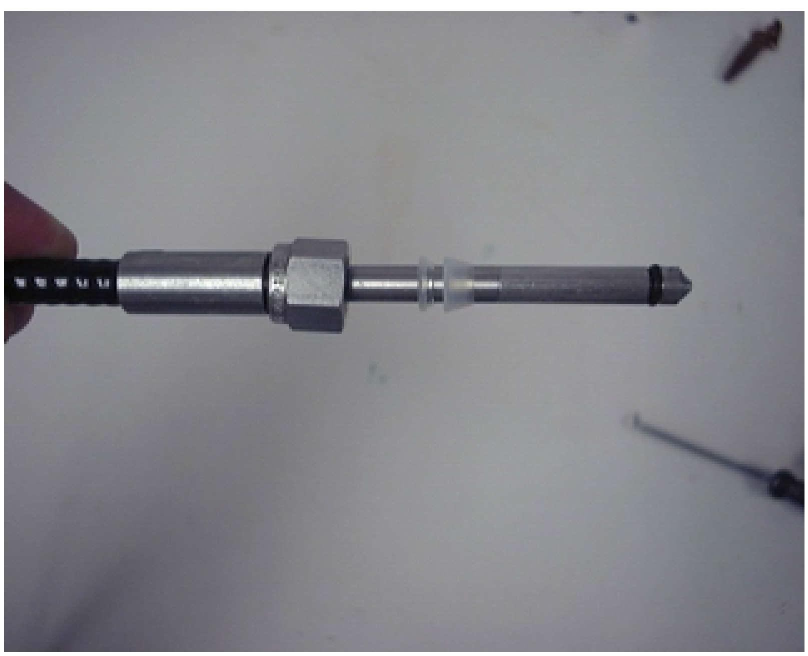


Figure 8. Properly assembled fiber terminator

With mirror temporarily in position, remove Swage from other end of SPOC and install onto the fiber terminator. If no o-ring is on fibers or if it shows damage VERY CAREFULLY slide a new o-ring (vacuum grease conditioned) over the fiber tip and into the groove. Be careful not to get o-ring grease or any other contamination on fiber faces. Make sure there is no lint/debris on any tip surface. Insert the fiber terminator all the way in as far as reasonable force allows. This gets close to optimal position (but a little too far – we'll adjust that later).

Figure 9. Window SPOC seal inserted

Turn the laser off temporarily to avoid eye contact. Now place the SPOC seal (a short section of inverted silicone tubing) into the hole and align with brass nipple inside (Figure 10). Essentially, once we screw in a window, this tubing seals the dust/moisture out of the small section of the assembly between the window and the mirror.

Figure 10. Inspect and prepare window

Make sure that the window, mirror, and internal cavity are free from dirt, moisture, lint, etc. Examine window **VERY** carefully. Any fluorescent contamination will create unacceptably high background. With tubing stuck down into hole, condition an o-ring and install onto a window assembly. Prior to screwing the window in, displace any moisture from large interior portion of the SPOC by "snaking" the tube of a can of inert gas (electronics/dusting "canned air") past the tube seal (on the outside) and spraying into the SPOC's main chamber for 5-10 seconds. Carefully remove spray can tip from having been snaked into the SPOC past the outside of the tube seal. Now, while lightly and continuously spraying canned air into the mirror/window hole (NEVER ALLOW COLD LIQUID REFRIGERANT FROM CAN TO TOUCH MIRROR - ALWAYS HOLD CAN UPRIGHT) insert the window and tighten with window tool. Make sure the pins line up and you do not slip – marring the holes and/or bending window tool pins. Make sure the tubing that you inserted earlier is going around the outside of the lower window "nipple" and did not fold in - causing it to be crushed between window nipple and brass nipple. It should form a seal around outside of both window and brass nipple when window is tightened. Tighten window very securely – perhaps even tapping the top of window tool lightly while torquing to gently "hammer drive" the window into a secure fit (prevent loosening during hammering).

Figure 11. Carefully engage window with window tool

Figure 12. Fully seat tool's pins into window's holes

Now comes the technically important part. We must securely tighten the mirror and fibers into place to hold them during violent hammering and seal the parts from water/mud/fuel entry. The mirror has to be adjusted to be at the optimum position described in figures 14 and 15. Turn the laser back on. With mirror rotation centering the beam side-to-side, make sure that the laser beam is not being clipped by brass tube (too close to tip-end of SPOC) and yet is not imaging the epoxy of the mirror (even upon reflection from outer surface of the sapphire window). Use the clear window-alignment business card as your general guide. Push/pull the mirror (possibly rotating to get it to move) to get it just right. Use clear guide and align beam with smaller circle. Tighten mirror securely holding mirror in proper position with 90 degree pick.

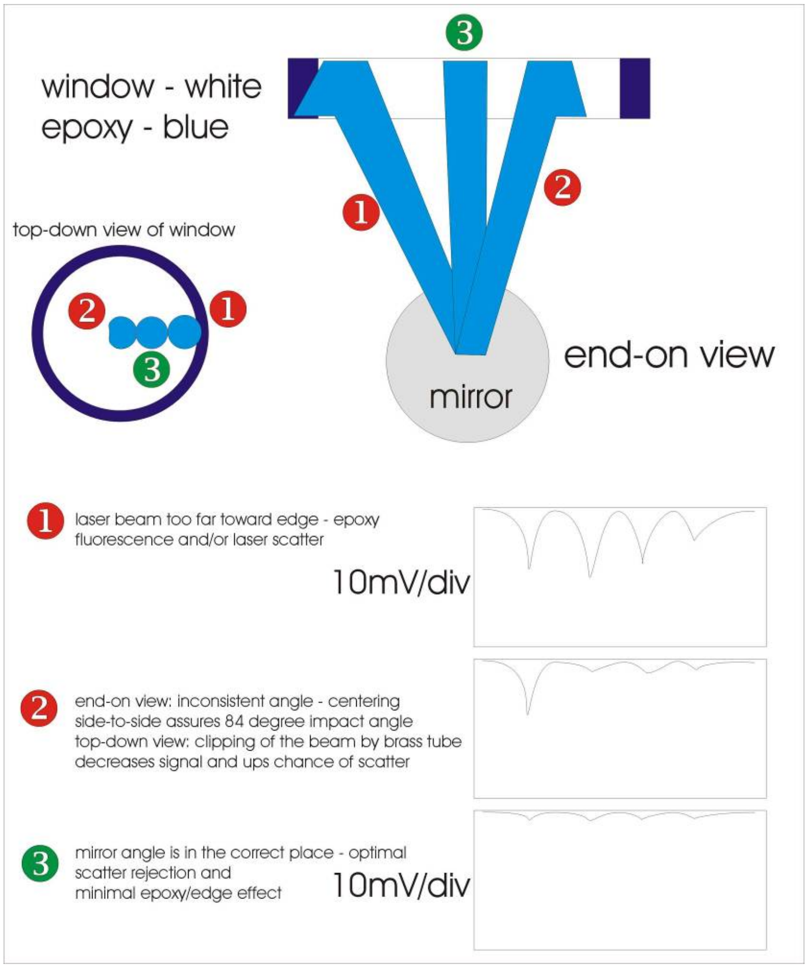


Figure 13. Optimal mirror position – view 1

The mirror is now in correct position and secure – but beam is likely poorly collimated. With laser lasing and enough laser light being emitted to see readily on a fluorescent yellow card (or similarly fluorescing material) adjust the fiber terminator in/out until you get as collimated a beam as possible being reflected out the window. Accomplish this by achieving the roundest/cleanest round laser image on visualization card held approximately 2 feet from SPOC while moving fiber terminator back and forth. Now tighten the Swage fitting on the fiber terminator securely. Check for final proper mirror alignment with clear alignment card.

Check the SPOC for moisture with an ice cube – look for condensation. It's OK if you observe a tiny amount – but this is very cold compared to ground. If ice cube test shows lots of fogging you'll need to remove window, re-purge interior of SPOC chamber, then flush optics portion while screwing window back in. Need for repeated drying and chronic fogging means a likely leak in SPOC seals, o-rings, etc. or the annulus surrounding internal assembly has drops of water in it.

If you ever "flood" a SPOC due to window shatter, it's best to replace with a clean, dry SPOC. Thoroughly clean/dry the flooded SPOC with soapy water, copious rinsing, and long term dry in hot oven, sunny vehicle dash, motel room heater, etc. It's best not to let the SPOC, especially the mirror and cavity, dry with dirty water or fuel in the SPOC. These dry stains/deposits are very difficult if not impossible to remove. The reflectivity if the mirror will be reduced and the background will likely be too high. Also, any dried "mud" inside the SPOC cavity can later be made into a fine dust due to percussion hammering. That dust coats the fiber faces, mirror, and window, negatively affecting the spectroscopy.

Now place the Reference Emitter (RE) on the window and adjust energy (adjustment on front panel of rack) to achieve 3/4 scale response at 20mV/div. The reason for this is to get "in the ballpark" with the laser energy.

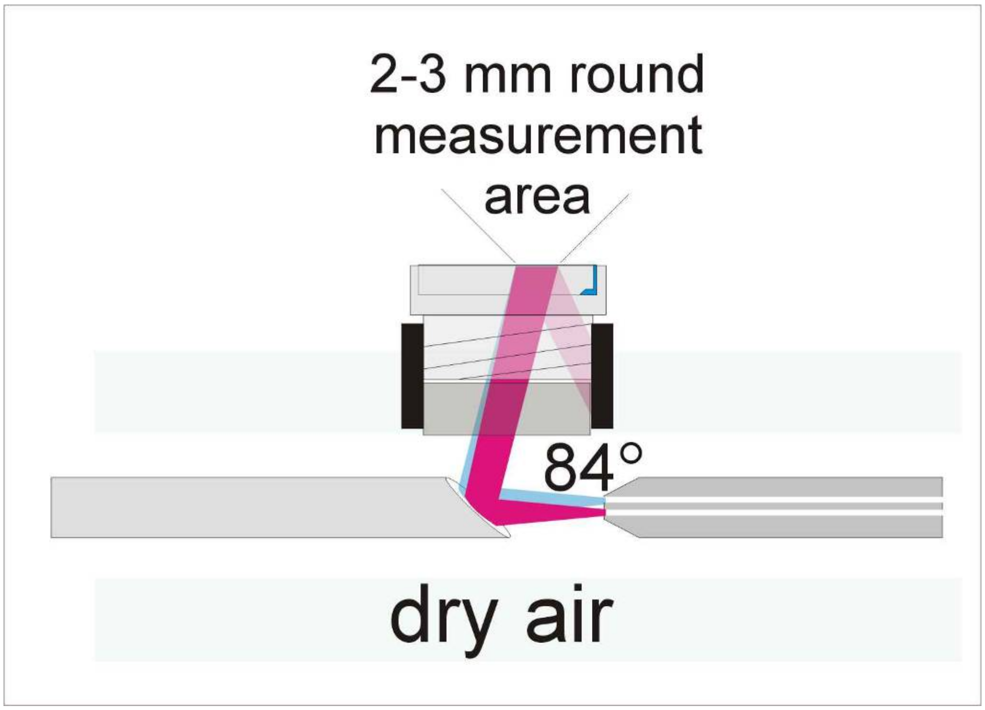


Figure 14. Optimal mirror placement – view 2

Finally – clean the window thoroughly. Place RE on window, then acquire a RE waveform. Remove RE from window, clean window again. Acquire a Background with OST, observing the background waveform on oscilloscope. The blank/background should be < 5mV maximum peak voltage (<200 pVs or <.5% RE). This may not always be possible – even the mirrors and windows vary in fluorescence – but NEVER exceed 10mV peaks (400 pVs or 1.0%RE) - that's getting really bad. If it exceeds the recommended background you MUST CORRECT prior to logging! High backgrounds are especially vexing when the background waveform looks like contaminant.

Please note that direct daylight or bright sunlight will cause "photon noise" due to constant bombardment of the PMT with photons that have nothing to do with the laser excitation. Shield/darken the window area if necessary. However, be aware that the mirror can collect fluorescence from items several feet from the window – so your shielding method (cloth, etc.) needs to be non-fluorescent for a representative Background reading! When bright daylight or similar conditions allow “CW” photons to elevate/overwhelm the baseline, Dakota recommends the use of Liquitex® Value Series Acrylic Color Mars Black or similar flat black water-soluble paint that contains no fluorescent dyes. Flat black water soluble paint acts as perfect “black soil” – allowing only that light generated internally by the entire system to make it back to the detector.

With experience, you may want to test window/mirror cleanliness using RE and background technique before going through entire assembly. These assembly instructions assume a clean fiber terminator, window, and mirror. Discovering a piece of lint, fuel, or other contaminant after assembly is frustrating and unnecessary. Again – always RESIST the temptation to hold the outer SPOC during torque procedures – use the wrenches to hold against torque!