CB&I Federal Services LLC

Final
September 2014

Addendum to the Baseline Human Health and Screening Level Ecological Risk Assessment Work Plans for Waste Water Treatment Plant No. 2, TNT Area C to Waste Water Treatment Plant No. 2 Sewer Lines, and Waste Water Treatment Plant No. 2 Steel Sewer Line

Baseline Ecological Risk Assessment Letter Work Plan for Waste Water Treatment Plant No. 2
FUDS Project No. G05OH001818

Former Plum Brook Ordnance Works
Sandusky, Ohio

200-1e

G05OH001818_03.11_0501_a

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September 05, 2014

U.S. Army Engineer District, Nashville
ATTN: CELRN-EC-E (Ms. Paula Coleman)
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Nashville, Tennessee 37203

Subject: ***Submittal of the Final Addendum to the Baseline Human Health and Screening Level Ecological Risk Assessment Work Plans for Waste Water Treatment Plant No. 2, TNT Area C to Waste Water Treatment Plant No. 2 Sewer Lines, and Waste Water Treatment Plant No. 2 Steel Sewer Line, Baseline Ecological Risk Assessment Letter Work Plan for Waste Water Treatment Plant No. 2 Former Plum Brook Ordnance Works, Sandusky, Ohio Contract No. W912QR-08-D-0013: CB&I Project Number 140606***

Dear Ms. Coleman:

In accordance with the requirements of Task Order No. DX19 of Contract No. W912QR-08-D-0013 awarded to CB&I Federal Services, we are pleased to submit the Final Letter Work Plan for the Baseline Ecological Risk Assessment at the Waste Water Treatment Plant No. 2 (WWTP2) site at the Former Plum Brook Ordnance Works (PBOW) located in Sandusky, Ohio. This letter work plan is an Addendum to the Baseline Human Health and Screening Level Ecological work plans for WWTP2 (DERP-FUDS Project No. G05OH001818). This work plan was prepared consistent with U.S. Environmental Protection Agency and Ohio Environmental Protection Agency guidance.

Enclosed for your review are four copies of this report. Copies have also been sent to those on the distribution list as indicated for their review.

Should you have any questions or require additional information regarding this submittal, please do not hesitate to contact me at (865) 694-7496.

Sincerely,

Steven. T. Downey, PE, PMP
Project Manager

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Shaw Environmental & Infrastructure, Inc.

Client Name: U.S. Army Engineer District, Nashville; CELRN-EC-E

Project Description: Addendum to the Baseline Human Health and Screening Level Ecological Risk Assessment Work Plans for Waste Water Treatment Plant No. 2, TNT Area C to Waste Water Treatment Plant No. 2 Sewer Lines, and Waste Water Treatment No. 2 Steel Sewer Line, Baseline Ecological Risk Assessment Letter Work Plan for Waste Water Treatment Plant No. 2
Former Plum Brook Ordnance Works, Sandusky, Ohio

Contract No. W912QR-08-D-0013 Delivery Order No. DX19

Project No. 140606 Task/Phase Number: 19000000

Document Type		Identify specific section or segment covered by this checkprint	Document Origin
☐	Technical / Cost Proposal		X Originator Developed
☐	RFP		☐ Edited Standard
☐	Contract / Subcontract		☐ Client Furnished
X	Work Plans	BERA Work Plan	
☐	Report		**Document Status**
☐	Risk Assessment / Evaluation		☐ Preliminary
☐	Specifications & Plans		☐ Internal Draft
☐	Design Calculations		☐ Draft
☐	Tables		☐ Draft Final
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FINAL

Addendum to the Baseline Human Health and Screening-Level Ecological Risk Assessment Work Plans for Waste Water Treatment Plant No. 2, TNT Area C to Waste Water Treatment Plant No. 2 Sewer Lines, and Waste Water Treatment Plant No. 2 Steel Sewer Line, Baseline Ecological Risk Assessment Letter Work Plan for Waste Water Treatment Plant No. 2 Former Plum Brook Ordnance Works, Sandusky, Ohio

1.0 Introduction

The U.S. Army is conducting studies of the environmental impact of suspected hazardous waste sites at the former Plum Brook Ordnance Works (PBOW), which is being investigated under the Defense Environmental Restoration Program for Formerly Used Defense Sites. The investigation is being managed and technically overseen by the Nashville District of the U.S. Army Corps of Engineers. This 9,000-acre facility was used for the manufacture of explosives during World War II. The site is currently controlled and maintained by the National Aeronautics and Space Administration and operated as the Plum Brook Station of the John Glenn Research Center at Lewis Field.

This letter work plan for additional investigation at Waste Water Treatment Plant No. 2 (WWTP2) is an addendum to the baseline human health risk assessment (BHHRA) and screening-level ecological risk assessment (SLERA) work plans (Shaw Environmental, Inc. [Shaw], 2013a,b) and also describes sampling collection activities supplemental to the *Site-Specific Sampling and Analysis Plan, Remedial Investigation, Waste Water Treatment Plant #2 Area, TNTC Waste Water Sewer Line, and Waste Water Treatment Plants Steel Sewer Line* (Shaw, 2011). The Site-Specific Sampling and Analysis Plan and this addendum work plan were developed in accordance with the PBOW Sitewide Sampling and Analysis Plan and the Quality Assurance Project Plan (Shaw, 2008a) to ensure that work performed at the subject site will be of the quality required to satisfy the overall and site-specific project objectives. A sitewide accident prevention/sitewide safety and health plan (Shaw, 2008b) was also prepared for this investigation to help provide a safe work environment. An updated site-specific safety and health plan along with a radiation protection plan have also been developed for this supplemental investigation at WWTP2 and will be submitted under separate cover.

1.1 Objectives

There are two objectives of the supplemental fieldwork to be performed at WWTP2. The first objective is to perform a baseline ecological risk assessment (BERA) that will address uncertainties and refine the ecological risk estimates described in the SLERA. The second

objective is to improve delineation of lead in soil at WWTP2 for remediation purposes. These will be discussed in Chapters 2.0 and 3.0, respectively.

1.2 Site Background Information

Remedial investigation activities, including the Site Characterization Report (Shaw, 2014a), the BHHRA (Shaw, 2014b), and the SLERA (Shaw, 2014c) have been completed for the site and have undergone internal Army review. For brevity, only information germane to the activities proposed in this addendum work plan is included in the following discussion.

The SLERA performed at WWTP2 identified lead as a chemical of potential ecological concern (COPEC) that requires additional evaluation. The background screening concentration of lead in soil at PBOW has been established at 48.6 milligrams per kilogram (mg/kg); concentrations detected in soil at WWTP2 ranged from 6.6 to 18,100 mg/kg, with a mean of 907 mg/kg. The exposure point concentrations (EPC) used in the SLERA as conservative estimates of the concentration that receptors would be exposed to (typically based on a 95 percent upper confidence limit of the mean) were 15,262 and 3,947 mg/kg for surface and total soil, respectively. (Surface soil includes soil 0 to 0.5 feet below ground surface [bgs] and total soil includes soil 0 to 6 feet bgs; surface soil was used as the medium of exposure for nonburrowing receptors in the SLERA, and total soil was used as the medium of exposure for burrowing receptors.) Estimated exposure to elevated concentrations of lead resulted in ecological hazard quotients (EHQ) that exceeded 10 for multiple wildlife receptors using both the no-observed-adverse-effect level (NOAEL) and the less conservative lowest-observable-adverse-effect level (LOAEL) toxicity reference values (TRV) as estimated using a food chain model (Shaw, 2014c).

Lead was also identified as a chemical of concern in the baseline BHHRA based on elevated risk to humans (Shaw, 2014b). Although a remedial goal (RG) has not been formally proposed for lead, a human health-based value of 400 mg/kg would be a likely candidate RG for adoption; lead at this concentration in soil is protective of the target blood lead concentration in children of 10 micrograms of lead per deciliter of blood. This soil lead concentration of 400 mg/kg is also a human health screening level used in the BHHRA and was discussed in the BHHRA as a target concentration to replace elevated lead detections at WWTP2 that would result in unrestricted use of the site.

1.3 Need for Additional Data Collection at WWTP2

The use of 400 mg/kg as a potential RG for lead in soil at WWTP2 may not be protective of environmental receptors. If an EPC of 400 mg/kg of lead in soil is used in the SLERA food chain model, EHQs for representative receptors still exceed the target value of 1 by a considerable margin. For example, 400 mg/kg of lead in soil resulted in EHQs of 28 and 2.8, based on a

NOAEL and LOAEL TRV, respectively, for the marsh wren, which represents insectivorous birds at the WWTP2 site and was identified in the SLERA as the most sensitive receptor to lead in soil. This suggests that the residual concentrations of lead in soil following any potential cleanup for human health to the value of 400 mg/kg would be approximately three times the concentration that produced an observable adverse effect in laboratory toxicity tests.

Because residual ecological hazards based on a likely cleanup goal for lead are still elevated under SLERA assumptions, a BERA is proposed for refining critical exposure pathways and replacing default (i.e., conservative) information used in the SLERA with site-specific data. Also, because lead in soil results in elevated human health and ecological risk/hazard, remediation will likely be required. To perform this remediation, additional delineation of lead will likely be necessary.

2.0 WWTP2 Baseline Ecological Risk Assessment

This chapter describes the BERA approach proposed for WWTP2. The intent of the BERA is to refine some of the assumptions used in the SLERA and develop revised EHQs based on site-specific studies.

2.1 Problem Formulation

WWTP2 is a wooded site with habitat that is adequate for supporting ecological receptors. The marsh wren was used in the SLERA to represent the avian insectivore community at the site, and several bird species that rely on terrestrial invertebrates for a majority of their diet (e.g., American robin [*Turdus migratorius*], Carolina wren [*Thryothorus ludovicianus*], wood thrush [*Hyocichla mustelina*], etc.) were observed at the site during the site reconnaissance visits (Shaw, 2014c).

In ecological risk assessments, unless threatened or endangered species are present, the ecological endpoints of concern are populations rather than individuals (U.S. Environmental Protection Agency [EPA], 1997). No threatened or endangered species were identified at WWTP2 (Shaw, 2014c). Therefore, protection of wildlife populations at WWTP2 is the endpoint of concern, not protection of individuals. An area use factor approach was used in the food chain modeling performed in the SLERA to adjust wildlife exposure estimates by multiplying the COPEC dose by the fraction of the size of the site to the total home range of the receptor. Thus, if the site comprises a very small portion of the home range, the lower exposure to contaminated media within that small area compared with the larger surrounding “clean” habitat within its home range will be appropriately reduced. The home range used for the marsh wren in the SLERA was 0.13 acre, which is much smaller than the area of WWTP2 of 1.4 acres, and implies that one or more wrens (or similar species) may utilize the site.

Because the food chain model used in the SLERA essentially estimates risk to an individual assessment receptor that is using the site, some professional judgment must be exercised to determine whether potential risk at the population level is realistic. Based on a recommended approach by the Oregon Department of Environmental Quality (ODEQ), the area required to support a local population of a given receptor may be estimated using the following relationship (ODEQ, 2001):

$$\textit{Population Area [acres]} = (100 \times \textit{Home Range [acres]}) / \pi$$

Using the above equation and a home range of 0.13 acre, the estimated area required to support a marsh wren population is 4 acres. As the estimated size of the WWTP2 is 1.4 acres, the percent of the affected population area for the wren is 35 percent. Thus, 35 percent of a receptor population may potentially be affected by elevated lead in soil at WWTP2. This percentage warrants concern for insectivorous bird populations at WWTP2 because potential loss of 35 percent of the local population might not be compensated by migration from outlying regions and/or increased reproduction.

The SLERA performed on WWTP2 (Shaw, 2014c) intentionally used conservative assumptions to avoid the possibility of prematurely eliminating a chemical from further consideration. Ohio Environmental Protection Agency (OEPA) guidance (OEPA, 2008) recommends proceeding to a Level IV field BERA when the previous risk assessment steps fail to eliminate all COPECs as candidates for having potential adverse effects to assessment receptors. The BERA refines the risks to the receptors of concern (i.e., those having an EHQ value greater than 1) by using site-specific data to adjust the conservative assumptions used in the SLERA that resulted in the elevated EHQs. Two primary factors are involved in the calculation of the SLERA EHQs: the estimated exposure dose and the TRV. TRVs are based on one or more toxicity tests that carefully observe responses of the test species to multiple doses of the chemical being studied to develop a dose/response relationship. Studies to develop alternate TRVs for the receptor of concern are typically not performed in a BERA because of the cost of such studies and because little additional information may be gained from the effort (i.e., unless there is reason to believe otherwise, the results are unlikely to provide more accurate TRVs than the ones originally used in the SLERA). Rather, it is often more efficient to examine the accuracy of the assumptions used in the SLERA food chain model to estimate the intake dose for the most significant exposure pathways. Site-specific conditions that affect the actual dose experienced by the receptor in natural systems often vary greatly from the assumed conditions used in the SLERA. For example, bioavailability is assumed to be 100 percent in the SLERA; however, often chemicals such as lead are bound in nonbioavailable complexes in the soil matrix and are not readily transferred to the body burdens of prey items. Thus, the exposure in terms of the

bioavailable fraction experienced by the receptor is often much lower than the dose estimated in the SLERA food chain model.

The critical exposure pathway for concern for the marsh wren (and other receptors with EHQs greater than 1 for lead) is the bioaccumulation of lead into terrestrial invertebrates (i.e., earthworms), which are then ingested as prey items by insectivorous birds and mammals. This pathway comprises approximately 86 percent of the modeled total daily dose of lead for the marsh wren, and thus is responsible for approximately 86 percent of the total estimated hazard. The bioaccumulation factor (BAF) used in the SLERA to estimate concentrations in terrestrial invertebrate prey items was obtained from the EPA Ecological Soil Screening Level (Eco-SSL) Guidance (EPA, 2008). Eco-SSLs were developed by a multi-stakeholder workgroup for 13 contaminants (including lead) by the EPA following a thorough review of the available literature and data. Eco-SSLs are considered protective of ecological receptors that commonly come into contact with soil or ingest biota that live in soil. The Eco-SSL soil-to-soil invertebrate BAF for lead is a regression equation that calculates the concentration in prey tissue based on the concentration in soil. This regression equation was developed using empirical data from multiple studies that were performed using various soil types. However, it is unknown to what degree the soil conditions at WWTP2 are similar to those used to develop the regression model or to what degree the model overestimates (or possibly underestimates) uptake occurring at WWTP2. Therefore, to refine the soil-to-terrestrial invertebrate BAF for lead that was used in the SLERA, a BERA is proposed for the WWTP2 site to reduce the uncertainty associated with this critical pathway by developing a site-specific BAF for lead in soil to terrestrial invertebrates.

2.2 Proposed WWTP2 BERA Approach

The BERA will include Steps 3b through 8 following EPA (1997) guidance, which is also consistent with OEPA (2008) guidance:

- Step 3b: Problem Formulation (initial discussion contained in this addendum work plan)
- Step 4: Study Design and Data Quality Objectives (initial discussion contained in this addendum work plan)
- Step 5: Verification of Field Sampling Design
- Step 6. Site Investigation and Data Analysis
- Step 7: Risk Characterization
- Step 8: Risk Management.

Based on the conclusions and recommendations presented in the WWTP2 SLERA (summarized previously), the following BERA laboratory test is recommended:

- Soil: 28-day survival toxicity and uptake test, earthworm *Eisenia fetida*, following American Society for Testing and Materials (ASTM) (2012) guidelines (ASTM-E1676).

Details on how these test results will be used in the BERA are presented in Table 1.

This bioaccumulation test requires 6 liters of soil per sample. Eight soil samples will be collected from WWTP2 for performing the bioaccumulation study. The protocol for the ASTM-E1676 Standard (ASTM, 2012) will be followed for performing the earthworm bioaccumulation test. The full standard is available at the ASTM web page (http://www.astm.org/Standards/E1676.htm). Briefly, a shovel or auger will be used to collect the soil samples from areas at the site that have been cleared of vegetation. One reference sample from an unimpacted area will also be collected. Samples will be screened to remove oversize material such as rocks and then mixed to ensure homogeneity. After a sub-sample is collected and sent for laboratory testing (Eurofins Calscience, located in Garden Grove, California), the soil samples will be shipped in coolers to the laboratory that will perform the bioaccumulation study (Nautilus Environmental, located in San Diego, California). Once the soil samples have arrived at the laboratory, earthworms (*Eisenia fetida*) will be introduced into the test chambers containing the site soil samples under controlled conditions. Under the ASTM standard, multiple replicates (typically three) may be performed for each field sample. Less than 10 percent mortality in the reference sample is required for a valid test. Feeding is generally not recommended unless the soil has low total organic carbon, in which case some supplemental feeding may be appropriate. After 28 days, the earthworms will be removed from the test chambers, rinsed with test water, blotted, counted, and weighed. Depuration is usually recommended for 24 hours to eliminate gut contents. Earthworms will then be frozen in preparation for chemical analysis. Test results will be reported as the magnitude of contaminant concentration above either the Day 0 tissue baseline analysis or the Day 28 tissues from the negative control or reference soil. A comparison of the tissue concentrations to the soil concentrations will provide information about the bioavailability of lead in site soil.

Uptake rates for many chemicals, especially metals, can vary depending on the concentration of the contaminant in soil. Because of this phenomenon, the best representation of uptake may be a regression equation that adjusts uptake rates based on the concentrations present in soil rather than a single numerical value. To capture this relationship between lead concentration and uptake to invertebrates in WWTP2 soil, the BERA sample collection effort will attempt to collect soil samples from areas with a broad range of lead concentrations. Remedial investigation sample

results will be used as an initial guide as to where the samples will be collected. Additionally, field readings of lead will be obtained using a hand-held x-ray fluorescence (XRF) analyzer unit to further identify optimal sample locations for the BERA bioaccumulation study (Chapter 3.0). XRF produces high-quality data for cations such as lead, can quickly analyze a large number of soil samples, and provides real-time data while in the field. Please see Chapter 3.0 for a description of the sample collection procedures.

2.3 Use of the Data in the BERA

The analytical and laboratory soil and earthworm bioaccumulation test results will be used to prepare the BERA report. As discussed previously, the primary focus of the BERA will be to more accurately estimate bioaccumulation of COPECs in the food chain (specifically the soil-to-invertebrate uptake of lead) rather than attempt to estimate alternative toxicity data for avian wildlife. However, results from the bioaccumulation tests may also provide some indication of toxicity of lead from site soil to earthworms, which could translate into reduced invertebrate prey items in areas where elevated concentrations occur. Thus, any toxicity of earthworms observed during the test will be noted and reported in the BERA.

In the BERA, a revised soil EPC for lead will be calculated using a combination of the data used in the remedial investigation, and any new analytical data from grab soil samples (discussed in more detail in Chapter 3.0) obtained during the delineation and/or BERA sampling effort will be generated and compared with the previous SLERA EPC. Note that XRF data will only be used for characterization and delineation and will not be used in the recalculation of EPCs. A BERA food chain model will be run using this revised lead EPC as well as the site-specific soil-to-soil-invertebrate BAF for lead obtained from the bioaccumulation study. The protectiveness of a human health-based lead concentration for ecological receptors will then be re-evaluated by considering the EHQs from the BERA food chain model. If the BERA concludes that the human health value is still not protective of environmental receptors, a lower concentration based on protection of ecological receptors may be proposed as an RG, as appropriate.

3.0 Lead Delineation in Soil

A second objective of the field investigation described in this work plan is to provide additional delineation for lead in soil at WWTP2. These additional data will assist in refining the area(s) required for any future remediation. An RG for lead has not been formally determined to this point; therefore, a preliminary target concentration that is likely to ultimately be protective of both human health and environmental receptors will be used for delineation. Based on professional judgment, 100 mg/kg will be used as this preliminary target concentration. This target concentration was selected because any alternate RG selected for protection of

environmental receptors is expected to be between 100 mg/kg and the human health RG of 400 mg/kg.

Although the marsh wren is likely only exposed to surface soil, elevated lead in deeper soils may pose a risk to other species. For example, the short-tailed shrew, which was hypothetically exposed to total soil (0 to 6 feet bgs) in the SLERA, also had EHQs greater than 1 due to ingestion of lead in invertebrate prey items. Therefore, samples with elevated lead that were within the total soil sample list, including some samples that slightly exceeded the 6 feet bgs total soil depth limit (e.g., sample WW0079), will be included for delineation. The sample locations shown in the following table had detected lead concentrations that exceeded 100 mg/kg:

Sample Location	Sample Number	Concentration of Lead (mg/kg)	Sample Date	Start Depth (feet)	End Depth (feet)
WP2SO08	3280	113	10/2/1996	0	0.5
WP2SO05	3250	514	10/2/1996	0	0.5
WWTP2-SB07	WW0085	767	6/30/2011	3	5
WWTP2-SB01	WW0079	898	5/10/2011	5	7
WP2SO10	3300	2870	10/2/1996	4	5
WWTP2-SB07	WW0077	18100	6/30/2011	0	1

Thus, additional delineation of lead will be performed at sample locations WP2SO05, WP2SO08, WP2SO10, WWTP2-SB01, and WWTP2-SB07. At each of these sampling locations, lead delineation in soil will be performed by collecting a sample for XRF analysis at distances of 10 and 20 feet in each of the four cardinal directions from the original sample location. A sample will be collected from each of the three depth intervals where lead has previously been detected at elevated concentrations (0 to 1, 3 to 5, and 5 to 7 feet bgs). Thus, for each of the five locations, up to 25 XRF samples will be collected and analyzed for lead. Should refusal be encountered before reaching the target depth, a second offset boring will be attempted within 5 feet of the original boring to collect samples from the deeper interval(s). If refusal is encountered in the second boring, no further sampling will be attempted. If any of the XRF samples exceed 100 mg/kg, additional step-out samples will be performed as necessary based on professional judgment. Figure 1 depicts the soil sample locations sampled during previous investigations and their associated lead concentrations and the proposed sample locations for this BERA and lead delineation study.

Grab soil samples will be collected from up to 12 of the XRF samples (10 percent) and sent to an off-site laboratory for confirmation analysis. The samples selected for confirmation will include

sample locations where low as well as elevated lead concentrations were detected to evaluate XRF accuracy across the range of concentrations present in WWTP2 soil.

Samples for the bioaccumulation study described in Section 2.2 will be collected concurrently with the lead delineation effort. Once the XRF data are reviewed, eight grab soil samples will be collected for the bioaccumulation study. As discussed previously, a broad range of lead concentrations in soil samples is desirable for establishing a regression-based BAF that may vary depending on the concentrations in soil. The samples collected for the bioaccumulation test may be obtained from eight individual locations, or soil from multiple locations may be combined (i.e., mixed) to produce the desired range of lead concentrations for the bioaccumulation study. For example, if the XRF data identify a few areas of elevated lead concentrations and all other sample results are at background levels, samples used for the bioaccumulation test may be created by "diluting" soil from the areas with elevated lead with soil from areas with non-elevated lead in varying quantities to produce samples with the desired range of concentrations. Because the goal of the bioaccumulation study is to determine the bioavailability of lead in WWTP2 soil, and because all soil used in the samples would originate from WWTP2 (albeit from multiple locations), this site-specific approach would maximize the variability of lead concentrations used in the bioaccumulation study, retaining all inherent qualities that affect bioavailability and uptake. Prior to their use in the bioaccumulation test, an aliquot of the samples will be sent to an off-site laboratory and analyzed for lead (Analytical Method 6010C) and general chemistry and physical parameters (including pH, total organic carbon, grain size, and percent moisture). The final locations for collection of soil samples will be determined following discussion and coordination with the U.S. Army Corps of Engineers.

The data uses and needs for this investigation are summarized in Table 2. Soil samples will be collected according to the methods and procedures described in the WWTP2 Sampling and Analysis Plan (Shaw, 2011) and in Table 2. Table 3 summarizes the samples and analytical parameters. Procedures describing the collection of bulk soil samples are provided in the WWTP2 Site-Specific Sampling and Analysis Plan (Shaw, 2011). The use of a hand-held XRF analyzer is not covered by this plan. Attachment 1 presents the standard operating procedures for the use of the XRF unit in the field.

Table 4 summarizes the analytical parameters required and associated laboratory methods to be used during this investigation. Decontamination procedures will be performed according to the procedures described in the WWTP2 Sampling and Analysis Plan (Shaw, 2011).

Sample containers and preservatives/preservation methods are summarized in Table 5. Sample containers will be supplied and shipped to the job site by the designated primary laboratory.

Sample processing will occur as described in the WWTP2 Sampling and Analysis Plan (Shaw, 2011).

A qualified geologist or geotechnical engineer will be on site for all sampling operations. The geologist/geotechnical engineer will perform logging and collect other information. An XRF technician with current certification in the use of the XRF equipment will be present and perform all XRF data collection. An ecologist will also be present to ensure sample locations are appropriate and that the bioaccumulation samples are prepared properly.

4.0 References

American Society for Testing and Materials, 2012, ***Standard Guide for Conducting Laboratory Soil Toxicity or Bioaccumulation Tests with the Lumbricid Earthworm Eisenia fetida and the Enchytraeid Potworm Enchyrtraeus albidus***, ASTM-E-1676-12.

Ohio Environmental Protection Agency (OEPA), 2008, ***Ecological Risk Assessment Guidance Document***, Division of Emergency and Remedial Response, Columbus, Ohio, April.

Oregon Department of Environmental Quality (ODEQ), 2001, ***Guidance for Ecological Risk Assessment: Levels I, II, III, IV***, Waste Management & Cleanup Division, Final, December.

Shaw Environmental, Inc. (Shaw), 2014a, ***Waste Water Treatment Plant No. 2 Remedial Investigation Report (Includes Waste Water Treatment Plant No. 2, TNT Area C Sewer Line to Waste Water Treatment Plant No. 2, and Waste Water Treatment Plants Steel Sewer Line), Volume 1, Site Characterization Report***, CX Draft, January.

Shaw Environmental, Inc. (Shaw), 2014b, ***Waste Water Treatment Plant No. 2 Remedial Investigation Report (Includes Waste Water Treatment Plant No. 2, TNT Area C Sewer Line to Waste Water Treatment Plant No. 2, and Waste Water Treatment Plants Steel Sewer Line), Volume 2, Baseline Human Health Risk Assessment***, CX Draft, January.

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Shaw Environmental & Infrastructure, Inc. (Shaw), 2013a, ***Final Baseline Human Health Risk Assessment Work Plan, Waste Water Treatment Plant No. 2, TNT Area C to Waste Water Treatment Plant No. 2 Sewer Lines, and Waste Water Treatment Plants Steel Sewer Line, Plum Brook Ordnance Works, Sandusky, Ohio,*** June.

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Shaw Environmental, Inc. (Shaw), 2008a, ***Site-Wide Quality Assurance Project Plan, Rev. 2, Plum Brook Ordnance Works, Sandusky, Ohio***, September.

Shaw Environmental, Inc. (Shaw), 2008b, ***Site-Wide Accident Prevention Plan/Site-Wide Health and Safety Plan Appendix, Rev. 2, Former Plum Brook Ordnance Works, Sandusky, Ohio***, September.

U.S. Environmental Protection Agency (EPA), 2008, ***Guidance for Developing Ecological Soil Screening Levels***, Office of Solid Waste and Emergency Response, Directive 92857.7-55, Washington, D.C., SSL values on line at: http://epa.gov/ecotox/ecossl/index.html.

U.S. Environmental Protection Agency (EPA), 1997, ***Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments***, EPA/540-R-97-006.

TABLES

Table 1

Proposed Assessment and Measurement Endpoints
Risk Questions and Testable Hypotheses [a]
Waste Water Treatment Plant No. 2 BERA and Lead Delineation
Plum Brook Ordnance Works, Sandusky, Ohio

Assessment Endpoint	Measurement Endpoint—Measures of Effect and Exposure	Risk Questions Testable Hypothesis
AE-1: Survival, growth, and reproduction of insectivorous birds and mammals	ME-1: Intake/food-chain model EHQ using site-specific bioaccumulation factors developed via a 28-day bioaccumulation laboratory study on soil-dwelling invertebrates (*Eisenia fetida*) exposed to site soil.	ME-1 Risk Question: Does exposure to site soil cause reduced survival or growth for terrestrial birds and mammals? ME-1 Testable Hypothesis: Revised EHQs using site-specific bioaccumulation factors indicate that the potential for adverse impacts are minimal.

[a] Assessment and measurement endpoints and the risk questions and testable hypothesis apply to Steps 3b and 4 of the 8-step ecological risk assessment process.
AE - Assessment endpoint.
BERA - Baseline ecological risk assessment.
EHQ - Ecological hazard quotient.
ME - Measurement endpoint.
Note: ME-1 may also be used to assess potential toxicity of metals for terrestrial invertebrates.

Table 2

Summary of Data Quality Objectives
Waste Water Treatment Plant No. 2 BERA and Lead Delineation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Potential Data Users	Available Data	Conceptual Model	Medium of Concern	Data Uses and Objectives	Data Types	Analytical Level
OEPA DOD USACE NASA Shaw Other Contractors Possible Future Land Users	Historical and remedial investigation data are available for WWTP2. These data indicate the presence of lead contamination in soil associated with waste handling processes.	Contaminant Source Production of TNT, DNT, and pentolite. Past DOD operations. Migration Pathways Soil, sediment, surface water, and groundwater Potential receptors Wildlife, human Potential Contaminants of Concern Lead	Soil	Delineate elevated lead in soil. Determine the uptake of lead into terrestrial invertebrates. Determine ecological risk to assessment receptors that ingest terrestrial invertebrates.	Soil Metals (lead only) General Chemistry (pH, TOC, etc.) Moisture Grain Size Tissue Metals (lead only) Lipids Moisture	Field screen Laboratory screen Definitive Stage 4 Data Package

BERA - Baseline ecological risk assessment.
DOD - U.S. Department of Defense.
EPA - U.S. Environmental Protection Agency.
NASA - National Aeronautics and Space Administration.
OEPA - Ohio Environmental Protection Agency.
Shaw - Shaw Environmental, Inc.
TOC - Total organic carbon.
USACE - U.S. Army Corps of Engineers.
WWTP2 - Waste Water Treatment Plant No. 2.

Table 3

Summary of Soil Analytical Samples
Waste Water Treatment Plant No. 2 BERA and Lead Delineation
Former Plum Brook Ordnance Works, Sandusky, Ohio

WWTP2 Soil (Grab) Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Lead Delineation						
TAL Metals (Lead Only)	12	1	1	1	0	1
TOC	12	1	1	1	0	1
pH	12	1	1	1	0	1
Moisture	12	1	1	1	0	1
Bioaccumulation Study						
TAL Metals (Lead Only)	8	0	0	0	0	0
TOC	8	0	0	0	0	0
Grain Size	8	0	0	0	0	0
pH	8	0	0	0	0	0
Moisture	8	0	0	0	0	0

WWTP2 Tissue Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
TAL Metals (Lead Only)	8	0	0	0	0	0
Lipids	8	0	0	0	0	0
Moisture	8	0	0	0	0	0

BERA - Baseline ecological risk assessment.
QA - Quality assurance.
QC - Quality control.
TCL - Target compound list.
TAL - Target analyte list.
TOC - Total organic carbon.
WWTP2 - Waste Water Treatment Plant No. 2.

Table 4

Summary of Soil Analytical Parameters and Methods
Waste Water Treatment Plant No. 2 BERA and Lead Delineation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters[a]	Analytical Method[b]
Soil	TAL Metals (Lead only)	3050B/6010C
	TOC	Lloyd-Kahn/9060M
	pH	9045D
	Grain Size	ASTM D 422
	Moisture	EPA 160.3
Tissue	TAL Metals (Lead only)	3052/6010C
	Lipids	NOAA 1993a
	Moisture	EPA 160.3
Soil IDW	TCLP Volatile Organic Compounds	SW-846 1311/5030B/8260B
	TCLP Semivolatile Organic Compounds	SW-846 1311/3510C/8270D
	TCLP Metals	SW-846 1311/3010A/6010C/7470A
	Ignitability	SW-846 1010A
	Corrosivity	SW-846 1110A
	Reactivity	7.3.3.2/7.3.4.2

[a]Target analyte list (TAL) and target compound list (TCL) are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages.
[b]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* USEPA Publication, Third Edition, and *Methods for Chemical Analysis of Water and Wastes* , EPA-600/4-79-020, March 1983 and subsequent revisions, except as noted.
[c]Water quality parameter.
[d]Field testing will use an appropriate field test kit or method according to EPA 600/4-79-020: Method for Chemical Analysis of Water and Waste in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication, Third Edition.

EPA - U.S. Environmental Protection Agency.
IDW - Investigation-derived waste.
NOAA - National Oceanic and Atmospheric Administration.
TCLP - Toxicity characteristic leaching procedure.
TOC - Total organic carbon.

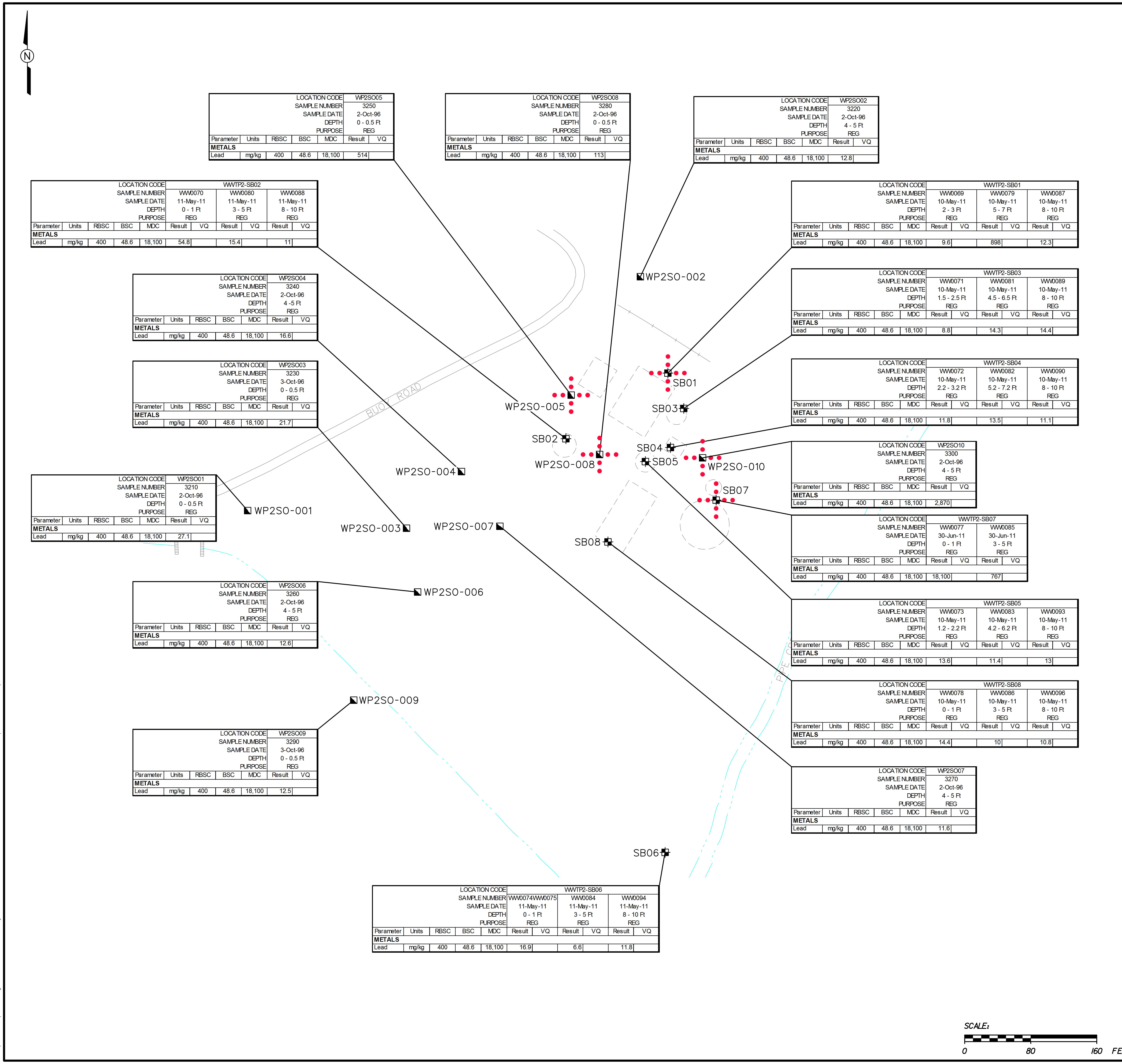
Table 5

Analytical Methods, Containers, Preservatives, and Holding Times
Waste Water Treatment Plant No. 2 BERA and Lead Delineation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Soil (grab, delineation and bioaccumulation)	TAL Metals (lead only)	6010C	(2) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	6 months
	TOC	Lloyd-Kahn/9060M			28 days
	pH	9045D			ASAP
	Moisture	EPA 160.3			7 days
	Grain Size	ASTM D 422		None	NA
Soil (grab, bioaccumulation)	NA	NA	(1) 6-L HDPE container(s)	Cool to 4°C	45 days from field collection until analysis
Earthworm Tissue	TAL Metals (lead only)	6010C	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	6 months
	Lipids	NOAA 1993a			6 months
	Moisture	EPA 160.3			7 days
Soil IDW	TCLP VOCs	SW-846 1311/5030B/8260B	(1) 8 oz CWM glass with Teflon-lined lid (1) 4 oz CWM glass with Teflon-lined lid - no headspace (VOCs)	Cool to 4°C	14 days extraction
	TCLP SVOCs	SW-846 1311/3510C/8270C			14 days extraction/40 days
	TCLP Metals	SW-846 1311/3010A/6010B/7470A			14 days /ext./6 months (28 days for Hg)
	Ignitability	SW-846 1010			ASAP
	Corrosivity	SW-846 1110			ASAP
	Reactivity	7.3.3.2/7.3.4.2			ASAP

°C - Degrees Celsius.
ASAP - As soon as possible.
CWM - Clear widemouth.
HDPE - High-density polyethylene.
L - Liter.
mL - Milliliter.
TAL - Target analyte list.
TOC - Total organic compound.
IDW - Investigative-derived waste.
OZ - Ounces.
*Number of containers required in ( ).

FIGURE



				LOCATION CODE	WP2SO05	
				SAMPLE NUMBER	3250	
				SAMPLE DATE	2-Oct-96	
				DEPTH	0 - 0.5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	514	

				LOCATION CODE	WP2SO08	
				SAMPLE NUMBER	3280	
				SAMPLE DATE	2-Oct-96	
				DEPTH	0 - 0.5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	113	

				LOCATION CODE	WP2SO02	
				SAMPLE NUMBER	3220	
				SAMPLE DATE	2-Oct-96	
				DEPTH	4 - 5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	12.8	

				LOCATION CODE	WWTP2-SB02					
				SAMPLE NUMBER	WW0070		WW0080		WW0088	
				SAMPLE DATE	11-May-11		11-May-11		11-May-11	
				DEPTH	0 - 1 Ft		3 - 5 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	54.8		15.4		11	

				LOCATION CODE	WWTP2-SB01					
				SAMPLE NUMBER	WW0069		WW0079		WW0087	
				SAMPLE DATE	10-May-11		10-May-11		10-May-11	
				DEPTH	2 - 3 Ft		5 - 7 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	9.6		898		12.3	

				LOCATION CODE	WP2SO04	
				SAMPLE NUMBER	3240	
				SAMPLE DATE	2-Oct-96	
				DEPTH	4 -5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	16.6	

				LOCATION CODE	WWTP2-SB03					
				SAMPLE NUMBER	WW0071		WW0081		WW0089	
				SAMPLE DATE	10-May-11		10-May-11		10-May-11	
				DEPTH	1.5 - 2.5 Ft		4.5 - 6.5 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	8.8		14.3		14.4	

				LOCATION CODE	WP2SO03	
				SAMPLE NUMBER	3230	
				SAMPLE DATE	3-Oct-96	
				DEPTH	0 - 0.5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	21.7	

				LOCATION CODE	WWTP2-SB04					
				SAMPLE NUMBER	WW0072		WW0082		WW0090	
				SAMPLE DATE	10-May-11		10-May-11		10-May-11	
				DEPTH	2.2 - 3.2 Ft		5.2 - 7.2 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	11.8		13.5		11.1	

				LOCATION CODE	WP2SO10	
				SAMPLE NUMBER	3300	
				SAMPLE DATE	2-Oct-96	
				DEPTH	4 - 5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	2,870	

				LOCATION CODE	WP2SO01	
				SAMPLE NUMBER	3210	
				SAMPLE DATE	2-Oct-96	
				DEPTH	0 - 0.5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	27.1	

				LOCATION CODE	WWTP2-SB07			
				SAMPLE NUMBER	WW0077		WW0085	
				SAMPLE DATE	30-Jun-11		30-Jun-11	
				DEPTH	0 - 1 Ft		3 - 5 Ft	
				PURPOSE	REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ
METALS								
Lead	mg/kg	400	48.6	18,100	18,100		767	

				LOCATION CODE	WP2SO06	
				SAMPLE NUMBER	3260	
				SAMPLE DATE	2-Oct-96	
				DEPTH	4 - 5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	12.6	

				LOCATION CODE	WWTP2-SB05					
				SAMPLE NUMBER	WW0073		WW0083		WW0093	
				SAMPLE DATE	10-May-11		10-May-11		10-May-11	
				DEPTH	1.2 - 2.2 Ft		4.2 - 6.2 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	13.6		11.4		13	

				LOCATION CODE	WWTP2-SB08					
				SAMPLE NUMBER	WW0078		WW0086		WW0096	
				SAMPLE DATE	10-May-11		10-May-11		10-May-11	
				DEPTH	0 - 1 Ft		3 - 5 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	14.4		10		10.8	

				LOCATION CODE	WP2SO09	
				SAMPLE NUMBER	3290	
				SAMPLE DATE	3-Oct-96	
				DEPTH	0 - 0.5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	12.5	

				LOCATION CODE	WP2SO07	
				SAMPLE NUMBER	3270	
				SAMPLE DATE	2-Oct-96	
				DEPTH	4 - 5 Ft	
				PURPOSE	REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ
METALS						
Lead	mg/kg	400	48.6	18,100	11.6	

				LOCATION CODE	WWTP2-SB06					
				SAMPLE NUMBER	WW0074WW0075		WW0084		WW0094	
				SAMPLE DATE	11-May-11		11-May-11		11-May-11	
				DEPTH	0 - 1 Ft		3 - 5 Ft		8 - 10 Ft	
				PURPOSE	REG		REG		REG	
Parameter	Units	RBSC	BSC	MDC	Result	VQ	Result	VQ	Result	VQ
METALS										
Lead	mg/kg	400	48.6	18,100	16.9		6.6		11.8	

LEGEND:

- HISTORICAL SOIL SAMPLE
- SOIL BORING
- CREEK, DITCH, CONVEYANCE
- FORMER RAILROAD
- ROAD
- APPROXIMATE LOCATION OF FORMER WWTP2 STRUCTURES
- mg/kg MILLIGRAMS PER KILOGRAM
- PLANNED XRF SAMPLE LOCATIONS (0 TO 1 FOOT, 3 TO 5 FEET, AND 5 TO 7 FEET). ADDITIONAL SAMPLES MAY BE COLLECTED. SEE TEXT FOR DETAILS.

SCALE:
0 80 160 FEET

FIGURE 1

HISTORICAL AND PROPOSED SAMPLES FOR LEAD IN SOIL, WASTE WATER TREATMENT PLANT No. 2, FORMER PLUM BROOK ORDNANCE WORKS

WWTP2 BASELINE ECOLOGICAL RISK ASSESSMENT WORK PLAN
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

CB&I Federal Services LLC

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ATTACHMENT 1

PROCEDURE MANUAL
SCREENING FOR METALS IN SOIL USING THE INNOV-X-XRAY FLUORESCENCE INSTRUMENT (ELECTRONIC ONLY)

PROCEDURE MANUAL

SCREENING FOR METALS IN SOIL USING THE INNOV-X X-RAY FLUORESCENCE INSTRUMENT

Manual Revised by:

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List of Attachments

Attachment A – XRF Project Planning and Setup, a Checklist of Questions to Consider
Attachment B – Setup “Pocket Controller Pro” Bluetooth Software Instructions
Attachment C – List of State Radiological Oversight Agencies
Attachment D – Generic Radiation Protection Plan (RPP) / Radiation Caution Signs
Attachment E – Example XRF Forms
Attachment F – How to Configure “Sync Manager - Pocket Controller Pro” File Synchronization Software

1.0 Scope and Application

The following procedure manual describes the steps required to use an Innov-X X-ray Fluorescence (XRF) instrument for the screening level analysis of metals in soils and sediments. The manual is based on the Draft U.S. Environmental Protection Agency (EPA) SW-846 Method 6200 (1998 and 2007) with minor modifications based on CB&I Federal Services, LLC (CB&I) experience with the Innov-X. Specifically for projects performed for the U.S. Army Corps of Engineers (USACE), the Corps has prepared their own guidance (USACE, 2008). This manual also addresses the additional steps needed to comply with their guidance for USACE projects.

Among other applications for XRF that are possible include the analysis of lead based paint and coatings, filter media, and wipe samples – however those applications require specific hardware/software and different procedures which are not within the scope of this manual. Please contact CB&I Equipment if you have questions regarding those applications.

A checklist of questions to help assess the informational needs of the responsible person during the planning and setup of an XRF project has been prepared and included in this manual as Attachment A. This checklist covers a wide variety of subjects including how to refine the XRF scope, plan logistics and staffing, procure supplies and equipment, address the radiation safety requirements, and anticipate the data flow and usability. Using this checklist will hopefully prompt the responsible person to think through the process and address the critical planning issues necessary for a successful program.

It is important to know that this type of XRF instrument uses state-of-the-art x-ray tube technology instead of radioactive sources to generate the radiation needed to cause metals fluorescence. With the tube, the instrument generally falls into the category of “x-ray producing machine” for regulatory control. As such, certain radiation safety precautions are required by the various states, federal government, and/or CB&I’s own policy. This SOP outlines the general steps that must be completed to comply.

The manual is applicable to in situ (direct analysis) and ex situ (analysis of samples) detection and quantification of XRF target metals (Table 1) in soil and sediment matrices. Data from XRF analysis using this manual is considered to be "screening level" only and is useful for initial screening and contaminant delineation. "Screening level" data generated by the XRF should not be used for risk assessments and never used for waste disposal. Matrix effects, inadequate sample

preparation, metal heterogeneity in the soil, and inter-element interferences may affect comparability with fixed-base laboratory methods for metals analysis.

The detection limits achieved with the XRF are dependent on the analyte of interest, sample preparation, count times, matrix affects, and interferences. Table 1 summarizes the detection limits that are typically achievable in "blank" soil matrices (i.e., silica sand). Actual detection limits in site soils may be higher.

This manual is prepared specifically for the Innov-X XRF instrument. The general approach described in the procedure is also applicable to other x-ray tube-based instruments with modification for their particular equipment specifications and requirements. In all cases, the instrument manufacturer's directions and instructions will be followed.

Use of this manual should be restricted to personnel trained and knowledgeable in the operation of an XRF instrument or under the direct supervision of personnel who are trained and knowledgeable in the operation of an XRF instrument. All XRF users must have documented radiological health and safety training.

Table 1. List of Metals Detected by the Alpha XRF and Typical Detection Limits

	Alpha XRF[1]	
Metal	**Average DL (ppm)**	**RSD**
Arsenic	3.66	2.8%
Lead	5.14	3.0%
Copper	14.7	2.6%
Nickel	29.7	1.6%
Zinc	6.51	4.5%
Chromium	69.2	3.9%
Mercury	7.34	3.3%
Antimony	56.2	0.9%
Tin	51.7	3.2%
Cadmium	31.1	1.0%
Silver	31.1	0.8%
Selenium	2.31	3.2%
Titanium	480	2.8%
Manganese	36.1	4.3%
Iron	28.7	4.7%
Cobalt	2.00	5.2%
Rubidium	1.97	2.2%
Strontium	2.55	2.0%
Zirconium	4.10	1.4%
Molybdenum	16.2	1.2%
Barium	178	2.6%

DL - detection limit.
ppm - part-per-million.
RSD - relative standard deviation.

[1]Based on 17 replicate measurements of SiO2 blank sand using a 90 sec
Note: Actual DLs in soil matrices will probably be higher.

2.0 Method Summary

2.1 Principles of Operation

XRF is a nondestructive qualitative and quantitative analytical technique used to determine the metal components of samples. The Innov-X XRF uses a high-energy, x-ray tube to produce the radiation necessary to irradiate samples. The metal atoms in the sample either absorb or reflect the x-rays. When an atom absorbs the source x-rays, a shifting of electrons occurs between electron shells. The rearrangement of electrons results in the emission of x-rays, or fluorescence and each element present emits a characteristic x-ray line spectrum. The element may be identified by the energy of the wavelength. Fluorescent and reflected (backscattered) x-rays enter through a detector window where their energies are converted to electric pulses. The number of counts at a given wavelength per unit of time is representative of the analyte concentration. An onboard data processor converts the detector signals into useable information: a spectra of the fluorescence, the elements present, their concentrations in parts-per-million, and the standard deviation (error) of the measurement.

2.2 Instrument Description

The Innov-X XRF instrument is a recent design that incorporates new technology into XRF field instrumentation. The technological improvements of this instrument over existing XRF machines are many. These include the use of a high energy x-ray tube instead of sealed radioactive sources; the use of an integrated personal data assistant (PDA) to control the instrument and capture and report data; and an improved detector and electronics that help increase instrument sensitivity and shorten the instrument time required to perform the analysis. The XRF also comes with a separate test stand to aid in sample presentation and analysis. The machine itself has a similar design to a portable power drill, allowing one-handed operation by the analyst. Innov-X has included a handle-mounted battery pack and an instrument trigger. The x-ray tube assembly is mounted above the handle, sending the x-rays along the instrument barrel towards the Kapton film window which directly interfaces with the sample to be analyzed at the end of XRF. The instrument detector is also mounted at this end of the instrument, sending its signals back to the onboard data processor which in turn reports the calculated results to the PDA. The PDA is mounted to the top of the instrument in a special socket and can be removed and/or re-inserted during use without turning the XRF off.

The Innov-X instrument manual should be thoroughly reviewed for first time users and referred to by the analyst for project-specific instrument set up. This CB&I procedure manual will review typical setup and operation only.

2.3 Sample Preparation Procedures

Sample preparation is dependent on the mode of analysis. The simple in situ analysis method is performed by preparing a sample spot on the ground surface and placing the XRF window in contact with this spot. It requires the least amount of sample preparation time and is therefore is subject to the most potential bias. This manual recommends a more comprehensive ex situ approach where soil/sediment from the sample location is collected and homogenized within a plastic Ziplock bag. The XRF is placed in contact with the side of the Ziplock containing the prepared soil and analysis is conducted through the bag wall. The ex situ method has several advantages including greater sample homogenization and therefore lowering of potential bias. It also results in a sample of the location which may be XRF analyzed in duplicate or triplicate and then sent to the off-site laboratory for definitive metals analysis.

For all samples analyzed in the field (in situ or ex situ), any rock and vegetative matter will be removed as the sample is homogenized. If any metal debris (such as bullets, bullet fragments, or paint chips) is present in the sample, they will be identified by the analyst and removed by hand. The amount and type of metal debris observed will be recorded on the sample analysis form or sample collection log.

"In Situ" Analysis. Taking direct measurements on prepared spots on the ground is fast and simple to do in the field. It is an approach that can be used when informal concentration information is needed to make decisions about where to take more definitive ex situ samples, however the use of in situ data alone should be cautioned as generally when in situ data are compared to off-site laboratory confirmation data, the differences between the measurements can be great due to the biases that have not been addressed with the limited sample preparation steps. To protect the Innov-X XRF analysis window from damage, this manual strongly recommends that after preparing the sample spot, the XRF analyst cut a Ziplock bag in half and use half of the bag as a protective barrier between the instrument and the ground surface. Also, if the sample location is under water or even in a water-saturated area in situ analysis should not be attempted because water may leak into the instrument through the film window.

"Ex Situ" Analysis. The most common way to analyze soil and sediment samples will be the ex situ approach where the sampler will collect material from the location using a sampling tool (such as a hand trowel, spoon, or bucket auger) and then place it inside a Ziplock bag for processing and analysis. The Ziplocks used should be non-textured plastic, storage or freezer bags, either one quart or one pint size.

If the soil is rock-free, easy to homogenize, and is not wet, the analyst can mix the soil by breaking up larger clumps of solids by "kneading" the soil within the bag using the thumbs and then shaking the sealed bag to mix the sample. Using disposable wooden spatulas (like craft sticks) is a recommended way to help manipulate the soil in the Ziplock during the homogenization step. The analyst should then compress and smooth the material inside the bag using his gloved hands forcing the soil to the bottom of the bag and working it into a consistent, flat sample interface for analysis. If the bag has any printing on the front side, the analyst will turn the bag over and analyze the sample through the reverse (unprinted) side.

Sieving. If the analyst finds many rocks or vegetative debris in the bagged sample that has not been removed during the collection step or if the analyst suspects the soil may contain metal fragments or paint chips, it should be further processed by screening through a sieve (if the objects cannot be removed by hand). In any case, some kind of sieving is preferred to not sieving at all to remove rocks and any fragments/chips as the presence of either of these can lead to a direct and significant adverse impact on sample homogeneity. If a sieve is used, the analyst must further assess whether the material is dry (and fine) enough to pass the sieve without further treatment. Generally two sizes of sieves are used – a ¼-inch (or similar) "coarse" sieve and a #10 (2-mm pore size) "fine" sieve. If the material is rocky but the soil itself is dry and small enough to pass through both sieves without drying, crushing, and sieving – then the most advantageous method would be to proceed with sieving using both sieves in tandem. If very little material passes the fine sieve, then what does pass can be re-combined with the material that passes the coarse sieve before analysis, if necessary. Using disposable wooden spatulas is a recommended way to help manipulate the soil in the sieve if just shaking the soil or tapping the sieve is not working well. In all cases, used sieves are considered to be contaminated and will be decontaminated by wiping and/or brushing until the residual soil is removed. If metal fragments or paint chips are found in the sieve after separation, they will be noted on the sample documentation.

Drying. If the material contains a high amount of moisture (generally free water is present at the location or in the bag after sampling) the analyst must take steps to minimize the impact of water in the sample by removing it during preparation. The absolute first step is to assess if simply moving the sample location to a drier spot is an option. If that is not the case, then the location should be sampled by ex situ procedures using a trowel, spoon, or auger. Any collected free liquids should be drained during collection either in the sampling tool or in the Ziplock bag. A fast and effective way to reduce moisture in the field is to place a small aliquot of the saturated material in small stacks coffee filters or paper towels. The aliquot can then be gently squeezed with a gloved hand as the filters or towels absorb the water. This process can be repeated with fresh filters/towels for the same aliquot until the sample begins to resemble a dried "pancake." These dried aliquots can be placed into another Ziplock bag and then further homogenized for analysis.

Onsite Laboratory Preparation. If the soil is wet and rocky or wet and thought to contain metal fragments or paint chips, then the best overall approach is to do a thorough preparation which would include drying an aliquot of the sample in a laboratory oven (4 hours minimum at least 120 degrees Celsius), crushing the dried sample with a ceramic pestle, sieving though the coarse (if needed) and fine sieves, and then homogenizing the sample. Homogenized samples can be placed in specialty plastic XRF cups and sealed with Mylar film windows as per EPA Method 6200, or simply transferred to a small, labeled Ziplock bag and analyzed through the bag.

Note: Oven drying is not recommended if mercury is a site contaminant of concern as it may volatilize. Samples for mercury screening should be air dried overnight at ambient temperatures.

This laboratory preparation procedure is ideal for all sample types and it helps to address most known biasing effects, however it can significantly reduce the number of samples that are analyzed per day because this procedure will take more time per sample to complete. It must also be noted that oven drying and crushing the sample will raise certain health and safety concerns such as how to properly vent the oven and how to effectively control the sample preparer's exposure to possibly high concentration metals-contaminated dust. These critical factors must be weighed against the data quality objectives (DQOs) of the work during the project planning stage.

2.4 Sample Analysis

Sample analysis begins by exposing the sample to primary radiation from the source. The Innov-X has two options for sample presentation to the instrument – direct analysis in hand held mode or the use of the integrated test stand.

2.4.1 Hand Held Mode

If direct analysis with the Innov-X in hand held mode is performed, the analyst will ensure the instrument window is in direct, stable contact with the sample bag or cup so that the instrument window and the sample surface are properly aligned. The analyst will initiate the analysis by depressing the XRF trigger mechanism as he holds the instrument down against the sample bag or cup. To comply with CB&I H&S policy, the XRF will be operated in hand-held mode with the deadman trigger switch engaged so that if the trigger is released during operation, the analysis (and the x-rays) will stop. This will help prevent accidental exposure to x-rays for the analyst. The instrument manual has more information about the deadman trigger safety feature.

The instrument next will open the shutter and perform a proximity test safety check and then allow the analysis to begin if it detects the presence of a “sample” in front of the window. The analyst must carefully hold the instrument upright and maintain a steady contact with the sample while the instrument is in the "on" position. If the contact is lost with the sample and the XRF is no longer detecting backscatter radiation, then the XRF will stop the analysis and abort that test. This is another safety feature of the instrument to help prevent radiation exposure to the analyst.

Note that the XRF has a flashing red strobe light mounted on the top of the instrument and a small LCD display on the rear of the instrument. While taking a direct reading, the light will flash and the LCD display will show a counter of the total seconds elapsed. The PDA screen will also change to indicate the analysis is in progress and show preliminary concentration readings of the elements detected even as it gathers additional data about the sample. The Innov-X manual describes the setup of the software to report preliminary data in more detail.

Radiation Safety. **The XRF analyst should always be aware that ionizing x-ray radiation is produced by the instrument during analysis! Therefore, <u>never</u> hold the sample in their hand during analysis.** Furthermore, to reduce any possible radiation exposure, the analyst will <u>always</u> avoid placing your hands on the barrel of the instrument or fingers near the analysis window while the machine is in the “on” position and the strobe light is flashing.

2.4.2 Test Stand Analysis

Using the integrated test stand, the instrument is mounted in a cradle and the instrument window fits into a slot beneath the test platform so the XRF window faces "up." The PDA is removed from the XRF in this configuration and is attached to the stand in its holder and connected to the XRF via a data cable. The analyst places the bagged or cupped soil on the test platform directly over the XRF window of the unit, the test stand's protective cover is closed over the analysis area, and the analysis is started using the PDA. The test stand includes a red warning light mounted on top of the stand that will flash when analysis is underway and x-rays are being produced. When analyzing the sample, the test stand cover must remain closed to reduce radiation risk to the analyst. If the cover is accidentally opened, the safety switch inside the test stand will immediately stop the run. Once the analysis run is complete, the PDA display changes and the red light returns to steady.

Either hand-held or test stand method can be used to analyze ex situ samples prepared in bags or in XRF cups. The test stand is very convenient when a single analytical station can be set up in the field and ex situ samples collected and brought to the station for prep and analysis. If the instrument must be moved from place to place for in situ type readings, then hand held mode analyses should be performed. <u>It is key that the analyst lock the instrument trigger (via the PDA) using the software trigger lock prior to moving the instrument</u>. In this manner the XRF can be safely transported without having to power down the instrument between readings.

During the analysis, the instrument will constantly update the PDA to show the elapsed count time of the run, the concentration and standard deviation of the metals detected, and the detection limit of the metals which are not detected. The analyst should monitor this display, but operating in the default, standard mode, Innov-X programming will discontinue the analysis run when at least 60 seconds has elapsed. The Innov-X will reach lower detection limits with longer count times and this can be changed by the XRF analyst to meet project objectives. If required, the XRF count time can be extended via the PDA analytical programming to marginally lower the reporting limits further. Check the instrument manual for instructions. The needs of the project and the objective of the XRF measurement will be taken into account by the analyst to determine the optimal length of analysis.

2.4.3 Sample Replicates

Depending on the project objectives, the analyst should replicate the analysis for the same sample to produce duplicate or triplicate readings especially when the initial results indicate that the metals of interest could be present in the sample at concentrations that are near the action limit. When replicate measurements are made, the analyst will take the prepared sample in the bag, remix the sample, and re-prep and reposition it before initiating a separate analysis. When prompted to identify the sample on the PDA, the analyst should use the same sample ID followed by the designation "(R2)" or "(R3)" to indicate the result is a second or third replicate analysis. When downloading the data electronically, the original, R2 and R3 results can then be grouped together and an average concentration and relative standard deviation (RSD) can be calculated. RSD is equal to the standard deviation of the replicate measurements divided by the average concentration expressed as a percentage. RSDs of less than 50% (less than 20% on projects for the USACE) indicate that the soil was homogenized well. If the RSD is greater than 50% (greater than 20% on projects for the USACE) the sample should be considered for further preparation (perhaps drying, crushing, and sieving) and additional analysis, again depending on project objectives. On projects for the USACE, those samples will be re-prepared and re-analyzed in another series of triplicate readings ("R4"-"R6"). If the RSD for the second set of triplicate readings also exceeds 20%, then that sample will be documented and set aside for offsite laboratory analysis. For all samples targeted for offsite laboratory analysis, replicate XRF analysis is essential. RSDs for these samples should be as low as possible.

2.4.4 Utilizing Bluetooth Technology for Controlling the XRF

Using the wireless capabilities of Bluetooth technology, all functions of the XRF can be controlled through a Bluetooth enabled laptop computer. This is particularly helpful because routine functions such as data file transfer and data file naming can be facilitated using a computer keyboard as compared to manipulating a PDA's onscreen keyboard with a stylus for file naming. Wireless controller software such as "Pocket Controller-Professional" controls the XRF via the PDA (see Attachment B - Innov-X Systems "Pocket Controller Pro" Setup Instructions for detailed installation and configuration instructions).

3.0 Interferences

3.1 Physical Matrix Effects

Physical matrix effects result from variations in parameters such as moisture, particle size, uniformity, and homogeneity, and sample position. These matrix effects can lead to significant variability in the data if the biases are not controlled. Fortunately through adequate sample preparation steps, most of the factors can be reduced.

3.1.1 Moisture Content

Overall bias from moisture is minimal for soil with moisture contents of 5% to 20%. Drying in a laboratory oven can further minimize this potential source of bias. No sample will be analyzed in situ if it contains greater than 20% moisture (i.e., the soil is visually wet or contains any free water). In-the-field measurements can be performed on soil that is dried by squeezing the material through coffee filters or paper towels to absorb water from the samples prior to analysis. Alternatively, the sample can be collected in the field and brought into the onsite laboratory for oven drying. If necessary, the samples will be dried for 4 hours (or more) at least 120 degrees Celsius to remove moisture. Oven drying is not recommended if mercury is a site contaminant of concern. For mercury analysis, a small sample aliquot will be air dried at ambient temperature overnight to reduce moisture.

3.1.2 Particle Size, Uniformity, and Homogeneity

To best control the physical biases attributable to particle size, uniformity, and homogeneity laboratory prepared samples can be crushed, sieved and homogenized as part of a complete sample preparation process. Crushing will be performed using a ceramic pestle or a soil grinder, if needed. Crushed material will be passed through a fine (ASTM No. 10, 2-mm pore size) standard sieve to remove small rock and debris. Finer size sieves may be used also depending on the project objectives. Once crushed and sieved, the material that passes through the sieve is piled onto a sheet of wax paper where it is homogenized and blended by using a rolling action. Prepared samples can be placed into XRF cups and sealed with Mylar film or placed into a small Ziplock bag for direct analysis.

Depending on the DQOs established for the XRF project in the sample planning stages, modified sample preparation procedures may be performed which will reduce the time spent but will likely increase the potential bias factors of size and homogeneity. The main factors to consider in

selection of any sample preparation steps is to seek to remove or reduce as much as possible any potential negative biases (rock or vegetative material for example) and/or any positive biases (such as metal fragments or paint chips), then to increase sample homogeneity. Preparation steps are described in detail in Section 2.3.

3.1.3 Sample Position and Density

Inconsistent positioning of samples is another potential source of error. The x-ray signal decreases as the distance from the source increases. The window of the XRF should be in direct contact with the soil bag, cup window, or sampled surface. The analyst must make sure that if analyzing in hand held mode, the instrument window stays in constant, even contact with the sample surface. If operating in test stand mode, the sample bag or cup will be positioned so that the analysis window is completely covered before closing the test stand cover.

Sample density also has a direct impact on bias. Therefore if the samples are prepared in Ziplock bags, the analyst will compress the homogenized soil back together as much as possible to produce a smooth and compact analytical surface to present to the analysis window. This will reduce any void space within the sample and help reduce bias.

3.2 Chemical Matrix Effects

Concentrations of certain elements interfere with others. The effects may occur as spectral peaks overlap, x-ray absorption, or x-ray enhancement. The Innov-X has advanced data control programming and hardware improvements to minimize these effects, however they cannot be eliminated entirely.

Common matrix effects include: a high lead concentration elevates the detection limit of arsenic or biases the result high; iron may interfere with the quantification of copper and cobalt, and the presence of vanadium may affect chromium quantification. Consult the instrument manual if these conditions exist at the site and these metals are of concern. The most problematic of the element interferences is probably the lead/arsenic relationship. Method 6200 suggests that if the lead concentration is greater than 10x the arsenic concentration, then confirmation of the arsenic should be performed at an off-site laboratory. In common practice as long as lead concentrations are less than 75 to 100 ppm, then its interference with arsenic should be minimal.

4.0 Safety

Because XRF analysis relies on the production of ionizing radiation to cause the metals in the sample to fluoresce, there are inherent radiation safety considerations and precautions associated with the instrument to prevent the analyst from being exposed. In addition to radiation safety, the XRF analyst often handles samples with potentially high concentrations of toxic metals such as lead, arsenic, and mercury, among others. Reduction of dermal exposure, ingestion, and the inhalation of dusts must also be controlled to protect XRF project workers.

4.1 Radiation Safety

The process of radiation safety begins in the project planning stage. The Attachment A checklist of questions to consider describes several key elements that must be addressed for the project to comply with state and federal laws as well as CB&I policy. Figure 1 is a flow diagram which summarizes the process of defining the radiation safety program for a specific job. Primary among these include determining who will be the regulatory authority for the XRF project.

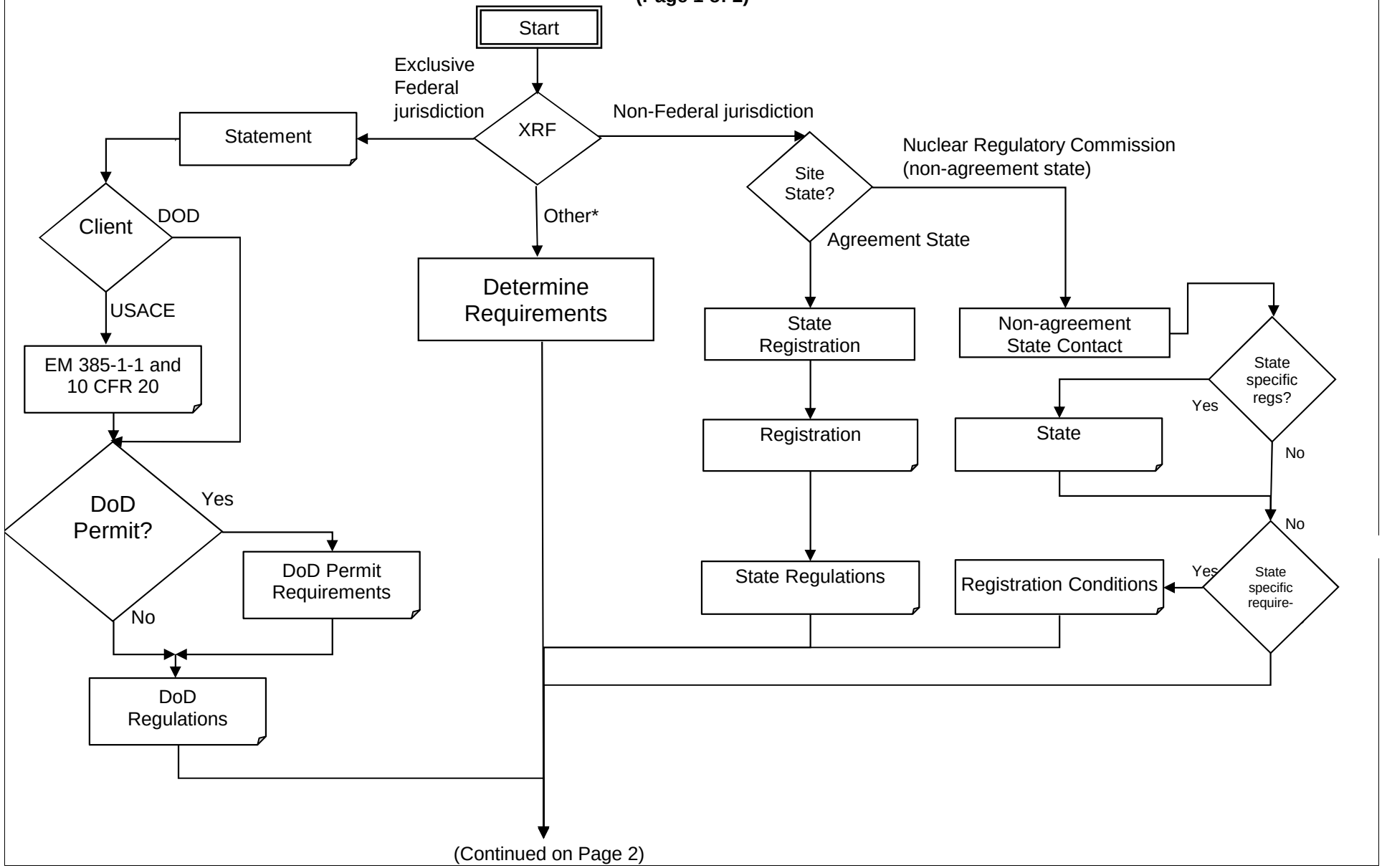
State Registration/Compliance. The state has that authority in cases where the XRF will be used on private or publicly-owned land. The states generally fall into two broad categories, "Agreement States" and "Non-agreement States." Agreement states are those that have approved specific regulations regarding the control and registration of radioactive materials and "radiation producing" machines (like the XRF) within their state borders. Non-agreement states generally default to the federal Nuclear Regulatory Commission regulations and therefore have different requirements.

Fortunately most states now have an internet website that summarize the governing regulations, contain downloadable forms, and provide the names and phone numbers of the department personnel who oversee the program. Attachment C of this manual includes a listing of current state contacts/telephone numbers as well as state website addresses for reference. Sometimes when contacted state employees that do this work are already knowledgeable about XRF instruments and have handled these requests previously. If not, it is usually helpful to direct them to the Innov-X web page for the instrument: http://www.innovx.com/products/alpha.

Registration usually requires completing a state-specific form and possibly including a fee payment (most are less than $100). Registrations generally expire after one year (and that may be dependent on the state's annual registration calendar). The registration process can take a few

Figure 1. XRF Regulation and Identification

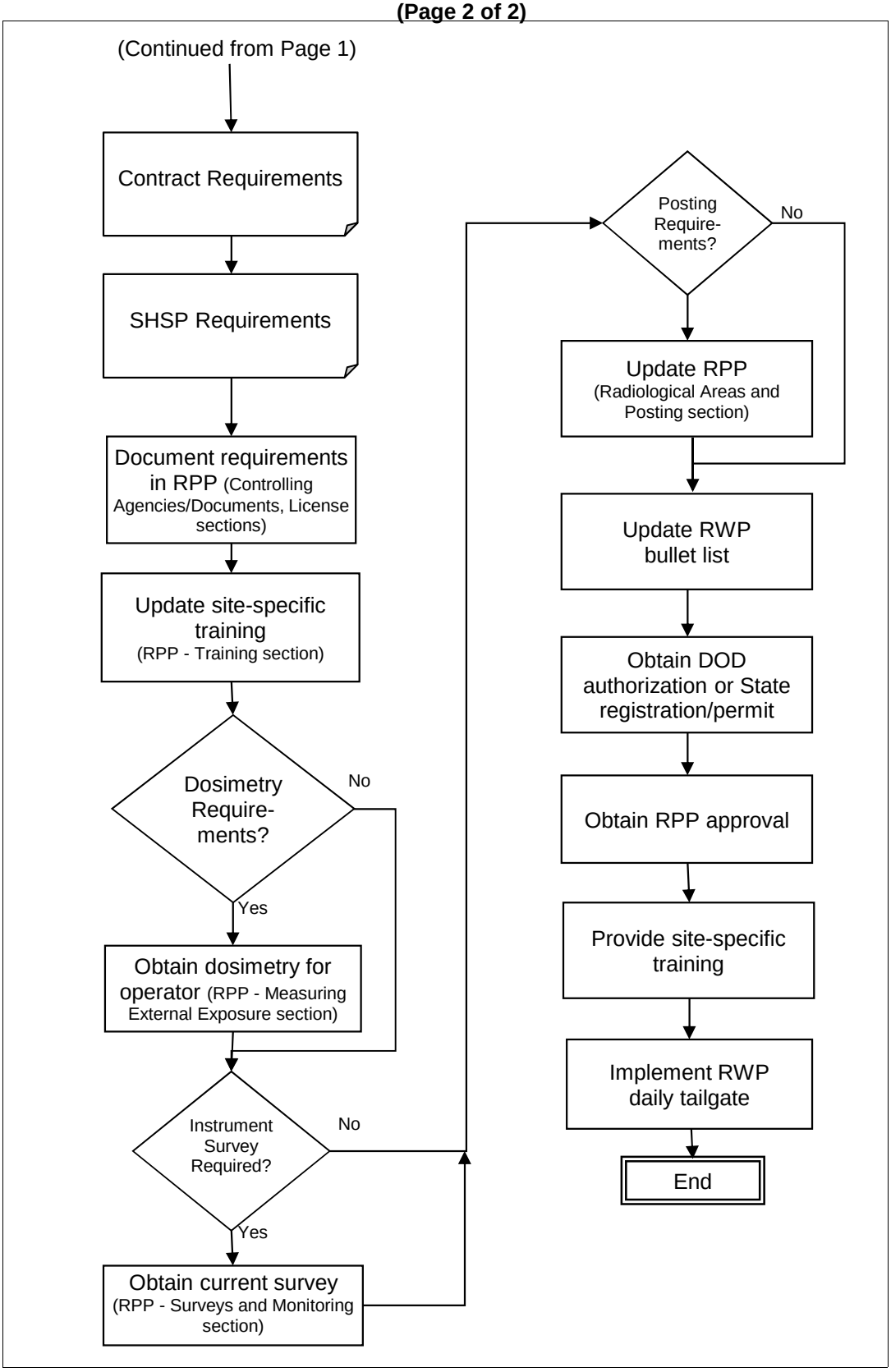
(Page 1 of 2)



*Department of Energy, US General Services Administration (GSA), US Post Office, Department of Interior, Department of Homeland Security, etc.

Figure 1. XRF Regulation and Identification (Continued)

(Page 2 of 2)



days to several weeks to accomplish and therefore should be started well in advance of going to the field. At the time of this manual Revision 2.0, CB&I already has registered in the following states: New York, North Carolina, Florida, and New Mexico and is pending in Ohio.

Other state requirements may include written notification when the instrument is received at or shipped off the site, documentation of the XRF analyst's training, a hardcopy of the state's radiation regulations, documentation of a dosimetry program, an inspection by the state or a state-licensed inspector, the printing and displaying of the state-specific "Notice to Employee" form, and the displaying of radiation warning signs in the area where the instrument will be used (Attachment D). CB&I is responsible for complying fully with each state's requirements, otherwise the company is subject to violations and/or fines. Therefore it is key that a project designate a person responsible for researching and implementing this program weeks before the field program is scheduled to start. CB&I Equipment requires that copies of any state registrations and/or "authorization to operate" letters be sent to their Findlay, Ohio office to document the success of this process before the CB&I XRF will be shipped to the field.

Federal Compliance. When CB&I uses the XRF on a DoD or other large federal facility that has a designated person or department onsite to oversee radiation safety, then we must work with that person or department to ensure compliance with all of their specific policies and procedures. If CB&I is performing the work specifically for the USACE, then their radiation safety regulations stated in the Corps Engineering Manual EM-385-1-1 and in those in the Code of Federal Regulations (10 CFR 20) apply. Generally the steps required in compliance while working on large government facilities involves finding the right person to talk to within their organization, establishing with them what it is CB&I plans to do, completing their notification forms, and ultimately having them sign an "authorization to operate"-type letter for our files. Usually our client contacts will be able to direct us to the proper facility department, but surprisingly this process can also take several weeks to accomplish and therefore must be started well in advance of going to the field. CB&I Equipment will want to see documentation of compliance by a signed authorization to operate letter from the government facility before the XRF is shipped to the field.

CMS-710-01-PR-04000 Policy Compliance. In addition to the state and federal requirements, the project must also comply with the internal CB&I policy that regulates the use of ionizing radiation producing machinery such as the XRF. The primary requirements of the

CMS-710-01-04000 are to designate a responsible person for overseeing the registration process for each XRF project and complete a radiation protection plan (RPP). The elements of the RPP are outlined in the CB&I policy. Because the actual instrumentation and usage procedures do not generally change from one XRF project to another, the majority of the project-specific RPP language is in the compliance of the state or federal requirements such as those outlined previously. Attachment D is a generic RPP which can be adapted for the specific projects and their necessary requirements. The RPP will be reviewed approved by the project radiation safety officer, the designated radiation safety manager, the health and safety manager, as well as the project manager. The completed RPP can be placed in the work plan as an attachment to the site HASP. During field implementation, the requirements of the RPP need to be reviewed as part of the site orientation for new project employees and reviewed daily as part of the tailgate safety meeting.

Dosimetry Program. At the time of this Manual's Revision 2.0, CB&I Corporate H&S will provide ring badges to employees who will operate the XRF as part of their job responsibilities. These badges will be employee-specific and analyzed quarterly at no cost to the project. CB&I Radiation Safety Department will issue the ring badges and will administer the program. A point of contact for the program has not been determined. Contact CB&I Equipment during the set up phase to get the latest information on this program.

4.2 XRF Field Safety

When in the field, the instrument will be operated in compliance with the manufacturer's recommended procedures found in the instrument manual**. <u>Under no circumstances will the XRF instrument case be opened or serviced by the analyst</u>.** If the instrument malfunctions, the CB&I Equipment Division and manufacturer will be contacted for further instructions.

The safety procedures found in the instrument manual will be explicitly followed. These include:

- The analyst will always be aware of the position and angle of the x-rays during analysis. **<u>The analyst will never hold the sample in their hand</u>** and will avoid holding the XRF by the barrel or placing their fingers near the XRF sample window during analysis.
- If using the XRF in hand held mode, the deadman trigger lock will be engaged so that the instrument trigger must be held down to operate the instrument. If the trigger is released when the deadman trigger is engaged, the Innov-X will stop producing x-rays and the run will terminate. Therefore mounting the XRF in the instrument test stand is

both the safest and easiest way to operate the instrument and should be used whenever possible.

- The software trigger lockout will be manually engaged (via the PDA) when the instrument is not in use and set up by default for automatic lock within no more than 5 minutes of inactivity. This lock prompts the user via the PDA screen to unlock the instrument before starting a test run.

- If not in use for longer than one hour, the analyst should power down the instrument to save battery power. If the XRF is not mounted in the test stand, it should be secured and stored inside the case.

- The analyst will operate the instrument only on a stable, flat surface when performing a measurement. If the test stand is used, the test stand should be placed on stable surface (work table or truck tailgate, for example).

- A radiation control zone within a five foot radius around the instrument will be maintained by the XRF analyst during active sample analysis. The XRF work area will be separate from other work areas and dedicated to sample preparation and analysis as much as possible. Personnel who are not directly involved in the sample preparation or analysis should not frequent the XRF area. Radiation warning signs will be posted in this area in compliance with the RPP.

- When the XRF is not in use overnight or for longer time periods, it will be stored in its original shipping container with the battery and the PDA removed. The XRF case will then be placed in a secure, designated area for storage.

Radiation Exposure. CB&I's health and safety personnel and a certified health physicist have reviewed instrument safety procedures of the Innov-X XRF while in operation. Human exposure to radiation is typically measured in rems or in one-thousandths of a rem, called millirem (mR). The allowable limit in the U.S. for occupational exposure is 5,000 mR/year for a whole-body or 50,000 mR for shallow penetration of extremities. Innov-X has published a maximum exposure rate of < 0.1 mR/hour to the hand while holding the trigger using the XRF in hand held mode. Assuming this rate for the hand, if the instrument is used continuously (24 hours per day) for an entire year - exposure from a properly used Innov-X will be less than 1,000 mR per year, a level less than 2% of the U.S. extremity dose limit. If the XRF is operated in a safe manner for 2,080 hours for an average work-year (40 hours per week, 52 weeks a year), approximately 200 mR total exposure is calculated.

It should be noted that significant exposure to ionizing radiation is possible if the XRF is used improperly. If a bagged soil sample is held in the hand opposite the trigger hand and the instrument run is started so that the x-rays could pass through the sample and into the analyst hand, a rate of up to 28,000 mR/hour could be expected. At this rate, this scenario would exceed the U.S. extremity dose rate in less than 2 hours of improper use. Therefore the analyst must always review the safety procedures summarized in the RPP and review the XRF usage guide in the Innov-X instrument manual before testing.

Using the accepted ALARA (as low as reasonably achievable) concepts about radiation safety specified in the state and federal regulations, radiation exposure declines by controlling three factors: time, distance, and shielding. In the typical XRF application, all three factors can be managed best if the XRF test stand mode is used.

Chemical Exposure Prevention. Personnel that collect and prepare the samples for analysis are potentially exposed to high concentrations of toxic metals in the soil. The XRF project HASP should address the precautions like wearing the proper PPE (especially gloves) to reduce the contact hazards. Employees should simply avoid contact with the soil if at all possible. The XRF analyst must also use caution in handling the calibration verification standards. These standards are a series of certified NIST-traceable soils of low, medium, and high concentrations prepared in XRF plastic cups and sealed with Mylar film. They are very fragile and if broken, can expose the analyst to high levels of metals contaminated dust.

All employees working directly with the sampled soil must also wash their hands, arms, face, and any other exposed body parts before eating, drinking or smoking at the end of the work day, during lunch, or during other breaks. They should avoid hand-to-mouth contact to reduce the possibility of ingestion. Finally, when handling dried and crushed samples (or just especially dry and sandy native soils), employees should work under a hood or in a well-ventilated area (like outdoors) if at all possible. Dust filter masks that have a built in exhalation valve are recommended to protect against metals-contaminated dust inhalation. PPE, personnel decontamination, and inhalation precautions should be reviewed periodically during the field work and discussed frequently at tailgate safety meetings.

5.0 Equipment and Supplies

- XRF analyzer - An XRF analyzer should have two major components: the integrated instrument (batteries, trigger, x-ray tube, window, detector, and PDA) and the instrument test stand and its cables. The Innov-X manual will be included in the instrument kit. It's highly recommended to have at least one extra PDA stylus available. At least one Kapton replacement window will also be included in the kit.

- Stainless steel coupon (disk) for test stand mode or stainless steel clip for hand held mode to complete the required energy calibration. Only one of each is included per kit and they are absolutely necessary to operate the instrument.

- Calibration verification standards (blank silica sand and certified standard reference materials) prepared in XRF cups. Spare sand, SRMs, cups and Mylar film should also be available onsite to prepare replacement standards if needed.

- Spare battery and a charger. One battery should be charging at all times while the other battery is in use. Need to have electricity available onsite to charge battery or have a AC/DC converter to charge in the CB&I truck/vehicle.

- PDA cradle and cables for connection to laptop.

- Laptop computer with an available high speed USB connection. Laptop needs to have Microsoft ActiveSync software installed (available as a free download from Microsoft) and Excel from MS Office. Recommended that laptop have internet access and printing capabilities, especially for longer term projects. A USB data storage device (jump drive) is also recommended for file backup and transfer. Using a Bluetooth enabled laptop is also an advantage especially if the majority of samples will be analyzed in test stand mode.

- Per XRF analyst, a ring dosimeter and any associated documentation

- Hardcopies of the XRF analyst training records, state (or federal) XRF registration and authorization to operate letter, any specific documentation required in the authorization letter, Notice to Employees, radiation warning signs (Attachment D), and a copy of the approved work plan/HASP and final RPP.

- A copy of this manual and a copy of EPA Method 6200.

- Sample documentation – at least two standard forms: an XRF Calibration Form (modified for the project-specific SRMs used) and an XRF Sample Analysis Log. Results may also be documented in a bound field logbook, if required.

- Sampling and homogenizing tools (examples: steel trowel, hand rake, stainless steel spoons, stainless steel hand auger, disposable wooden spatulas, laboratory scoopula)
- Ziplock storage bags – gallon, quart, and pint-sized, storage or freezer. Surfaces should be smooth and have at least one non-printed side.
- Drying oven (if oven drying samples). Properly venting the oven to outside air is highly recommended.
- Oven-safe drying containers (disposable aluminum pans), if oven drying samples
- Wax paper – rolls or pre-cut sheets
- Mylar x-ray window film, XRF cups, and glass wool (if samples will be cupped).
- Mortar and pestle or soil grinder (if required)
- Sieves (1/4-inch or similar, and #10), sieve pan, and sieve brushes
- Coffee filters or paper towels for soil drying
- Waste container(s) for the IDW solid material that does not pass sieve and for left over samples not sent to the laboratory for analysis
- Indelible marking pens
- Paper toweling, disposable wipes, DI water in a spray bottle for equipment decontamination.
- Gloves, safety glasses, and dust mask (if crushing and sieving fine dried soils) or preferably a laboratory hood vented to the outside.
- Off-site laboratory sampling supplies – bottles, coolers, ice (if shipping on ice), large plastic trash bags, Ziplock bags for ice, chain-of-custody forms, sample labels, bubble wrap, tape, shipping papers (overnight air bills), and custody seals.

6.0 Standards

6.1 Standard Reference Materials

Standard reference materials (SRMs) are prepared soil samples containing certified concentrations of metals in soil or sediment. Typically SRMs are purchased from the National Institute of Standards and Technology (NIST) or commercial supplier such as Environmental Resource Associates (ERA) or Resource Technology Corporation (RTC) that provides NIST-traceable standards. They are used for accuracy and performance checks of XRF analyses. Three standards containing the analytes of interest at low, medium, and high levels are recommended to verify the instrument performance across a range of concentrations. Historical concentrations at the site and the concentrations of any project-specific regulatory clean up or remedial goals or action levels of the analytes of interest will be evaluated in the selection of SRMs. The instrument kit will contain several SRMs. Contact CB&I Equipment Division for a current list.

Site-specific SRMs made up of a site soil which are prepared (dried, crushed, and sieved), thoroughly homogenized, and split with fixed-base laboratory for comparison analysis are not typically used to support XRF projects that generate data of “screening level” quality. If sufficient number of analytical replicates (recommended 10 and a minimum of 3 per sample) is performed at the fixed-base laboratory, the average result may be acceptable to use as a “certified” standard if the replicates agree within a 15% relative standard deviation. Method 6200 has more specific details about site-specific SRMs.

6.2 Blanks

A blank sample of “clean” silica dioxide or quartz sand that is free of any of the analytes of interest at the detection limits is required. Usually this material will be supplied by the instrument manufacturer and is included in the test kit.

7.0 Quality Control

7.1 Data

All field data sheets and quality control data should be maintained for reference or inspection.

7.2 Calibration

Unlike other types of field instruments, the Innov-X XRF is factory calibrated and is not adjustable in the field. It uses a fundamental parameters calibration software routine. The details of instrument calibration are discussed in the manufacturer's operator manual. The XRF analyst is only therefore required to check the accuracy of the instrument and not adjust the calibration or prepare a calibration curve in the field.

The Innov-X instrument undergoes an internal system check during start up or when the instrument is reset. The manual highly recommends that the instrument start up include at least a 15 minute warm up period for the detector and internal electronics to achieve steady state before beginning any analyses. Next the XRF analyst must perform an energy calibration using the stainless steel coupon (if using the test stand) or clip (hand held mode) after a successful system check. Energy calibrations are recorded in the XRF data logger and should be transferred to the reporting Excel spreadsheet at the end of the day. Energy calibrations should be performed at least once during the day along with a mid-point SRM to verify accuracy. Usually this check is performed at mid-day or when a battery change out is required. If the instrument is turned off for any reason, this process must be repeated (including the 15 minute warm up).

7.3 Calibration Verification Checks

A calibration verification is performed using the blank and SRMs to check the accuracy of the instrument, to assess the instrument's "zero" response, and check the XRF stability for analytes of interest. The full suite of check samples (blank and three SRMs) should be analyzed at least at the beginning of each day. Additional checks should be analyzed both during the day (mid-day standards) and at the end-of-day depending on the total number of samples that are analyzed. Mid-day and end-of-day standards should consist of at least the blank and the mid-point standard. The instrument count time of the calibration check should be the same as the analysis time of the field samples (60 to 120 seconds are typical).

In general, the measured value for each target analyte should be less than 20% difference (%D) from the certified value. The %D is defined as the absolute difference divided by the certified

value and is expressed as a percent. If the %D falls outside this range, the check should be reanalyzed. If the value is outside the acceptable range again, the analyst should note this condition on the calibration log form. At very low concentrations near in the detection limit, exceedances of the 20% criterion are not uncommon. Restandardization with the stainless steel coupon or clip followed by re-analysis of the SRM should occur if the both the original and re-analysis are outside 20% D. In the unlikely event that the SRM results still are outside the 20% criterion, Innov-X technical support should be contacted for further directions.

Depending on the objective of the XRF measurements, the analyst should consider increasing the count time of the verification check (and also the field samples) to determine if the XRF measurement accuracy would improve with increased x-ray exposure.

7.4 Blanks

A blank sample of quartz or silica dioxide sand should be analyzed at the beginning of each day. No analytes of interest should be detected above the typical detection limit (Table 1).

7.5 Detection Limits

The Innov-X XRF calculates and reports the detection limit for each metal on a sample-specific basis. These are based on the standard deviation of the measurement and compensate for inter-element interferences present in the sample. Three times the standard deviation (3σ) is reported by the XRF as the typical detection limit (e.g. reported on the screen along with a "<LOD" result). This standard deviation can be theoretically decreased by increasing the instrument count time as appropriate to meet the objectives of the work. Typically the Innov-X analysis run is 60, 90, or 120 seconds. Beyond 120 seconds, the improvement of the detection limit becomes less and less.

The instrument count time can be increased if necessary to meet the needed data objective. Typically 60 seconds is the shortest duration for XRF analysis of soil samples, 90 seconds is average, and 120 seconds is also common, especially when arsenic is of concern. The analyst should always be aware of the detection limits in the blank, SRMs and in the field samples and make needed changes in the count time to achieve the detection limits needed to support the project. All count times should be consistent for the blank, SRMs and the samples. Review the XRF manual to find the procedure to change the instrument count time.

Typical limits are shown on Table 1 for a blank, silica sand matrix that were analyzed for 90 seconds. The silica sand blank represents a matrix-free environment and inter-element interferences are minimized. Detection limits achievable on actual field samples will probably be higher.

8.0 Procedure

Before operating any XRF instrument, consult the manufacturer's manual.

8.1 Instrument Warm-up and Operating Environment

After installing a newly charged battery, turn the instrument on and allow it to warm-up for at least fifteen minutes. The instrument performs best in a dry, temperature-controlled environment. The Innov-X can be operated in light to moderate rain (as long as the instrument and sample remain dry) and in relatively high and low ambient temperatures. Caution should be taken to protect the PDA from direct exposure to strong sunlight (by covering the instrument screen or operating in the shade). If the internal temperature of the XRF exceeds operating specifications, the instrument will show a warning message on the display screen and shut down. If this rare event does occur, the analyst should leave the instrument off and move the XRF to a lower temperature environment (interior of an air conditioned building or car) for 15 to 30 minutes and then restart the instrument and recalibrate.

8.2 Internal Calibration

CB&I has developed an XRF calibration form and sample result form that can be adapted for each individual project. They are included as Attachment E. The following procedure steps are summarized on the calibration form.

Check the PDA clock date/time and also verify that it is correctly reading “AM” or “PM” before beginning analysis. Adjust the time for the local time zone if needed. This is a very important step because all the XRF analytical results will be date/time stamped using the PDA clock time.

Either assemble and mount the XRF in the test stand or if the instrument will be used to collect direct measurements in hand held mode, immediately begin the automated internal calibration/equipment check sequence of the XRF. Remember to wait at least 15 minutes after start up before continuing. Use the stainless steel coupon (disk) in test stand mode or use the “clip on” attachment for hand held mode when prompted to do the energy calibration. Document that the instrument passes the energy calibration check by recording the energy resolution on the calibration form.

8.3 Blank Analysis

After completing a successful internal/energy calibration sequence, analyze a silica dioxide or quartz sand blank. If the XRF is mounted in the test stand, the polyethylene sample cup is placed directly over the instrument window with the cup's Mylar film facing down. Close the test stand cover and initiate analysis using the PDA touch screen.

In hand held mode, position the cup with the film window facing up and align the XRF window over the cup. Hold the instrument in place and depress the trigger to start analysis. Carefully hold the XRF to maintain good contact with the cup's film window. Do not push down on the instrument as the cups and film windows are very fragile and will rupture easily and may spill high concentration metals-contaminated dust. To avoid x-ray exposure, do not ever hold the XRF cup in your hand when analyzing the samples and make every effort to keep hands and fingers away from the XRF barrel and window.

The XRF will open the shutter and test for the presence of the sample. If the sample is in place and fluorescence is detected, the instrument will begin analysis. The instrument-mounted and/or test stand-mounted red strobe light will flash to indicate the analysis is underway. After a minimum count time of at least 60 seconds (or approximately 90 seconds of actual elapsed clock time), the analysis will be automatically terminated with the PDA control. Once the run has started, it must be completed before disengaging the XRF from the sample. If the cup is moved or the test stand cover is opened during a run, the XRF will stop the run and report an error message on the PDA. Use the PDA-based control button to terminate the run early, or if analyzing in hand held mode with the deadman trigger engaged, simply release the trigger to abort the run.

When the run is complete, the PDA will display the final XRF results of the run – up to 21 metal concentrations and their standard deviations (in units of part-per-million). The software will prompt the analyst for the text entry into multiple data fields designed to identify the sample/run ("Test Information" Mode). For the calibration blank and standards, use the pop-up keypad on the PDA to type the identifying information into these fields for data log storage. When the data are transferred electronically, these fields are transferred along with the analytical results to help identify the sample. See the XRF manual for the specific software mode screens and how to switch from one to another. Record results on the XRF Calibration Form (Attachment E) or a bound logbook may be used instead.

Detection Limits. Constantly review the achieved detection limits in the blank and assess them for the project analytes of interest. Make adjustments in the XRF count time as necessary to meet the project DQOs.

8.4 Calibration Check Verification

After successful analysis of a blank, analysis of a series three concentration level SRMs is recommended (low, medium and high level) depending on project objectives and the availability of SRMs. The sample cup containing the SRM is analyzed in the same manner as the blank. After a count time of at least 60 seconds (as set up by the analyst), the analysis will be completed automatically by the software. Record identifying sample information on the PDA popup key pad and manually on the XRF Calibration Form.

8.5 Sample Analysis

After successful verification of calibration, sample analysis can begin. Follow the procedures described in Sections 2.3 and 2.4. After a count time of at least 60 seconds, the analysis will be completed automatically. Record identifying sample information with the PDA popup key pad and record results manually on the XRF Sample Analysis Log (or similar form or logbook). Ensure that the sample depth is recorded in one of the Test Information fields to help identify the sample if multiple depths of collection are planned at one location (soil borings or post-excavation confirmation sampling, for example). If replicate measurements of the same sample are collected, make sure they are documented and reported together and the average concentration and precision are calculated. Usually the designations “(R2)” and “(R3)” are used as suffixes to designate duplicate and triplicate measurements of the same sample. Section 2.4.3 discusses replicate analysis in more detail.

Off-site Laboratory Analysis. Immediately after analysis, the prepared sample can be archived for up to 6 months at room temperature for confirmation metals analysis at an off-site laboratory (unless mercury is a site contaminant of interest). It is recommended that the sample be sealed in a labeled Ziplock storage bag and placed in refrigerated onsite storage for archive if possible. If the sample is to be sent for off-site laboratory analysis, then no further processing is necessary, however it is highly recommended that the sample be analyzed in triplicate with the XRF to gain the maximum amount of information about the sample prior to shipping to the laboratory. Once analyzed with the XRF, the samples should be directly transferred from the Ziplock storage bag

into the laboratory-provided glass wide-mouth containers for labeling and shipping using the project chain-of-custody forms.

Following sample preparation and analysis, all disposable materials that have come in contact with the soil will be discarded appropriately. Materials that are reusable will be decontaminated using brushes, disposable wipes, paper toweling, and air drying.

8.6 Post-Sample Analysis Calibration Check Verification

After daily analysis of project field samples, the calibration should be verified at the end of the analysis cycle to document instrument stability. Repeat step 8.3 in total or use a blank and the mid-level SRM. The necessity of this check depends on the project objectives and the number of samples analyzed in a day.

9.0 Data Analysis

Forms. All data from the XRF is manually captured and reported by the analyst using project-specific forms (Attachment E) or logbook. Forms will be used to record the sample collection, preparation, and analysis and XRF instrument calibration. Electronic and hardcopy field data are then compared by the XRF analyst before release to check the data quality. Finalized hardcopy records are stored onsite until the end of the task or project and then brought back to the CB&I office for organization, management, copying, and storage.

Electronic Data. The XRF is capable of storing results and spectra for thousands of samples. Data is stored in the PDA by analysis date. At the end of each day's analysis, the days results should be exported to a ".CSV" file on the PDA hard drive using the Innov-X software (review the procedure in the instrument manual). PDA should be removed from the XRF and placed in the cradle attached to the laptop. Using Microsoft ActiveSync software, the data will be transferred from the PDA hard drive to the laptop as a ".CSV" file. This type of file can be directly imported into Excel for data reduction and reporting. Downloads will occur according to project-specific requirements.

The downloaded spreadsheet data will include specific fields such as the sequential run number for a given day, the date/time stamp of the analysis, the count time, and the analyst entered sample ID fields (location and depth, for example) as well as all of the instrument-measured data – the concentrations of up to 21 metals and the standard deviation of each measurement in parts-per-million. Using the Excel "Data Sort" or "Data Filter" commands the analyst can then sort, filter, and format a variety of data reports tailored for the specific needs of the task.

The XRF analyst will make sure that multiple copies of the raw data exist – at least both on the PDA hard drive and on the laptop hard drive. Data reduction can then occur on the working Excel spreadsheet version of the raw data files. Reduction would include sorting the data, reviewing QC checks, and calculating average concentrations and RPD/RSD for replicate analyses. Manipulated data are then stored separately from the raw .CSV files as an Excel spreadsheet file (".XLS") on the laptop hard drive and sent usually via email to the project team for review.

In addition to the XRF recorded data, at this point the XRF analyst could insert blank columns and import X,Y coordinate data from either a GPS or from surveyors to assist GIS processing.

GIS is a powerful tool to organize and present the XRF data in a map format for visual interpretation.

Bluetooth Transfer. Another option for transferring data files from the PDA to a computer utilizes wireless Bluetooth technology that is built-in to the Innov-X instrument. This technique allows the PDA to remain in the instrument socket and automates the data transfer procedure. This eliminates the need to manually remove the PDA from the XRF.

The procedure for setting up a Bluetooth file transfer protocol is detailed using the File Transfer Function "Sync Manager," in the "Pocket Controller Professional" software available from SOTI (www.soti.net). See Attachment F - "Sync Manager Pocket Controller Pro" for configuration instructions. Sync Manager is the software tool used to manage all of the synchronization settings and rules. It allows Pocket Controller to synchronize the files/folders, their locations, and how and when to synchronize them. By using Sync Manager, data is kept up-to-date between the PDA and computer according to the user-specified rules.

9.1 Exporting Data

Exported data is saved as comma delimited files. To transfer data to a laptop, ActiveSync must be installed on the computer. This program is available for free from Microsoft's website. The transfer procedure is initiated while in the "Innov-X RESULTS" screen.

Data Export Procedure

Export Data files from the PDA while in the "Innov-X Results" screen.

1. Choose File → Export Readings
2. Select readings to be exported. <Tap> OK
3. Input filename, folder, <Tap> OK

The results will be stored in the default, "My Documents," folder on the PDA. Perform this procedure daily after the last sample is analyzed on the XRF.

ActiveSync Installation Procedure

Do the following steps to install ActiveSync:

1. To start the installation, run the "Install ActiveSync" program.
2. Complete the install process
3. Restart the computer.

4. After restarting, insert the PDA dock into a free USB port on the computer. Dock the PDA in the cradle. The PDA should immediately communicate with the computer.
5. When the computer communicates, you will be prompted to "Set Up a Partnership."
6. Select, "Yes" with this computer.
7. Enter a name for the PDA and <click> next.
8. You will be prompted to "Select Synchronization Settings." Select "Files" only.
9. Step through the rest of the process.
10. A folder will be automatically created on the laptop desktop with the name of the device entered in Step 7.

Procedure for Data Transfer from PDA to PC using a PDA Cradle:

1. Insert the PDA Cradle into the laptop USB port.
2. Place the PDA in the PDA Cradle.
3. The PDA should immediately communicate with the computer and transfer result files.

9.2 Data Management

Large amounts of data can be generated while analyzing soil samples. It is essential that the data is properly managed and backed up on a daily basis or whenever new data is generated.

It is recommended that the raw data files be backed up daily on a removable media such a USB drive. It is possible to have up to 50 fields for each sample analyzed. These fields include count time, date, time, run number, calibration check, sample ID, metal concentration and standard deviation data.

The Innov-X instrument exports the data into a comma separated variables (.CSV) format. Once saved on the computer, for data integrity purposes, these files should be stored in a unique subdirectory. For example, the subdirectory should be named "RAW Data." The original .CSV files should not be edited. A second subdirectory should be created and named, for example "MANAGED data." For editing and data management purposes, .CSV files should be imported into Excel and saved in an Excel (.XLS) format in the "MANAGED" subdirectory. The analyst can then select the information appropriate to the project as required to meet the project objectives. Multiple .XLS files can be combined into daily, weekly, or end-of-project data reports for data management.

It is highly recommended that all data from the RAW and MANAGED subdirectories be copied onto CD or dedicated USB storage device for long-term storage and archiving at least once (for short-term projects) or alternatively, several times during the project lifespan (for long term projects).

10.0 Waste Management

No liquid waste should be generated from the analysis of soils by XRF. All sample debris (what does not pass the sieves), used personal protective equipment, and laboratory waste will be collected and disposed in compliance with project-specific waste management practices. Archived soil samples can be held for up to 6 months at room temperature without preservation before disposal.

11.0 References

Innov-x User Instruction Manual, Innov-X Systems Alpha Series X-Ray Fluorescence Spectrometers, P/N 100392, Revision B, March 2007.

U.S. Army Corps of Engineers (USACE), 2008, USACE-Omaha District, Military Munitions Design Center, *Small Arms Range Characterization of Lead Using X-Ray Fluorescence (XRF)*, Revision 1, December 4, 2008.

U.S. Environmental Protection Agency (EPA), 1996, Region 1, EPA-New England, ***Standard Operating Procedure for Elemental Analysis using the X-MET 920 Field X-ray Fluorescence Analyzer***, October 1996.

U. S. Environmental Protection Agency (EPA), 1998 and 2007, Test Methods for Evaluating Solid Waste, Physical/Chemical Properties, SW-846, Method 6200, ***Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment***, February 2007 (latest EPA method revision at the time of Revision 2.0).

Pocket Controller-Professional Software; v 5.07 build 966; www.SOTI.net

Attachment A

XRF Project Planning and Setup, a Checklist of Questions to Consider

XRF Work Instruction, Attachment A - XRF Project Planning and Setup: A Checklist of Questions to Consider

A. Refine the XRF scope of work

- ☐ 1. Is this work an investigation? Remediation? Remediation with investigation?
- ☐ 2. What's the site history? Has a conceptual site model been developed?
- ☐ 3. What is the form of the contamination source (fragments, dust, chips, solvents)?
- ☐ 4. Is there any previous data? Can you relocate the sample points?
- ☐ 5. What are the metals of concern? What are their regulatory/screening levels? Are the metals of interest detectable by XRF at the action levels?
- ☐ 6. Are there sediments from streams or wet areas that will need sampling as well?
- ☐ 7. If more than one metal, are they co-located or spread? Are there any organic contaminants also onsite (skeet pigeons containing PAHs for example)?
- ☐ 8. If an investigation, what are the site dimensions? Can a sampling grid be established? If gridded, how large are the squares? How many nodes (points) are there to sample?
- ☐ 9. If a remediation, have the excavation limits been fully defined? How will post-excavation samples be collected? What are the depths of excavation?
- ☐ 10. Is there any UXO possible? Is a UXO plan required?
- ☐ 11. What are the provisions for offsite analytical? Frequency of collection? Lab contact?

B. Set up logistics and staffing of the project

- ☐ 1. What is the field scheduled start date? Field duration? Any major breaks in schedule?
- ☐ 2. Is there a work plan in place and is it approved? If so, can it be modified?
- ☐ 3. How many field staff will be required? Will a 2-man sampling team and an XRF analyst approach be used (3 persons onsite, 50-70 samples/day) or will XRF analyst also sample (2 total onsite, 30-50 samples/day)?
- ☐ 4. Is there a trained XRF analyst available? Do they have an XRF training certificate?
- ☐ 5. Has CB&I Equipment in Findlay OH been contacted about XRF availability?
- ☐ 6. If CB&I XRF is not available, can schedule be altered or will a rental XRF be needed? (Note: If a rental unit is used, the same radiation safety procedure [See Part D] still applies).

C. Procure XRF, supplies, and equipment

- ☐ 1. Is there a secure place onsite (preferably with electricity) where the XRF can be staged/operated? Is it accessible to CB&I?
- ☐ 2. Has someone sent the schedule, site address, job number, and XRF analyst info to CB&I Equipment to reserve the XRF?
- ☐ 3. Are the metals of interest also present in the XRF calibration standards at appropriate concentration levels? Should new standards be purchased?
- ☐ 4. If a sample grid is planned, are surveyors subcontracted or is CB&I going to use GPS or other survey techniques to establish grid?
- ☐ 5. Have arrangements been made to locally procure consumable sampling supplies?
- ☐ 6. If a significant number of samples will be dried, is a laboratory oven needed?
- ☐ 7. Consider the sample prep procedure carefully. What will be required to complete? Are special tools required? Will sample prep reduce the number of planned samples/day?
- ☐ 8. Once samples are prepared/analyzed is there enough space to store them onsite in archive for possible lab analysis (if needed)?
- ☐ 9. Have provisions been made for handling/disposing of IDW (residual soils after analysis)?
- ☐ 10. Does the XRF analyst have access to a laptop? Does it have ActiveSync software installed? Will they have printer access onsite or internet access?
- ☐ 11. Have the laboratory-provided supplies been arranged for offsite sample shipments?

D. Ensure radiation safety compliance - (Begin this process early!)

- ☐ 1. Determine if the project falls under state jursidiction (is the site on public/private land?) or federal laws (is site the on a federal government facility?).
- ☐ 2. Has the XRF RSO reviewed the radiation registration requirements for the state (if site is on private/public land)? Alternatively, has the responsible person/group (if site is on a Federal Government facility) been contacted by the RSO about the XRF?
- ☐ 3. If state is the authority, have the correct registration or notification forms been completed and returned for review and approval? (Note: the approval process could take several weeks)
- ☐ 4. If a federal facility, have their requirements been met?

- ☐ 5. Has authorization to operate been received from the registration or permit-issuing agency? Have these approvals been passed on to CB&I Equipment? Are copies available on site?
- ☐ 6. Has the XRF RSO completed the required Radiation Protection Plan (RPP), and sent it to the management and safety team personnel for review and approval?
- ☐ 7. Once finalized, has a copy of the RPP been sent to CB&I Equipment and are copies available onsite? Is it reviewed by all employees as part of onsite H&S training?
- ☐ 8. Has the XRF analyst dosimetry been considered and set up with the CB&I Radiation Protection Program?
- ☐ 9. Has the state-specific "Notice to Employees" rules been researched, printed out, and posted at the job site?
- ☐ 10. Are radiation warning signs in place at the job site and is the required safety zone around the instrument being maintained?
- ☐ 11. Is the analyst aware of and prepared to emplement all state-required and/or facility-required notifications, monitoring, testing, and training requirements to operate the XRF?

E. Anticipate data flow and responsibilities

- ☐ 1. What decisions will be made using the XRF data versus the data provided by the off-site laboratory?
- ☐ 2. Determine how the XRF data will be generated, reviewed and reported onsite. To whom will the XRF analyst report the data? How often? In what format?
- ☐ 3. Will the data be used by GIS for map making? Are GPS/survey data needed as well? Who will be responsible for GPS/survey data?
- ☐ 4. Who will select the samples for off-site laboratory analysis? What criteria will they use? What's the frequency of laboratory split samples?
- ☐ 5. Who will receive the off-site lab data? How will it be incorporated into the data flow?
- ☐ 6. Will the XRF analyst need to keep a logbook in addition to the sampling/analysis documentation?
- ☐ 7. Are site photographs required?
- ☐ 8. What will the XRF analyst do with the electronic data, photos, and hardcopy forms at the end of the project?
- ☐ 9. Is the XRF analyst expected to produce the final report (or participate in it)?

XRF Work Instruction, Attachment A - Part 2: An Equipment and Materials Checklist

Order	Rcvd	
		XRF analyzer - An XRF analyzer should have two major components: the integrated instrument (batteries, trigger, x-ray tube, window, detector, and Alpha PDA) and the instrument test stand and its cables. The XRF manual will be included in the instrument kit. It's highly recommended to have at least one extra PDA stylus available. At least one Kapton replacement window will also be included in the kit.
		Stainless steel coupon (disk) for test stand mode or stainless steel clip for hand held mode to complete the required energy calibration. Only one of each is included per kit and they are absolutely necessary to operate the instrument.
		Calibration verification standards (blank silica sand and certified standard reference materials) prepared in XRF cups. Spare sand, SRMs, cups and Mylar film should also be available onsite to prepare replacement standards if needed.
		Spare battery and a charger. One battery should be charging at all times while the other battery is in use. Need to have electricity available onsite to charge battery or have a AC/DC converter to charge in the CB&I truck/vehicle.
		PDA cradle and cables for connection to laptop.
		Laptop computer with an available high speed USB connection. Laptop needs to have Microsoft ActiveSync software installed (or Microsoft Windows 7) and Excel from MS Office. Recommended that laptop have internet access and printing capabilities, especially for longer term projects. A USB data storage device (jump drive) is also recommended for file backup and transfer. Using a Bluetooth enabled laptop is also an advantage especially if the majority of samples will be analyzed in test stand mode.
		Per XRF analyst, a ring dosimeter and any associated documentation
		Hardcopies of the XRF analyst training records, state (or federal) XRF registration and authorization to operate letter, any specific documentation required in the authorization letter, Notice to Employees, radiation warning signs, and a copy of the approved work plan/HASP and final RPP.
		A copy of the XRF Work Instruction and a copy of EPA Method 6200.
		Sample documentation – at least two standard forms: an XRF Calibration Form (modified for the project-specific SRMs used) and an XRF Sample Analysis Log. Results may also be documented in a bound field logbook, if required.
		Sampling and homogenizing tools (examples: steel trowel, hand rake, stainless steel spoons, stainless steel hand auger, disposable wooden spatulas, laboratory scoopula)
		Ziplock storage bags – gallon, quart, and pint-sized, storage or freezer. Surfaces should be smooth and have at least one non-printed side.
		Drying oven (if oven drying samples). Properly venting the oven to outside air is highly recommended.

XRF Work Instruction, Attachment A - Part 2: An Equipment and Materials Checklist

Order	Rcvd	
		Oven-safe drying containers (disposable aluminum pans), if oven drying samples
		Wax paper – rolls or pre-cut sheets
		Mylar x-ray window film, XRF cups, and glass wool (if samples will be cupped).
		Mortar and pestle or soil grinder (if required)
		Sieves (1/4-inch or similar, and ASTM #10), sieve pan, and sieve brushes
		Coffee filters or paper towels for soil drying
		Waste container(s) for the IDW solid material that does not pass sieve and for left over samples not sent to the laboratory for analysis
		Indelible marking pens
		Paper toweling, disposable wipes, DI water in a spray bottle for equipment decontamination.
		Gloves, safety glasses, and dust mask (if crushing and sieving fine dried soils) or preferably a laboratory hood vented to the outside.
		Off-site laboratory sampling supplies – bottles, coolers, ice (if shipping on ice), large plastic trash bags, Ziplock bags for ice, chain-of-custody forms, sample labels, bubble wrap, tape, shipping papers (overnight air bills), and custody seals.

Attachment B

Setup "Pocket Controller Pro" Bluetooth Software Instructions

Innov-X Systems Pocket Controller Setup Instructions

(This document assumes that you have Microsoft Active Sync v 4.0.2 or later installed. If not, download the latest version from Microsoft's web site.)

I. Downloading and installing "Pocket Controller Professional"

1. Download and install the Pocket Controller Professional software from the Internet: http://inx.innovxsys.com/support/PCPro507Setup.exe
2. Run the Pocket Controller Professional set up file you have saved to your desktop.

3. Follow the on-screen instructions to finish the installation.

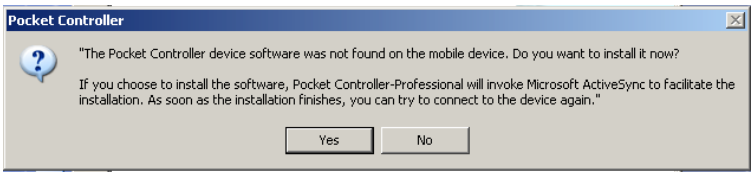
II. Installing the "Pocket Controller Professional" software onto Your iPAQ

1. Place the iPAQ into the cradle and connect it to your computer. The software may begin to automatically install, if it does, skip to step 5.

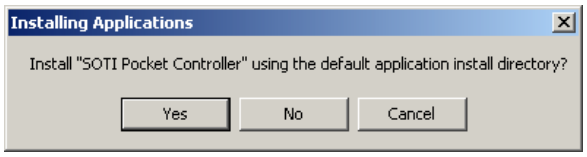
2. Once ActiveSync has started up and asked you to create a partnership (you can cancel out of creating a partnership) start the Pocket Controller Professional software on the PC.

3. Click the "Start" Button in the upper right hand corner of the Pocket Controller Professional software.

4. You will be asked about installing the client software to the iPAQ. Click Yes.



5. You will be asked if you would like to install to the “Default Installation Directory.” Click Yes.

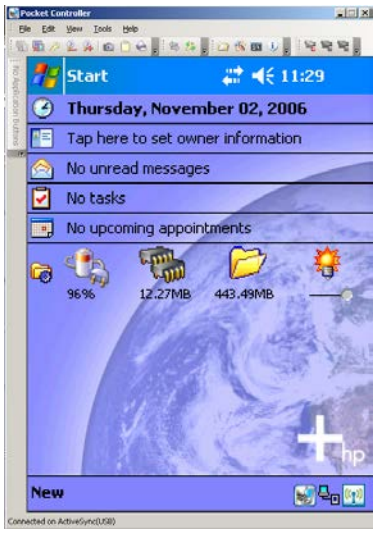


6. The iPAQ will ask you if you would like to install the software to the “Device” or “Storage Card.” Select “Device” and tap Install. When it tells you that installation is complete, tap the OK button in the upper right hand corner of the screen.

7. In the Pocket Controller software, click “Tools” and select “Configure.”

8. Click the “Edit Connection” button. Under the “Connection Type” box change the “Connect Mode” to “Standard.” Click OK twice so that you are back at the Pocket Controller home screen.

9. After the software is finished installing, click “Start” in the Pocket Controller software to test the software. The iPAQ screen should show up on your PC, and you should now be able to control the iPAQ from the Pocket Controller Software on the PC.



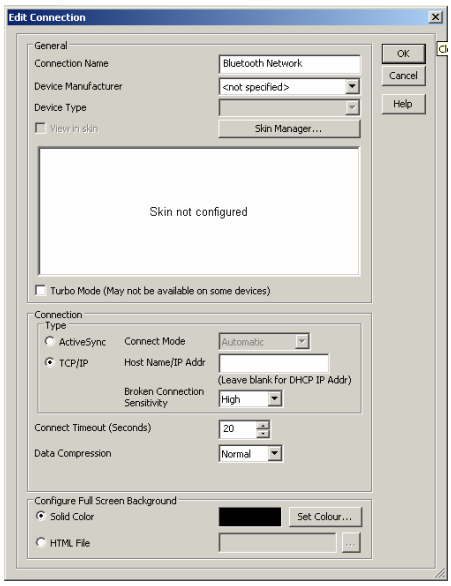
10. Click the file menu and choose ‘Disconnect’.

III. Configuring the Pocket Controller Software to connect to the iPAQ over Bluetooth

1. From the Tools menu in the Pocket controller software, select ‘Configure’.

2. Click the “New Connection…” button.

3. In the box marked “Connection Name” type in “Bluetooth Network”, Under connection type select ‘TCP/IP’, and click OK twice so that you are back at the Pocket Controller home screen.



IV. Configuring the iPAQ to create a Bluetooth network connection with the computer.

1. Go to the Today screen on the iPAQ.

2. Tap the iPAQ wireless icon in the lower right hand corner of the screen. (Shown in the red box in the image below).

3. Turn on Bluetooth by tapping the Bluetooth logo so that the blue light on the iPAQ begins to flash. (If the light is already flashing, Bluetooth is already on).

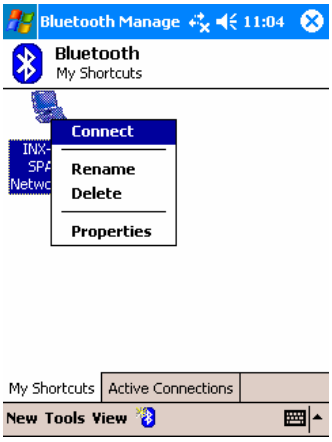
4. Tap the “Manager” button.

5. Tap on the new menu and select “Explore a Bluetooth device”.

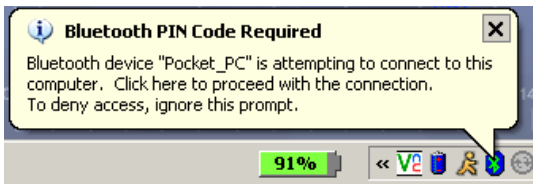
6. The Bluetooth browser will prompt you with a list of Bluetooth enabled devices in the area, select your PC.

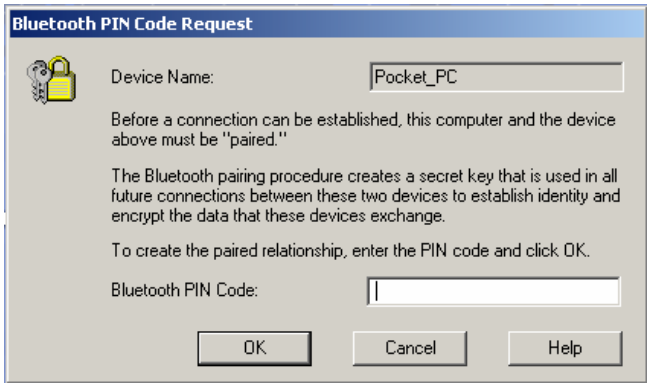
7. A service selection screen will pop up. Select “Network Access” and click Next. Click Finish. This will return you to the “My Shortcuts” screen.

8. Tap and hold on the new shortcut you just created for Network Access and select “Connect.”



9. On your PC, you may get a box asking for a Bluetooth PIN code. Click on this box and specify a code of 1234.





10. When you click OK, you should get a similar authorization message on your iPAQ. Type in the same code and tap “OK”.

11. On your PC, you will get a box in the lower right hand corner of your screen telling you that the iPAQ is attempting to connect. You must click on this box and select “allow”. (Recommended: Check off the check box marked “Always allow”).

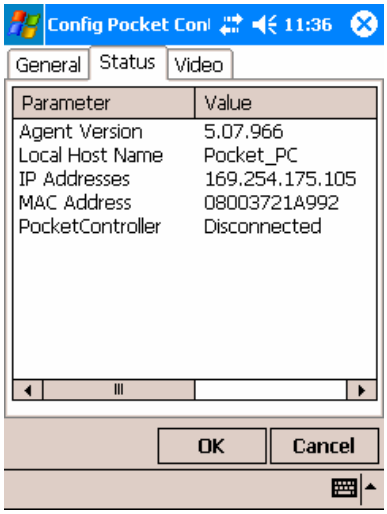
12. Your iPAQ and PC should now have a working Bluetooth network connection between the two of them.

V. Initiating a connection to the iPAQ over Bluetooth.

1. Remove iPAQ from cradle and insert into instrument.

2. On the Today screen, tap on the Pocket Controller logo (to the left of the iPAQ Wireless logo in the bottom right corner of the screen) and select “Configure”.

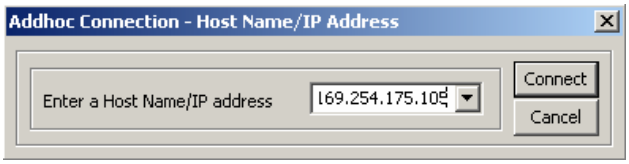
3. Go to the “Status” tab of the configuration option.



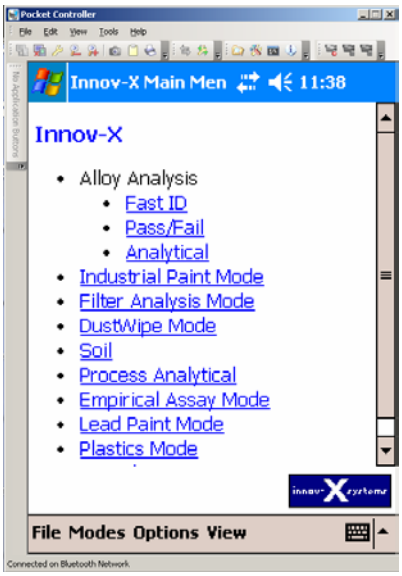
4. Look for the IP Address value, and write the number down. If the IP address is 127.0.0.1, that means the Bluetooth IP address has not refreshed. Tap on the “OK” button at the bottom of the screen, and then repeat these steps from Step 2. If you still see 127.0.0.1, please repeat the steps in part IV.

5. On the Pocket Controller software on the PC, click the “Start” button. It will prompt you which type of connection you would like to use. Select “Bluetooth Network”. Click OK.

6. Now type in the IP address that you wrote down from the iPAQ and click OK.



7. The iPAQ screen should now show up in the Pocket Controller software, and you should be all set.



8. To change the size of the iPAQ display on the PC, go to the “View” menu, and the “Zoom” sub menu. Recommended sizes are 100% and 200%, the other sizes look much more blurry.

Attachment C

List of State Radiological Oversight Agencies

State	Contact	Form	Instructions
New			
AAAlists	state radiation safety state regulations state radiation programs Radiation Control Programs NRC Innov-X Manual Excerpt - Radiation Safety		
Alabama	Jim McNees Office of Radiation Control Alabama Dept. of Public Health The RSA Tower, Suite 700 P.O. Box 303017 Montgomery, AL 36130-3017 (334)206-5391 FAX (334)206-5387 jmcnees@adph.state.al.us	Call 334-206-5391	AL Radiation Control No fee. Registration required within 30 days of receipt of device.
Alaska	Clyde E. Pearce, MEd. 4500 Boniface Parkway Anchorage, AK 99507-2107 (907) 334-2107 (voice) (907) 334-2161 (fax) clyde_pearce@health.state.ak.us	Registration Application	AK Radiological Health
Arizona	Robert H. Cope Program Manager, X-ray Compliance Program Arizona Radiation Regulatory Agency 4814 South 40th St. Phoenix AZ 85040 (602) 255-4845 x231 FAX (602) 437 0705 rcope@arra.state.az.us	Instructions General Form (ARRA-4) Specific (Industrial Gauge) Form - ARRA-4IG	Innov-X must be registered (blue form, no fee). Innov-X must inform ARRA of sale into Arizona. ARRA will send the relevant forms (ARRA-4, ARRA-4IG) to the customer. Innov-X may provide on website, or a link to the ARRA site. Customer fee, $36 per calendar year per tube. Could be pro-rated if necessary.

State	Contact	Form	Instructions
Arkansas	William (Rick) Kelley, Radioactive Materials Program, Department of Health 4815 West Markham Street, Slot #30 Little Rock, AR 72205-3867 (501)661-2301 FX (501)661-2849 wkelley@healthyarkansas.com	XRA-19	$50 fee for each device up to maximum of three. XRF Analizer falls under "Other" category on XRA-19. AR Radioactive Materials
California	Victor Anderson Radiologic Health Branch Division of Food, Drugs, and Radiation Safety California Department of Health Services P.O. Box 942732 Sacramento, CA 94234-7320 (916)322-3482 FAX (916)324-3610 VAnderso@dhs.ca.gov	CA Form Downloads	CA Radiologic Health
Colorado	Eugene W. Potter, CHP, Manager Radiation Management Program, HMWMD-B2 Hazardous Materials & Waste Management Division Department of Public Health & Environment 4300 Cherry Creek Drive South Denver, CO 80246-1530 (303)692-3428 FAX (303)759-5355 Eugene.Potter@state.co.us	Robert M. Quillin - Director Laboratory & Radiation Control Division Colorado Dept. of Public Health & Environment 8100 Lowry Blvd Denver, CO 80220-6928 (303) 692-3038 (303) 343-3697 robert.quillin@state.co.us	CO Radiation Safety
Connecticut	Andrew Zwick Division of Radiation Department of Environmental Protection 79 Elm Street Hartford, CT 06106-5127 (860)424-3029 FAX(860)424-4065 andrew.zwick@po.state.ct.us	in contact with Don Sackett	CT Xray Registration

State	Contact	Form	Instructions
Delaware	Frieda Fisher-Tyler, Administrator Office of Radiation Control Division of Public Health P.O. Box 637 Dover, DE 19903 (302)744-4546 FAX (302)739-3839 frieda.Fisher-Tyler@state.de.us	forms on web site, no fee	Radiation Control
District of Columbia	Harold Monroe, Bureau Chief Department of Health Environmental Health Administration Bureau of Food, Drug, and Radiation Protection 51 N Street NE, Room 6025 Washington, DC 20002 (202)535-2188 FAX: (202)535-135 hmonroe@dchealth.com		DC Radiation Protection
Florida	Philip Thomas, Don Steiner (904) 395-6363. RadiationControl@doh.state.fl.us		FL Regulations Chapter 10D-89 of FL code Must register within 30 days of installation. Registration fee is $47.
Georgia	Jodie Matthews DHR Two Peachtree Street, NW Atlanta, Georgia 30303-3186 (404) 657-7993 or Jodie Matthews (404) 657-5400 jrmathew@dnr.state.ga.us		GA Environmental Protection

State	Contact	Form	Instructions
Hawaii	Lynn M. Nakasone Supervisor, Radiation Section Noise, Radiation & IAQ Branch Department of Health 591 Ala Moana Boulevard Honolulu, HI 96813-4921 808)586-4700 FAX (808)586-5838 rtakata@ehsdmail.health.state.hi.us		HI Radiation HI Regulations
Idaho	Doug Walker, Senior Health Physicist Development of Environmental Quality 900 N. Skyline, Suite C Idaho Falls, ID 83402 (208)528-2617 FAX (208)528-2605 dwalker@deq.state.id.us		ID Environmental Quality
Illinois	Paul Brown or Don Agnew Division of Electronic Products Illinois Department of Nuclear Safety 1035 Outer Park Drive Springfield IL 62704 (217) 785-9968 brown@idns.state.il.us.	Gary N. Wright, Assistant Director Illinois Emergency Management Agency Division of Nuclear Safety 1035 Outer Park Drive Springfield, IL 62704 (217)785-9868 FAX (217)524-4724 wright@iema.state.il.us	IL Nuclear Safety $100 registration fee
Indiana	Mary Stiker Indoor & Radiologic Health Division State Department of Health 2 N. Meridian Street Indianapolis, IN 46204-3003 (317)233-7146 FAX (317)233-7154 mstiker@isdh.state.in.us		IN Industrial Xray Machines Indiana Radiologic Health

State	Contact	Form	Instructions
Iowa	Charlene Craig Bureau of Radiological Health Iowa Department of Public Health 401 SW 7th Street, Suite D Des Moines, Iowa 50309 (515)725-0306 FAX (515)725-0318 CCRAIG@health.state.ia.us		IA Radiological Health
Kansas	Victor L. Cooper, Section Chief Air Operating Permit & Compliance Section Bureau of Air & Radiation Division of Environment Kansas Department of Health & Environment 1000 SW Jackson, Suite 310 Topeka, KS 66612-1366 (785)296-1561 FAX (785)291-3953 vcooper@kdhe.state.ks.us		KS Radiation Control
Kentucky	Janice H. Jasper, Radioactive Material Specialist Radiation Health & Toxic Agents Branch Cabinet for Health Services 275 East Main Street Frankfort, KY 40621-0001 (502)564-3700 ext 3698 FAX (502)564-1492 Jan.Jasper@mail.state.ky.us	Robert L. Johnson, Manager Radiation Health & Toxic Agents Branch Cabinet for Health Services 275 East Main Street Mail Stop HS 2E-D Frankfort, KY 40621-0001 (502)564-7818 EXT 3697 FAX (502)564-1492 robertL.johnson@mail.state.ky.us	KY Radiation Health
Louisiana	Michael J. LeRay LA Department of Environmental Quality Registrations and Certifications Section PO Box 82135 Baton Rouge, LA 70884-2135 (225) 765-5098 FAX (225) 765-0220 mleray@ldeq.org	LA Registration Form	

State	Contact	Form	Instructions
Maine	Linda Plusquellic Linda.Plusquellic@maine.gov	Form HHE-805	ME Registration Regulations, Part E Regulations, Part H $40 annual fee Note also: Requirements for Industrial Unit
Maryland			MD Radiological Health
Massachusetts	Robert Walker, Director Radiation Control Program Department of Public Health 90 Washington Street Dorchester, MA 02121 (617)427-2944 FAX (617)427-2925 Bob.walker@state.ma.us		MA Radiation Control
Michigan	James Camburn, Chief Radiation Safety Section Division of Health Facilities & Services Bureau of Heath Systems G. Mennen Wiliams Building PO Box 30664 Lansing MI 48909 (517) 241-1989 jcambu@michigan.gov		MI Xray Registration

State	Contact	Form	Instructions
Minnesota	Timothy Donakowski Section of Asbestos, Indoor Air, Lead and Radiation Division of Environmental Health Department of Health 121 E. Seventh Place, Suite 360 P.O. Box 64975 St. Paul, MN 55164-0975 (651)215-0945 FAX (651)215-0975 Timothy.Donakowski@state.mn.us		MN Radiation Regulations
Mississippi	Bobby Smith Radioactive Material Branch Director State Department of Health 3150 Lawson Street, P.O. Box 1700 Jackson, MS 39215-1700 (601)987-6893 FAX (601)987-6887 Bobby.Smith@msdh.state.ms.us		MS Radiologic Health $75 registration fee per year Notify whom you ship it to, contact, address, phone number. Users need to provide training certificate with application.
Missouri	Keith Henke, Planner Section for Environmental Public Health Division of Environmental Health and Communicable Disease Prevention Missouri Department of Health and Senior Services 930 Wildwood P.O. Box 570 Jefferson City, Missouri 65102-0570 (573) 751-6111 FAX (573) 526-6946 HenkeK@dhss.state.mo.us		MO Industrial Xray Regulation

State	Contact	Form	Instructions
Montana	George Eicholtz, Coordinator Radiological Health Program Licensure Bureau Department of Public Health & Human Services P.O. Box 202951 Helena, MT 59620-2951 (406)444-5266 FAX (406)444-1742 GEICHOLTZ@MT.GOV	Juan Stevens, Coordinator Radiological Health Program Department of Public Health & Human Services Licensure Bureau 2401 Colonial Drive P.O. Box 202953 Helena, MT 59620-2953 (406)444-1510 FAX (406)444-3456 justevens@state.mt.u	
Nebraska	Brent G. Friesen, Health Physicist Department of Health and Human Services Regulation and Licensure PO Box 95007 Lincoln NE 68509 (402) 271-8788 (maybe 471-8788) FAX (402) 471-0169	X-Ray Registration Form	NE Radiation Regulations
Nevada	Dorothy Rink Radiological Halth 1179 Fairview Drive, Ste 102 Carson City, NV 89701-5405 (775) 687-5394 (775) 687-5751 (Fax)	yes, paper in file	NV Xray Registration
New Hampshire	Wayne F. Johnston, Supervisor NH DHHS Office of Community & Public Health Radiation Machines Program 29 Hazen Drive Concord, NH 03301-6527 3301-6527 (603)271-4588 FAX (603)225-2325 WJohnston@dhhs.state.nh.us	Radiation Machine Registration Reciprocal Recognition	NH Radiological Health

State	Contact	Form	Instructions
New Jersey	Paul Orlando, Chief Bureau of Radiological Health Division of Environmental Safety, Health & Analytical Programs Department of Environmental Protection, P.O. Box 415 Trenton, NJ 08625-0415 (609)984-5634		NJ Radiation Protection Rules and Regulations
New Mexico	William Floyd, Program Manager Radiation Protection Program Field Operations Division Environment Department 1190 St. Francis Drive, Rm S2100 P.O. Box 26110 Santa Fe, NM 87502-0110 (505)476-3236 FAX (505)476-3232 William_floyd@nmenv.state.nm.us		NM Radiation Protection
New York	William Varcasio Associate Radiophysicist New York State Department of Labor Radiological Health Unit Building 12, Room 169 State Office Building Campus Albany NY 12240 (518) 457-1202 FAX (510) 485-7486 William.Varcasio@Labor.State.NY.Us	Fax, paper copy. There's no reference number. Registration using this form is free and mandatory for purchasers, for rental customers and for transient users. Rental and transient customers should mark on the form that the unit is in use in NY temporarily. The same form should be used to register the manufacturer/supplier. Mark on it that you are distributing the equipment.	NY Radiological Health Note: Exemption 11
New York City	Gene Miskin, Director Bureau of Radiological Health New York City Department of Health Two Lafayette Street, 11th Floor New York, NY 10007 (212)676-1556 FAX (212)676-1548 gmiskin@health.nyc.gov		

State	Contact	Form	Instructions
North Carolina	Beverly O. Hall, Chief Division of Radiation Protection Department of Environment & Natural Resources 3825 Barrett Drive Raleigh, NC 27609-7221 (919)571-4141 ext. 201 FAX (919)571-4148 beverly.hall@ncmail.net		NC Radiation Protection
North Dakota	Warren Freier Radiation Specialist Radiation Specialist Division of Air Quality North Dakota Department of Health 1200 Missouri Avenue P.O. Box 5520 Bismarck, ND 58506-5520 (701)328-5188 FAX (701)328-5200 toclair@state.nd.us		ND Radiation Control
Ohio	Neann C. Manubay, Supervisor Radiological Technology Program Ohio Department of Health Oliver R. Ocasek Government Office Building 161 South High Stret, Suite 400 Akron, Ohio 44308-1612 (330) 643-1300 FAX (300) 643-1346	yes	OH Xray Equipment Registration

State	Contact	Form	Instructions
Oklahoma	Mark.Conley Radiation Management Section Oklahoma Department of Environmental Quality P.O. Box 1677 Oklahoma City, OK 73101-1677 (405)702-5155 FAX (405)702-5101 Mark.Conley@deq.state.ok.us		OK Environmental Quality
Oregon	Terry D. Lindsey, Program Director Radiation Protection Services Oregon Health Services Department of Human Services 800 N.E. Oregon Street, Suite 260 Portland, OR 97232-2162 (503)731-4014 ext. 660 FAX (503)731-4081 terry.d.lindsey@state.or.us		OR Radiation Protection
Pennsylvania	Carol L X-ray Regristration (717) 783-5920 (717) 783-8965 (Fax) David Allard, CHP, Director Bureau of Radiation Protection Department of Environmental Protection Rachel Carson State Office Building P.O. Box 8469 Harrisburg, PA 17105-8469 PH (717)787-2480 FX (717)783-	yes, paper in file	PA Radiation Protection
Rhode Island	Jack Ferruolo Division of Occupational & Radiological Health Department of Health 3 Capitol Hill, Room 206 Providence, RI 02908-5097 (401)222-2438 JackF@doh.state.ri.us		attachment RI Radiologic Health $115 annual fee, expires August 31 provider of x ray services $75

State	Contact	Form	Instructions
South Carolina			SC Radiologic Health
South Dakota	Bob McDonald Environmental Project Scientist Office of Health Care Facility Licensure & Certification Systems Development and Regulations 615 East 4th Street Pierre, SD 57501-1700 (605)773-3356 FAX (605)773-6667 BobMcDonald@state.sd.us		
Tennessee	Robert N. Young X-ray Registration and Machine/Device Permitting Manager Department of Environment and Conservation Division of Radiological Health 401 Chruch Street. Nashville, TN 37243-1532 Robert.Young@state.tn.us	yes, paper in file	TN Radiation Protection X-ray Registration
Texas	bureau radiation control Texas Department of Health Bureau of Radiation Control Attn: Registration 1100 W. 49th St. Austin, Texas 78756-3189 (512) 834-6688	download form from web site	TX Radiation Control
Utah	Craig Jones Division of Radiation Control Department of Environmental Quality 168 North 1950 West P.O. Box 144850 Salt Lake City, UT 84114-4850 (801)536-4250 CWJones@utah.gov		UT Radiation Control

State	Contact	Form	Instructions
Vermont	Carla A. White, RRPT, CHP Radiological Health Specialist Vermont Department of Health 108 Cherry Street Burlington, VT 05401 (802) 865-7743 FAX (802)865-7745 cwhite@vdh.state.vt.us		Registration required, no fee
Virginia	Leslie P. Foldesi, CHP, Director Bureau of Radiological Health Division of Health Hazards Control Department of Health Main Street Station 1500 East Main, Room 240 Richmond, VA 23219 (804)786-5932 FAX (804)786-6979 LFOLDESI@VDH.STATE.VA.US	Virginia X-ray Registration Look under Office of Epidemiology, and then Radiological Health, under X-ray Inspection forms., Registration for Radiation Sources Not Used in the Healing Arts	Registration required once every six years. No fee
Washington	Mike Odlaug X-ray Manager Radiation Protection Division 360 236 3237 fax 2266 Mike.Odlaug@DOH.WA.GOV	1-800-299 XRAY or DOH-XRAY, PO Box 47827, Olympia WA 98504-7827	WA Radiation Protection $49 base fee plus &77 tube fee, total $126 annually InnovX must send notice of Sale or Assembly, with date, customer name, type of X-ray device sold
West Virginia	Dan Hill, Chief Radiological Health Program 815 Quarrier Street - Suite 418 Charleston, WV 25301 (304)558-6772 FAX (304) 558-0524 dhill@wvdhhr.org contact listed on web site		WV Radiological Health

State	Contact	Form	Instructions
Wisconsin	Mark C. Bunge, Supervisor Radiation Protection Section Division of Public Heath 1 West Wison Street PO Box 2659 Madison, WI 53701-2659 (608) 267-4784 FAX (608) 267-4799 bungemc@dhfs.state.wi.us	yes, paper in file	WI X-Ray Registration
Wyoming	David A. Finley, Administrator Solid & Hazardous Waste Division Department of Environmental Quality Herschler Building, 4E Cheyenne, WY 82002 (307)777-7753 FAX (307)777-5402 dfinle@state.wy.us		no registration requirements for radioactive source materials in Wyoming, other than those imposed by the US Nuclear Regulatory Commission

Attachment D

Generic Radiation Protection Plan (RPP)/Radiation Caution Signs

RADIATION PROTECTION PLAN

Use of the Innov-X Systems Alpha Series X-Ray Fluorescence Spectrometer at
<<project name and location>>

<<location, project>>

Prepared for: <<client>>

Revision: 0

<<date>>

Developed by:

Shaw® Shaw Environmental, Inc.
<<originating office>>

Radiation Protection Plan

Project Number: <<project number>>

Date Effective: <<anticipated start date>>

Prepared by: _____ Date: _____
<<name>>
Project Manager

Approved by: _____ Date: _____
<<name>>
Site Safety Professional

Approved by: _____ Date: _____
James Langsted, CHP
Radiation Safety Officer

Approved by: _____ Date: _____
Tom Peterson
Radiation Protection Manager

Radiation Protection Plan

This Radiation Protection Plan (RPP) covers work with the Innov-X X-Ray Fluorescence Spectrometer at <<project name, site name, location>>.

Identification of Radiation Hazards

- Radiation generating device
- Ag or W anode, 10-40kV, 5-50µA, 5 filter positions, x-ray source
- Maximum dose rate of 28,160 mrem/hr to the fingers possible at the port in the primary beam
- Dose rates at all other locations <0.1 mrem/hr.

Identification of Controlling Agencies and Documents

- Controlling Agency – <<agreement state, military branch (carefully determined)>>
- <<regulatory authorization document>>
- Work will be performed in accordance with Controlling Documents –
    - <<specific regulations defined by the regulatory authority>>
- Required documentation in accordance with <<regulator>> requirements will be identified by the RSO and provided to each XRF analyst. The analyst is responsible to have this documentation in their possession at the worksite.

Evaluation of Potential Exposure to Workers

- Assuming worst-case (continuous operation): <40 mrem/yr torso exposure and <200 mrem/year hand exposure (Innov-X User Manual Version 2.1, Section 3.8)
- Worst-case scenarios are less than 10% of applicable limits (<<applicable regulation>>)
- XRF will be used test-stand mode (and possibly in hand held mode), approximately <<anticipated duration of the project>>.

Evaluation of Public Dose

- Work location on the site is a secure location and not readily accessible by the public <<or how the public will be excluded from the work area>>
- Operating procedures will keep public at least 40 feet away, reducing dose several orders of magnitude below worker exposure levels.

Training Program Development

- Any analyst must have documented attendance of internal Shaw XRF (or XRF manufacturer's) radiation safety training and instrument-specific operations training
- Training certification for each trained operator will be kept with this RPP.

Declared Pregnant Woman Program

- Workers are not likely to exceed 100 mrem/yr (deep dose equivalent) which provides protection of the embryo/fetus
- Shaw has a policy concerning radiological protection of the embryo/fetus
- If a female worker has questions concerning protection of the embryo/fetus, the Shaw RSO is available to address these issues.

Radiation Protection Plan

ALARA Program

- External exposure controls identified in this RPP will keep exposure ALARA
- Operating procedures, XRF operator training, limited use anticipation, and equipment design will implement these controls.

External Exposure Control

- A five-foot exclusion zone will be established for all project personnel, except for the XRF trained operator and potentially an XRF operator trainee. The trained operator will maintain access to this exclusion zone through visual and verbal means.
- For hand-held operation, the trained operator will utilize the "Deadman" trigger feature and will not deactivate this feature while operating the instrument. This will require the trained operator to maintain trigger pressure for the full period of analysis.
- For Testing Stand operation, use of the iPAQ screen "Start" button will preclude the need for holding the trigger.

Internal Exposure Control

- No internal exposure potential with this operation

Monitoring and Measuring External Exposure

- External exposure is not likely to exceed 100 mrem/yr.
- XRF operators will wear Shaw-issued finger ring dosimeters while operating the XRF unit. These dosimeters will be available from the RSO.

Completion of the XRF Usage Log (attached) is required on a daily basis. At the end of the calendar quarter or upon completion of field work, a copy of the log shall be sent to the RSO.

Monitoring and Measuring Internal Exposure

- Not applicable because no internal exposure potential

Surveys and Monitoring

- No surveys or monitoring will be required during this operation

Contamination Control

- Not applicable because no loose for fixed contamination potential exists.

Instrumentation

- No radiation protection survey instrumentation will be used

Radiological Areas and Posting

- A controlled area of 5 feet around the instrument during use will be maintained by the XRF analyst using visual and verbal control.
- "Caution - Radiation Area" signs will be posted in the area where the XRF will be used.

Radiation Protection Plan

Control of Radiological Work

- Use of this instrument will be controlled by trained analysts using the manufacturer's Instruction Manual and the Shaw XRF Procedure Manual

Credentialing of Staff

- Any XRF operator assigned to this project will be required to provide certification of training.

Procurement, Receipt, and Inventory

- The equipment will be received by the trained analyst, stored under locked conditions, and controlled by the analyst during the period of use.

Shipping and Transportation of Radioactive Materials

- No radioactive materials will be shipped as a result of this project

Control of Radioactive Waste

- No radioactive waste will be generated during use of this instrument

Radiation Protection Records

- Project records associated with the radiological safety of this instrument will be maintained as part of the project record. This will include:
  - this RPP
  - XRF analyst training certificates
  - Regulator Acknowledgement Letter, attached
  - A hardcopy of applicable state or federal regulations as cited above.

Reports and Notifications

- No reports are required by this RPP

The XRF Operator shall have onsite a copy of:
- This RPP
- Operating procedures
- <<regulations and other documents as defined by the Shaw RSO>>.

Licenses

- Authorization has been obtained from the <<regulator>>. This document will be carried when operating at the site and all special conditions stated therein will be met.

Review and Approvals of RPPs

- This RPP is reviewed and approved in accordance with the Shaw Procedure HS700, as indicated on the signature page of this document.

Planned Special Exposures (PSE)

- Planned Special Exposure is not allowed under this RPP

Radiation Protection Plan

Self-Assessment, Reviews, and Corrective Actions

- No audits are anticipated. The Shaw Radiation Protection Program may perform review as necessary. Any corrective actions will be managed under the Shaw Quality Assurance program.

Personnel

- Radiation Safety Officer – James M. Langsted, CHP
  - (720) 554-8182 office
  - (303) 870-2802 cell

- Trained XRF Analysts -
  - <<names and cell phone numbers>

Attachments

- Regulator Authorization of Use Letter
- XRF Use Log
- Analyst Training Certifications
- "CAUTION Radiation Area" Posting.

Radiation Protection Plan

(regulator authorization letter)

Radiation Protection Plan

XRF Usage Log

Site Name:		Project Number:		Page:
		Number of Analyses		**Finger Ring Dosimeter Worn?**
Date	**Operator Name**	Hand-held operation	Testing Stand operation	

Keep original copy of this log with project files

Please forward copy of this log to Radiation Safety Officer at the end of the calendar or at completion of field work

Radiation Protection Plan

(trained analyst training certificate)

Radiation Protection Plan

(trained analyst training certificate)

Radiation Protection Plan

(trained analyst training certificate)

Radiation Protection Plan

(Insert Radiation Sign Here)

CAUTION
RADIATION
AREA

CAUTION
RADIATION
AREA

Attachment E

Example XRF Forms

Low Lead-CRM 036					
	Conc	XRF Meas		XRF Meas	
Element	Certified	Low	% D	High	% D
As	**114**	91	20%	137	20%
Pb	**190**	152	20%	228	20%
Cu	**271**	218	20%	324	20%
Sb	**53**	42.5	20%	63.5	20%
Zn	**199**	160	20%	238	20%

Arsenic			Lead			Copper			Antimony			Zinc		
XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D
<81	114	No	<136	190	No	<194	271	No	<37	53	No	<142	199	No
81	114	29%	136	190	28%	194	271	28%	37.5	53	29%	142	199	29%
83	114	27%	138	190	27%	197	271	27%	38	53	28%	145	199	27%
85	114	25%	140	190	26%	200	271	26%	38.5	53	27%	148	199	26%
87	114	24%	142	190	25%	203	271	25%	39	53	26%	151	199	24%
89	114	22%	144	190	24%	206	271	24%	39.5	53	25%	154	199	23%
91	114	20%	146	190	23%	209	271	23%	40	53	25%	157	199	21%
93	114	18%	148	190	22%	212	271	22%	40.5	53	24%	160	199	20%
95	114	17%	150	190	21%	215	271	21%	41	53	23%	163	199	18%
97	114	15%	152	190	20%	218	271	20%	41.5	53	22%	166	199	17%
99	114	13%	154	190	19%	221	271	18%	42	53	21%	169	199	15%
101	114	11%	156	190	18%	224	271	17%	42.5	53	20%	172	199	14%
103	114	10%	158	190	17%	227	271	16%	43	53	19%	175	199	12%
105	114	8%	160	190	16%	230	271	15%	43.5	53	18%	178	199	11%
107	114	6%	162	190	15%	233	271	14%	44	53	17%	181	199	9%
109	114	4%	164	190	14%	236	271	13%	44.5	53	16%	184	199	8%
111	114	3%	166	190	13%	239	271	12%	45	53	15%	187	199	6%
113	114	1%	168	190	12%	242	271	11%	45.5	53	14%	190	199	5%
115	114	1%	170	190	11%	245	271	10%	46	53	13%	193	199	3%
117	114	3%	172	190	9%	248	271	8%	46.5	53	12%	196	199	2%
119	114	4%	174	190	8%	251	271	7%	47	53	11%	199	199	0%
121	114	6%	176	190	7%	254	271	6%	47.5	53	10%	202	199	2%
123	114	8%	178	190	6%	257	271	5%	48	53	9%	205	199	3%
125	114	10%	180	190	5%	260	271	4%	48.5	53	8%	208	199	5%
127	114	11%	182	190	4%	263	271	3%	49	53	8%	211	199	6%
129	114	13%	184	190	3%	266	271	2%	49.5	53	7%	214	199	8%
131	114	15%	186	190	2%	269	271	1%	50	53	6%	217	199	9%
133	114	17%	188	190	1%	272	271	0%	50.5	53	5%	220	199	11%
135	114	18%	190	190	0%	275	271	1%	51	53	4%	223	199	12%
137	114	20%	192	190	1%	278	271	3%	51.5	53	3%	226	199	14%
139	114	22%	194	190	2%	281	271	4%	52	53	2%	229	199	15%
141	114	24%	196	190	3%	284	271	5%	52.5	53	1%	232	199	17%
143	114	25%	198	190	4%	287	271	6%	53	53	0%	235	199	18%
145	114	27%	200	190	5%	290	271	7%	53.5	53	1%	238	199	20%
147	114	29%	202	190	6%	293	271	8%	54	53	2%	241	199	21%
>148	114	No	204	190	7%	296	271	9%	54.5	53	3%	244	199	23%
			206	190	8%	299	271	10%	55	53	4%	247	199	24%
			208	190	9%	302	271	11%	55.5	53	5%	250	199	26%
			210	190	11%	305	271	13%	56	53	6%	253	199	27%
			212	190	12%	308	271	14%	56.5	53	7%	256	199	29%
			214	190	13%	311	271	15%	57	53	8%	>257	199	No
			216	190	14%	314	271	16%	57.5	53	8%			
			218	190	15%	317	271	17%	58	53	9%			
			220	190	16%	320	271	18%	58.5	53	10%			
			222	190	17%	323	271	19%	59	53	11%			
			222	190	17%	326	271	20%	59.5	53	12%			
			224	190	18%	329	271	21%	60	53	13%			
			226	190	19%	332	271	23%	60.5	53	14%			
			228	190	20%	335	271	24%	61	53	15%			
			230	190	21%	338	271	25%	61.5	53	16%			
			232	190	22%	341	271	26%	62	53	17%			
			234	190	23%	344	271	27%	62.5	53	18%			
			236	190	24%	347	271	28%	63	53	19%			
			238	190	25%	>347	271	No	63.5	53	20%			
			240	190	26%				64	53	21%			
			242	190	27%				64.5	53	22%			
			244	190	28%				65	53	23%			
			246	190	29%				65.5	53	24%			
			>246	190	No				66	53	25%			
									66.5	53	25%			
									67	53	26%			
									67.5	53	27%			
									68	53	28%			
									68.5	53	29%			
									>69	53	No			

Mod Lead-NIST 2586					
	Conc	XRF Meas		XRF Meas	
Element	Certified	Low	% D	High	% D
As	**18.9**	15.2	20%	22.6	20%
Pb	**432**	345	20%	520	20%
Cu*	**81**	65	20%	97	20%
Cr	**301**	240	20%	360	20%
Zn	**352**	280	20%	422	20%

***Copper is not a certified value.**

Arsenic			Lead			Copper*			Chromium			Zinc		
XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D
<13	18.9	No	<305	432	No	<58	81	No	<213	301	No	<250	352	No
13.5	18.9	29%	305	432	29%	58	81	28%	213	301	29%	250	352	29%
14	18.9	26%	310	432	28%	59	81	27%	216	301	28%	255	352	28%
14.5	18.9	23%	315	432	27%	60	81	26%	219	301	27%	260	352	26%
15	18.9	21%	320	432	26%	61	81	25%	222	301	26%	265	352	25%
15.5	18.9	18%	325	432	25%	62	81	23%	225	301	25%	270	352	23%
16	18.9	15%	330	432	24%	63	81	22%	228	301	24%	275	352	22%
16.5	18.9	13%	335	432	22%	64	81	21%	231	301	23%	280	352	20%
17	18.9	10%	340	432	21%	66	81	19%	234	301	22%	285	352	19%
17.5	18.9	7%	345	432	20%	68	81	16%	237	301	21%	290	352	18%
18	18.9	5%	350	432	19%	70	81	14%	240	301	20%	295	352	16%
18.5	18.9	2%	355	432	18%	72	81	11%	243	301	19%	300	352	15%
19	18.9	1%	360	432	17%	74	81	9%	246	301	18%	300	352	15%
19.5	18.9	3%	365	432	16%	76	81	6%	249	301	17%	305	352	13%
20	18.9	6%	370	432	14%	78	81	4%	252	301	16%	310	352	12%
20.5	18.9	8%	375	432	13%	80	81	1%	255	301	15%	315	352	11%
21	18.9	11%	380	432	12%	82	81	1%	258	301	14%	320	352	9%
21.5	18.9	14%	385	432	11%	84	81	4%	261	301	13%	325	352	8%
22	18.9	16%	390	432	10%	86	81	6%	264	301	12%	330	352	6%
22.5	18.9	19%	395	432	9%	88	81	9%	267	301	11%	335	352	5%
23	18.9	22%	400	432	7%	90	81	11%	270	301	10%	340	352	3%
23.5	18.9	24%	405	432	6%	92	81	14%	273	301	9%	345	352	2%
24	18.9	27%	410	432	5%	94	81	16%	276	301	8%	350	352	1%
>24	18.9	No	415	432	4%	96	81	19%	279	301	7%	350	352	1%
			420	432	3%	98	81	21%	279	301	7%	355	352	1%
			425	432	2%	100	81	23%	282	301	6%	360	352	2%
			430	432	0%	102	81	26%	285	301	5%	365	352	4%
			435	432	1%	104	81	28%	288	301	4%	370	352	5%
			440	432	2%	>104	81	No	291	301	3%	375	352	7%
			445	432	3%				294	301	2%	380	352	8%
			450	432	4%				297	301	1%	385	352	9%
			455	432	5%				300	301	0%	390	352	11%
			460	432	6%				303	301	1%	395	352	12%
			465	432	8%				306	301	2%	400	352	14%
			470	432	9%				309	301	3%	405	352	15%
			475	432	10%				312	301	4%	410	352	16%
			480	432	11%				315	301	5%	415	352	18%
			485	432	12%				318	301	6%	420	352	19%
			490	432	13%				321	301	7%	425	352	21%
			495	432	15%				324	301	8%	430	352	22%
			500	432	16%				327	301	9%	435	352	24%
			505	432	17%				330	301	10%	440	352	25%
			510	432	18%				333	301	11%	445	352	26%
			515	432	19%				336	301	12%	450	352	28%
			520	432	20%				339	301	13%	455	352	29%
			525	432	22%				342	301	14%	>460	352	No
			530	432	23%				345	301	15%			
			535	432	24%				348	301	16%			
			540	432	25%				351	301	17%			
			545	432	26%				354	301	18%			
			550	432	27%				357	301	19%			
			555	432	28%				360	301	20%			
			>560	432	No				363	301	21%			
									366	301	22%			
									369	301	23%			
									372	301	24%			
									375	301	25%			
									378	301	26%			
									381	301	27%			
									384	301	28%			
									384	301	28%			
									387	301	29%			
									389	301	29%			
									>389	301	No			

High Lead-CRM 025					
	Conc	XRF Meas		XRF Meas	
Element	Certified	Low	% D	High	% D
As	**339**	270	20%	408	20%
Pb	**1,450**	1160	20%	1,740	20%
Hg	**99.8**	80	20%	120	20%
Cd	**369**	295	20%	443	20%
Zn	**52**	41.5	20%	62.0	20%

Arsenic			Lead			Mercury			Cadmium			Zinc		
XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D	XRF	Cert	%D
<240	339	No	<1,030	1,450	No	<70	100	No	<260	369	No	<37	52	No
240	339	29%	1,045	1,450	28%	72	100	28%	265	369	28%	37	52	29%
245	339	28%	1,060	1,450	27%	74	100	26%	270	369	27%	38	52	27%
250	339	26%	1,075	1,450	26%	76	100	24%	275	369	25%	39	52	25%
255	339	25%	1,090	1,450	25%	78	100	22%	280	369	24%	40	52	23%
260	339	23%	1,105	1,450	24%	80	100	20%	285	369	23%	41	52	21%
265	339	22%	1,120	1,450	23%	82	100	18%	290	369	21%	42	52	19%
270	339	20%	1,135	1,450	22%	84	100	16%	295	369	20%	43	52	17%
275	339	19%	1,160	1,450	20%	86	100	14%	300	369	19%	44	52	15%
280	339	17%	1,175	1,450	19%	88	100	12%	305	369	17%	45	52	13%
285	339	16%	1,190	1,450	18%	90	100	10%	310	369	16%	46	52	12%
290	339	14%	1,205	1,450	17%	92	100	8%	315	369	15%	47	52	10%
295	339	13%	1,220	1,450	16%	94	100	6%	320	369	13%	48	52	8%
300	339	12%	1,235	1,450	15%	96	100	4%	325	369	12%	49	52	6%
305	339	10%	1,250	1,450	14%	98	100	2%	330	369	11%	50	52	4%
310	339	9%	1,265	1,450	13%	100	100	0%	335	369	9%	51	52	2%
315	339	7%	1,280	1,450	12%	102	100	2%	340	369	8%	52	52	0%
320	339	6%	1,295	1,450	11%	104	100	4%	345	369	7%	53	52	2%
325	339	4%	1,310	1,450	10%	106	100	6%	350	369	5%	54	52	4%
330	339	3%	1,325	1,450	9%	108	100	8%	355	369	4%	55	52	6%
335	339	1%	1,340	1,450	8%	110	100	10%	360	369	2%	56	52	8%
340	339	0%	1,355	1,450	7%	112	100	12%	365	369	1%	57	52	10%
345	339	2%	1,370	1,450	6%	114	100	14%	370	369	0%	58	52	12%
350	339	3%	1,385	1,450	4%	116	100	16%	375	369	2%	59	52	13%
355	339	5%	1,400	1,450	3%	118	100	18%	380	369	3%	60	52	15%
360	339	6%	1,415	1,450	2%	120	100	20%	385	369	4%	61	52	17%
365	339	8%	1,430	1,450	1%	122	100	22%	390	369	6%	62	52	19%
370	339	9%	1,445	1,450	0%	124	100	24%	395	369	7%	63	52	21%
375	339	11%	1,460	1,450	1%	126	100	26%	400	369	8%	64	52	23%
380	339	12%	1,475	1,450	2%	128	100	28%	405	369	10%	65	52	25%
385	339	14%	1,490	1,450	3%	>130	100	No	410	369	11%	66	52	27%
390	339	15%	1,505	1,450	4%				415	369	12%	67	52	29%
395	339	17%	1,520	1,450	5%				420	369	14%	>68	52	No
400	339	18%	1,535	1,450	6%				425	369	15%			
405	339	19%	1,550	1,450	7%				430	369	17%			
410	339	21%	1,565	1,450	8%				435	369	18%			
415	339	22%	1,580	1,450	9%				440	369	19%			
420	339	24%	1,595	1,450	10%				445	369	21%			
425	339	25%	1,610	1,450	11%				450	369	22%			
430	339	27%	1,625	1,450	12%				455	369	23%			
>435	339	No	1,640	1,450	13%				460	369	25%			
			1,655	1,450	14%				465	369	26%			
			1,670	1,450	15%				470	369	27%			
			1,685	1,450	16%				475	369	29%			
			1,700	1,450	17%				>480	369	No			
			1,715	1,450	18%									
			1,730	1,450	19%									
			1,745	1,450	20%									
			1,760	1,450	21%									
			1,775	1,450	22%									
			1,790	1,450	23%									
			1,805	1,450	24%									
			1,820	1,450	26%									
			1,835	1,450	27%									
			1,850	1,450	28%									
			1,865	1,450	29%									
			>1,880	1,450	No									

Low Lead-NIST 2702					
	Conc	XRF Meas		XRF Meas	
Element	Certified	Low	% D	High	% D
As	**45.3**	36	20%	54	20%
Pb	**132.8**	106	20%	159	20%
Cu	**117.7**	94	20%	141	20%
Mn	**1,757**	1,400	20%	2,100	20%
Zn	**485**	388	20%	582	20%

Arsenic		
XRF	Cert	%D
<32	45.3	No
32	45.3	29%
33	45.3	27%
34	45.3	25%
35	45.3	23%
36	45.3	21%
37	45.3	18%
38	45.3	16%
39	45.3	14%
40	45.3	12%
41	45.3	9%
42	45.3	7%
43	45.3	5%
44	45.3	3%
45	45.3	1%
46	45.3	2%
47	45.3	4%
48	45.3	6%
49	45.3	8%
50	45.3	10%
51	45.3	13%
52	45.3	15%
53	45.3	17%
54	45.3	19%
55	45.3	21%
56	45.3	24%
57	45.3	26%
58	45.3	28%
>59	45.3	No

Lead		
XRF	Cert	%D
<93	132.8	No
94	132.8	29%
95	132.8	28%
96	132.8	28%
97	132.8	27%
98	132.8	26%
99	132.8	25%
100	132.8	25%
101	132.8	24%
102	132.8	23%
103	132.8	22%
104	132.8	22%
105	132.8	21%
106	132.8	20%
107	132.8	19%
108	132.8	19%
109	132.8	18%
110	132.8	17%
111	132.8	16%
112	132.8	16%
113	132.8	15%
114	132.8	14%
115	132.8	13%
116	132.8	13%
117	132.8	12%
118	132.8	11%
119	132.8	10%
120	132.8	10%
121	132.8	9%
128	132.8	4%
129	132.8	3%
130	132.8	2%
131	132.8	1%
132	132.8	1%
133	132.8	0%
134	132.8	1%
135	132.8	2%
136	132.8	2%
137	132.8	3%
138	132.8	4%
139	132.8	5%
140	132.8	5%
141	132.8	6%
142	132.8	7%
143	132.8	8%
144	132.8	8%
145	132.8	9%
146	132.8	10%
147	132.8	11%
148	132.8	11%
149	132.8	12%
150	132.8	13%
151	132.8	14%
152	132.8	14%
153	132.8	15%
154	132.8	16%
155	132.8	17%
156	132.8	17%
157	132.8	18%
158	132.8	19%
159	132.8	20%
160	132.8	20%
161	132.8	21%
162	132.8	22%
163	132.8	23%
164	132.8	23%
165	132.8	24%
166	132.8	25%
167	132.8	26%
168	132.8	27%
169	132.8	27%
170	132.8	28%
171	132.8	29%
>172	132.8	No

Copper		
XRF	Cert	%D
<82	117.7	No
83	117.7	29%
84	117.7	29%
85	117.7	28%
86	117.7	27%
87	117.7	26%
88	117.7	25%
89	117.7	24%
90	117.7	24%
91	117.7	23%
92	117.7	22%
93	117.7	21%
94	117.7	20%
95	117.7	19%
96	117.7	18%
97	117.7	18%
98	117.7	17%
99	117.7	16%
100	117.7	15%
101	117.7	14%
102	117.7	13%
103	117.7	12%
104	117.7	12%
105	117.7	11%
106	117.7	10%
107	117.7	9%
108	117.7	8%
109	117.7	7%
110	117.7	7%
111	117.7	6%
112	117.7	5%
113	117.7	4%
114	117.7	3%
115	117.7	2%
116	117.7	1%
117	117.7	1%
118	117.7	0%
119	117.7	1%
120	117.7	2%
121	117.7	3%
122	117.7	4%
123	117.7	5%
124	117.7	5%
125	117.7	6%
126	117.7	7%
127	117.7	8%
128	117.7	9%
129	117.7	10%
130	117.7	10%
131	117.7	11%
132	117.7	12%
133	117.7	13%
134	117.7	14%
135	117.7	15%
136	117.7	16%
137	117.7	16%
138	117.7	17%
139	117.7	18%
140	117.7	19%
141	117.7	20%
142	117.7	21%
143	117.7	21%
144	117.7	22%
145	117.7	23%
146	117.7	24%
147	117.7	25%
148	117.7	26%
149	117.7	27%
150	117.7	27%
151	117.7	28%
152	117.7	29%
>153	117.7	No

Manganese		
XRF	Cert	%D
<1238	1,757	No
1239-1256	1,757	29%
1257-1273	1,757	28%
1274-1291	1,757	27%
1292-1308	1,757	26%
1309-1326	1,757	25%
1327-1344	1,757	24%
1345-1361	1,757	23%
1362-1379	1,757	22%
1380-1396	1,757	21%
1397-1414	1,757	20%
1415-1431	1,757	19%
1432-1449	1,757	18%
1450-1467	1,757	17%
1468-1484	1,757	16%
1485-1502	1,757	15%
1503-1519	1,757	14%
1520-1537	1,757	13%
1538-1554	1,757	12%
1555-1572	1,757	11%
1573-1590	1,757	10%
1591-1607	1,757	9%
1608-1625	1,757	8%
1626-1642	1,757	7%
1643-1660	1,757	6%
1661-1677	1,757	5%
1678-1695	1,757	4%
1696-1713	1,757	3%
1714-1730	1,757	2%
1731-1748	1,757	1%
1749-1765	1,757	0%
1766-1783	1,757	1%
1784-1800	1,757	2%
1801-1818	1,757	3%
1819-1836	1,757	4%
1837-1853	1,757	5%
1854-1871	1,757	6%
1872-1888	1,757	7%
1889-1906	1,757	8%
1907-1923	1,757	9%
1924-1941	1,757	10%
1942-1959	1,757	11%
1960-1976	1,757	12%
1977-1994	1,757	13%
1995-2011	1,757	14%
2012-2029	1,757	15%
2030-2046	1,757	16%
2047-2064	1,757	17%
2065-2082	1,757	18%
2083-2099	1,757	19%
2100-2117	1,757	20%
2118-2134	1,757	21%
2135-2152	1,757	22%
2153-2169	1,757	23%
2170-2187	1,757	24%
2188-2205	1,757	25%
2206-2222	1,757	26%
2223-2240	1,757	27%
2241-2257	1,757	28%
2258-2275	1,757	29%
>2276	1,757	No

Zinc		
XRF	Cert	%D
<341	485	No
342-346	485	29%
347-351	485	28%
352-356	485	27%
357-361	485	26%
362-366	485	25%
367-371	485	24%
372-375	485	23%
376-380	485	22%
381-385	485	21%
386-390	485	20%
391-395	485	19%
396-400	485	18%
401-404	485	17%
405-409	485	16%
410-414	485	15%
415-419	485	14%
420-424	485	13%
425-429	485	12%
430-434	485	11%
435-438	485	10%
439-443	485	9%
444-448	485	8%
449-453	485	7%
454-458	485	6%
459-463	485	5%
464-468	485	4%
469-472	485	3%
473-477	485	2%
507-511	485	5%
512-516	485	6%
517-521	485	7%
522-526	485	8%
527-531	485	9%
532-535	485	10%
536-540	485	11%
541-545	485	12%
546-550	485	13%
551-555	485	14%
556-560	485	15%
561-565	485	16%
566-569	485	17%
570-574	485	18%
575-579	485	19%
580-584	485	20%
585-589	485	21%
590-594	485	22%
595-598	485	23%
599-603	485	24%
604-608	485	25%
609-613	485	26%
614-618	485	27%
619-623	485	28%
624-628	485	29%
>629	485	No

Mod Lead-NIST 2781					
	Conc	XRF Meas		XRF Meas	
Element	Certified	Low	% D	High	% D
As	**7.82**	6.25	20%	9.40	20%
Pb	**202**	162	20%	242	20%
Cu	**627**	500	20%	755	20%
Zn	**1,273**	1,020	20%	1,530	20%

Arsenic			Lead			Copper			Zinc		
XRF	Cert	% D	XRF	Cert	% D	XRF	Cert	% D	XRF	Cert	% D
5.5	7.82	30%	<142	202	No	<440	627	No	<890	1,273	No
5.6	7.82	28%	145	202	28%	445	627	29%	900	1,273	29%
5.7	7.82	27%	150	202	26%	450	627	28%	920	1,273	28%
5.8	7.82	26%	155	202	23%	460	627	27%	940	1,273	26%
5.9	7.82	25%	160	202	21%	465	627	26%	960	1,273	25%
6	7.82	23%	162	202	20%	470	627	25%	980	1,273	23%
6.1	7.82	22%	165	202	18%	475	627	24%	1000	1,273	21%
6.2	7.82	21%	170	202	16%	485	627	23%	1020	1,273	20%
6.25	7.82	20%	175	202	13%	490	627	22%	1040	1,273	18%
6.3	7.82	19%	180	202	11%	495	627	21%	1060	1,273	17%
6.4	7.82	18%	185	202	8%	500	627	20%	1080	1,273	15%
6.5	7.82	17%	190	202	6%	510	627	19%	1100	1,273	14%
6.6	7.82	16%	195	202	3%	515	627	18%	1120	1,273	12%
6.7	7.82	14%	200	202	1%	520	627	17%	1140	1,273	10%
6.8	7.82	13%	205	202	1%	525	627	16%	1160	1,273	9%
6.9	7.82	12%	210	202	4%	535	627	15%	1180	1,273	7%
7	7.82	10%	215	202	6%	540	627	14%	1200	1,273	6%
7.1	7.82	9%	220	202	9%	545	627	13%	1220	1,273	4%
7.2	7.82	8%	225	202	11%	550	627	12%	1240	1,273	3%
7.3	7.82	7%	230	202	14%	560	627	11%	1260	1,273	1%
7.4	7.82	5%	235	202	16%	565	627	10%	1280	1,273	1%
7.5	7.82	4%	240	202	19%	570	627	9%	1300	1,273	2%
7.6	7.82	3%	242	202	20%	575	627	8%	1320	1,273	4%
7.7	7.82	2%	245	202	21%	585	627	7%	1340	1,273	5%
7.8	7.82	0%	250	202	24%	590	627	6%	1360	1,273	7%
7.9	7.82	1%	255	202	26%	595	627	5%	1380	1,273	8%
8	7.82	2%	260	202	29%	605	627	4%	1400	1,273	10%
8.1	7.82	4%	>262	202	No	610	627	3%	1420	1,273	12%
8.2	7.82	5%				615	627	2%	1440	1,273	13%
8.3	7.82	6%				620	627	1%	1460	1,273	15%
8.4	7.82	7%				630	627	0%	1480	1,273	16%
8.5	7.82	9%				635	627	1%	1500	1,273	18%
8.6	7.82	10%				640	627	2%	1520	1,273	19%
8.7	7.82	11%				645	627	3%	1530	1,273	20%
8.8	7.82	13%				655	627	4%	1540	1,273	21%
8.9	7.82	14%				660	627	5%	1560	1,273	23%
9	7.82	15%				665	627	6%	1580	1,273	24%
9.1	7.82	16%				670	627	7%	1600	1,273	26%
9.2	7.82	18%				680	627	8%	1620	1,273	27%
9.3	7.82	19%				685	627	9%	1640	1,273	29%
9.4	7.82	20%				690	627	10%	>1660	1,273	No
9.5	7.82	21%				695	627	11%			
9.6	7.82	23%				705	627	12%			
9.7	7.82	24%				710	627	13%			
9.8	7.82	25%				715	627	14%			
9.9	7.82	27%				720	627	15%			
10	7.82	28%				730	627	16%			
10.1	7.82	29%				735	627	17%			
>10.2	7.82	No				740	627	18%			
						745	627	19%			
						755	627	20%			
						760	627	21%			
						765	627	22%			
						770	627	23%			
						780	627	24%			
						785	627	25%			
						790	627	26%			
						795	627	27%			
						805	627	28%			
						810	627	29%			
						>815	627.00	No			

High Lead-XRF 408					
	Conc	XRF Meas		XRF Meas	
Element	Certified	Low	% D	High	% D
As	500	400	20%	600	20%
Ba	500	400	20%	600	20%
Cd	500	400	20%	600	20%
Cr	500	400	20%	600	20%
Pb	500	400	20%	600	20%
Hg	500	400	20%	600	20%
Se	500	400	20%	600	20%
Ag	500	400	20%	600	20%

As, Cd, Pb, Hg…		
XRF	Cert	% D
<350	500	No
360	500	28%
365	500	27%
370	500	26%
375	500	25%
380	500	24%
385	500	23%
390	500	22%
395	500	21%
400	500	20%
405	500	19%
410	500	18%
415	500	17%
420	500	16%
425	500	15%
430	500	14%
435	500	13%
440	500	12%
445	500	11%
450	500	10%
455	500	9%
460	500	8%
465	500	7%
470	500	6%
475	500	5%
480	500	4%
485	500	3%
490	500	2%
495	500	1%
500	500	0%
505	500	1%
510	500	2%
515	500	3%
520	500	4%
525	500	5%
530	500	6%
535	500	7%
540	500	8%
545	500	9%
550	500	10%
555	500	11%
560	500	12%
565	500	13%
570	500	14%
575	500	15%
580	500	16%
585	500	17%
590	500	18%
595	500	19%
600	500	20%
605	500	21%
610	500	22%
615	500	23%
620	500	24%
625	500	25%
630	500	26%
635	500	27%
640	500	28%
645	500	29%
>650	500	No

CB&I Federal Services

XRF Calibration Form

Site Name - City, State

Project No: Add Number | Contract Title / Client Name | Cost Code: Add Number

1. Initial Calibration Data: Date: _____ Check PDA clock on XRF.

Is XRF warm-up >15 min? **Yes** **No** Time: _____ Agree? **Yes** **No**

Reminder: Wear your ring dosimeter!

Internal calibration complete? **Yes** **No** Comments: _____

Record energy resolution: _____ eV

2. Start-of-Day Calibration: **ALPHA** or **DELTA** Serial Number: _____

Read #:_____ **Blank - SiO_2,** Count: _____sec

Element	Conc (ppm) Certified	Conc (ppm) Detected	< RLs Accept?
Pb	< 8		
Cu	< 20		
Sb	< 60		
Zn	< 10		

Other metals: As (< 5) _____, Ni (< 40) _____,

Cr (<80) _____, Cd (< 35)_____, Fe (< 30) _____

Read #:_____ **Low Lead - NIST 2702,** Count: ___ sec

Element	Conc (ppm) Certified	Conc (ppm) Detected	% D Accept?
Pb	132.8		
Cu*	118 *		
As	45.3		
Zn	485		

Other metals: Ni (75.4) _____,

Cr (352) _____, Cd (225) _____, Fe (79.1K) _____

Read #:_____ **Mod Lead - NIST 2586,** Count: ____ sec

Element	Conc (ppm) Certified	Conc (ppm) Detected	% D Accept?
Pb	432 ± 17		
Cu*	81*		
Sb*	NC*		
Zn	352		

Other metals: As (8.7) _____, Ni (75*) _____,

Cr (301)_____, Cd (<3) _____, Fe (51.6K) _____

Read #:_____ **High Lead - NIST 2711a,** Count: ___ sec

Element	Conc (ppm) Certified	Conc (ppm) Detected	% D Accept?
Pb	1,400		
Cu	140		
Sb	24		
Zn	414		

Other metals: As (107) _____ , Cd (54.1) _____,

Cr (52.3) _____, Ba (730)_____, Fe (28.2K)_____

Comments: * Not a NIST certified value. %D = difference of certified and measured values, divided by certified value. Expressed as %.

Proj Action Levels (ppm): Pb=400

CB&I Federal Services

XRF Calibration Form

Site Name - City, State

Project No: Add Number | Contract Title / Client Name | Cost Code: Add Number

3a. Mid-Day Calibration Data: Date: _____ Check XRF clock.

Is XRF warm-up >15 min? **Yes** **No** **N/A** Time: _____ Agree? **Yes** **No**

Internal calibration complete? **Yes** **No** Comments: _____

Record energy resolution: _____ eV

Read #:_____ **Blank - SiO_2,** Count: _____sec

Element	Conc (ppm) Certified	Conc (ppm) Detected	< RLs Accept?
Pb	< 8		
Cu	< 20		
Sb	< 60		
Zn	< 10		

Other metals: As (< 5) _____, Ni (< 40) _____,

Hg(<10) ____, Cr (<80) _____, Cd (< 35)_____, Fe (< 30) _____

Read #:_____ **Mod Lead - NIST 2586,** Count: _____sec

Element	Conc (ppm) Certified	Conc (ppm) Accept?	% D Accept?
Pb	432 ± 17		
Cu	81*		
Sb	NC*		
Zn	352		

Other metals: As (8.7) _____, Ni (75*) _____,

Cr (301)_____, Cd (<3) _____, Fe (51.6K) _____

Comments: * Not a NIST certified value. %D = difference of certified and measured values, divided by certified value. Expressed as %.

Proj Action Levels (ppm): Pb=400

CB&I Federal Services

XRF Calibration Form

Site Name - City, State

Project No: Add Number | Contract Title / Client Name | Cost Code: Add Number

4. End-of-Day Calibration: Date: _____ Check XRF clock.

Is XRF warm-up >15 min? **Yes** **No** **N/A** Time: _____ Agree? **Yes** **No**

Internal calibration complete? **Yes** **No** Comments:

Record energy resolution: _____ eV

Read #:_____ **Blank - SiO_2,** Count: _____sec

Element	Conc (ppm) Certified	Conc (ppm) Detected	< RLs Accept?
Pb	< 8		
Cu	< 20		
Sb	< 60		
Zn	< 10		

Other metals: As (< 5) _____, Ni (< 40) _____,

Hg(<10) ____, Cr (<80) _____, Cd (< 35)_____, Fe (< 30) _____

Read #:_____ **Mod Lead - NIST 2586,** Count: _____ sec

Element	Conc (ppm) Certified	Conc (ppm) Accept?	% D Accept?
Pb	432 ± 17		
Cu	81*		
Sb	NC*		
Zn	352		

Other metals: As (8.7) _____, Ni (75*) _____,

Cr (301)_____, Cd (<3) _____, Fe (51.6K) _____

Comments: * Not a NIST certified value. %D = difference of certified and measured values, divided by certified value. Expressed as %.

Proj Action Levels (ppm): Pb=400

Reminder: Remove your ring dosimeter!

Form Completed by:

Signature Date

XRF Summary of Results Log - (Project Name - City, State)

Analysis Date: _____ Site Name: _____

Page ____ of ____ Analyst: _____

Location ID		Sampling Data		Prep			Reading	AL = 400		
Location	Depth (ft)	Date	Time	Bag	Lab	Frag?	No.	Pb	Std	Comments
R__										
R__										
							AVG:			
							STDev:			
							RSD%:			
R__										
R__										
							AVG:			
							STDev:			
							RSD%:			
R__										
R__										
							AVG:			
							STDev:			
							RSD%:			
R__										
R__										
							AVG:			
							STDev:			
							RSD%:			

XRF Summary of Results Log - (Project Name - City, State)

Analysis Date: _____ Site Name: _____

Page ____ of ____ Analyst: _____

Location ID		Sampling Data		Prep			XRF Data		Conc (ppm)					Split to	Other
Location	Depth (ft)	Date	Time	Bag	Lab	Frag?	Read No.	Count (sec)	Pb	Std	As	Std	Other Metals	Lab	Comments

Federal Services

XRF Usage Log

Site Name:		Proj No.:		Page:
		Number of Analyses		Finger Ring Dosimeter Worn (Y/N)?
Date	Operator Name	Hand-held Operation	Testing Stand Operation	

Keep original copy of this log with project files.

Please forward a cop of this log to the Radiation Safety Officer at the end of the calendar or at the completion of field work.

Attachment F

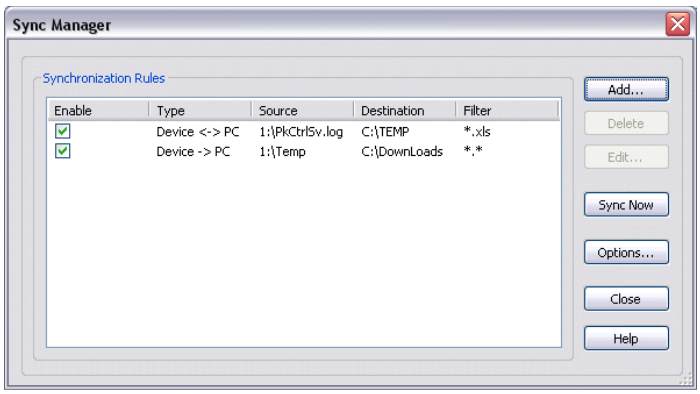
How to Configure
"Sync Manager – Pocket Controller Pro"
File Synchronization Software

How to Configure Sync Manager

Sync Manager is the software tool used to manage all synchronization settings and rules. It allows Pocket Controller what files/folders to synchronize, where they are located, how to synchronize them, and when. By using Sync Manager, Data is kept up-to-date between the PDA and computer according to user specified rules.

I. Accessing Sync Manager

1. To access Sync Manager, from the Tools menu select Sync.
2. Then, select Sync Manager (the screen shot below shows the Sync Manager dialog).



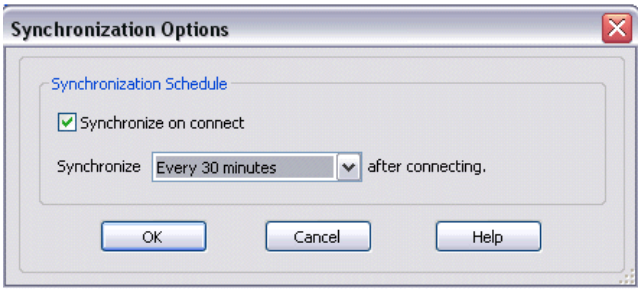
Sync Manager Dialog

The following table lists the options on the Sync Manager dialog and their function:

Button	Function
Add	To add a rule, click on the Add button, the Add/Edit Rule wizard will be displayed.
Delete	To delete a rule, select a rule from the list and then click on the Delete button.
Edit	To edit a rule, select a rule from the list and then click on the Edit button, the Add/Edit Rule wizard will be displayed.
Option	Click the Option button will bring out the Sync Option Dialog.
Sync Now	The Sync Now button allows you to manually trigger an immediate synchronization. When a manual synchronization is triggered the status of the synchronization will be displayed as it proceeds through each rule. Automatic synchronizations run in the background and generally do not display any information unless conflicts or errors occur.

II. Sync Options

1. To synchronize on connect - When this option is enabled Pocket Controller will do an immediate synchronization whenever a connection to a device is established.
2. Synchronize after connecting - This field allows users to select how often Pocket Controller should check for files that need to be synchronized.



Sync Option Dialog

Scheduling Synchronization Rules:

1. Option A: *Manual Synchronization* - Rules can be executed at any time by choosing the “Sync Now” button located on the left side of the Sync Manager dialog.
2. Option B: *Synchronize on Connection* - Rules can be scheduled to execute each time Pocket Controller Pro is accessed by selecting the "Synchronize on connect" checkbox located on the bottom left of the Sync Manager screen.
3. Option C: *Scheduled Synchronization* - Synchronization rules can execute every 5, 10, 30, or 60 minutes by choosing the appropriate option from the drop-down list located at the bottom of the Sync Manager dialog.

Creating/Editing Synchronization Rules:

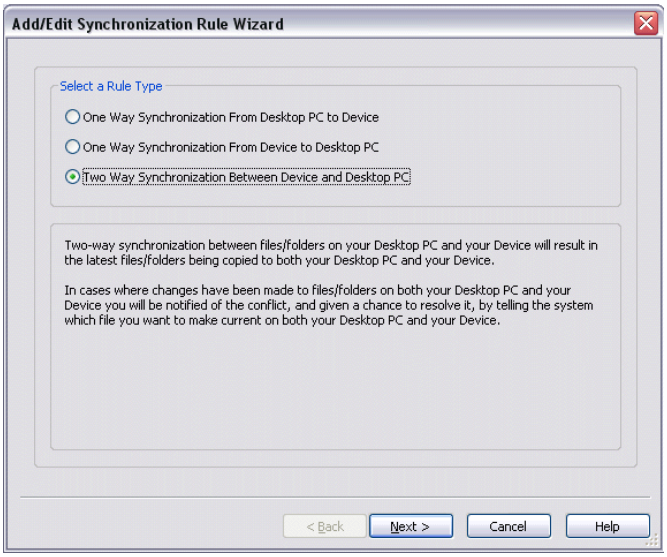
The Add/Edit Rule Wizard is used to add a new rule or to edit an existing rule. This Wizard can be accessed by:

1. Clicking on the Add button in the Sync Manager dialog
2. Or, by selecting a rule in the Sync Manager dialog
3. Then, clicking on the Edit button.

III. Using Rule Types

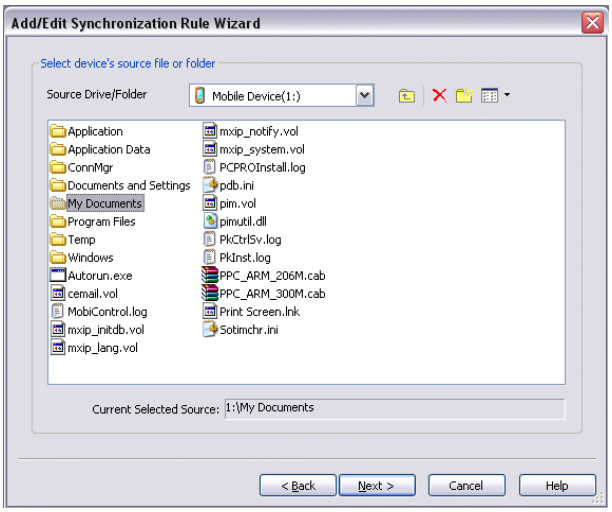
The first page of the wizard allows you to select one of three types of synchronization rules. The text at the bottom of the page displays information about the selected rule type. After selecting

the appropriate "Rule Type" click on the Next button. The page to select the source file/folder or first file/folder will be displayed.



Rule Type Page

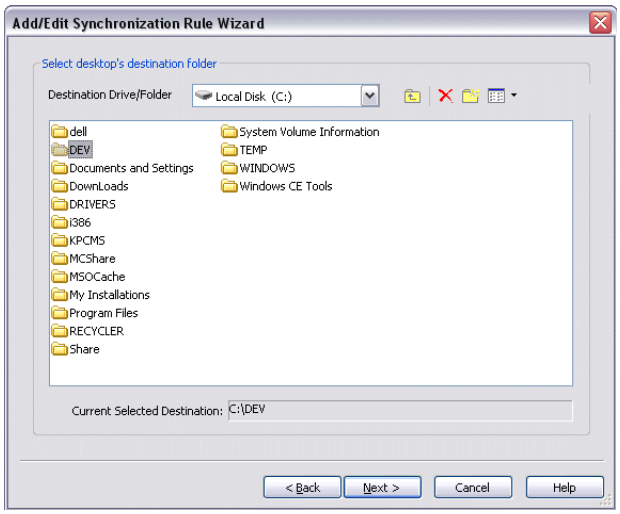
1. Selecting the "One Way" synchronization rule type will allow selection of the source folder file for synchronization.
2. Selecting the "Two Way" synchronization rule type will allow selection of the first file or folder of the two way synchronization.



Select Source/First File or Folder Page

After selecting the appropriate file/folder click on the Next button. The page to select the destination file/folder or second file/folder will be displayed.

3. If "One Way" synchronization rule type is chosen on the first page of the wizard then, this dialog will allow selection of the destination file or folder.
4. If "Two Way" synchronization rule type is chosen on the first page of the wizard then this page will allow selection of the second file or folder of the two way synchronization.

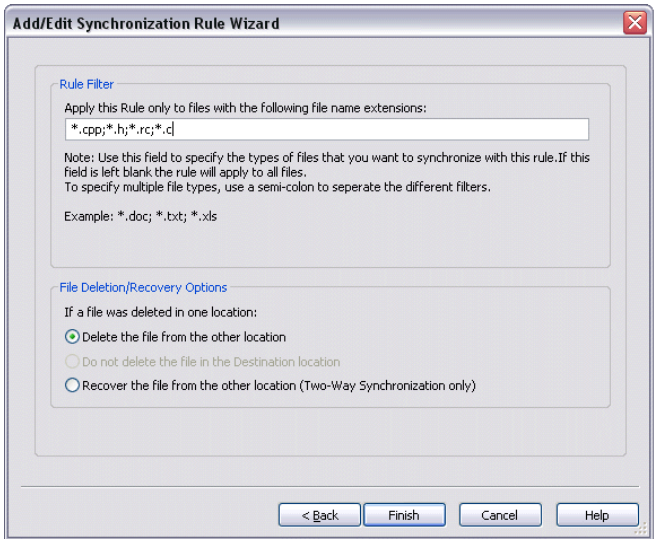


Select Destination/Second File or Folder Page

5. After selecting the appropriate destination file/folder click on the Next button. The page to select the filter according to the file extension is displayed.

IV. Optional Rule Filters

The final step in creating a synchronization rule is to specify optional Rule filters. Rule filters allow the control of file types that are to be synchronized by the rule. On this page, rule behavior is controlled for deleted files.



Add Rule/File Filters

The following table describes the fields in this dialog:

Option	Function
Rule Filter	Use this field to specify the types of files that are synchronized with this rule. If this field is left blank, the rule will apply to all files. To specify multiple file types, use a semi-colon to separate the filters. Example: *.doc;*.psw;*.xls
File Deletion/Recovery Options	This option allows you to control how the synchronization rule will handle the situation where one or more files were deleted between synchronizations. • **Delete file from the other location** - If the file was deleted in the source location (in any location in case of two-way synchronization) then delete the file in the destination location. • **Do not delete the file in the Destination location** - If the file was deleted in the source location, then leave the file in the destination location. • **Recover the file from the other location** - If the file was deleted from one location,

	then copy the file from the other location to where it was deleted from. This option is only available for a two-way synchronization rule.

To delete a rule:

1. Select the rule for deletion by clicking on it.
2. Then, click on the delete button located on the right side of the Sync Manager dialog.

To edit a rule:

1. Click on the rule to edit.
2. Click on the edit button located on the right side of the Sync Manager dialog.

To enable/disable a rule:

1. Click on the enable/disable checkbox located to the left of the rule on the Sync Manager dialog.

V. Resolving Synchronization Conflicts

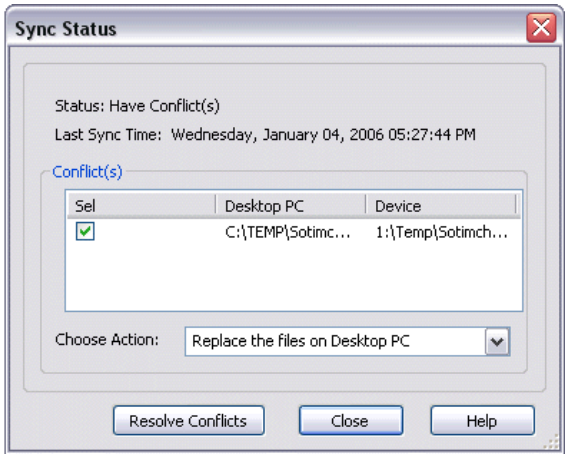
If a two-way synchronization rule has been selected and subsequently changed, the files/folders located on both the PDA and computer will cause a conflict to occur. Sync Manager does not know which file to keep. In these cases, you will be notified of the conflict through the Sync Status screen (as depicted below).

Choose either to:

1. Replace the file(s) on the PDA,

or

2. Select an action from the “Choose Action” drop-down box
3. And, select the rule to resolve by clicking on the checkbox to the left of the rule.



Sync Status Dialog

RESPONSE TO COMMENTS

Response to Ohio Environmental Protection Agency Comments on the Draft BERA Letter Work Plan, Addendum to the BHHRA and SLERA Work Plans, WWTP2 (WWTP2, TNT Area C to WWTP2 Sewer Lines, and the WWTP2 Steel Sewer Line) Former Plum Brook Ordnance Works, Sandusky, Ohio, Dated July 24, 2014

FUDS Project No. G05OH001818

The Draft BERA Letter Work Plan was reviewed by Paul Jayko, Ohio Environmental Protection Agency, who had no comments as communicated by correspondence received via email on August 15, 2014.