Interim Cleanup Action Plan

Evergreen Infiltration Range
Fort Lewis, Washington

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1.0 INTRODUCTION

This document describes the interim cleanup actions proposed for the Former Evergreen Infiltration Range (Area of Concern (AOC) 4-6.3), which is a site being addressed under the Fort Lewis Agreed Order (No. E00HWTRSR-1122) between Fort Lewis Public Works and Washington Department of Ecology. This action is being expedited ahead of the Agreed Order Cleanup Action Plan to accommodate the "Whole Barracks Renewal" Military Construction Project planned for this area. The barracks construction is scheduled to begin in 2005.

1.1 PURPOSE

The purpose of this Interim Cleanup Action Plan (ICAP) is to:

- Summarize the interim action selected and how it will meet the requirements of Washington Administrative Code (WAC) 173-340-430.
- Describe the cleanup levels, points of compliance, and compliance monitoring program for the site
- Provide a document through which public comment may be solicited.

The ICAP presents the site description and history, and summarizes the results of previous investigation efforts. Sampling efforts are described in detail in the Site Investigation Report. The ICAP also presents the proposed interim action for the site and the rationale and evaluation criteria for the action. This ICAP was prepared in accordance with WAC 173-340-430, which identifies the requirements for the ICAP.

1.2 OPERATIONAL HISTORY

Fort Lewis is a major military facility located approximately 6 miles south of Tacoma, Washington. The facility consists of approximately 86,000 acres of cantonment areas, natural prairies, lakes, wetlands, and forest. Weapons qualifications and field training have been conducted at Fort Lewis since the Fort was established in 1917.

The former Evergreen Infiltration Range is located in the main Fort Lewis Cantonment Area, adjacent to Evergreen Avenue as shown in Figure 1. It was identified from a 1951 aerial photograph. The infiltration range is about 600 feet long and about 300 feet wide. The west end contains concrete footings that hold four machine gun emplacements. A 5-foot deep trench encircles the firing area. An earthen impact berm is located approximately 300 feet east of the firing area. The berm is approximately, 330 feet long, 120 feet wide and about 25 feet high. Range layout is shown in Figure 2.

In general, the infiltration range provided conditioning for soldiers to move under live fire and simulated combat situations. The fixed-position machine guns provided live fire using 30-caliber cartridges. Soldiers exited the trench adjacent to the firing area and crawled eastward through barbed wire and other obstacles. Demolition pits containing explosives were detonated while the soldiers traversed the range.

There are no records pertaining to discontinued use of this range; however, based upon growth of vegetation, observed during site visits, and historical analyses of aerial photography, activity at this range decreased from 1955 to 1957. The range appears to be in disuse in 1965 photographs.

Numerous bullet slugs and fragments are evident at the impact berm. The bullet slugs contain 97% lead and < 2% antimony with trace amounts of copper. Bullet jackets containing copper are also present. Potential contaminants of concern are lead, antimony, arsenic, copper, tin, and zinc.

1.3 REGULATORY HISTORY

In 1980, Fort Lewis submitted a Notification of Hazardous Waste Activity to EPA that identified the requirement to manage dangerous wastes at the Dangerous Waste Management Facility. An initial RCRA Facility Assessment Report (RFA) was conducted in 1986. Sites identified as having potential releases were addressed under the 1990 Federal Facilities Agreement (FFA) and were addressed in cooperation with the EPA.

A second detailed RCRA Facility Assessment Report (RFA) was initiated by the United States Environmental Protection Agency (EPA) in 1995 and finalized based on site visits and discussions in June 1997 (EPA, 1997). This document is cited as the "1996" RFA based on the commonly used name for this document.

Fort Lewis and Ecology entered into the Fort Lewis Agreed Order (FLAO) No. DE00HWTRSR-1122 in 2001 to address Solid Waste Management Units and Areas of Concern (AOCs) with RCRA corrective action recommended in the "1996" RFA. In addition, a few sites identified following the "1996" RFA that had potential for release are also being addressed under the FLAO by agreement between Ecology and Fort Lewis. Although the FLAO includes former ranges (AOC 4) in general terms, a preliminary assessment of the Evergreen Infiltration Range (AOC 4-6.3) to determine whether further action was necessary at the site was not completed until 2003.

In the FLAO, Fort Lewis agreed to conduct a Remedial Investigation Work Plan (RIWP), a Remedial Investigation (RI), a Feasibility Study (FS) Work Plan, a Feasibility Study, and a Cleanup Action Plan under Ecology approval to satisfy corrective action requirements of WAC 173-303-646. Following approval of the RI/FS, the Cleanup Action Plan will be developed to satisfy the requirements of WAC 173-340-400 and 173-303-646. Following public review and comment, the Cleanup Action Plan will be finalized. Fort Lewis and Ecology will then negotiate and attempt to enter into either an amendment to the FLAO, a new order, or consent decree to design, operate, and monitor the selected cleanups/corrective actions.

As discussed previously, the Evergreen Infiltration Range Interim Action is being expedited ahead of the Agreed Order Cleanup Action Plan to accommodate the "Whole Barracks Renewal" Military Construction Project planned for this area. Barracks construction is scheduled to begin in 2005 and will be completed in 2007.

1.4 INVESTIGATIVE HISTORY

A Site Investigation was conducted from September through December 2003 by the U. S. Army Corps of Engineers (USACE) to evaluate potential releases that may have occurred from range use activities. Soil sampling started at the impact berm, where soil contamination was most likely. A total of 203 samples on the berm were analyzed for total lead using a field portable X-Ray Fluorescence (XRF). Additional metals and Toxicity Characteristic Leaching Procedure (TCLP) lead samples were analyzed using a fixed laboratory. Sample depths were based on the extent of contamination observed from field XRF measurements. In addition, nine demolition pits were sampled for explosives. Firing points were sampled for total metals. Details of XRF and chemical sampling protocol are described in the SAP Addendum (USACE, 2003a) and are included in Appendices A and B for convenience. Details of sample results are presented in the Site Investigation Report (USACE, 2004). In general, soil contamination was limited to the berm area. Distribution of lead in the 0-1 and 1-2 foot intervals are presented in Figures 3 through 6. The USACE treatability study team also excavated 12 test pits on the front and back sides of the berm. Test pit locations are shown on Figures 3 and 5. Soil samples from the test pits were composited and analyzed. These data were used to extrapolate lead concentrations below 2 feet (Pers. Comm. J. Gillie, 2004). Concentration above 250 mg/kg below 2 feet deep are reflected in the excavation plan shown in Figure 7.

Based on the site investigation, the following conclusions were reached:

- Soil concentrations greater than 250 mg/kg are present across the front of the berm with highest concentrations located at the impact zone. Bullet fragments were limited to the impact zone of the front of the berm;
- Concentrations are significantly higher in the middle of the impact zone and extend below depths of 2 feet, with decreasing lead concentrations encountered moving away from the impact zone;
- Lead concentrations greater than 250 mg/kg are present down slope along the toe of the berm in the 0 to 1 foot depth interval
- Soil lead concentrations greater than 250 mg/kg are present in the 0 to 1 foot depth interval across the back face of the berm. This contamination is highly heterogeneous and is likely due to ricocheted bullets;
- Lead concentrations ranged from non-detect (<45 mg/kg) to 329 mg/kg in samples collected in the trench approximately 75 feet southeast of the berm;
- Explosive residues were not detected in any of the samples collected from the infiltration range.
- TCLP analyses were conducted on five samples from the front of the berm including three from the impact zone. Soil concentrations of lead (without bullets or bullet fragments) ranged from 37.5 to 62,500 mg/kg. TCLP concentrations of these five samples exceeded 5 mg/L lead and would designate as hazardous waste per the Washington Dangerous Waste Regulations (Chapter 173-303 WAC).
- Laboratory analysis of duplicate soil samples confirmed that lead is the primary contaminant.
- After lead, antimony was the most frequent metal above the Washington Model Toxics Control Act (MTCA) Method A cleanup limits.
- Other metals were not above cleanup levels when lead was not above criterion. Therefore, lead was used to define extent of metals.
- The nine demolition pits were sampled and analyzed for explosives and explosive residues. All samples were either non-detect or below MTCA A and B reporting limits.

During the SI, the USACE and others completed treatability studies on soil from the Evergreen and other nearby closed firing ranges. Scope of the studies was to evaluate metals/soils separation and stabilization technologies. The results of the studies indicated that the lead bullets in the ranges can be successfully separated. Remaining soil also can be successfully stabilized to below Dangerous Waste levels of 5 mg/l TCLP lead. Details of typical physical separation process as well as soil stabilization are contained in Appendix C. Details of the treatability studies are in Appendix D.

2.0 INTERIM ACTION SELECTION

This section briefly explains the selection process, describes the preferred interim action, and presents cleanup levels. Points of compliance and monitoring compliance plans are also discussed.

2.1 REMEDIAL GOALS AND OBJECTIVES

The following interim remedial action objectives (RAOs) were developed for the site:

- Protection of site workers from exposure to contaminated soil
- Protection of site users from exposure to contaminated soil

2.1.1 Cleanup Levels

The results of the SI indicate that the contaminant of concern is lead. The action level of 250 mg/kg from MTCA Method A will be used based on the following criteria:

- The interim action involves a limited number of contaminants, in most instances, only lead.
- The cleanup involves a limited choice of cleanup action alternatives (See Section 2.2).
- The preferred interim action, source removal, is a reliable and proven methodology of accomplishing cleanup standards.
- No MTCA Method B cleanup level for lead is available.

A site-specific terrestrial ecological evaluation (SSTEE) will be required for the final CAP. The risk assessment, in turn, may result in a lower action level for lead. Pending results of the SSTEE, Fort Lewis understands that additional sampling and analysis, excavation of soils or other remedial action on the Evergreen Infiltration range may be required in the future as part of the final cleanup of the site to achieve the cleanup level for lead determined from the SSTEE. Implementation of this interim action will not preclude future remediation required by a lower action level. Human health, however, will be protected by the Method A cleanup level of 250 mg/kg.

2.1.2 Points of Compliance

WAC 173-340-740(6) provides the factors to be considered in establishing a point of compliance for soil. The point of compliance for soil can vary depending on the basis for the soil cleanup levels. For soil cleanup levels based on direct contact, the point of compliance is the upper 15 feet of soil throughout the site. For cleanup levels based on terrestrial ecological risk, a conditional point of compliance has been established throughout the site to a depth of 6 feet below ground surface (bgs).

2.2 INTERIM ACTIONS EVALUATED

Four cleanup alternatives were developed by the USACE for the soil interim action and are summarized below. A No Further Action Alternative was also included, which served as a basis for comparing the effectiveness of other approaches to site cleanup.

A detailed evaluation of remedial technologies was not conducted for the interim action. Cleanup of firing ranges is a Department of Defense wide activity and much research has been previously conducted (ITRC, 2003) in the remediation of small arms firing ranges. The results of this considerable body of research and testing were used to directly develop the interim action alternatives presented here.

The most common available technologies for firing range cleanup include:

- excavation and haul,
- soil washing/particle separation,
- soil stabilization,
- chemical extraction,
- asphalt emulsion batching-encapsulation, and
- phytoextraction and stabilization approaches.

Of these technologies, excavation and haul, soil washing/particle separation, and soil stabilization were retained for detailed analysis. These technologies were retained because they were considered the most effective and efficient to implement and those that local contractors would be most familiar with. Chemical extraction and phytoextraction were not included in the detailed analysis because of their relative complexity of implementation. Asphalt emulsion batching-encapsulation was not considered because of the large volume of material requiring treatment with no subsequent need on the installation for such a large volume of asphalt surfacing.

Interim actions alternatives considered were:

1. No action.
2. Excavation of lead contaminated soils and transport of all material to an approved Transfer, Storage, or Disposal Facility (TSDF).
3. Excavation of lead contaminated soils, and transport to an active Ft Lewis firing range. Hazardous material would not be treated, but would be added to similar existing hazardous material. Material would be used in construction of soil berm backstops on the ranges and will acquire additional lead sources.
4. Excavation of lead contaminated soils, separation of lead bullet fragments from soil, disposal or recycling of recovered lead, and transport of remaining soils to a TSDF.

5. Excavation of lead contaminated soils,, separation of lead bullet fragments from soil, disposal or recycling of recovered lead, stabilization of remaining soils to designate as non-hazardous waste and use of the soils as construction backfill material on the active ranges.

The five alternatives were evaluated against the State of Washington Model Toxics Control Act (MTCA) threshold criteria:

- Protects human health and the environment
- Complies with cleanup standards
- Complies with applicable state and federal regulations
- Provides for compliance monitoring.

Other MTCA criteria are:

- Uses permanent solutions to the maximum extent practicable
- Provides for reasonable restoration timeframe
- Considers public concerns
- Cost

Table 1 shows the results of the evaluation and includes order of magnitude cost estimates.
Of these alternatives, Alternative 5, source removal, separation and stabilization was selected at the preferred interim action and is described below.

3.0 DESCRIPTION OF PREFERRED INTERIM ACTION

Based on the USACE and AMEC (See Appendix C) sampling, USACE estimates 4400 cubic yards of soil exceed 250 mg/kg for lead at the Evergreen Range (See Table 2). Estimated excavation areas and depths for this range are presented on Figure 7. Data shows that the majority of soil contains lead fragments from bullets and fails TCLP. Therefore, the remediation will consist of excavation of identified soils, removal of lead bullet fragments, stabilization of remaining waste stream to pass TCLP, and transport and placement of soils at active ranges on Fort Lewis. Final excavation areas and depths will be determined through compliance sampling (See Section 6.0). Additional excavation will be conducted as necessary until documented results of compliance sampling confirm that concentrations of lead in all remaining soils at the site are below 250 mg/kg. The site will be rough graded following excavation and on-site soils confirmation.

Work will be conducted using performance based goals. Details of the performance criteria for each portion of the cleanup action are summarized below and described in more detail in Section 6.0 Compliance Monitoring.

During excavation, on-site soils will be tested for lead concentrations using a combination of portable X-Ray Fluorescence (XRF) and standard laboratory chemical analysis. The interim cleanup level will be 250 mg/kg lead. The XRF will be used as a screening tool to determine final excavation depths. Confirmation soil samples for laboratory analysis will then be collected based on a statistical analysis of the XRF data (See Section 6.0).

The Contractor will be required to provide a written proposal that will describe the specific technology and procedures to be used for removal of bullet fragments from the excavated soils. The Contractor will also be required to provide documentation that the Contractor or a selected subcontractor has experience in previous application of the proposed technology. The Contractor will be required to identify in the proposal the specific methods that will be employed to manage the excavated lead-contaminated soils as hazardous waste prior to results of confirmation sampling using TCLP verifying that these soils no longer designate as hazardous waste. The facility where the removed lead will be recycled or disposed will also be required to be identified in the Contractor's proposal. The Contractor will be required to obtain USACE, Fort Lewis and Ecology approval of the Contractor proposal prior to implementing the proposed procedures for bullet fragment separation".

The Contractor will be required to recycle or dispose of the reclaimed bullet fragments at the facility identified in the Contractor's proposal as approved by USACE, Fort Lewis and Ecology In accordance with MTCA and the Dangerous Waste Regulations, the remaining excavated soils will be stabilized to ensure soils pass TCLP criteria prior to transporting and placing in the active firing ranges. The remediation contractor will be required to use an appropriate technology for soil stabilization and is expected to use the same or similar methods of stabilization that the treatability testing utilized. Based on the treatability studies (Appendix D), it is anticipated that a phosphate based stabilizer such as Enviro 50:50™ or other proprietary blend will be used to ensure that excavated soils meet the TCLP lead criterion. The Enviro 50:50™ stabilizer mixed at 3% by weight was successful in achieving the performance goal for the TCLP concentration of 5 mg/l lead.

The Contractor will be required to provide a written proposal that will describe the specific technology and procedures to be used for stabilizing the excavated soils. The Contractor will also be required to provide documentation that the Contractor or a selected subcontractor has experience in previous application of the proposed technology. The Contractor will be required to obtain government (USACE, Fort Lewis and Ecology) approval of the Contractor proposal prior to implementing the proposed procedures for stabilizing the excavated soils.

The performance of separation technology utilized by the contractor will be evaluated as follows:

For approximately every ton of treated soil, the contractor will be required to obtain a 5 kg sample from a representative portion of the treated soil and hand search the sample for bullet material. The contractor will be required to provide documentation that the treated soil contains less than 0.1% (1/1000) bullet material by volume for the total 5 kg sample. If documented results indicate that this criterion is not met, additional treatment will be required until the contractor is able to document that a representative sample of the treated soil achieves this criterion. This evaluation is to be performed and results documented by the contractor.

The performance of soil stabilization will be evaluated by collecting 1 representative composite sample per 100 yd^3 of soil, with a minimum of 30 sub-samples per composite sample, and analyzing for TCLP lead. The extract shall meet the chemical post-treatment testing of 5 mg/L.

In addition, the following performance criteria will also be considered:

- The soil must maintain pH (as measured using TCLP method, 5 g of soil in equilibrium with 95 mL of DI water) between 6 to 9. If native soil is outside this range, then the contractor must not allow pH to change more than 1 pH unit. The pH cannot exceed >12 or <2 (Federal (RCRA) hazardous waste criteria).

- The contractor must not allow the soil to exceed any criteria that would classify the material as a Federal RCRA hazardous waste or to be classified as a Ecology Dangerous Waste.

Following treatment, the soils will be transported to one of several active ranges and used as berm material. Descriptions and priority of need for active ranges are in Table 3. Locations and haul routes are presented on Figure 8. Priority of need indicates the construction hierarchy that the Fort Lewis Range Command has established. Long-term stabilization of placed material will not be monitored because the ranges are active and the berms will continue to acquire lead bullets.

4.0 JUSTIFICATION FOR PREFERRED INTERIM ACTION

4.1 REGULATORY EVALUATION

The preferred interim action has been designed to satisfy the MTCA threshold and other requirements (WAC 173-340-360(2)(a) and (b)) with the exception of site-specific terrestrial ecological evaluation (See Section 4.2). This was done so that the action may constitute the final cleanup action for the site (WAC 173-340-430(1)) if the site-specific terrestrial ecological evaluation shows that the 250 mg/kg cleanup level for lead is protective of the environment.. This section describes how the preferred cleanup action will satisfy these requirements.

The threshold requirements state that the overall interim action must provide the following:

- Protection of human health and the environment.

- Compliance with the cleanup standards set forth in WAC 173-340-700 through 173-340-760

- Compliance with applicable state and federal laws

- Provision for compliance monitoring.

MTCA also defines other requirements, which the interim action must satisfy. These are:

- Use of permanent solutions to the maximum extent practicable

- Provision for a reasonable restoration time frame

- Consideration of public concerns raised during the public comment period.

4.2 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The preferred remedies provide adequate protection of human health. This protection is afforded by eliminating the direct soil contact pathway to residential users of the former Evergreen Range site. In addition, soil removed from the site will be treated to meet Washington Dangerous Waste requirements and placed on existing firing ranges.

Ecological risk for this site has not been determined at this time. Preliminary assessment suggests that a Site Specific Terrestrial Ecological Evaluation (SSTEE) will be required for the site, i.e. more than 10 acres of native vegetation are within a 500 foot radius of the contaminated area. This also will likely be true after the area is developed into a barracks complex as discussed in Section 1.0. Figure 8 shows that if the development is completed as currently planned, approximately 13 acres of native vegetation will still be within the 500 foot radius following development. An alternative SSTEE will be conducted in the future per WAC 173-340-7493(3)(a) to (3)(g) to define the potential ecological risk. Additional remediation may be required as a result of the SSTEE. The proposed interim action, however, does not preclude future cleanup of the site to lower concentrations of the primary contaminant (lead).

4.3 COMPLIANCE WITH CLEANUP STANDARDS AND LAWS

The preferred interim action will comply with MTCA cleanup standards for human health. An SSTEE will be completed to determine compliance with MTCA cleanup standards for the environment. Additional compliance measures may be required as a result of the SSTEE. Compliance monitoring will be performed to assess whether cleanup levels for human health are achieved during this interim action. The interim action meets state and federal laws and all activities used to implement the remedy will meet the substantive requirements of laws requiring permits or approvals.

4.4 PROVISION FOR COMPLIANCE MONITORING

The preferred alternative provides for compliance monitoring during implementation of the remedy to ensure that human health is protected during construction and throughout the life of the remedy. This monitoring will be performed in compliance with a health and safety plan and substantive requirements of any applicable local permits.

4.5 USE OF PERMANENT SOLUTIONS

This criterion is based on the preference stated in WAC 173-340-360 to utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In order to determine whether a cleanup alternative is protective to the maximum extent practicable, the alternative is evaluated based on the following criteria:

- Overall protectiveness of human health and the environment
- Long term effectiveness
- Short term effectiveness
- Permanent reduction of toxicity, mobility, and volume of hazardous substance
- Ability to be implemented

- Cleanup costs.

Overall protectiveness of human health and the environment was previously discussed in Section 4.2 since these are also threshold criteria under MTCA. The other five criteria are discussed below.

4.5.1 Long Term Effectiveness

The long-term effectiveness criterion is primarily concerned with residual risk remaining at the site after completion of the cleanup action. This analysis includes consideration of the degree of threat posed by the hazardous substances remaining at the site after completion of the cleanup action and the adequacy of any controls used to manage these hazardous substances. Alternatives that afford the highest degree of long-term effectiveness and permanence are those that minimize waste remaining at the site such that long-term maintenance is unnecessary and reliance on institutional controls is minimized.

The preferred remedy for the Evergreen Range site includes removal of soil containing lead; therefore the goal for long term effectiveness of the remedy is achieved.

4.5.2 Short Term Effectiveness

The short-term effectiveness criterion addresses the effects to human health and the environment of the alternative during the construction and implementation phase until remedial response objectives are met. Factors used in assessing short-term effectiveness are:

- Short-term risks posed to the community during implementation of the alternative
- Risks to site workers during implementation
- Environmental impacts that may be caused by implementation
- The length of time that the short-term risks may be required.

The greatest short-term risk during remedial activities at the site will be related to soil handling and management during soil removal and treatment. Site workers will be trained in accordance with Occupational Safety and Health Act and Washington Industrial Safety and Health Act requirements for hazardous waste site workers. There will be no potential exposure to the community.

The proposed cleanup actions will be implemented to comply with applicable state and federal laws as described in Section 8. Requirements for necessary permits will be followed and permitting agencies will provide guidance and approval for necessary state and local permits.

4.5.3 Reduction of Toxicity, Mobility, or Volume Through Treatment

The reduction of toxicity, mobility, or volume through treatment criteria is a reflection of Ecology's expectation under WAC 173-340-360(3)(f)(ii) to implement cleanup actions that employ treatment technologies that permanently reduce the toxicity, mobility, or volume of the hazardous substances. This criterion is used to assess

- The volume of impacted media treated or recycled

- The degree to which the treatment is irreversible
- The type and quantity of the treatment residues
- The degree to which treatment reduces principal site concerns.

The preferred remedy provides for treatment of soil that is removed from the site. Soils will be treated to meet TCLP lead concentrations. Soil will be placed in active ranges.

4.5.4 Implementability

Department of Defense experience at other sites and site specific treatability studies indicate the preferred interim action can be implemented with standard remediation practices and reasonable contractor knowledge of remedial technologies.

4.5.5 Cost and Cost Effectiveness

Cost effectiveness is a measure of practicability. A cleanup alternative is not considered "practicable" if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative (WAC 173-340-360(3)(e)(i)). The proposed interim action (Alternative 5) provides the lowest cost of the alternatives that meet the threshold criteria. If, however, soil from the Evergreen range were placed on existing active ranges without treatment (Alternative 3), the proposed alternative would be four times the lowest cost alternative and may not meet the cost effectiveness criterion.

4.5.6 Reasonable Restoration Time Frame

The remedial approach recommended in this ICAP includes soil removal and treatment. Remediation is currently anticipated to commence in November 2004 and should be completed within six months.

4.5.7 Community Acceptance

The opinion of the community will be formally solicited during the public comment period. Assessment of community acceptance will occur following completion of the public comment period.

5.0 SCHEDULE FOR IMPLEMENTATION

The interim action is scheduled to begin in October 2004. The contractor will be required to submit all plans including the submittals described in this interim cleanup action plan and a detailed schedule to USACE, Ft Lewis, and Ecology within 30 days of Notice to Proceed. USACE, Ft Lewis and Ecology will in turn respond to the contractor's submittals within 30 days. All work will be completed by 30 May 2005.

6.0 COMPLIANCE MONITORING

Monitoring is one of the threshold requirements for cleanup actions under MTCA (WAC 173-340-360(2)(a)(iv)). Compliance monitoring as defined in WAC 173-340-410 requires three types of monitoring: Protection monitoring, performance monitoring, and confirmational monitoring.

- Protection monitoring is performed to confirm that human health and the environment are adequately protected during the construction and operation and maintenance periods of the action. This type of monitoring will be addressed in the site specific Environmental Health and Safety Plan to be provided by the Contractor.

- Performance monitoring is completed to confirm that the "cleanup action has attained cleanup standards or if appropriate other performance standards such as monitoring necessary to demonstrate compliance with a permit, or where a permit exemption applies, the substantive requirements of other laws" (WAC 173-340-410). Performance monitoring is described below.

- Confirmational monitoring is performed to confirm the long-term effectiveness of the cleanup action once cleanup standards, remediation levels, or other performance standards have been attained. Soils above MTCA Method A cleanup levels will be removed from the site, consequently, long-term monitoring will not be required.

The project compliance monitoring requirements that the cleanup action contractor must meet are provided in this section. Following award of the contract the cleanup action contractor will be required to submit a detailed work plan, sampling and analysis plan, a health and safety plan, and a quality assurance project plan that will be subject to review and approval by the USACE, Ft Lewis PW, and the Department of Ecology.

The Contractor will be required to perform sampling and analysis to confirm and document that performance standards as described in this Interim Cleanup Action Plan have been achieved for lead removal, bullet fragment separation and soil stabilization. Specific procedures to be utilized by the Contractor shall be described in a Field Sampling Plan to be prepared by the Contractor and approved by USACE, Fort Lewis and Ecology prior to beginning excavation activities.

The Contractor shall conduct surface soil sampling in excavated areas to confirm the presence or absence of contamination above MTCA Method A. Sufficient samples shall be collected as to provide confidence that the MTCA level is not exceeded. The Contractor shall design a sampling strategy that utilizes an XRF to confirm that all soils with lead above 250 mg/kg have been removed with a 90% confidence level. The 90% confidence level is for initial screening only and does not include the final confirmational sampling. Following XRF analysis any hot spots detected by the XRF will be removed.

The final confirmation sampling strategy will be designed by determining the XRF data pooled variance to calculate a relative standard deviation for the site. The appropriate number of confirmation samples to be sent to a fixed laboratory for ICP analysis will be calculated by utilizing the standard deviation from the XRF data and using 0.4 as the standard gray zone. All confirmation fixed laboratory samples shall be discrete samples. The gray zone reflects a region of decision uncertainty in a planned data set and allows calculation of the estimate of the number of confirmational samples to be collected. Using 0.4 (a narrow gray zone) will ensure that an adequate number of confirmational samples will be collected so that 95% upper confidence limit of the cleanup level can be determined. The final confirmation strategy will be submitted to USACE, Fort Lewis and Ecology for approval prior to beginning confirmational sampling.

A USACE representative shall be present to inspect the removal of contaminated material from within the project limits. Lead contamination extends throughout the project site as shown on the drawings. Therefore, the contractor shall initially excavate to the depths shown on the drawings. After excavation to the limits indicated on the drawings, the excavation shall be examined for evidence of contamination. If the excavation appears to be free of contamination, field analysis shall be used to determine the presence of lead contamination using XRF. Excavation of additional material beyond the limits indicated on the drawings shall be as directed by the Contracting Officer. After XRF analysis demonstrates that the site is compliant with all chemical parameters and respective action levels, collaborative samples shall be collected and lab analyzed for the following contaminants:

Chemical Parameter	Action Level (mg/kg)
Lead	250

The decision on whether an area complies with a cleanup level will be based on MTCA cleanup criteria: (1) the upper 95% confidence limit on one true population mean, calculated from sampling data, cannot exceed the cleanup level; (2) no sample will be twice the cleanup level; and (3) less than 10% of the samples can exceed the cleanup level. Based on test results, the Contractor shall propose any additional excavation, which may be required to remove material, which is contaminated above action levels.

The construction specifications require the Contractor to devise a sampling plan that detects and removes any hot spots of soils with lead above 250 mg/kg with a 95% confidence level. The Contractor is responsible for creating a field-sampling plan (FSP) that will identify potential hot spots. This FSP will be reviewed and approved by Fort Lewis, USACE, and Ecology.

6.1 STABILIZED SOIL TESTING

Soils that have been stabilized must meet or exceed the toxicity characteristic for lead as specified in state dangerous waste regulations WAC 173-303-090(8)(c). TCLP testing in accordance with Method 1311, Toxicity Characteristic Leaching Procedure shall be performed on representative samples of treated material. Representative samples shall be obtained consistent with WAC 173-303-110(2) in the state dangerous waste regulations. One representative composite sample per 100 yd^3 of soil, with a minimum of 30 sub-samples, shall be tested. Testing will be performed prior to loading for transportation so soil batches not meeting the TCLP performance criteria will require further treatment and performance testing.

6.2 BULLET FRAGMENT SEPARATION PERFORMANCE MONITORING

Performance of bullet fragment separation will be evaluated using the following criteria:

- For approximately every ton of treated soil, the contractor will be required to obtain a 5 kg sample from a representative portion of the treated soil and hand search the sample for bullet material. The contractor will be required to provide documentation that the treated soil contains less than 0.1% (1/1000) bullet material by volume for the total 5 kg sample. If documented results indicate that this criterion is not met, additional treatment will be required until the contractor is able to document that a representative sample of the treated soil achieves this criterion. This evaluation is to be performed and results documented by the contractor.

- The Contractor shall ensure that this waste stream is recyclable with required certification if cost effective. The Contractor is further encouraged to minimize solid waste generation throughout the duration of the project. The Contractor shall participate in State and local government sponsored recycling programs.

6.3 PERFORMANCE MONITORING REQUIREMENTS FOR WASTE WATER ANALYSIS

Liquid collected from excavations, storage areas, and decontamination facilities shall be sampled at a frequency of once for every 500 gallons of liquid collected or one per each distinct water waste stream. Samples shall be tested for the following:

Chemical Parameter	Action Level (ug/L)
Lead	15

Liquid with contaminant levels that exceed action levels shall be disposed of at an approved disposal facility. Analyses for contaminated liquid to be taken to an offsite disposal facility shall conform to local, state, and federal criteria as well as to the requirements of the disposal facility.

6.4 SOIL SAMPLING REQUIREMENTS UNDER STORAGE AREAS

Samples from beneath each storage unit shall be collected prior to construction of and after removal of the storage unit. Samples shall be collected at a frequency of one per each 10 square yards from a depth interval of 0 to 0.5 feet and shall be tested for the following:

Chemical Parameter	Action Level (mg/kg)
Lead	250

Based on test results, soil which has become contaminated above action levels shall be removed. If contaminated soil must be removed, additional sampling and testing shall be performed to verify areas of contamination found beneath stockpiles have been cleaned up to below action levels.

7.0 INSTITUTIONAL CONTROLS

Soils above MTCA Method A cleanup levels will be removed from the site, consequently, institutional controls (WAC 173-340-440) will not be required.

8.0 APPLICABLE STATE AND FEDERAL LAWS

MTCA requires that all cleanup actions comply with applicable state and federal laws (RCW 70.105D.030(2)(e); WAC 173-340-710). For purposes of MTCA, the term “applicable state and federal laws” includes (1) those requirements that apply as a matter of law to the cleanup action; and (2) those requirements that the Ecology determines, based on consideration of the criteria in WAC 173-340-710(4), are relevant and appropriate requirements. The term “relevant and appropriate requirements” includes those standards, criteria and other limitations established under state and federal law that, while not legally applicable to the hazardous substances, cleanup action, location or other specific circumstances at the Evergreen Infiltration Range, nevertheless address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the site. Table 4 summarizes applicable state and federal laws for the Evergreen Infiltration Range. Laws that are not "legally applicable" or "relevant and appropriate" are not listed.

9.0 REFERENCES

Gillie, James. 2004. Personal communication with Kym Takasaki. USACE. August 17.

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U.S. Army Corps of Engineers (USACE). 2003. Draft Final Remedial Investigation Work Plan Agreed Order # DE00HWTRSR-1122. DPW. Fort Lewis, WA. June.

________, 2003a, Final Sampling and Analysis Plan Addendum. Fort Lewis Agreed Order. Former Small Arms Ranges Miller Hill Pistol Range and Evergreen Infiltration Range (AOC 4-2.2 and 4-6.3). August, 2003.

_______, 2004, Draft Site Investigation Report Remedial Investigation Phase: Former Evergreen Infiltration Range (AOC 4-6.3), Miller Hill Pistol Range (AOC 4-2.2) and Skeet Range (AOC 4-3). Ft Lewis. 14 March

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Tables

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Table 1 Interim Cleanup Action Alternatives Evaluation

Interim Alternative	Meets MTCA threshold criteria	Uses permanent solutions	Provides reasonable restoration timeframe	Considers Public Concerns	Estimated Construction Cost[1]
1. No Action	No	No	No	(2)	**0$**
2. Excavation, TSDF Disposal Total	Yes[3]	Yes	Yes	(2)	$120,000 $2,180,000 **$2,300,000**
3. Excavation, Range disposal Total	No	Yes	Yes	(2)	$120,000 $180,000 **$300,000**
4. Excavation, Separation, TSDF disposal Total	Yes[3]	Yes	Yes	(2)	$120,000 $330,000 $1,250,000 **$1,700,000**
5. Excavation, Separation, Stabilization, Range Disposal Total	Yes[3]	Yes	Yes	(2)	$120,000 $330,000 $600,000 $150,000 $**1,200,000**

(1) Does not include costs to implement institutional controls or other administrative costs. Costs developed by Ft Lewis Public Works based on 5,500 cy (4,400 +25% contingency)
(2) Public concerns will be determined during the public comment period
(3) Ecological risk has not been determined at this time

Table 2 Volume Calculations

Action Level	Description	Contaminated + Clean Volume					Clean Volume		Contaminated Volume
(ppm)	Location, Below Ground Surface	Length (ft)	Width (ft)	Depth (ft)	Total (ft^3)	Total (yd^3)	Total (ft^3)	Total (yd^3)	Total (yd^3)
250	Front Side, 0' - 1' bgs	330	70	1.0	23,100	856	4,300	159	696
250	Front Side, 1' - 2' bgs	330	70	1.0	23,100	856	7,550	280	576
250	Front Side, 2' - 3' bgs. (Inferred from Treat Study.	330	70	1.0	23,100	856	7,550	280	576
250	Front Side Area (160x25), 3' - 7'bgs. Inferred from Treat Study	160	25	4.0	16,000	593	0	0	593
250	Back Side, 0' - 1' bgs	330	145	1.0	47,850	1772	17,550	650	1122
250	Back Side, 1' - 2' bgs	330	145	1.0	47,850	1772	41,050	1520	252
250	Back Side, 2' - 5.5' bgs (Inferred from Treat Study)	70	65	3.5	15,925	590	0	0	590
250	Total Volume	n/a	n/a	n/a	196,925	7,294	78,000	2,889	4,405

Table 3 Active Range Descriptions

Range No.	Status	Priority of Effort	Size (acres)	Type	Dist (mi)	First Est.	Necessary Maintenance	Estimated Volume (cu/yds)
22	Active	1	45	Small Arms (<.50 cal)	6	1966	New Backstop (300' x 25' x 50')	7,000
89	Active	2	4	Small Arms (<.50 cal)	9	No record	New Backstop (150' x 10' x 20')	600
90	Active	3	4	Small Arms (<.50 cal)	9	1970	2 New Berms: For left and right side of Range 90 (Each berm: 150' x 10' x 20')	1,200
21	Active	4	16	Small Arms (<.50 cal)	6	1970	New Backstop (300' x 25' x 50')	7,000
18	Active	5	3	Hand Grenade	6	1975	New Backstop (600' x 10' x 20')	2,200
19	Active	6	20	Small Arms (<.50 cal)	6	1962	New Berms on Ranges 18 &19 (600' x 10' x 20')	4,000

Table 4 Potentially Applicable or Relevant & Appropriate Requirements (ARARS)

Applicable or Relevant & Appropriate Requirement	Comment
FEDERAL ARAR'S	
Hazardous Material Regulation 40 CFR 171	No person may offer to accept hazardous material in commerce unless the material is properly classed, described. [packaged, marked, labeled, and in condition for shipment. These requirements are applicable to hazardous material generated during remedial activities that would be sent offsite for disposal.
Hazardous Materials Tables, Hazardous Materials Communications Requirements and Emergency Response Information Requirements 49 CFR 172	These requirements are applicable if hazardous material is generated during remediation and is transported offsite. Tables are used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Specific performance requirement are established for packages used for shipping and transport of hazardous materials.
National Historic Preservation Act of 1966 Title 16 USC 470	The National Preservation Act requires that historically significant properties be protected. The National Register of Historic Places is a list of sites, buildings or other resources identified as significant in U. S. history. An eligibility determination provides a site the same level of protection as a site listed on the National Register of Historic Places. The requirements of this federal law are potentially applicable based on a determination of whether the range site is a historic property.
Resource and Recovery Act Title 42 USC 6901 et seq	The Resource Conservation and Recovery Act (RCRA) consists of standards and criteria controlling the treatment, storage and disposal of hazardous wastes. The EPA has granted the State of Washington the authority to implement RCRA through the Dept of Ecology's dangerous waste program (Chapter 173-303 WAC). To avoid redundancy, RCRA criteria which are potential ARAR for the Evergreen Infiltration Range are not detailed here. The dangerous waste regulations are listed below in this table.
Standards for Generators, Transporters of hazardous waste, & Owners & Operators of treatment, storage & disposal facilities 40 CFR 262 - 264	Contains requirements for hazardous waste handling, transport, treatment, storage, and disposal. If remedial waste is shipped off-site, it must be sent for treatment, storage, or disposal at a facility acceptable under the NCP's Off-Site Disposal Rule.

Table 4 (cont'd)

STATE ARAR'S	
Washington Dangerous Waste Regulations (Chapter 173-303 WAC)	Parallels RCRA Subtitle C regulations; definition of dangerous waste is broader than the federal definition
Model Toxics Control Act (MTCA) (Chap 173-340 WAC)	Specifies requirements for the identification, investigation, and cleanup of hazardous waste sites. All cleanup actions must use permanent solutions to the maximum extent practicable. Sets cleanup levels for various environmental media. Governs use of institutional controls.
State Environmental Protection Act (SEPA) rules and procedures (Chaps 173-802 and 173-11 WAC)	Provides a way to identify possible environmental impacts that may result from governmental decisions. These decisions may be related to issuing permits for private projects, constructing public facilities, or adopting regulations, policies or plans. Information provided during the SEPA review process helps agency decision-makers, applicants, and the public understand how a proposal will affect the environment. This information can be used to change a proposal to reduce likely impacts, or to condition or deny a proposal when adverse environmental impacts are identified
Waste Discharge General Permit Form (Chap 173-226 WAC)	Establishes a state general permit program, applicable to the discharge of pollutants, wastes, and other materials to waters of the state, including discharges to municipal sewerage systems. Permits issued under this chapter are designed to satisfy the requirements for discharge permits under sections 307 and 402(b) of the federal Water Pollution Control Act (33 U.S.C. §1251) and the state law governing water pollution control
Water Quality Standards for Surface Waters of the State of Washington (Chap 173-201A WAC)	Establishes water quality standards for surface waters of the state of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife.
Washington State Clean Air Act (RCW 70.94, Chap 173-460 WAC)	Controls new sources of toxic air pollutants. Concentrations of toxic air contaminants at the site boundary are evaluated against Acceptable Source Impact Levels (ASILS).

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Figures

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AOC 4- 6.3 Evergreen Infiltration Range

Figure 1. Evergreen Infiltration Range Location Map

Figure 2. Site Features - Evergreen Infiltration Range (AOC 4-6.3)

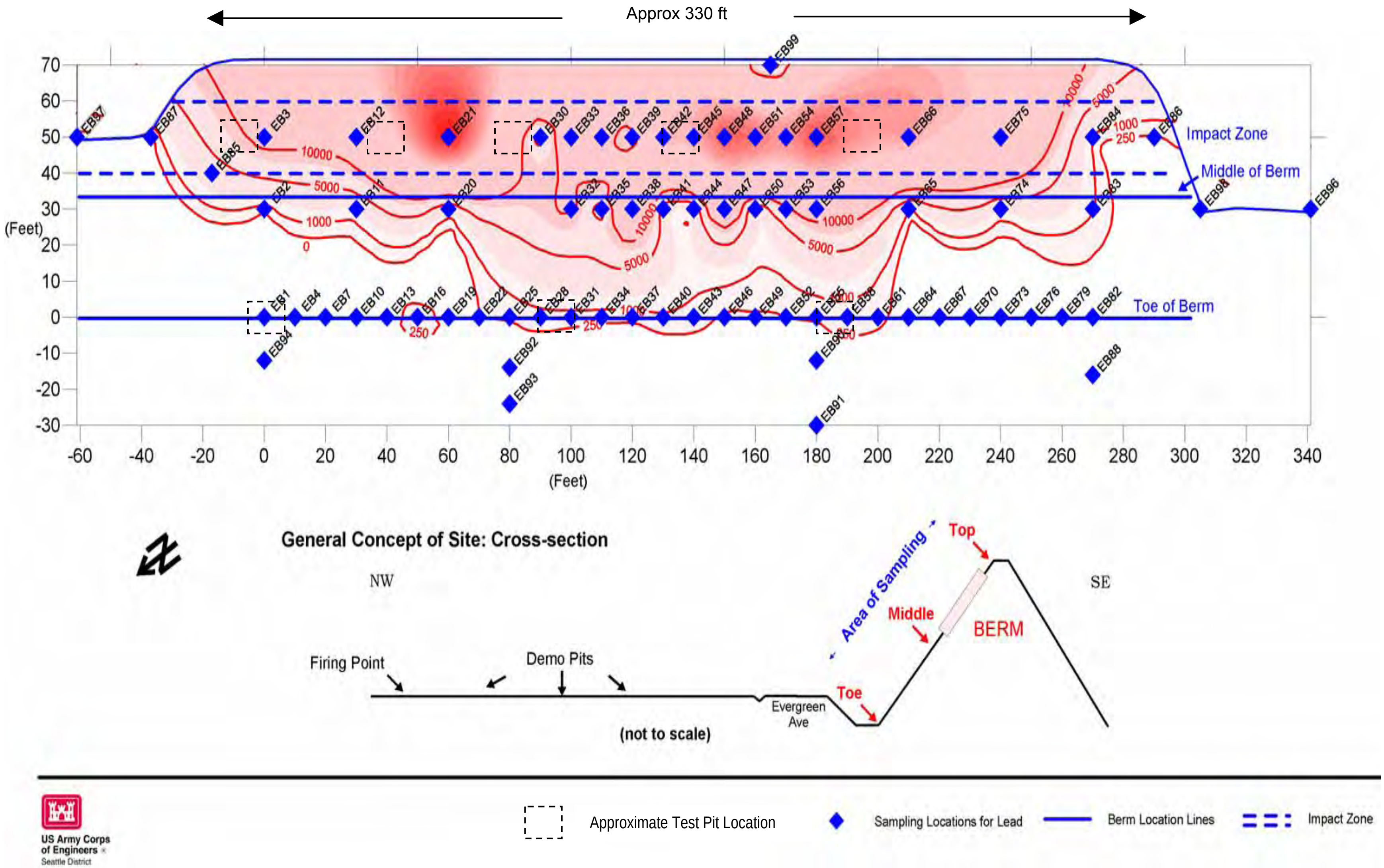


Figure 3. Lead Concentration Results for the Front Face Evergreen Infiltration Range (0-12 inches)

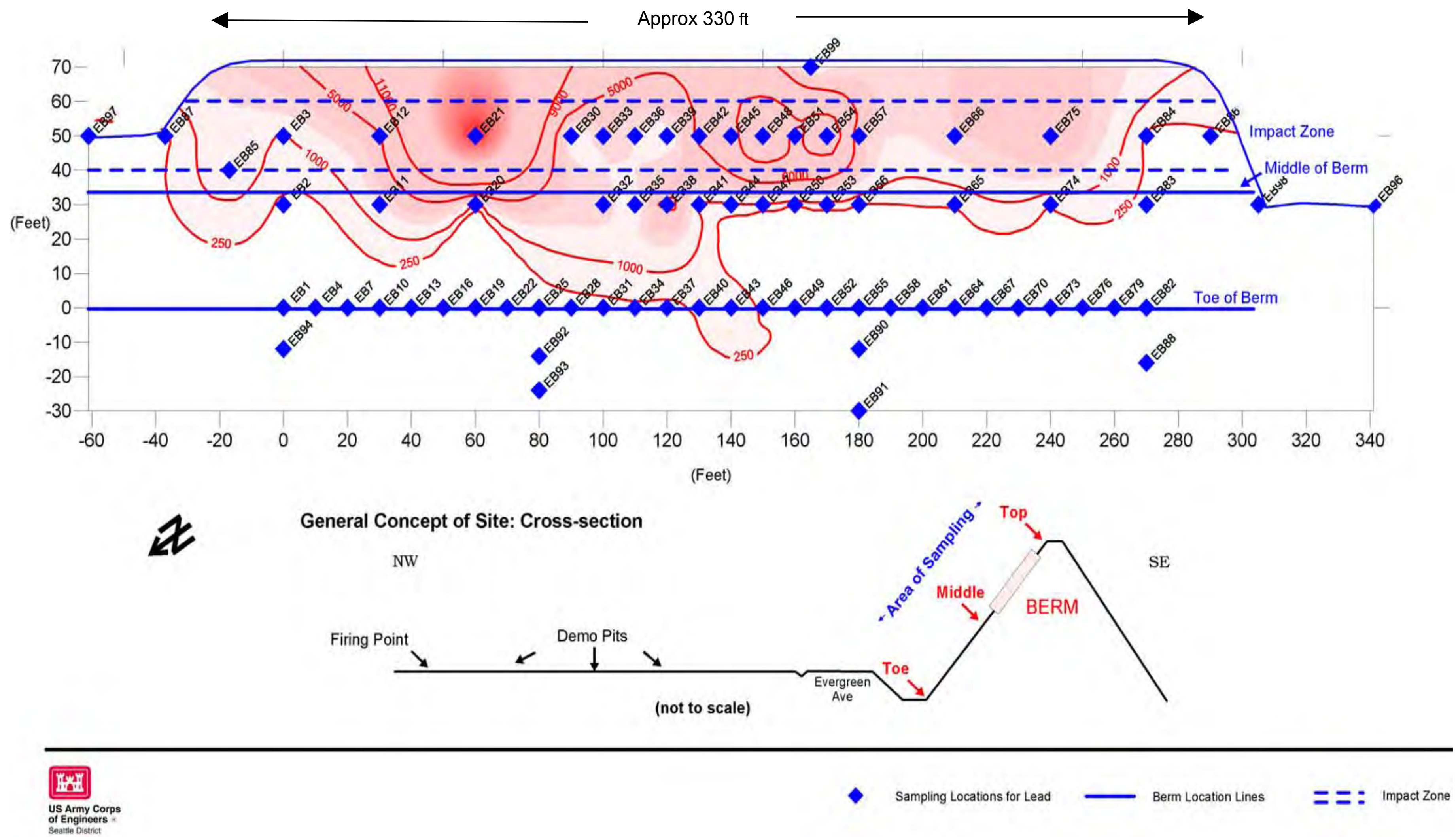


Figure 4. Lead Concentration Results for the Front Face Evergreen Infiltration Range (12-24 inches)

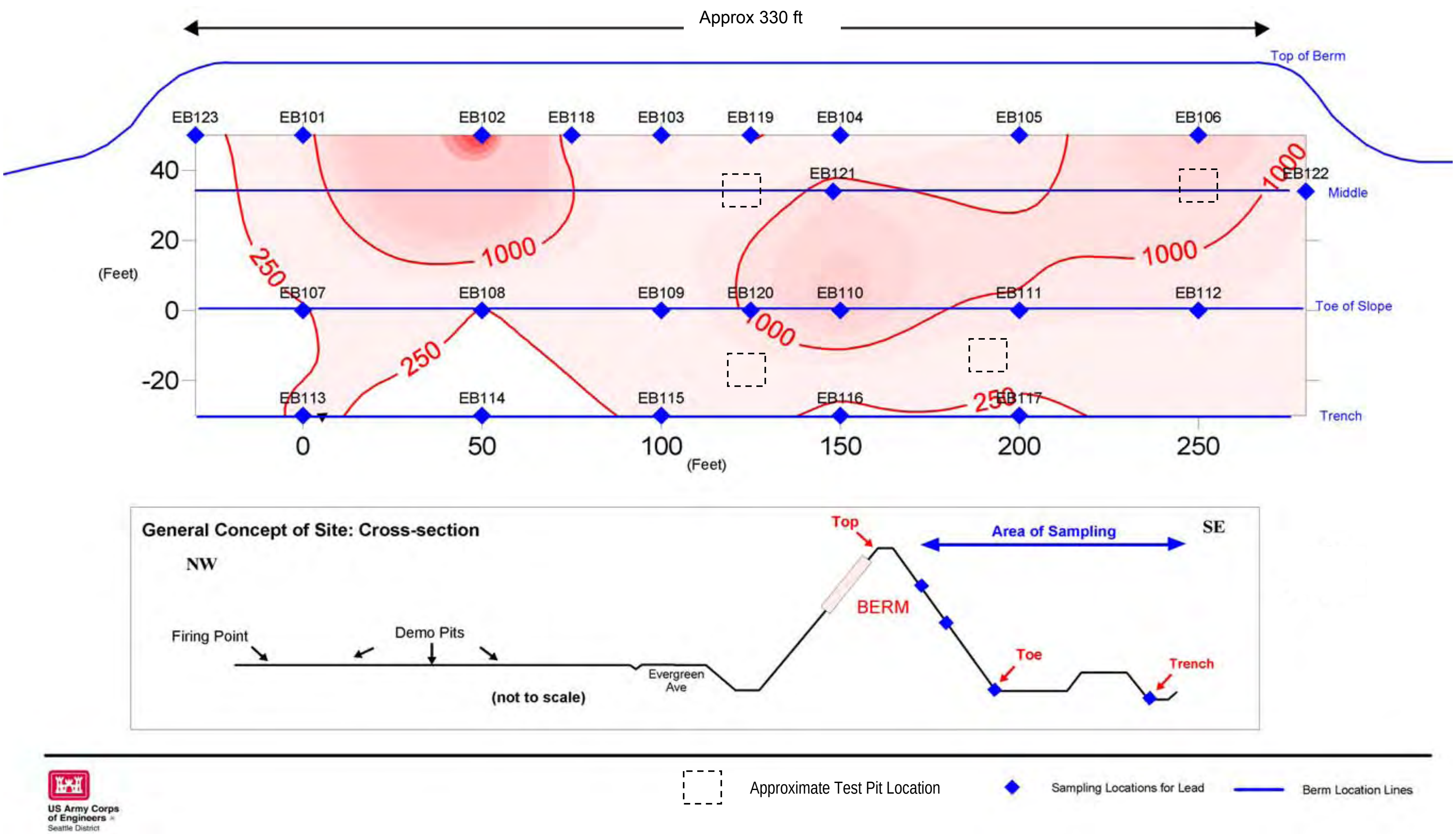
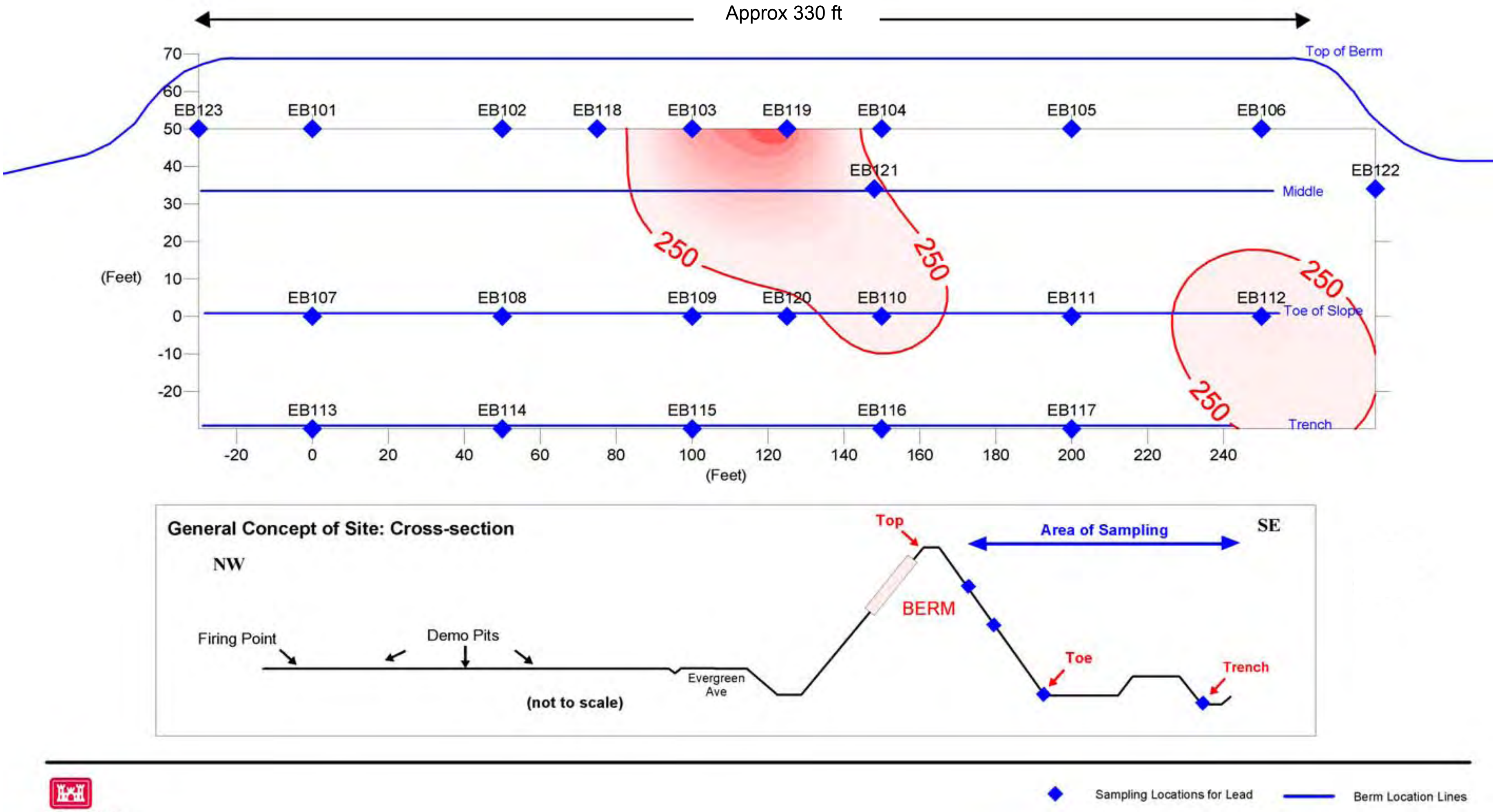
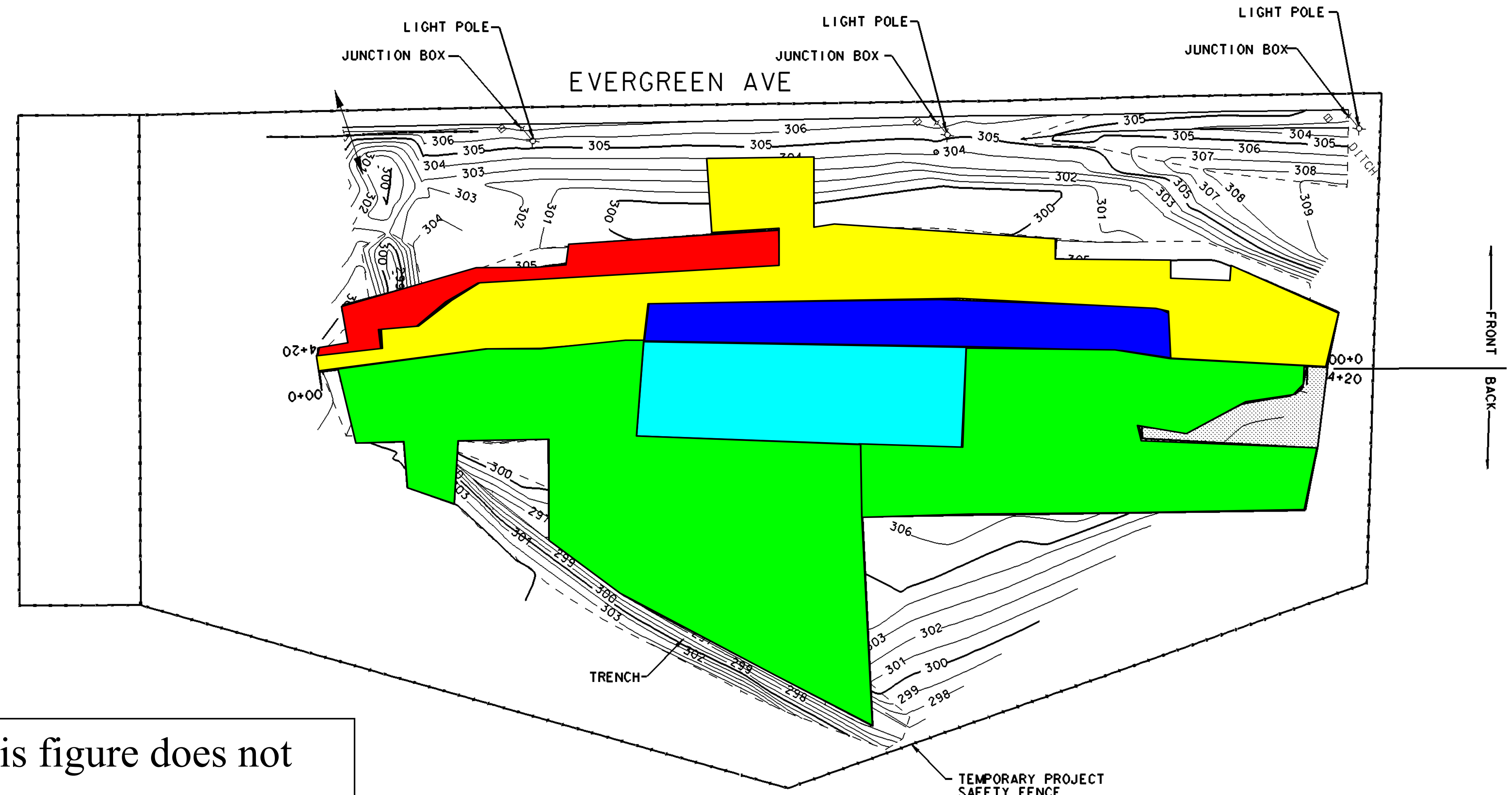


Figure 5. Lead Concentration Results for the Back Face of the Evergreen Infiltration Range (0 –12 inches)



US Army Corps of Engineers
Seattle District

Figure 6. Lead Concentration Results for the Back Face of the Evergreen Infiltration Range (12-24 inches)



NOTE: If this figure does not print correctly, use corresponding Figure 7. ppt file.

THE EXCLUSION ZONE (OR HOT ZONE) IS THE AREA WITH ACTUAL OR POTENTIAL CONTAMINATION AND THE HIGHEST POTENTIAL FOR EXPOSURE TO HAZARDOUS SUBSTANCES.

THE CONTAMINATION REDUCTION ZONE (OR WARM ZONE) IS THE TRANSITION AREA BETWEEN THE EXCLUSION AND SUPPORT ZONES. THIS AREA IS WHERE RESPONDERS ENTER AND EXIT THE EXCLUSION ZONE AND WHERE DECONTAMINATION ACTIVITIES TAKE PLACE.

LEGEND

FRONT	BACK
EXCAVATE FROM 0'-1' bgs (red)	EXCAVATE FROM 0'-1' bgs (green)
EXCAVATE FROM 0'-3' bgs (yellow)	EXCAVATE FROM 0'-2' bgs (tan)
EXCAVATE FROM 0'-7' bgs (blue)	EXCAVATE FROM 0'-5.5' bgs (cyan)

This project was designed by the Seattle District U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear within the specifications or on these project documents within the scope of their employment as required by ER 1110-1-8152, Professional Registration.

DATE AND TIME PLOTTED: 10-AUG-2004 08:53
DESIGN FILE: S:\CIV\FT. LEWIS EVERGREEN INFILTRATION\FTLEIRCG0D.DGN

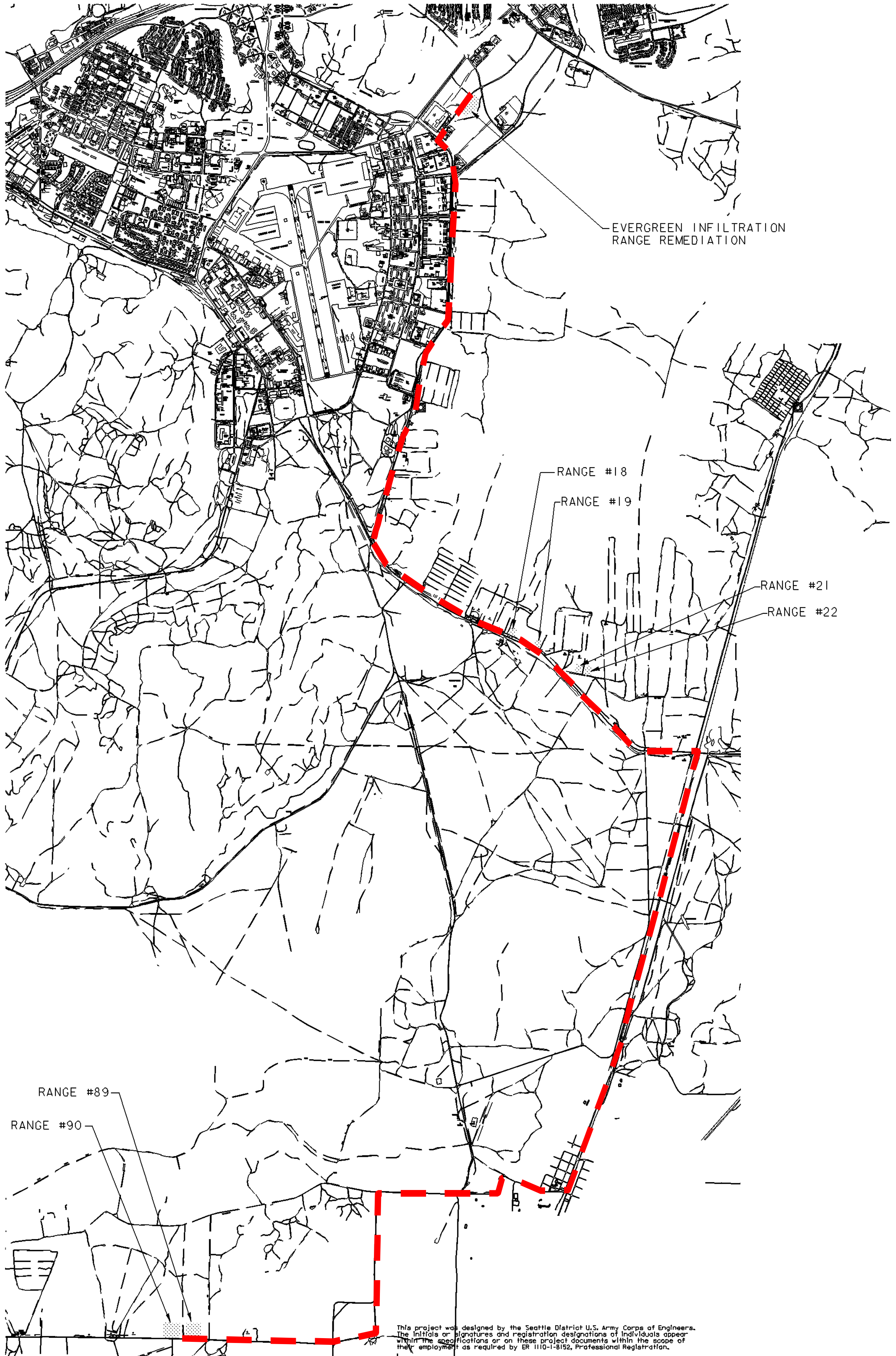
PREPARED:
DESIGN MANAGER
REVIEWED:
WILLIAM P. GRANEY
CHIEF, TECH ENGINEERING AND REVIEW SECTION
SUBMITTED:
CHIEF, DESIGN BRANCH
RECOMMENDED:
CHIEF, ENGINEERING & CONSTRUCTION DIVISION
APPROVED:
COL CORPS OF ENGINEERS DISTRICT ENGINEER

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FORT LEWIS
EVERGREEN INFILTRATION RANGE
COMTAMINATED SOIL REMEDIATION
PROJECT

Figure 7 Excavation Plan

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D			01 JUN 04	C-4
DSGN. BARRETT		CHK. FISCHER	SHEET 5	



MATERIAL HAUL PRIORITY LIST

STATUS	RANGE#	PRIORITY OF EFFORT	SIZE (ACRES)	TYPE	DISTANCE FROM EVERGREEN (mi)	1st ESTABLISHED	NECESSARY MAINTENANCE (L x Ht x W)
ACTIVE	22	1	44.68	SMALL ARMS (<.50 cal)	6	1966	NEW BACKSTOP (300' x 25' x 50')
ACTIVE	89	2	3.86	SMALL ARMS (<.50 cal)	9	NO RECORD	NEW BACKSTOP (150' x 10' x 20')
ACTIVE	90	3	3.85	SMALL ARMS (<.50 cal)	9	1970	2 NEW BERMS FOR LEFT AND RIGHT SIDE OF RANGE 90 (EACH BERM: 150' x 10' x 20')
ACTIVE	21	4	16.42	SMALL ARMS (<.50 cal)	6	1970	NEW BACKSTOP (300' x 25' x 50')
ACTIVE	18	5	3.02	HAND GRENADE	6	1975	NEW BACKSTOP (600' x 10' x 20')
ACTIVE	19	6	20.09	SMALL ARMS (<.50 cal)	6	1962	NEW BERM TO SEPARATE RANGES 18 & 19 (600' x 10' x 20')

N

1" = 400' 400' 200' 0 400' 800'

DATE AND TIME PLOTTED: 03-AUG-2004 09:36
DESIGN FILE: S:\CIV\FT. LEWIS EVERGREEN INFILTRATION\FTLEIRCGOE DGN

REDUCED TO 50% OF FULL SIZE

PREPARED: BRYCE JONES, DESIGN MANAGER
REVIEWED: DEAN M. SCHMIDT, CHIEF, TECH ENGINEERING AND REVIEW SECTION
SUBMITTED: MARK A. OHLSTROM, P.E., CHIEF, DESIGN BRANCH
RECOMMENDED: HOWARD R. BLOOD JR., CHIEF, ENGINEERING & CONSTRUCTION DIVISION
APPROVED: DEBRA M. LEWIS, COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

FORT LEWIS
EVERGREEN INFILTRATION RANGE
COMTAMINATED SOIL REMEDIATION
PROJECT
FIGURE 8 MATERIAL HAUL ROUTE
FIGURE 8 MATERIAL HAUL ROUTE

SIZE: D | INVITATION NO.: | FILE NO.: | DATE: 01 JUN 04 | PLATE: C-5
DSGN. BARRETT | CHK. FISCHER | SHEET 6

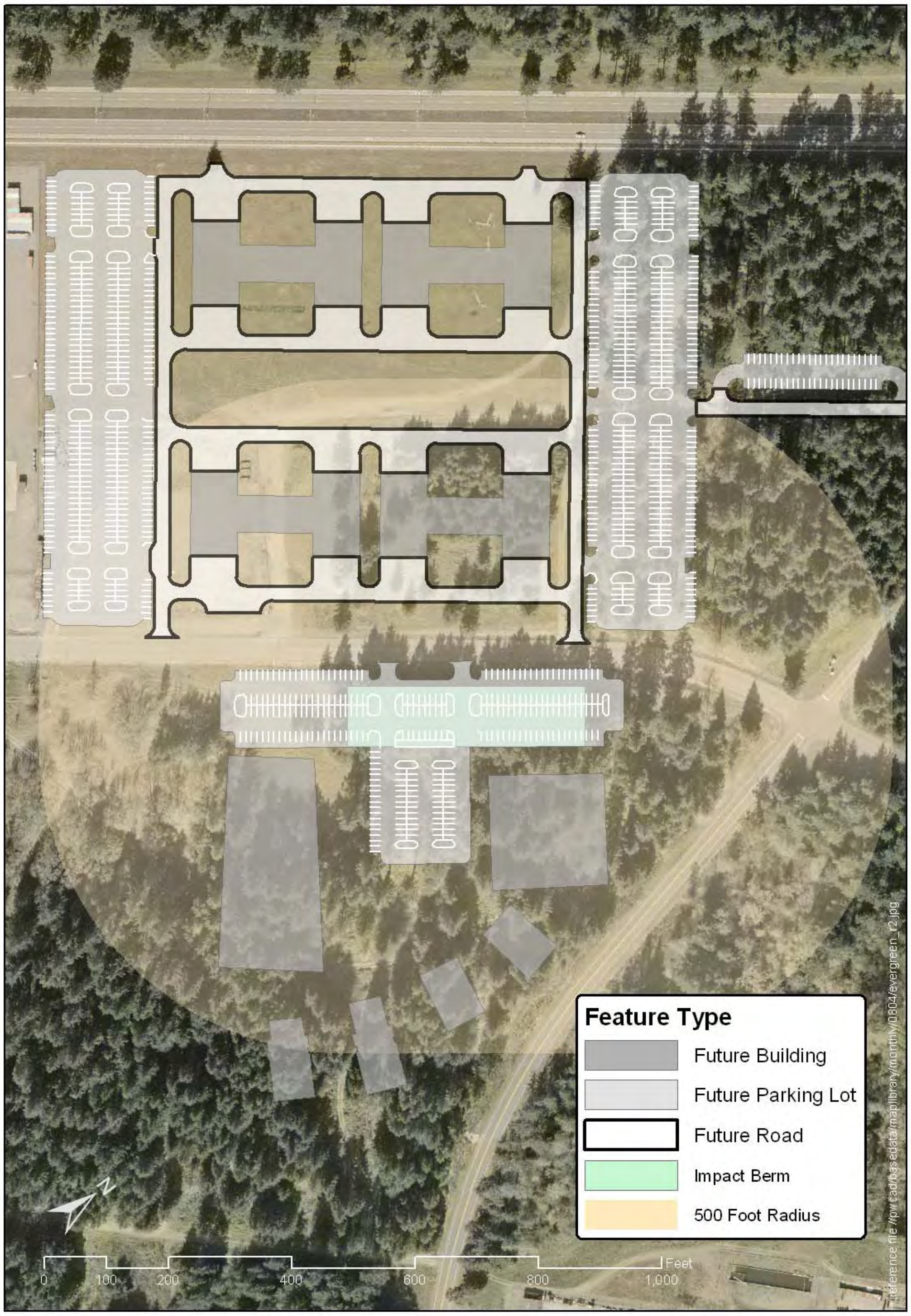


Figure 9. Evergreen Infiltration Range – Contiguous Undeveloped Land

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Appendix A
Field Portable XRF Protocol

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FIELD LABORATORY STANDARD OPERATING PROCEDURES – FIELD XRF

1.0 Introduction

This attachment presents the Standard Operating Procedures (SOPs) for the field portable x-ray fluorescence (XRF) spectrometer methodologies used during the sampling activities discussed in the Fort Lewis Agreed Order Former Small Arms SAP Addendums. The purpose of this SOP is to ensure that standard protocols are being followed during preparation and analysis of soil samples using the Niton 309 Series XRF spectrometer. The procedures discussed in this SOP include sample log-in, sample preparation, and sample analysis.

The XRF uses radiation from one or more radioisotope sources to generate characteristic x-ray emissions from elements in a sample. To measure the fluorescence, a sample is placed in front of the source-detector window and exposed to the primary source x-ray by pulling a trigger on the probe that exposes the sample to radiation from the source. The sample fluorescent and back-scattered x-rays enter through a detector window and are converted into electric pulses in the detector. Within the detector, energies of the characteristic c-rays are converted into a train of electric pulses, the amplitudes of which are linearly proportional to the energy of the x-rays. An electronic multichannel analyzer measures the pulse amplitudes, which is the basis of qualitative x-ray analysis. The number of counts at a given energy over time is representative of the element concentration in a sample and is the basis for quantitative analysis.

2.0 Sample Log-in and storage Procedures

Samples will be delivered to the field laboratory at a minimum of once a day with the Monitoring/Sample Location Summary form, the Sample Collection Form, and chain of custody. Upon receipt, the laboratory custodian will sign off on the custody form, review the field forms for consistency, and enter the field information on the Sample Log-In Form in the laboratory notebook. The sample bags from each residence will be placed in separate boxes for storage. The boxes will be labeled with the Residence ID and the sample IDs and maintained in a locked room for archiving purposes.

3.0 Sample Preparation Procedures

Soil samples will be dried and sieved prior to sample analysis to remove larger particles such as gravel, sticks, and large paint chips and to ensure samples are relatively homogeneous. The requirement for drying will be based on field measurements and will be recorded on the chain of custody. The following procedures are to be used for preparing soil samples for XRF analysis.

1. Re-homogenize the sample in the zipper locked baggie, and collect a 100 to 200 gram soil sample. Record the weight of the aliquot on the Sampling Sieving Form to 0.01 g.
2. If drying is required, dry the sample in a drying oven for a minimum of 2 hours at a maximum temperature of 150 $^{\circ}$C. Record the dried weight of the aliquot on the Sampling Sieving Form to 0.01 g.
3. Sieve through a No. 60 mesh sieve stacked on top of a No. 80 mesh sieve. Sieving will be conducted by placing the sieves on an automatic shaker until not more than 1% mass of the residue pass the sieves during 1 minute of sieving. Examine larger, retained particles and note their description in the laboratory notebook. Discard gravel, sticks, vegetation, etc. Depending on the state of the dried samples, the sample may be ground to allow it to pass through the sieve.
4. Weigh the masses retained on each sieve, and the mass that passes though onto the pan. Record weights on Figure 2 to 0.01 g. Confirm the sum of the masses is close to the original mass sieved.
5. Place the sample probe directly on the soil for analysis or analyze the soil directly through the plastic bag used for homogenization.
6. "Intrusive" samples follow steps 1 through 4 then mix the resulting sample, place in a XRF sample cup, and analyze.

QC requirements during the sample preparation phase include laboratory duplicates. XRF duplicate and confirmation (i.e., "intrusive") sample analyses are performed by taking aliquots of a soil sample from the same bag and performing duplicate preparation steps on each aliquot. This includes both the drying and the sieving preparation phases to assess the precision of each preparation phase. A sample splitter will be used to split samples at the different phases of analysis to create representative duplicate samples. The XRF reading will be recorded for each aliquot. The RPD is calculated for the primary and duplicate sample results. Duplicate sample analysis shall be one per every 20 samples. Confirmation sample analysis shall be one per every 10 samples. The purpose of the confirmation samples are to 1) detect metals that cannot be detected by the XRF, and 2) to ensure that XRF measurements continue to be accurate and precise. The RPD criteria should be 20 percent.

4.0 Sample Analysis Procedures

4.1 Interferences and Potential Problems

The following interferences or user related errors could affect total error of the XRF analysis:

Sample Placement. Maintaining the same sample distance from the source will prevent changes in the X-ray signal.

Sample Representativeness. Homogenize all samples prior to analysis and select a representative aliquot for analysis.

Chemical Matrix Effects. Interferences from non-target analytes can appear as either spectral interference (peak overlap) or as x-ray enhancement/absorption phenomena. Establishing all chemical matrix relationships and increasing the number of standards during calibration can reduce the error used in quantitation modeling.

Physical Matrix Effects. Particle size, moisture content, and homogeneity of samples can lead to analytical variability. Sieving, homogenizing, and drying samples using the techniques described below will minimize these effects.

Inappropriate Pure Element Calibration. The instrument calibration should include all elements that can be presents at the site, even if it is not a target element.

4.2 INSTRUMENT CALIBRATION

While the instrument is factory calibrated, an internal, self-calibration check must be performed whenever the instrument is turned on or instrument parameters are reset. In addition, the calibration check is to be performed once per hour or if ambient temperature changes by more than 10^{o} F since the previous calibration check. For detailed procedures for the instrument self-calibration check the User's Guide.

The high, medium, and low calibration check sample must be analyzed after every instrument internal self-calibration check according to the following procedure:

1. Turn the instrument on and allow it to warm up for 15 minutes.
2. Choose the "Bulk Sample" mode from the Setup screen.
3. Choose "Calibrate and Test" from the Main Menu. In about 1 minute the instrument will finish the internal self-calibration and display "ready to test."
4. Place the prepared soil sample in the testing platform and perform a 5-minute measurement. At the end of the test verify that the percent difference (%D) for each metal are below 20%.
5. If results are not within manufacturer's recommended ranges the instrument internal self-calibration must be performed and check samples reanalyzed. If, upon reanalysis, check sample results are still outside the acceptance range contact the instrument manufacturer technical service for diagnostic help.
6. One silicon sand blank sample will be analyzed for every twenty samples run. Place the silicon dioxide blank sample in the test stand and perform a one minute test**. Do not touch the surface of the blank or you may introduce contamination.** All elements should be reported as "less than limit of detection." If the instrument meets the acceptance criteria in step 4 above but reports a detected element in the silica blank, it is likely that the instrument window is contaminated. Gently wipe the window with a Q-tip that has been moistened with distilled water and wipe dry with a Kimwipe. Repeat the blank measurement.

4.3 Determining Detection Limits and Quantitation Limits

A low concentration calibration sample will be measured 10 times without moving it, using the anticipated field analysis measuring time. The standard deviation of the mean for each element is calculated from the results. The definition of the detection limit is the value of the mean plus three times the calculated standard deviation value. The quantitation limit is the value of the mean plus 10 times the standard deviation value.

4.4 Intrusive Sample Analysis

1. Following calibration and blank analysis, choose the "Bulk Sample" mode from the Setup screen.
2. Fill a XRF sample cup with a ¼ mil Mylar film window as described in the User's Guide. Label the outside of the cup using a marking pen.
3. Place the sample cup on the bulk testing platform and attach the XRF spectrometer.
4. Squeeze the instrument shutter release and press the instrument down to depress the shutter release plunger. The plunger must be fully depressed or the window will not be completely open and readings will be inaccurate. The back of the instrument must be flush with the test guard. **Caution! Do not put your hand on the end plate of the instrument or lift it off the test guard when the shutter is open.**
5. Observe the instrument readings to decide when the desired confidence level (95%) has been achieved (typically 0.5 to 1 minute). Record the result.
6. Lift the instrument. The plunger will back out of the bottom, closing the shutter. If not, push the plunger closed and call the Niton technical Service Department at (401) 294-1234.
7. The next sample is ready for testing.
8. A calibration check sample and blank sample analysis must be performed after every 20 samples or once per hour, whichever is more frequent. A calibration check sample analysis is also performed after the last sample is analyzed. If calibration acceptance criteria are not met, all samples analyzed since the last valid calibration must be reanalyzed.
9. A precision sample will be run at a minimum of one per day. For the first ten residences, three precision samples will be run. These samples will be a sample from the bulk measurement step, the drying step and the sieved step that has been and analyzed seven times in replicate. Following review of this data, the frequency of precision samples will be revised for the remaining sampling activities. The relative standard deviation (RSD) will be calculated for each of the precision samples.

4.5 Decontamination Procedures

All of the non-disposable equipment must be thoroughly decontaminated after each sample is processed to eliminate the possibility of sample cross contamination. Decontamination will be conducted according to the following procedure:

1. Brush off clumps of soil;
2. Scrub equipment in alconox and tap water wash;
3. Rinse with tap water;
4. Rinse with distilled water/nitric acid; and
5. Rinse with deionized water.

In addition, to prevent cross contamination, the technician will change into clean set of polyethylene disposable gloves during the handling of each sample for sieving and drying. Since contact with soil is not anticipated during actual XRF analysis portion, gloves do not have to be changed for each sample run.

4.6 REPORTING

At the end of each day, all sample results and spectra are to be downloaded to a computer using manufacturer supplied software. The analyst will review the spectra to evaluate if overlapping peaks are present. The reported value for each analysis should be as follows:

1. Round all sample results to the same degree of significance contained in the calibration samples.

2. All values less than the detection limits will be reported as not detected at the detection limit value.

3. All values greater than the detection limit and less than or equal to the quantitation limit will be reported as estimated (J flagged).

4. All values above the quantitation limits will be reported as is.

5. Values above the calibration range are flagged with an *.

The results are then recorded on the XRF form presented in the laboratory notebook.

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Appendix B

Evergreen Range Site Investigation Sampling and Analysis Plan

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SAMPLING and ANALYSIS PLAN ADDENDUM
FORT LEWIS AGREED ORDER

Former Small Arms Ranges
Miller Hill Pistol Range and Evergreen Infiltration Range (AOC 4-2.2 And 4-6.3)

FINAL

Approved by the Washington Department of Ecology
August 2003

Prepared by:

US Army Corps of Engineers®
Seattle District

For:

Fort Lewis Washington

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Table of Contents

(See sections preceded by "A-" in main Table of Contents.)

LIST OF ACRONYMS AND ABBREVIATIONS

FLAO	Fort Lewis Agreed Order
AOC	Area of Concern
bgs	Below Ground Surface
COC	Chain-of-custody
COPC	Contaminant(s) of Potential Concern
CSM	Conceptual Site Model
DCQCR	Daily Chemical Quality Control Reports
DMA	Demonstration of Method Applicability
DQI	Data Quality Indicators
DQO	Data Quality Objectives
DTM	Draft Technical Memorandum
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
ER	Engineering Regulation
FTM	Final Technical Memorandum
FWP	Field Work Plan
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTCA	Model Toxics Control Act
PM	Project Manager
PNNL	Pacific Northwest National Laboratory
PW	Fort Lewis Public Works
RL	Reporting Limits
QA	Quality Assurance
QC	Quality Control
RIWP	Remedial Investigation Work Plan
SAP	Sampling and Analysis Plan
SWMU	Solid Waste Management Units
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedure Analyses
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
VSP	Visual Sampling Plan
XRF	X-Ray Fluorescence

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A-1.0 INTRODUCTION

A-1.1 Background

This addendum to the Fort Lewis Agreed Order Remedial Investigation Work Plan addresses site-specific characterization at the former Miller Hill Pistol Range (AOC 4-2.2) and the Evergreen Infiltration Range (AOC 4-6.3). The RIWP provides the framework for site investigation of the former solid waste management units (SWMU) and areas of concern (AOC) identified in the agreed order between Fort Lewis and the Washington State Department of Ecology (Ecology).

This addendum should be considered as incorporated into the Draft RIWP (USACE, 2002). It was prepared in accordance with the Draft RIWP and the guidelines specified by the U. S. Army Corps of Engineers (USACE, 2001) and the Washington State Department of Ecology (Ecology, 2001). This addendum describes the site background, the proposed sampling activities, and the proposed work schedule for the soil-sampling event. A detailed Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP) and Accident Prevention Plan (APP) are presented in Appendix A and B of the Draft RIWP.

USACE will have overall responsibility for field sampling and data collection, with support for specific components provided by subcontractors.

A-1.2 Site Use and History

Fort Lewis is a major military facility located approximately 6 miles south of Tacoma, Washington. The facility consists of approximately 34, 875 hectares of cantonment areas, natural prairies, lakes, wetlands, and forest. Weapons qualifications and field training has occurred at Fort Lewis since around the time the Fort was established.

These sites were not included in the "1996" RFA. However, these sites were added to the FLAO RIWP because existing evidence suggest that these sites are former ranges similar to other sites within AOC 4.

Discontinued use of the former ranges discussed in this SAP has allowed nature to reclaim large portions of these former ranges. Most of these sites are overgrown with trees, grasses, and scrubs. A site map is shown in Figure A-1.

AOC 4-2.2 Former Miller Hill Pistol Range

The former Miller Hill Pistol Range is located near the intersection of Colorado and Jackson Avenues on the Fort Lewis Military Reservation, Pierce County, Washington. This potential range may have been active as early as the 1920s shortly after Fort Lewis was established (1917). A 1929 Fort Lewis map identifies this area as a pistol range. Aerial photography from the 1940s shows indications of clearing and a possible berm. The suspected berm was identified along the roadway during a site visit. However, later historical maps do not indicate an active range and aerial photography indicated re-vegetation by 1951. There are no records pertaining to use or discontinued use of this range; however, based upon growth of vegetation and historical analyses of aerial photography, indications are that this area was not likely to have been used since the late 1930s if a range did exist in this area.

For pistol ranges, most training is done with fixed or stationary targets at known distances, resulting in the formation of "bullet pockets' on the face of the berm similar to Engineer Bluff and other former Miller Hill ranges. The high-impact energy of these high-speed rounds with the rounds accumulated in the bullet pockets results in significant fragmentation and ricochet. The ammunition associated with pistol training during this era was the 45-caliber cartridge. The primary constituents in the bullet slugs consist of 97% lead and < 2% antimony with trace amounts of antimony, arsenic, copper, tin, and zinc. Potential contaminants of concern are presented in Table A-1.

AOC 4-6.3 Former Evergreen Infiltration Range

The former Evergreen Infiltration Range is located approximately 0.25 miles north of the intersection of Evergreen Ave and 4th Division Drive on the Fort Lewis Military Reservation, Pierce County, Washington. This former range was identified from a 1951 aerial photograph. There are no records pertaining to discontinued use of this range; however, based upon growth of vegetation, observed during site visits, and historical analyses of aerial photography, indications are that activity at this range was decreasing during 1955 and 1957, and the range appears to be in disuse in photographs from 1965. Identified as an infiltration range, the impact berm was set back approximately 300 feet from the firing discharge area. The impact berm is constructed earthen bank 40 feet high. A concrete footing, used to hold the machine gun posts, was constructed approximately 300 feet from front of the base of the berm. Bullet slugs, fragments, and shell casings are evident at the impact berm.

In general, infiltration ranges provided opportunity for conditioning soldiers to move under live fire and under combat type situations. Fixed-position machine guns provided the live fire training (see Figure A-2). The ammunition associated with infiltration range training during this era was the 30-caliber cartridge. The primary constituents in the bullet slugs consist of 97% lead and < 2% antimony with trace amounts of copper. Potential contaminants of concern are lead, antimony, arsenic, copper, tin, and zinc.

Site visits indicate that explosives were also part of training at this range. Nine demolition sites have been identified at this range (see Figures A-7 and A-10). A single crater has been identified at each demolition site, each crater approximately 6 feet in diameter. From remains present at the range, each of the demolition sites were surrounded by a low fence, approximately 1 foot high, of wood and chicken wire with the dimensions of approximately 20 feet by 20 feet (not all the fences remain). Some of the pits have remains of command wires for detonating explosives during training. One of the original signs has survived stating "DEMO PIT NO. 8". Barbed wired is also present, especially between ED1 and ED2. All of the demolition pits have some vegetation growing within and around the craters. Several of the demolition craters have trees growing out of them (ED1, ED9, and ED7). Therefore, additional potential contaminants of concern are explosives residues (TNT, 2,4-DNT, 2,6-DNT, RDX, HMX).

A-1.3 Site Geology

Site-specific geology is not available. However, the regional geology for this area is defined by the multiple glacial and nonglacial climatic events. The soils at this site are characteristic of the Steilacoom Gravel, a recessional outwash deposit. An overview of the geology of Fort Lewis is contained in the RIWP.

A-1.4 Site Groundwater

The combination of soil porosity and seasonal precipitation variability combine to result in considerable fluctuation in groundwater elevation. There are no monitoring wells in the immediate area of the site to confirm seasonal groundwater levels of fluctuation. An overview of groundwater conditions at Fort Lewis is contained in the RIWP.

A-2.0 COMMUNICATIONS, DATA MANAGEMENT, AND REPORTING

This section of the SAP describes the important project elements of communications between team members and the flow and management of data that has been collected for the proposed dynamic sampling. The method of reporting project results is also described.

A-2.1 Communication Strategy

Accelerated approaches to sampling and analysis, as required for this project, integrate various characterization tasks and measurements into a single coordinated effort. Accelerated approaches are conducted by a multidisciplinary group of experienced professionals, working as a team in the field to evaluate the data to further refine the CSM and plan the next measurement steps. Project team members and inter-group communication strategies are described below and shown on Figure A-3.

A-2.1.1 Project Team

The project teams consists of representatives from Fort Lewis Public Works (PW); Washington Department of Ecology; the Seattle District USACE; and contractors. The project team provides the overall framework for the sampling and analysis approach by defining project objectives and data quality requirements, and ensuring that both the objectives and data quality requirements are met.

Providing oversight of the project team throughout the process are individuals identified to ensure that project quality assurance/quality control and health and safety issues are addressed. At any time, any individual working on the project may contact the QA/QC Officer or the Health and Safety Officer to discuss project issues or concerns. It is the responsibility of the QA/QC Officer and the Health and Safety Officer to implement corrective actions if project requirements are not being met.

The project team must keep Fort Lewis PW Agreed Order PM (Rich Wilson) informed of how the project is proceeding. The approval of Ecology and the PW PM is required for any major deviations in the work. Project updates will be given to the PW PM and the USACE PM (Bill Graney) by the Field Investigation Lead (Gwyn Puckett) during regularly scheduled meetings and eRoom updates.

A-2.1.2 Core Technical Team

Within the project team is a core technical team made up of individuals who have expertise in geologic and chemical analytical methods appropriate for this site. They provide a continual, integrated, and multidisciplinary presence throughout the process. The members of the core technical team are involved in all steps of the process and are present in the field when data collection related to their areas of expertise is taking place. The optimization of field investigation activities and the quality of the evolving and final CSM depend on the interaction among the members of the core technical team, the project support technical team, and PW, each providing their own special perspective on the site.

The core technical team oversees analysis of the raw data, evaluates the data to further refine the CSM, and recommends to the lead of the core technical team next measurements that best test the crucial features of the CSM. Members of the core technical team should have whole-site-systems understanding of geology and contaminant chemistry. They work together to evaluate the data as they are obtained.

During this project, the core technical team will use field-based site characterization methods that will generate data that will be evaluated and integrated into the CSM in the field. The core technical team will follow a dynamic work plan that allows and requires on-site decision making by the project team. Successive steps are based on that evaluation and integration of field data into the CSM.

Core technical team members include:

- Project Chemist/Field Investigation Lead: Gwyn Puckett (USACE, Seattle District)
- Project Data Coordinator: Rebekah Barker
- XRF Analyst: Joseph Marsh
- Sampling Staff: Glen Terui and TBD

The Project Chemist, with the Support Technical team, is ultimately responsible for all decisions related to the design and implementation of this project, within the framework provided by the approved dynamic work plan. The Project Chemist is tasked with informing the USACE PM and Fort Lewis PW about all decisions that may impact project schedule or budget. Final decisions that impact budget and schedule will be made by the USACE PM and PW.

The Project Chemist and the Project Data Coordinator, supported by the core technical team members and project support technical team, are responsible for ensuring data quality and effective data management and also interpret data and integrate the results into the evolving site model and reports. They have the final authority on site technical decision-making concerning field operations. Other core technical team members are in the field for data collection involving their primary area(s) of expertise and are available for telephone consultation when they are not present in the field.

Although data management and QA/QC are specific project support functions, the Project Chemist, supported by other core technical team members is responsible for ensuring the following: (1) that data collection is relevant to the objectives of the project (i.e., necessary to satisfy data quality requirements); (2) that QA/QC procedures for data collection and processing for respective areas of expertise are strictly followed; and (3) that field data reduction and processing do not introduce errors into the data and evolving site model.

The core team will be in daily contact to discuss how the project is proceeding and any changes required by the PW PM. Additionally, daily meetings to discuss project technical issues will be held in the field with core technical team members present or linked by conference call. Representatives of subcontractors or project support team members (below) may also be asked to attend these meetings. Daily chemical quality control reports (DCQCRs) will be generated and faxed to the Project Data leader at the USACE Seattle District office. The DCQCR will include all field data generated on a daily basis, including mobile laboratory data, chain-of-custody forms, and field sampling forms. The report will be scanned and posted on the project eRoom.

A-2.1.3 Project Support Team

The project support team includes technical personnel and equipment operators involved in data collection and sampling and personnel who provide other support functions.

Project support team members include:

- Senior Technical Reviewer / QA/QC Officer: Kira Lynch (USACE, Seattle District)
- Technical Team Leader: Kym Takasaki (USACE, Seattle District)
- Project Geologist/Hydrogeologist: Lisa Scott (USACE, Seattle District)
- Health and Safety Officer (Industrial Hygienist): Kim Calhoun

The project support team will be in daily contact with the Field Investigation Lead, or designated technical task manager, when they are working on site. They may be asked to attend technical team meetings to present results or other technical issues, if needed. The Field Investigation Lead, or designee, as necessary, will contact off-site laboratories.

A-2.2 Data Flow

Two primary categories of data will be generated for this project: field data and fixed laboratory data. The procedures to be used for each type of data are described below.

A-2.2.1 Field Data

The core technical team will record field measurements/observations in logbooks and on the appropriate field forms. XRF and off-site fixed laboratory data will be generated on a daily basis and reported in formats that can be interpreted by the core technical team. All field data will be transferred to the Field Investigation Leader. Daily chemical quality control reports will be generated and posted on eRoom. The DCQCR will include all field data generated on a daily basis, chain-of-custody forms, and field sampling forms. Incoming project-related material, including correspondence, authorizations, chain-of-custody forms, or other information, will be marked with the date received and the project name. Postings to eRoom will include updated maps and diagrams of sampling activity and digital photographs of site activities. The Project Data Coordinator will interpret analytical data received from the fixed laboratory. This information will also be posted to eRoom.

Upon completion of the field program, the temporary file will be transferred from the site field office and incorporated into the USACE Seattle District office project file (the Project Data Coordinator will oversee the input of project records). Copies of all field documents may be made and retained by the originator for use in report preparation and later reference. The originals will be filed in the office project file.

On-site field measurements and laboratory data will be input into an electronic database. The data will then be printed out and compared to the original field records to ensure input accuracy. All review documentation will be initialed and dated by the reviewer, then filed with the quality review documentation.

A-2.2.2 Fixed Laboratory Data

Fixed laboratory data will be transferred from the project laboratories to the Project Data Coordinator in hard copy and Excel compatible electronic formats. Data will be loaded into an Excel spreadsheet. Hard copies of the laboratory deliverables will be used to verify the accuracy of electronic data. The original hard copies of laboratory deliverables will then be stored in the office project file.

The laboratories will maintain and follow their own detailed procedures for laboratory record keeping for support of the validity of all analytical work. Each data package submitted to the Project Data Coordinator will contain the laboratory's written certification that the requested analytical method was run and that all QA/QC checks were within established control limits on all samples, with exceptions noted. The Project Data Coordinator will be responsible for ensuring fixed-lab data quality and effective data management and also assist in interpreting data and integrating the results into the evolving site model and reports.

Severn Trent Laboratories (STL) will perform the analyses. The address and contact of the project laboratory is listed below.

STL Seattle
5755 8th Street East
Tacoma, WA 98424

Contact: Dawn Werner (253) 922-2310

A-2.2.3 Meetings and Conference Calls

Meetings or conference calls will be scheduled as needed to discuss project status updates, results from demonstration of applicability (correlation data, actions levels), determination of uncertainty limits for decision making, conceptual model data gaps, additional data needs, and discussion of implementation of the appropriate action when data suggests deviations from the conceptual model.

A meeting or conference call will be held with Ecology and PW to discuss the interim results of the Demonstration of Method Applicability (DMA) that will be subsequently documented in an appendix to the final site characterization report. Additional meetings will be scheduled if necessary to discuss results from the site investigation at the former Infiltration Range, the former Pistol Range at Miller Hill, and the former Skeet Range.

A-2.2.4 Daily Updates

Information on project status and available data will be posted daily on the project eRoom website by the core technical team. These postings will include updated maps and diagrams of sampling activity and digital photographs of site activities.

A-2.3 Schedule and Project Completion Reporting

The proposed schedule for the fieldwork is presented in the Table below.

Activity	Time of Completion in Calendar Days
Submit Final Sampling and Analysis Plan Addendum (SAP)	
Ecology Approval of SAP	TBD
Completion of Field Work	65 days after approval of FWP
Receipt of Final Analytical Results	2 days after Laboratory receives samples
Submit Draft Technical Memorandum (DTM)	21 days after completion of field activities and receipt of final Analytical Results
USACE Comments to DTM	14 days after receipt of DTM
Submit Written Responses to DTM	14 days after receipt of comments
USACE Approval of Responses	7 days after receipt of responses
Submit Final Technical Memorandum	14 days after approval of responses

Activity	Time of Completion in Calendar Days
(FTM)	
Submit Draft FTM to Ecology	7 days after receipt

Review of chemical data quality (precision, accuracy, representativeness, completeness, and comparability) shall be conducted by a qualified chemist to ensure that project goals will be met during the field investigation and acquisition of chemical data and their data quality indicators. A Technical Memorandum will be provided that includes:

- A concise and well written Executive Summary;
- Recommendations for further investigation (including evaluation of the need for groundwater sampling) or remedial action (if necessary);
- A site map showing relevant features, sampling locations, and analytical concentrations;
- A description of field activities, including field notebook, photographs and boring logs;
- Quality assurance review of the sample results;
- Tables summarizing the analytical results compared to applicable State and Federal action levels; and
- Laboratory certificates of analysis.

This technical memorandum will be provided to Ecology. The decision for additional remedial investigations will be determined following review of the technical memorandum. The RI report will include results of any followup investigations needed based on the results of this investigation.

A-3.0 SAMPLING PLAN

A-3.1 Sampling Objectives

Objectives of this sampling event are:

- Confirm the presence of contamination;
- Delineate the vertical and horizontal extent of the lead contamination to 50 ppm;
- Determine the concentration of contaminant of concern;
- Determine if lead can be used as driver to define extent at ranges;
- Collect data for XRF Demonstration of Method Applicability;
- Refine Conceptual Site Model based on field results.

The objectives and sample design associated with this project are in accordance with EPA DQO guidelines. The data gathered will assist in the design and planning of an appropriate, efficient and cost-effective remedy selection. Potential remedial actions include the installment of institutional controls, excavation for disposal, treatment, or treatment prior to disposal. Data will not be collected specifically to support risk assessments.

A-3.2 Demonstration of Method Applicability

To determine the usability of the XRF for lead soil sampling, a demonstration of method applicability (DMA) will be conducted on the impact berm at the former Evergreen Infiltration Range. Preliminary assessment of the former infiltration range determined that it was the most likely area to have high levels of lead contamination, making it suitable for the DMA.

In order to assure that a reasonable correlation can be substantiated between the proposed field-based sampling method, the fixed lab methods, and the decisions being made, samples representing a full range of lead concentrations will be selected. Sample locations will be chosen from the impact zone, below the impact zone and the toe of the berm (see Figure A-8). The samples for the DMA will be collected during the first two days of sampling (estimated at a minimum of 20 samples; approximately 20 samples can be processed per day).

Comparability of the XRF analysis procedure will be established by comparing results from sample pairs analyzed by both prepared-sample on-site analyses using the XRF analyzer and prepared-sample off-site laboratory analyses using conventional analysis by ICP-AES Method 6010/6020. The correlation of XRF to laboratory data will be expected to have a linear regression correlation coefficient (r) of at least 0.75.

This study will accomplish several goals:

- Initial evaluation of site specific heterogeneities that will support further design of the data collection program
  - Sampling design (how many samples to collect and where to collect them)
  - Refinement of the conceptual site model
- Evaluation of analytical performance on site specific sample matrices
  - Determine whether and how to modify methods to improve performance and/or cost-effectiveness
- Develop initial method performance/QC criteria based on site specific data needs
  - During project implementation, both field and analytical QC results will be judged against these criteria to determine whether procedures are "in control" and meeting the defined project needs
  - Develop list of corrective actions to be taken if QC criteria exceeded

- Decision thresholds ("action levels" to guide decisions about compliant vs. non-compliant soil or areas, and the routing of materials for final disposal)

- Evaluate the inherent bias of the field-based instrument technology such that an adequate safety factor can be built into the overall decision uncertainty limits

- Determine the correlation between the average bag-sample XRF analysis, the cup-sample XRF analysis and the fixed-lab analysis of the soil sample

- Determine the correlation between lead and other metals present.

- Confirm proposed method for soil sample collection (including sample and subsample support and sampling devices) and conducting XRF analysis meets project data quality requirements.

A-3.2.1 Sample Preparation for the DMA

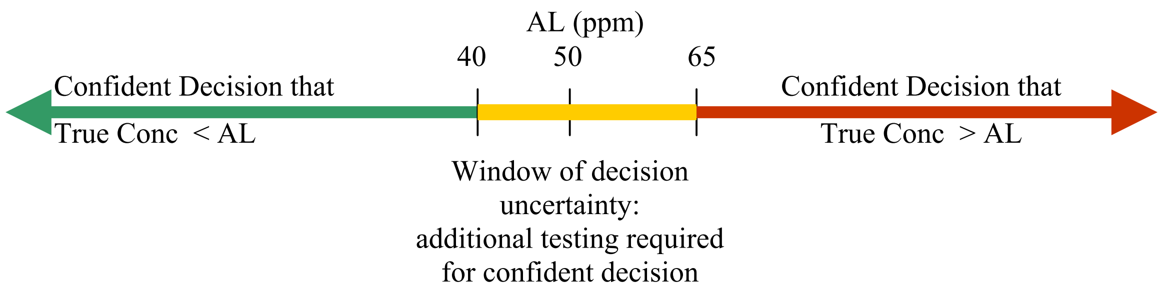
At each sampling location selected, surface samples will be collected from two depth intervals, 0 to 12 inches and 12 to 24 inches, with a hand auger or appropriate equipment. Each sample will be collected as a discrete sample. One or more hand auger samples will be collected at each sample location; the approximate volume collected should fill a gallon-sized zipper locked baggie. Enough soil volume must be collected for all analytical purposes including split samples for ICP metals analysis, TCLP and archived samples. At each sampling location the following procedures will be used:

1. Place the depth interval soil sample into a decontaminated stainless steel bowl.
2. Sieve the soil with a # 10 mesh (2 mm) to remove large particles such as gravel, sticks, and bullet fragments (as required by WAC 173-340-740 (7) (a)).
3. Homogenize the sample in the zipper locked baggie. Conduct 7 XRF bag measurements to determine within-sample variability of the collected volume.
4. Place an aliquot into a XRF sample cup, and conduct measurement with XRF for lead. Submit cup aliquot to fixed lab for metals analysis by ICP 6010/6020. Metals of interest include lead, antimony, arsenic, copper, tin, zinc, and iron.
5. For the DMA, all samples will be submitted for ICP metals analysis.

Rapid turnaround time for fixed lab metals will be required for soil collected during this phase. Results will be evaluated as soon as they become available by the technical team who will make decisions about the frequency of collaborative samples submitted for fixed-lab analysis (see Section A-3.3), method for sample collection and XRF analysis, and selection of subsequent sampling locations and depths to assure that the extent of contamination at the site are identified.

A-3.2.2 Uncertainty Management Issues

Decision uncertainty intervals are set as: (1) the interval where it is judged that the field data results can be confidently trusted to declare areas as “clean” (i.e., no further investigation needed); (2) the interval where field results can be trusted to confidently declare an area “dirty” (i.e., remedial action needed); and (3) the interval where the field results are considered ambiguous (the window of decision uncertainty), and a confident decision of “clean” or “dirty” would require more data to manage the decision uncertainty (see figure below). Table A-2 presents potential uncertainty issues and potential responses. The DMA will be used to calculate the interval of decision uncertainty for XRF measurements.



Source: TIO - Considerations for Developing a Methods Applicability Study, March 2003

A-3.3 Sampling Strategy for Metals

A systematic grid will be used to delineate the vertical and horizontal extent of contamination if present at both sites. Starting at the areas most likely to be contaminated, the impact berms, sample locations will be stepped out laterally until lead XRF values are below the action level determined in the DMA. To determine vertical extent of contamination, samples will be collected in 1-foot intervals starting at ground surface at every location, with maximum depth dependent upon lead criteria. Sample location density will be initially determined using process knowledge of site usage, and conceptual site models, to be modified as real-time data is collected. Initial grid spacing has been set at 10-foot intervals, based upon the reasonable volume of soil that potentially could be excavated for remedial action. The 1-foot depth interval was based upon the reasonable depth of soil that would be removed by a backhoe. Field-portable XRF instrumentation will be used to provide real-time sample analysis of soil lead concentration. Following analysis of the sample results and dependent upon information gaps in the conceptual site model, and uncertainty in definition of contaminant extent, additional samples may be required to further delineate the extent of lead contamination.

At each sampling location selected, surface samples will be collected in one-foot depth intervals with a hand auger or appropriate equipment. One or more hand auger samples will be collected at each sample location; the approximate volume collected should fill a gallon-sized zipper locked baggie. Enough soil volume must be collected for all analytical purposes including split samples for ICP metals analysis, TCLP and archived samples.

During the DMA, collaborative samples will be submitted to the fixed laboratory for all samples.; The information obtained from the collaborative sample collection in the DMA will be used to determine the frequency and types of collaborative samples for the remainder of the XRF sampling.. The number of collaborative samples will be guided by the need to manage decision uncertainty. The frequency of collaborative samples will be determined by the following criteria:

- The interval where field results are considered ambiguous; dependant upon metal concentration results and instrument sensitivity.

- How frequently field results are close to the project's action level; a confident decision of "clean" or "dirty" may require more data.

The results from these analyses will be evaluated to test the hypothesis that lead concentrations will drive decisions regarding this project. Metals to be analyzed by Method 6010/6020 include lead, antimony, arsenic, copper, tin, zinc and iron, contaminants mostly likely to be found at small arms firing ranges.

A-3.3.1 Evergreen Infiltration Range Impact Berm

At the Evergreen Infiltration Range, the impact berm extends upwards of 40 feet, and is approximately 300 feet long. The impact zone, where contamination is believed to be the highest, is easily identified by the lack of vegetation. Figure A-7 and A-8 provide sample locations and the initial field sampling design. The sample grid will be spaced 10 feet apart lengthwise within the impact zone, below the impact zone (to evaluate the extent of the contamination down the slope), and at the toe of the berm to determine any impacts of potential sloughing.

A-3.3.2 Evergreen Infiltration Firing Points

Four samples will be collected at each of the four firing point locations to determine if shells potentially impacted the surrounding soil. Initially, samples from the 0 – 12-inch depth interval will be collected from each side of the concrete pads and measured with XRF. If concentrations of lead are detected above the action level, sampling will continue until the extent of contamination is determined. Figure A-9 presents the sample locations at the firing points.

A-3.3.3 Miller Hill Pistol Range

The potential berm at AOC 4-2.2 is approximately 180 feet long and is covered in heavy vegetation, which may make sampling difficult (see Figure A-5). A secondary soil mound is located to the southeast, closer to Colorado Avenue. This soil mound is approximately 120 feet long and is newer than the primary "berm" to the west, as the mound is rougher and vegetation is younger. Most likely, this soil mound is an artifact from road construction occurring after the 1965. To determine the presence of contamination, samples will be collected from the "impact" side of the "primary" berm. Sample locations will be placed in 10-foot intervals lengthwise along the berm face. Figure A-6 provides the initial sampling grid at the Miller Hill Pistol Range.

A-3.4 Sampling Methods

From each of the locations, soil will be excavated using a decontaminated hand auger, or appropriate equipment. One or more hand auger samples will be collected at each sample location; the volume collected should fill a gallon-sized zipper locked baggie. Enough soil volume must be collected for all analytical purposes including split samples for ICP metals analysis, TCLP and archived samples. Soil will be sieved through a No. 10 mesh sieve so that larger particles such as gravel, sticks, and bullet fragments will be removed prior to analysis. Written documentation of site activities will include a description of soil samples and the percentage of bullets collected at each sampling site.

A-3.4.1 Sample Collection

The initial sampling depth at each sampling location is 0 to 12 inches. If lead readings are above the XRF action level determined in the DMA in the top 1-foot sample, then each sub-sampling area will be excavated using a decontaminated hand auger or other appropriate instrument, to a depth of 12 to 24 inches. Samples from 1-foot depth intervals will continue until lead concentrations are at or below the action level (see Figure A-4 for the sampling decision tree).

When necessary, and possible, a small backhoe may be used to assist in loosening the soil such that hand tools can be used to collect soil samples. The bucket of the backhoe will be decontaminated between sample points using either steam or flushing the bucket with de-ionized water. The sampling team will use caution to minimize mixing of soil layers in order to reduce cross contamination.

Each sample will be collected as a discrete sample. At each sampling location the following procedures will be used:

1. Sieve soil samples through a No. 10 mesh sieve (as required by WAC 173-340-740 (7)(a)). Examine larger, retained particles and note their description in the laboratory notebook, including a description of soil samples and the percentage of bullets collected at each sampling site. Discard gravel, sticks, vegetation, etc.

2. Place sieved soil into an appropriately labeled one-gallon zipper locked plastic baggie. Homogenize the soil within the bag.

3. Analyze the soil directly through the plastic bag used for homogenization. The XRF analysis time interval will last at least 120 seconds in order to obtain the lowest limits of detection following EPA protocol of 99.7% confidence level for testing times.

4. Seven readings for lead will be taken from various locations on the bag to determine within-sample variability, if the sample is chosen as precision sample. The frequency of such samples will be determined by the DMA based on the ranges of relative standard deviation calculated as described below in Section A-3.4.2 from precision samples in the DMA. Each XRF analysis time interval will last at least 120 seconds.

5. Place an aliquot into a XRF sample cup, and analyze, if sample has been selected for confirmation analysis after initial evaluation of XRF bag analysis. If the sample is selected for collaborative laboratory analysis, submit an aliquot to the analytical laboratory. Collaborative samples will be submitted from the range within the "window of decision uncertainty" determined by the DMA. The frequency of aliquot submittals for fixed-lab analysis will be determined from the results of the DMA.

A-3.4.2 Quality control for onsite XRF Analyses

This sampling effort will adhere to all requirements specified in the generic quality assurance project plan for the Fort Lewis Agreed Order RIWP/SAP (Appendix A). All field and laboratory data will be collected and reported as required by standard operating procedures specified in the generic quality assurance project plan and as described in Section A-3.0 of this document. Quality control samples will be collected as described in Table A-3.

The overall data quality objectives for this work are to determine the nature and extent of soil ~~contaminationand~~contamination and to produce data of known and appropriate quality to support the selection of remedial actions for soil at the former ranges. Appropriate procedures and quality control (QC) checks will be used so that known and acceptable levels of accuracy and precision are maintained for each data set. This goal is quantitatively expressed in terms of the Data Quality Indicators (DQIs) for the quality control checks performed. The quantitative requirements for accuracy measurements were established to ensure the data produced is shown to be effective for making defensible project decisions.

Accuracy. Accuracy is the agreement between a measured value and the true or accepted value. While it is not possible to determine absolute accuracy for environmental samples, the analysis of standards and spiked samples provides an indirect assessment of accuracy.

XRF accuracy will be established with a calibration check standard obtained from the XRF instrument manufacturer. A low, medium, and high concentration calibration standard will be used. Calibration verification checks will be conducted at the beginning and end of each day and after every 20 samples. The percent difference (%D) should be less than 20 percent. If this data quality indicator is not met, corrective actions as specified in the XRF User's Guide would be followed. Samples will not be analyzed until the calibration data are within acceptable range.

Precision. Precision is a measure of mutual agreement among replicate (or between duplicate) or co-located sample measurements of the same analyte. The closer the numerical values of the measurements are to each other, the more precise the measurement. Precision for a single analyte will be expressed as the relative percent difference for results of field and laboratory duplicate samples. Precision requirements for each sample type are presented below.

For FPXRF samples, a precision sample will be measured at a frequency to be determined by the DMA. A precision sample will be a sample that has been analyzed seven times in replicate. If possible, samples near the action level will be selected as the precision sample. Evaluation of precision samples at each of the preparation steps will allow for determination of precision at each of the steps. Following review of this data, the frequency of precision samples will be revised for the remaining sampling activities. The relative standard deviation (RSD) will be calculated for each of the precision samples using the following equation:

$$RSD = (SD/Mean) * 100$$

Where:

SD = standard deviation of the seven replicate results; and
Mean = mean concentration of seven replicate results.

The precision for the sample RSDs will below 20 percent. If this data quality indicator is not met, the data will be reviewed to determine appropriate corrective actions, if required. Corrective actions will be conducted in accordance with Appendix A of the RIWP.

XRF Field Duplicate Sample. Co-located field duplicate samples will be collected to assess combined sampling, and field variability. The co-located field duplicate will be collected from 0.5 to 3 feet way from the primary sampling point. The relative percent difference (RPD) is calculated for the primary and replicate sample results. Field duplicate samples shall be collected for XRF analysis at a minimum frequency of one per every 10 samples during the DMA. The frequency of XRF field duplicates for the remainder of the project will be determined by the ranges seen in the DMA but will not exceed 10 percent. The RPD criteria for XRF results for field duplicates will be less than 50 percent.

Soil for the field duplicates will be excavated using a decontaminated hand auger, or appropriate equipment. Co-located field duplicate sample locations will be established approximately two feet from the main sample location. One or more hand auger samples will be collected at each sample location; the volume collected must be sufficient to assess the variability within the grid area (to be determined during the DMA). Soil will be sieved through a No. 10 mesh sieve so that larger particles such as gravel, sticks, and bullet fragments will be removed prior to analysis. Written documentation of site activities will include a description of soil samples and the percentage of bullets collected at each sampling site.

Analytical Laboratory Duplicate Sample. Laboratory duplicate sample analyses are performed by taking aliquots of a well-homogenized sample from the same sample container to assess the precision of the analytical method. The RPD is calculated for the primary and replicate sample results. Laboratory duplicate sample analysis will be performed for soil and water analyses. Laboratory duplicate sample analysis shall be one per every 20 samples or one per analytical batch, whichever is more frequent. The RPD criteria for laboratory duplicates will be less than 35 percent for soils.

Representativeness. Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations (including the impact on the data from an evaluation of duplicate samples, rinsate blanks, and field blanks) at a sampling point, or an environmental condition. The design of and rationale for the sampling program (in terms of the purpose for sampling, selection of sampling locations, the number of samples to be collected, the ambient conditions for sample collection, the frequencies and timing for sampling, and the sampling techniques) ensure that environmental conditions have been sufficiently represented. Discussion of the methods and approaches used to satisfy the representativeness criteria is found throughout the sampling plan.

Care will be taken in the design of the sampling program to ensure sample locations are selected properly, sufficient numbers of samples are collected to accurately reflect conditions at the site, and samples are representative of the sampling locations. A sufficient volume of sample will be collected at each sampling station to minimize bias or errors associated with sample particle size and heterogeneity.

Comparability. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. The comparability goal will be achieved through the use of standard operating procedures to collect and analyze representative samples, and by reporting analytical results in appropriate and consistent units. Each analytical procedure selected from among the acceptable options will be used throughout the work assignment, unless a rationale is provided for an alteration. In essence, comparability will be maintained by consistency in sampling conditions, selection of sampling procedures, sample preservation methods, analytical methods, and data reporting units.

Split samples will be collected from well-homogenized discrete samples and submitted for ICP analysis. A correlation analysis will be performed between XRF and laboratory lead results will be performed to evaluate data comparability. It should be noted that numerical results might not be equivalent since XRF measures total lead in a bulk sample while laboratory analysis detects lead, which is extracted by nitric acid; i.e., one method may exhibit a high or low bias relative to the other. However, a linear regression correlation coefficient (r) greater than 0.75 is anticipated; evaluation of the correlation data will be conducted prior to using the information for subsequent field decision-making.

Completeness. Completeness is a measure of the number of valid measurements obtained in relation to the total number of measurements planned. The closer the numbers are, the more complete the measurement process. Completeness will be expressed as the percentage of valid-to-planned measurements. An objective of the field-sampling program is to establish the quantity of data needed to support the investigation. This will be achieved by obtaining samples for all types of analyses required at each individual location, a sufficient volume of sample material to complete the analyses, samples that represent all possible contaminant situations under investigation, and quality control samples. Completeness will take into consideration environmental conditions and the potential for change with respect to time and location. Target levels for completeness are 90 percent. These levels are evaluated for individual analytes as well as for locations and matrices.

A-3.5 Field Portable XRF Instrumentation

A detailed XRF instrumentation SOP will be provided as an appendix to the RIWP. The quality of instrumentation and method detection limits will be expected to be equivalent or better than the Niton 300 series. Table A-5 presents method detection and reporting limits for Niton 300 series XRF instrumentation.

A-3.6 Sampling for Explosives Residue

Samples will be collected from the nine demolition sites within the Infiltration Range (see Figures A-7 and A-10). Several of the demolition pits have trees growing out of them, which may make collecting samples difficult. These sites are ED1, ED9, and ED7. Previous studies indicate that explosive residue concentrations are consistently highest in the surface soils, approximately 0 – 4 inches in depth (USACE, 2001). Any explosive residues present will be biased high in the chosen sampling strategy, providing for a conservative estimate of contamination at each of the demolition sites.

As recommended by *Distribution and Fate of Energetics on DoD Test and Training Ranges: Interim Report 1* (USACE, 2001) a set of seven surface samples will be collected in a wheel pattern from the crater at each site, composited, and analyzed to determine if explosive residues are present. The top 6 inches of soil will be excavated using a decontaminated hand trowel and placed in a decontaminated stainless steel bowl, homogenized and placed into a labeled 8 oz clear wide mouth glass jar. Samples will submitted to a fixed laboratory for analysis by EPA Method 8330. A second set of composite samples will be collected from the 6 to 12 inch depth interval in the same manner and submitted for analysis. If residue is present, further samples may be required to determine extent of contamination. Two duplicates, and one MS/MSD will be collected with this sample delivery group. All soils samples will be collected using stainless steel trowels, which were carefully wiped with a clean paper towel, washed with acetone and air dried between samples.

A-3.7 Archived Samples

Soil samples collected from both ranges will be archived either in storage at the Seattle District or at Fort Lewis Public Works. Samples will be archived in the labeled sample bag or jar, with Chain-of-custody documentation, for further analysis if deemed necessary. Any subsequent analyses performed on the archived samples must be performed within the maximum holding time appropriate to the analytical method (See Table A-10).

A-3.8 Evaluation to Determine Additional Sampling Locations

The initial sampling strategy will be evaluated once real time data from XRF results have been obtained to determine if increased sampling density is required. Software programs such as Spatial Analysis and Decision Assistance (SADA) provides a number of tools for the visualization of data, geospatial analysis, statistical analysis, sampling design and decision analysis (TIEM 2003). Secondary sampling design applications assists in determining additional sample locations, such as placing new sample locations in areas where there is the greatest uncertainty about exceeding the action level, delineating the boundaries of the area of concern.

A-3.9 Groundwater Sampling

Previous groundwater sampling at Miller Hill and Engineer Bluff does not indicate impact to groundwater. Groundwater samples were collected from one location at Miller Hill and nine locations at Engineer Bluff. Groundwater was noted at depths ranging from roughly 20 to 32 feet below ground surface at Engineer Bluff and 40 feet below ground surface at Miller Hill. Total and dissolved fractions were collected at each sample location; both total and dissolved lead concentrations were below the screening criteria.

Based on results of previous monitoring, groundwater sampling at AOC 4-2.2 and 4-6.3 is not warranted at this time. However, once soil results have been collected, potential impact to groundwater will be evaluated including use of the 3-phase model.

A-3.10 Toxicity Characteristic Leaching Procedure Analyses

Following the completion all characterization data evaluation, a subset of samples will be selected that are representative of those soils that may potentially be disposed. These samples will be submitted for TCLP (EPA method 1311/6010) to evaluate waste disposal cost impacts (a potential for remedy selection). A minimum of five samples per range will be collected (see Table A-13). No remedial action or offsite disposal will take place under this remedial investigation.

A-3.11 Decontamination Procedures and Investigative-Derived Waste Plan

Decontamination of sampling equipment will be conducted in accordance with Appendix A Attachment A-1 of the RIWP.

Investigative-derived waste will be handled in accordance with the procedures outlined in Appendix A Attachment A-7 of the RIWP. It is anticipated that only PPE and decon water will be generated.

A-3.12 Sample Documentation and Handling Procedures

A-3.12.1 Field Notebooks

Sample custody and documentation are vital aspects of the site investigation. The field documentation system provides the means to identify, track, and monitor each individual sample from the point of collection through final data reporting. All field documentation will be completed using indelible ink. Errors will be scratched out with a single line, initialized and dated.

A bound book with consecutively numbered pages will be maintained by the sampling team to provide a daily record of significant events, observations, and measurements taken during the field investigation. The field logbooks are intended to provide sufficient data and observations to enable the field team to reconstruct events that occur during the project. The field logbooks will contain the following as a minimum:

1. Date and military time of sample collection.
2. Weather conditions, including temperature.
3. The location number and name.
4. Location of sampling point.
5. Sample identification number.
6. Type of sample.
7. Any field measurement taken
8. Field observations.
9. References, such as maps or photographs of the sampling site.
10. Any procedural steps taken that deviate from those outlined in this addendum.

3.12.2 Sample Labeling and Nomenclature

Sample labels will clearly indicate the sample number, date, sampler's initials, parameters to be analyzed, preservative added, and any pertinent comments. Sample nomenclature will consist of the sample location code (i.e., MH, EB, EF, ED), sample type (S for soil sample), and depth interval (if appropriate). Depth intervals will be numbered sequentially, 1 (0 – 12 inches), 2 (12 – 24 inches), 3 (24 – 36 inches), and so forth. For example, the first sample collected from the 0 – 12 inch depth interval at the impact berm at the Evergreen infiltration range will be labeled EB1-S1.

Site Name	AOC No.	Sample Location Code
Miller Hill Pistol Range (MH)	A4-2.2	MH1, MH2, MH3….
Evergreen Infiltration Range (E)	A4-6.3	
- Impact Berm (B)		EB1, EB2, EB3….
- 4 Firing Points (F)		EF1 through EF4 Sides of pads will be labeled A through D
- 9 Demolition Sites (D)		ED1 through ED9

A-3.12.3 Chain-of-custody Records

Chain-of-custody procedures are employed to maintain and document sample possession. A sample is considered under a person's custody if it is in that person's physical possession, within visual sight of that person after taking physical possession, secured by that person so that the sample cannot be tampered with, or secured by that person in an area that is restricted to unauthorized personnel.

Chain-of-custody records completed by the sampler will accompany all shipments of samples. Each cooler will have a chain-of-custody form listing the samples in the cooler. It is possible that more than one chain-of-custody form will be needed per cooler to list all the samples contained in the cooler. The purpose of these forms is to document the transfer of a group of samples traveling together; when the group of samples changes, a new custody record is initiated. The original chain-of-custody record always travels with the samples; the initiator of the record keeps a copy. The following procedures will be followed when using chain-of-custody record sheets.

1. The originator will fill in all requested information from the sample labels.
2. The person receiving custody will check the sample label and tag information against the chain-of-custody form. The person receiving custody will also check sample condition and note anything unusual under "Remarks" on the chain-of-custody form.
3. The originator will sign the "Relinquished by" box and keep a copy of the chain-of-custody form.
4. After delivery by the commercial carrier, the person receiving custody will sign in the "Received by" box adjacent to the "Relinquished by" box (may also be filled in by recipient as "Federal Express" or other carrier name). All signatures and entries will be dated.
5. When custody is transferred to the analytical laboratory, blank signature spaces may be left and the last "Received by" signature box used. Another approach is to run a line through the unused signature boxes.

6. In all cases, it must be readily seen that the same person receiving custody has relinquished it to the next custodian.
7. If samples are left unattended or a person refuses to sign, this will be documented and explained on the chain-of-custody form.

A-3.12.4 Chain-of-custody Documentation for XRF Samples

Chain-of-custody records will be completed by the sampler and accompany all XRF samples to be archived (see Section A-3.7). COCs for the XRF samples may be in the form of spreadsheets. Otherwise, the XRF COCs will follow the same guidelines described in Section A-3.12.3.

A-3.12.5 Sampling Handling

Sample packaging and shipping procedures are based on EPA specifications, USDOT regulations, and USACE ER 1110-1-263. All samples will be shipped as "Environmental Samples" and not as hazardous material. Ice will be placed in each cooler to maintain a temperature of 4°C to meet sample preservation requirements. All samples will be delivered to the laboratory within 24 hours of collection. Tables A-6 to A-11 identify sample containers, method detection limits, QC limits, and preservation requirements.

The following are general packaging procedures:

1. Sample labels with adhesive backing will be securely attached to each sample container.
2. Labeled sample containers will then be sealed into plastic bubble-wrap bags or Ziploc-type bags prior to being loaded into the sample coolers.
3. Insulated plastic or metal-clad plastic coolers will be used as shipping containers. The drain plugs shall be taped shut (using strapping tape) on the inside and outside. Several plastic bubble-wrap sheets shall be placed on the interior bottom and sides of the coolers for shock absorption. One to three inches of Styrofoam pellet packing material may also be placed in the bottom of the coolers for additional shock absorption at the discretion of the Sampling Team Site Manager. New, clean, heavy-duty plastic garbage-type bags will be used as protective liners inside all coolers. Bagged sample containers will be placed within the liner.
4. Styrofoam pellets may also be placed between sample containers to protect the containers from breakage during shipment and handling.
5. All samples requiring refrigeration will be chilled to 4°C with the addition of four bags (gallon-size Ziploc type – double bagged) of cubed ice or block ice spalls.
6. The paperwork intended for the laboratory will be placed inside a plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The original chain-of-custody form will be included in the paperwork sent to the laboratory. If samples are sent by air transport, the air bill will be completed before the samples are handed over to the carrier.

7. Two signed custody seals will be placed over the lid of the cooler, one on the right front and one on the upper left, and covered with clear plastic tape.
8. The cooler will be securely taped shut with strapping tape wrapped completely around the cooler at least once in a minimum of two locations.
9. "Up Arrow" symbols will be placed on all four sides of cooler.
10. The completed shipping label will be attached to the top of the cooler. The cooler will then be delivered to the overnight courier.

The project and QA laboratories will be notified, two weeks prior to sample collection and again two days prior to arrival of samples, of the approximate number of samples, matrix, and requested analyses. A key to field identification numbers will be provided to the QA laboratory only.

A-3.13 Field Quality Control Samples

One rinse blank per day will be required for this project since the equipment used to collect samples during this field sampling investigation shall not be dedicated. Field duplicates will also be collected at a frequency of 1 per 10 samples for explosives and for XRF lead analysis for the DMA (see Table A-3). The frequency of collection of XRF field duplicates for the remainder of the project will be determined by the DMA.

A-4.0 QUALITY ASSURANCE PROJECT PLAN

The purpose of the Quality Assurance Project Plan (QAPP) is to define, in specific terms, the quality assurance (QA) and quality control (QC) objectives, organization, and functional activities associated with the sampling and analysis of soil samples obtained during this investigation. Details of the QA/QC requirements are presented in the Draft RIWP.

All analyses for soil samples will be performed in general accordance with the methods specified in the Shell document (USACE, 1998). Laboratory Standard Operating Procedures (SOPs) are maintained in the project files.

Tables A-5, A-6, and A-7 present the methods of analysis and reporting limits to be used for this project. Reporting limits (RLs) typically achieved by the laboratory for the methods are defined in the Draft RIWP; however, matrix interferences may result in higher sample quantitation limits. In general, RLs will reflect the lowest levels of analyte that can be accurately and reproducibly detected by the analytical method employed. The RL can vary from sample to sample depending on sample size, matrix interferences, moisture content, and other sample-specific conditions. Reporting limits usually correspond to the lowest calibration standard.

Tables A-8 and A-9 present the QC criteria to be used by the project laboratory for soil samples. In general, these criteria meet the data quality objectives presented in the RIWP.

All analytical data generated by the laboratory shall be extensively reviewed prior to report release to assure the validity of the reported data. Each step of this review process involves evaluation of data quality based on both the results of the QC data and the professional judgment of those conducting the review.

If a problem is detected during the field program and/or a routine audit, an investigation will be conducted immediately to evaluate the problem and to determine the most appropriate corrective action, if necessary. Similar action will also be conducted for off-site laboratory analysis, if necessary. Corrective actions will be conducted in accordance with Appendix A of the RIWP.

A-5.0 ACTIVITY HAZARD ANALYSIS

All work described in this Sampling and Analysis Plan will be performed according to the RIWP Appendix B: Accident Prevention Program (APP). This APP will be made available to all personnel involved with the sampling.

A-6.0 REFERENCES

Air Force Center for Environmental Excellence. 2000. Technical Protocol for Determining the Remedial Requirements for Soils at Small Arms Firing Ranges. Technology Transfer Division (AFCEE/ERT). Prepared by Parsons Engineering.

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Figures

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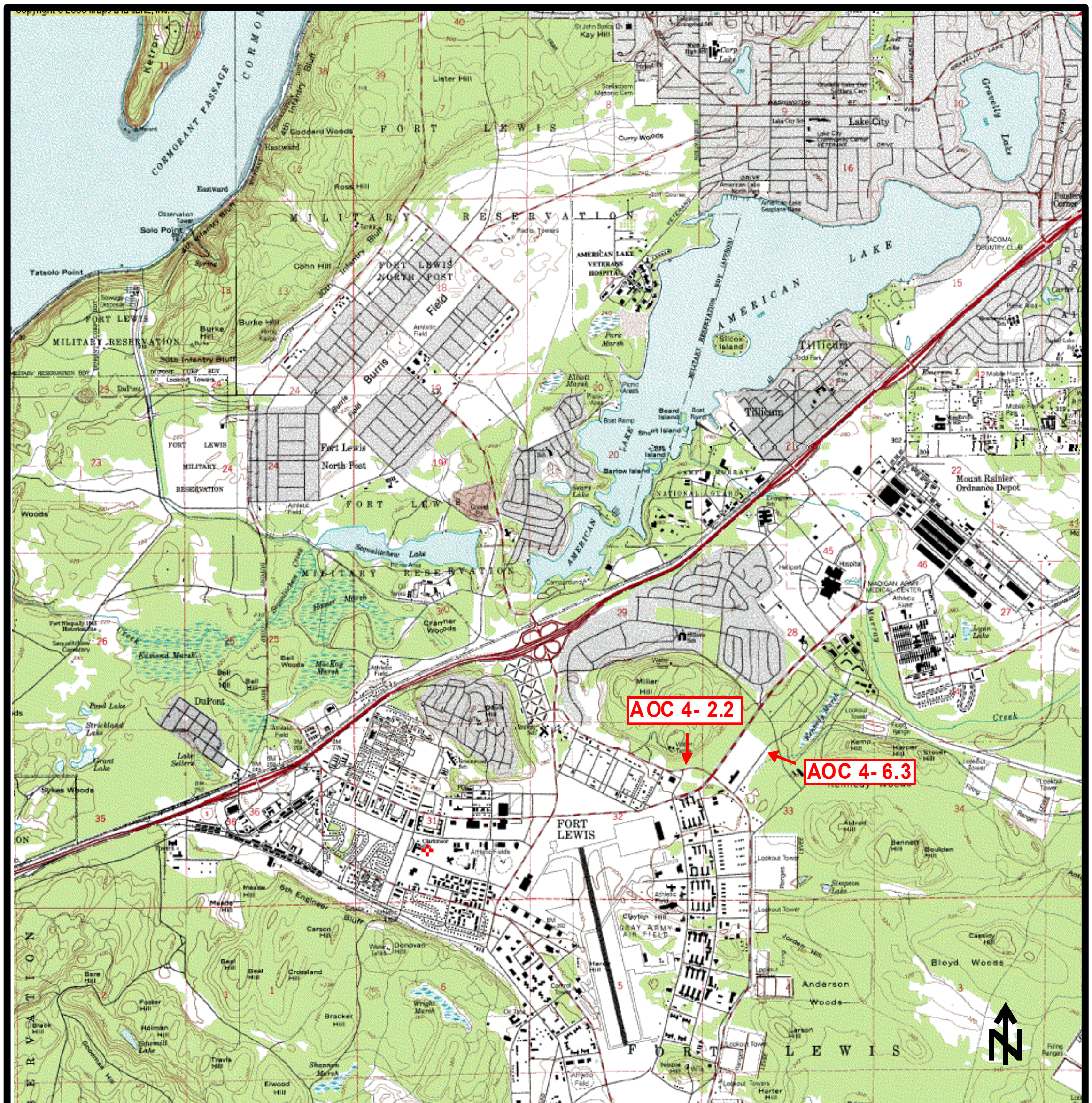


AOC 4- 2.2 Miller Hill Pistol Range
AOC 4- 6.3 Evergreen Infiltration Range
Fort Lewis Agreed Order Remedial Investigation
Fort Lewis, Washington

US Army Corps of Engineers
Seattle District

Figure A-1. Site Locations

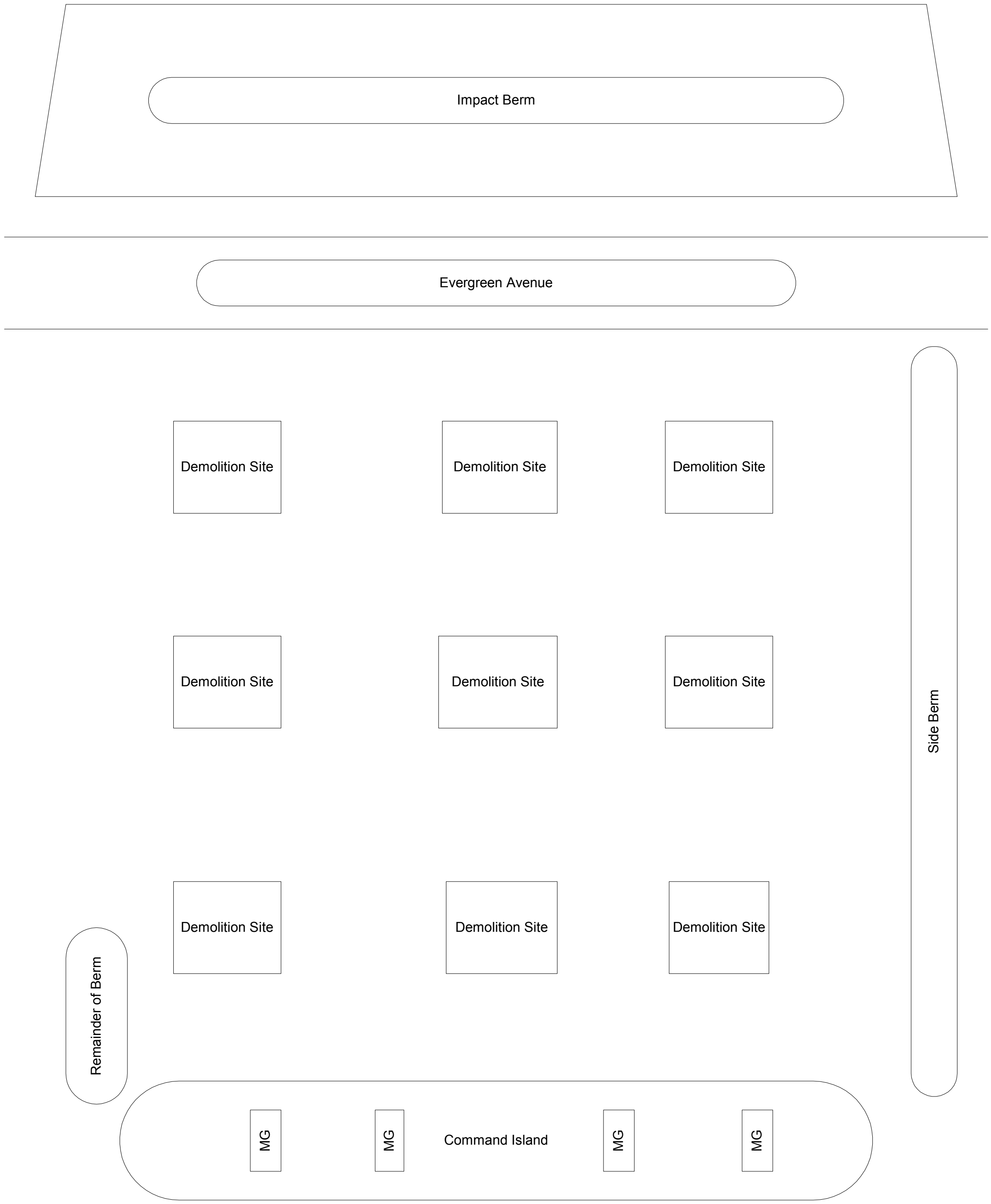


Figure A-2. Illustration of the Infiltration Range (Not Drawn to Scale)

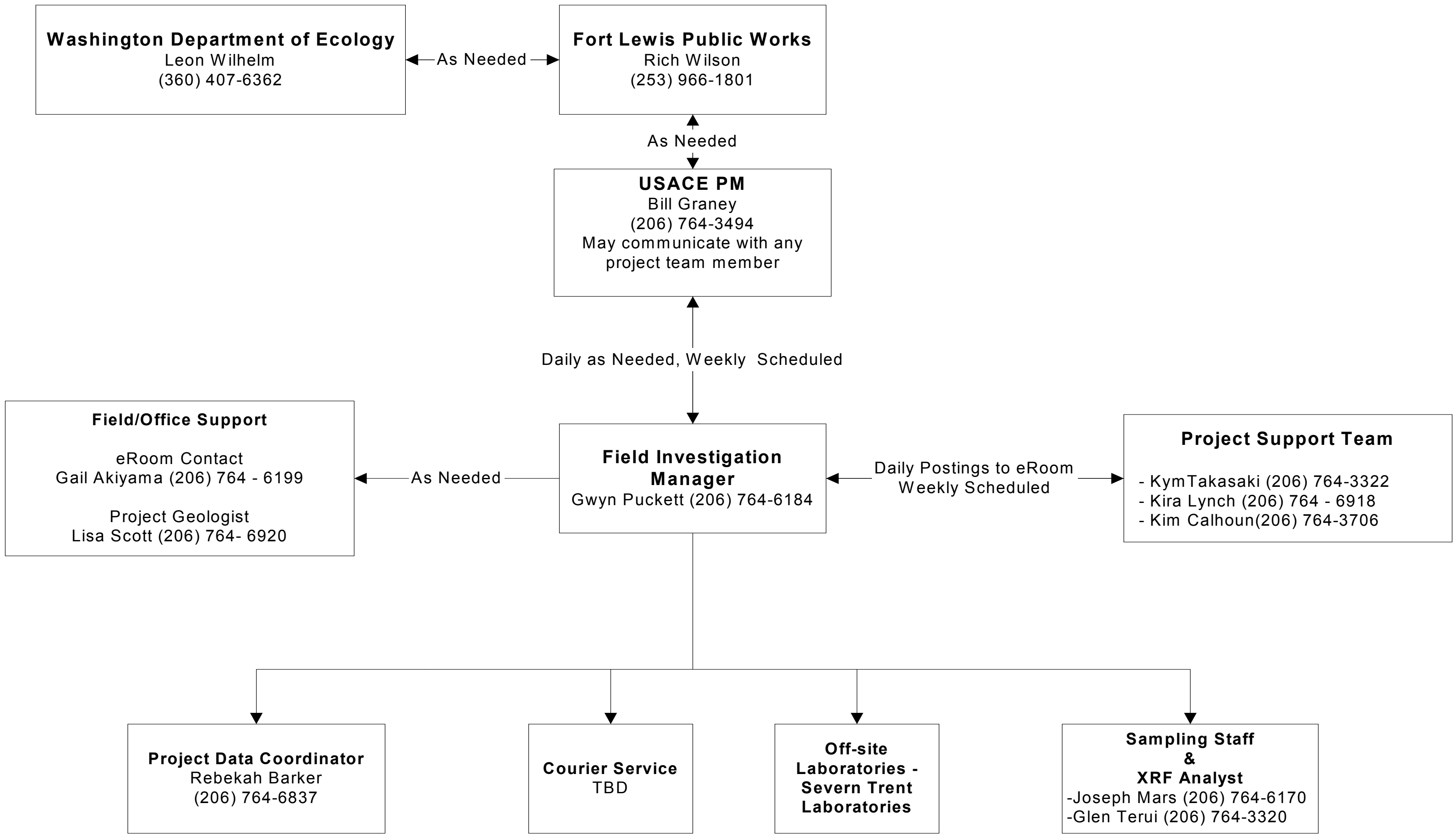


Figure A-3. Communication Strategy

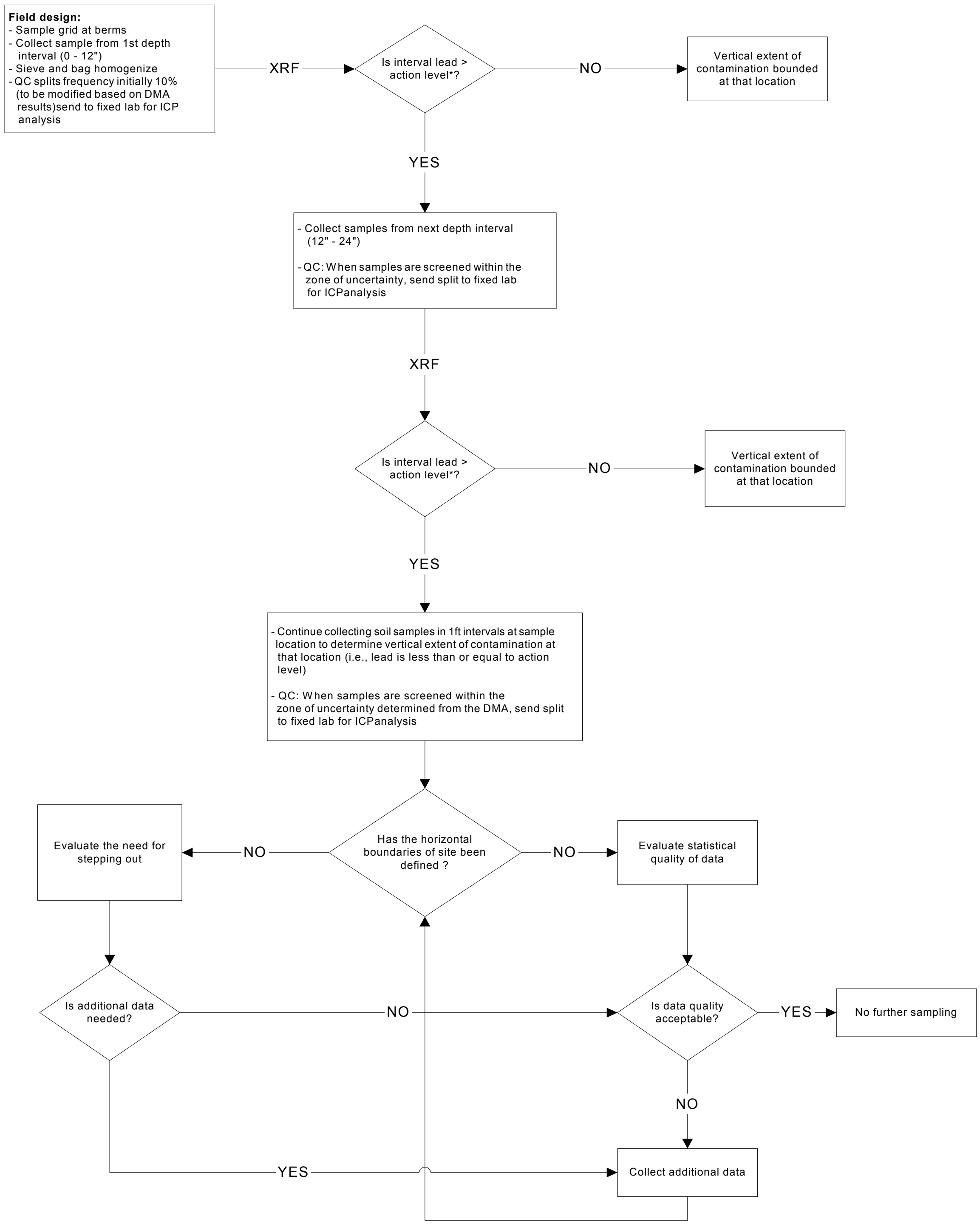
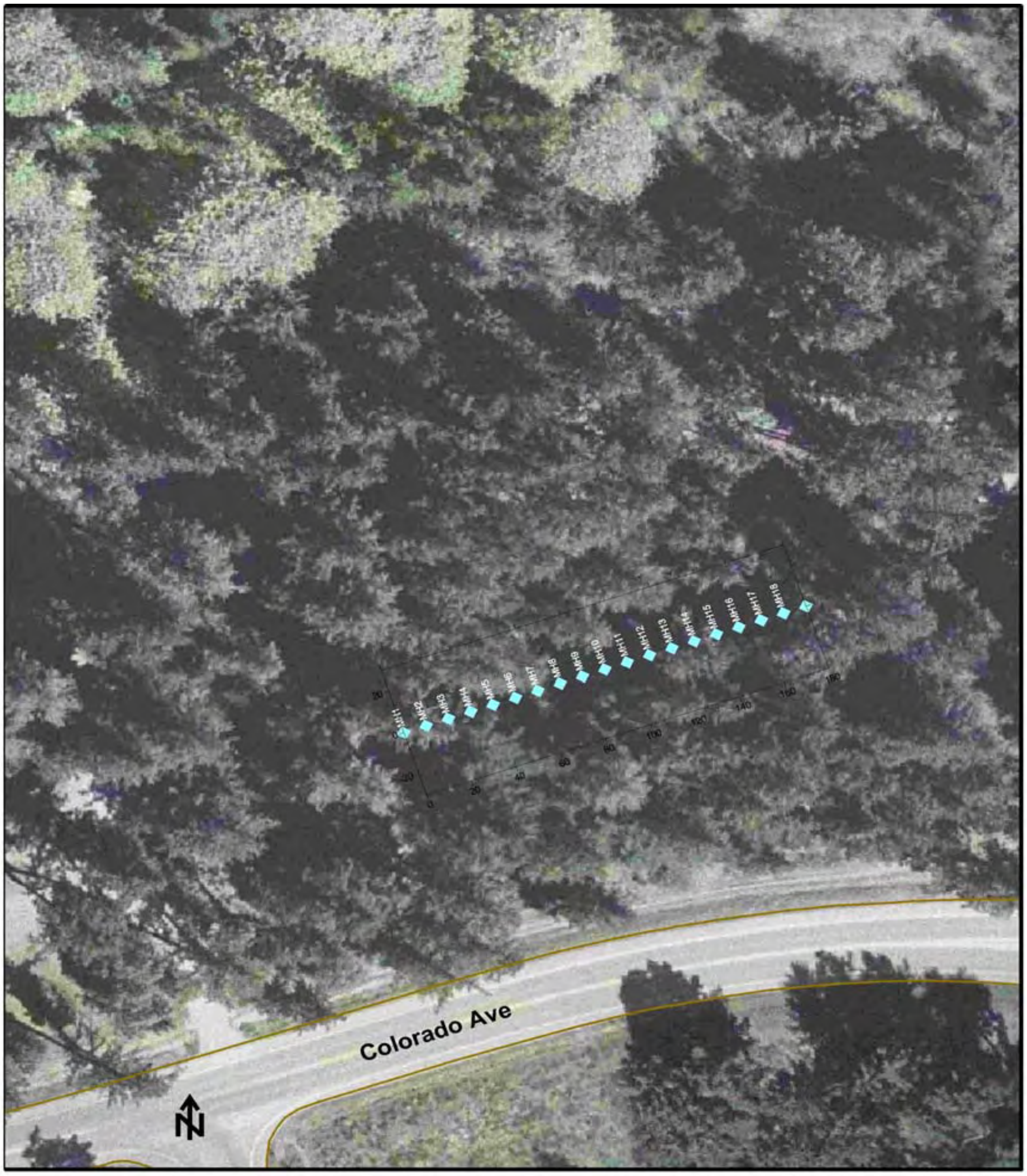


Figure A-4. Decision Tree for Field XRF Analysis

* The initial action level of 50 ppm will be modified for XRF during the DMA



AOC 4-2.2
Miller Hill Former Pistol Range
Sample Locations - Aerial Photograph 2002

US Army Corps of Engineers
Seattle District

Sampling Locations for Lead

Figure A-5. Sample Locations at Miller Hill Pistol Range (AOC 4-2.2)

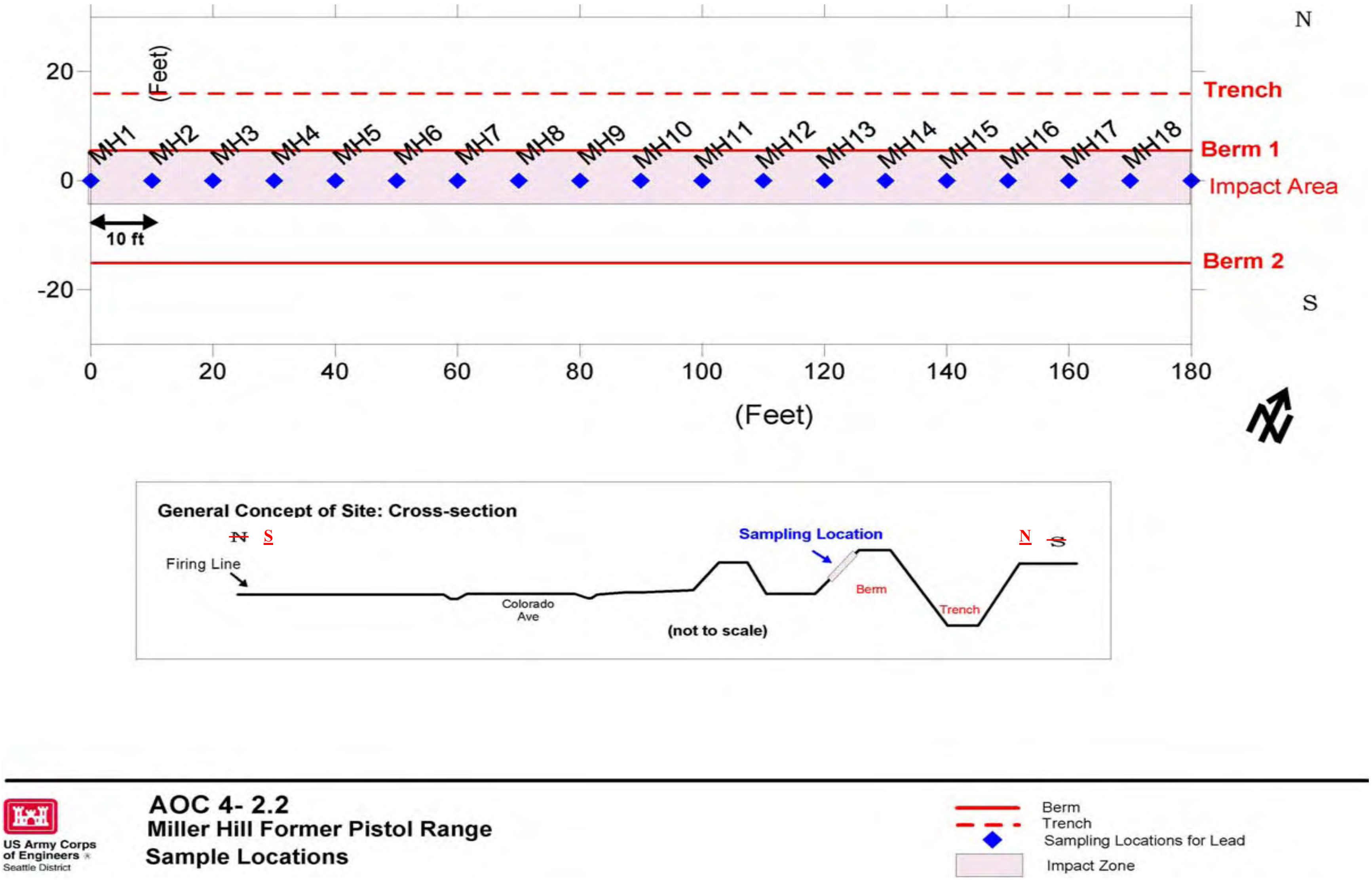
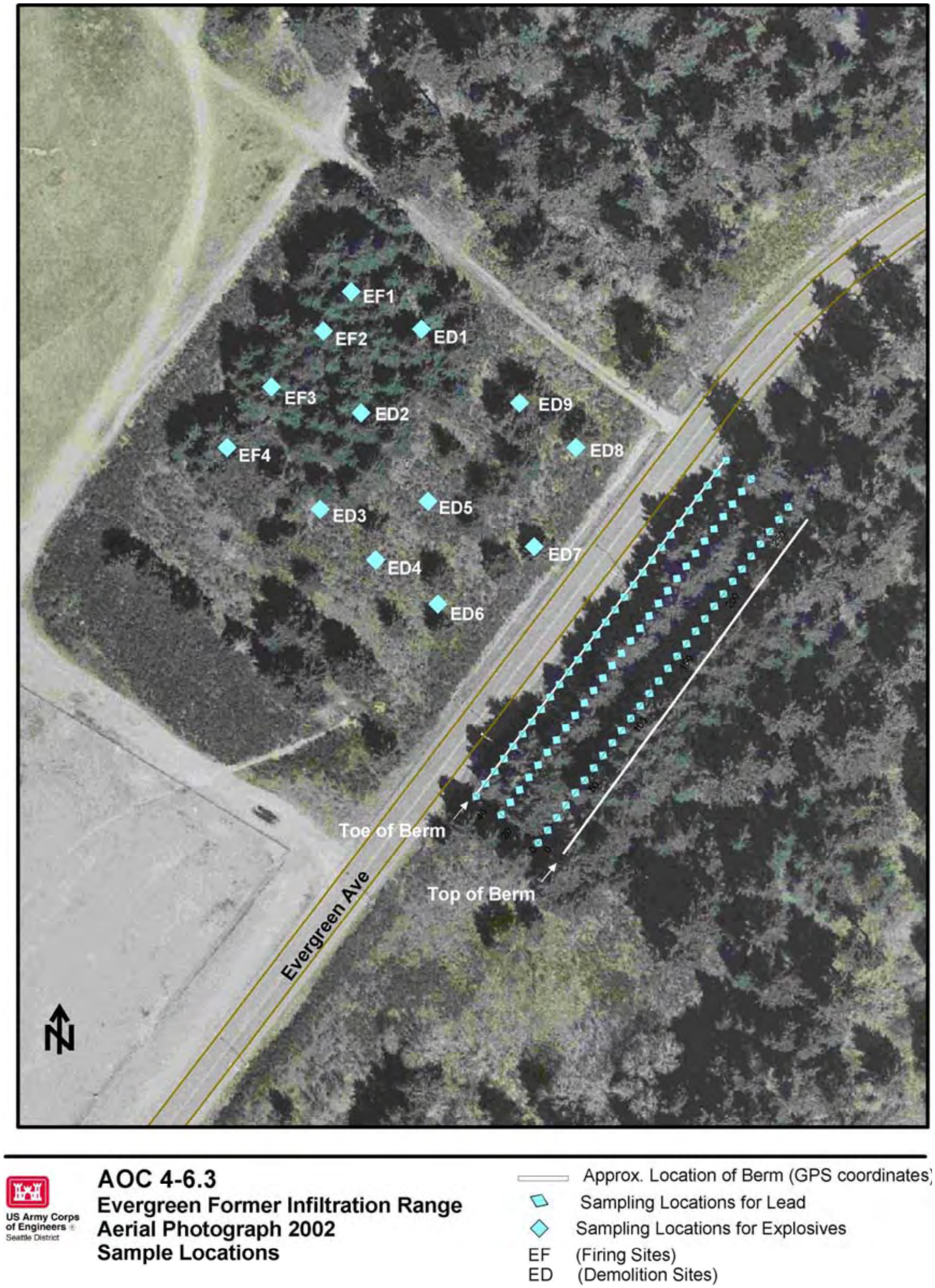


Figure A-6. Sampling Grid For Impact Berm at the Miller Hill Pistol Range (AOC 4-2.2)



Note: These locations are based on GPS, and locations need to be field verify. Errors appears to be occuring at Demo locations.

Figure A-7. Sampling Locations at Evergreen Infiltration Range (AOC 4-6.3)

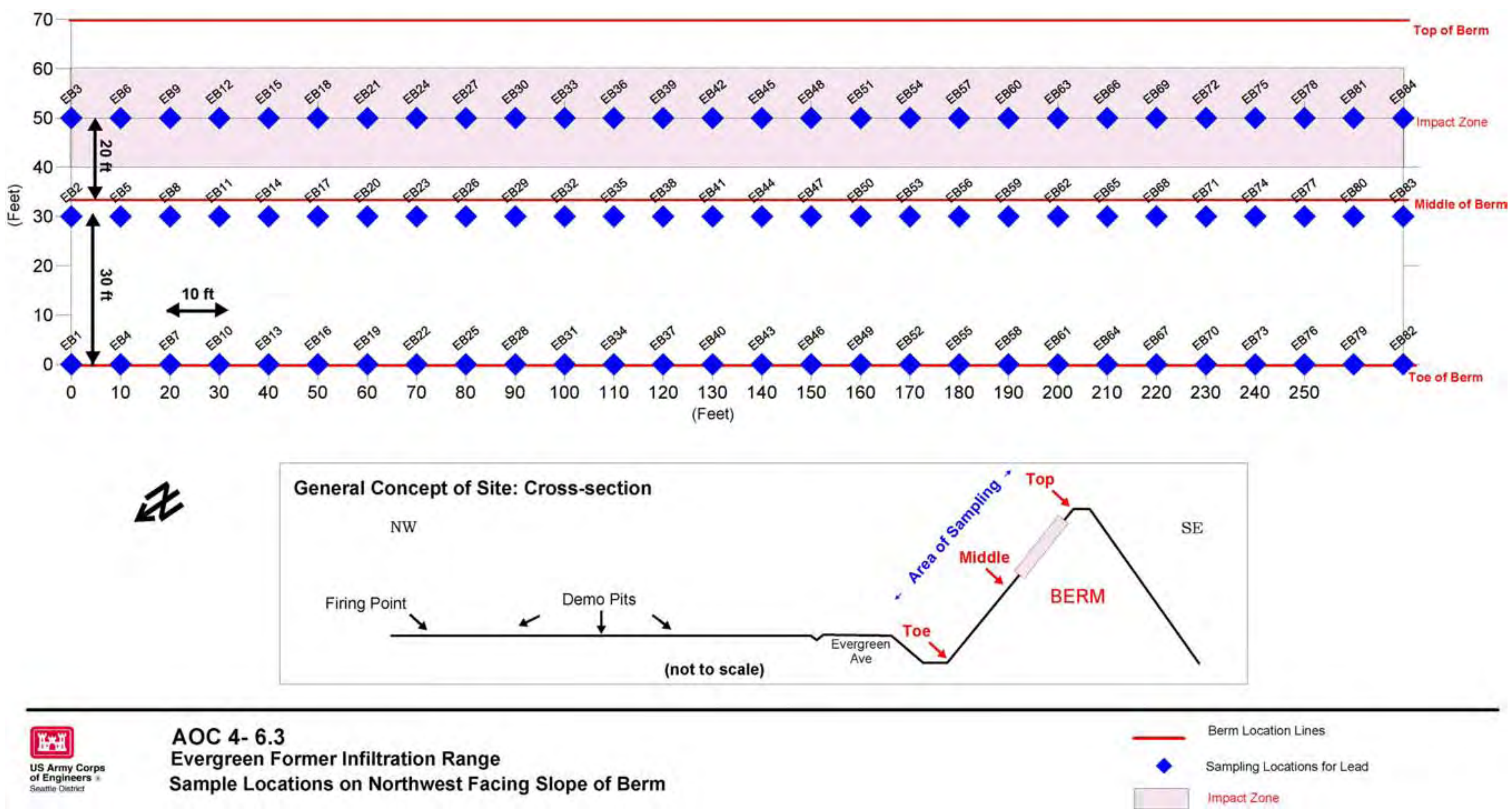


Figure A-8. Sampling Grid For Impact Berm at the Evergreen Infiltration Range (AOC 4-6.3)

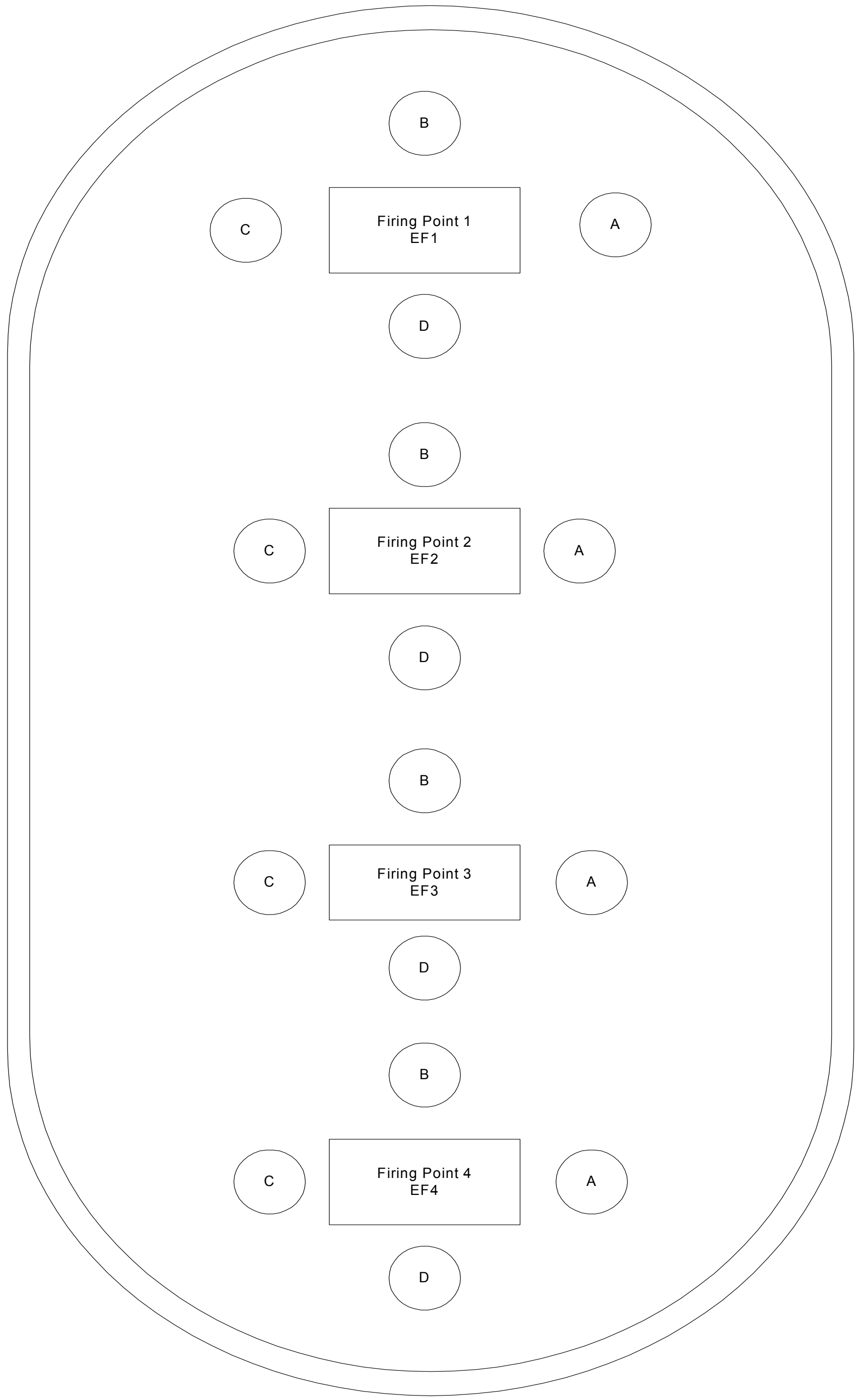


Figure A-9. Sampling Locations for the Firing Points in the Command Island at Evergreen Infiltration Range (drawing not to scale)

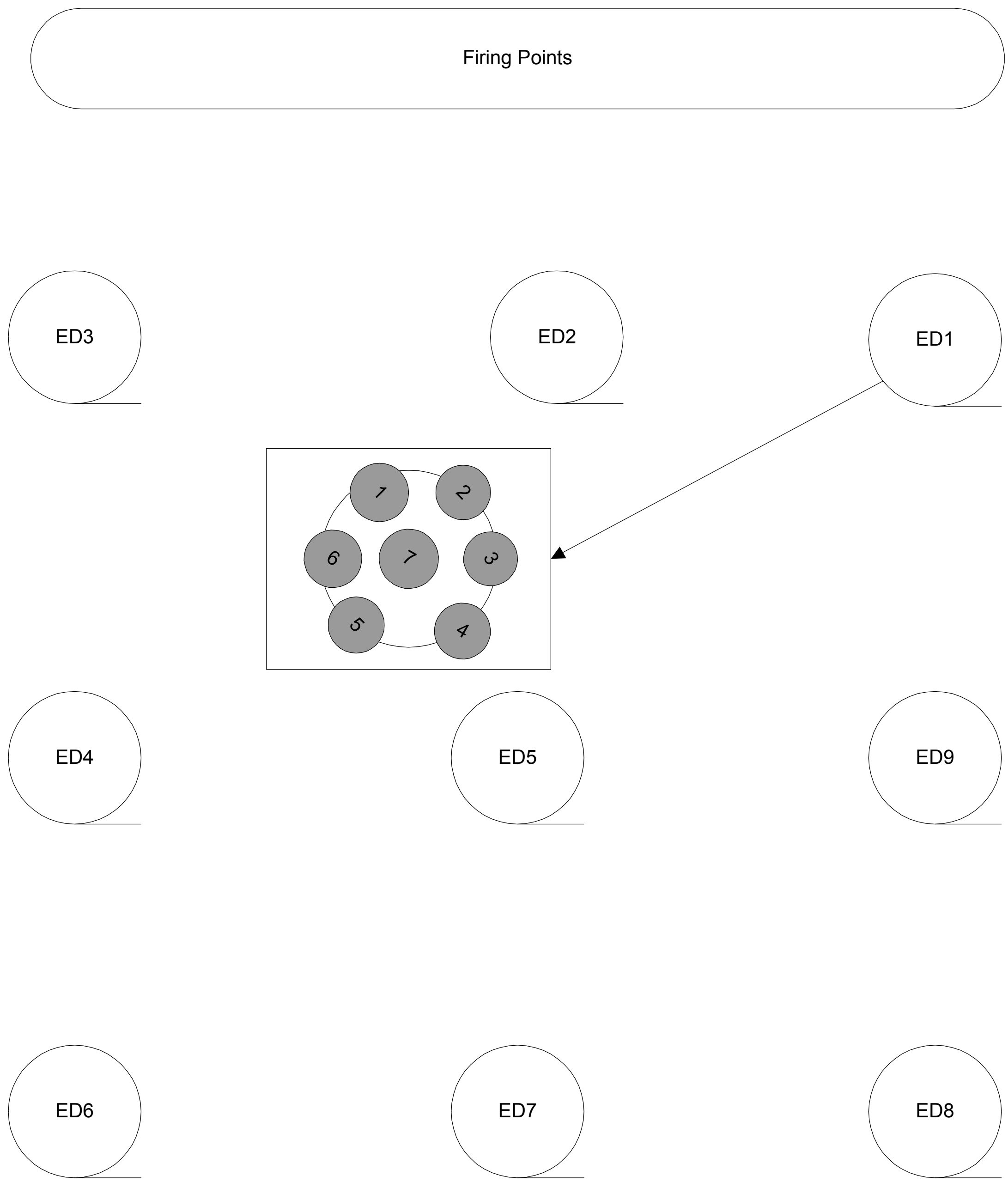


Figure A-10. Sampling Locations for Nine Demolition Sites at Evergreen Infiltration Range

. (drawing not to scale). The insert for ED1 is representative of the composited samples to be collected from each of the demolition sites.

Tables

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TABLE A-1. CONTAMINANTS POTENTIALLY FOUND AT SMALL ARMS FIRING RANGES

Constituent	Comment
Lead metal	Primary bulk constituent of a projectile
Lead Styphnate/Lead Azide	Detonating compounds
Antimony	Increases hardness
Arsenic	Present in lead shot. A small amount is necessary in the production of small shot since it increases the surface tension of dropped lead, thereby improving lead shot roundness.
Copper bullet core alloy	Increases hardness
Tin	Increases hardness
Copper	Jacket alloy metal
Zinc	Jacket alloy metal
Iron	Iron tips on penetrator rounds

Source: ITRC – Characterization and Remediation of soils at Closed Small Arms Firing Ranges, January 2003

TABLE A-2. UNCERTAINTY MANAGEMENT ISSUES AND POTENTIAL RESPONSES

Problem	How to Identify	Resolution
Matrix heterogeneity	Compare the results of samples collected at known distances from each other (co-located duplicates)	After determining the scale over which it is important to understand the impact of heterogeneity, increase the sampling density in those areas where incorrect decisions would be risky from a protectiveness or economic aspect
Inadequate sample preparation/ homogenization	Compare the precision of replicate sample prep + 7 XRF analyses on bag to the analysis performed on a single cup sample	Improve the consistency of sample preparation procedures, or select a procedure more appropriate to the matrix. Increasing sample size or the use of compositing might also need to be considered.
High analytical variability	Analytical QC sample results are outside required performance criteria or interferences are suggested by analysts observations	Apply additional sample cleanup steps or use an alternative peak to perform the analyte quantitations. For example, use an alternative spectral line for quantitation of arsenic when lead concentrations are high.
Detection limits are elevated due to the presence of interferences.	Non-detections are above the action level for the site resulting in the calculation of artificial risk	Same as above and selection of an alternative method that is more analyte specific. For example, use of a selective ion monitoring method for poly nuclear aromatics versus the standard SW-846 method 8270 for semivolatile organics
Detection frequencies are insufficient or the distribution of results so erratic that the maximum value has to be used for comparison to the action level	If detection frequencies are less than 50 percent and data distributions cannot be established as either normal or lognormal use of a UCL for determination of attainment may not be possible.	Block or stratify the data into different populations that could be more amenable to statistical analysis. Collect more data based on a geostatistical design to focus on where the highest uncertainty is predicted
Results are very close to the action level making decision making difficult	Based on the project limits of uncertainty the results fall in the category of too close to call	Decide that the result should be considered dirty, take a conservative approach, collect additional confirmation results and make a decision based on the average

TABLE A-3. QUALITY CONTROL SUMMARY TABLE FOR XRF AND LABORATORY ANALYSIS

QC Sample	Frequency	Acceptance Range	Purpose
PXRF			
Calibration Check sample	Beginning/end of day, 1 for every 20 samples	%D < 20%	Evaluate accuracy of FPXRF instrument
Precision sample	Every Sample for DMA. Frequency for the remainder of project will be determined during DMA.	%RSD <20%	Evaluate precision of FPXRF analysis at each step
Blank	1 for every 20 samples	< Reporting Limit	Determine presence of contamination on FPXRF equipment
Lab duplicate	1 for every 20 samples at every stage of prep	RPD <20%	Evaluate precision of FPXRF prep at each step
Field duplicate	1 for every 10 samples	RPD< 50%	Evaluate overall precision of sampling effort
Laboratory			
Matrix Spike	1 for every 20 samples	75%<R<125%	Evaluate accuracy of FPXRF instrument
Equipment Blank	1 per day	< Reporting Limit	Determine presence of contamination on field equipment
Lab duplicate	1 for every 20 samples	RPD <20%	Evaluate precision of laboratory analysis
Field duplicate	1 for every 10 samples	RPD< 50%	Evaluate overall precision of sampling effort

TABLE A-4. CLASSES OF EXPLOSIVES

Classes of Explosives		Standard Method
Nitroaromatics	TNT, DNT, TNB, DNB, NB, & Tetryl	EPA 8330
Cyclic nitramines	RDX & HMX	
Nitro esters	PETN, nitroglycerin, & nitrocellulose	

TABLE A-5. DETECTION/REPORTING LIMITS FOR XRF

Analyte	Matrix	Method Detection Limit (ppm) in Matrix	
		120 SECOND TESTING TIME	
		Sand	Standard Reference Materials (STM)
Lead	Soil	35	45

TABLE A-6. REPORTING LIMITS FOR METALS EPA 6010/6020

Parameter/Method	Analyte	MTCA Method A/B (in mg/kg)	Soil	
			RL	Unit
ICP Screen for Metals SW6010/6020	Antimony	32	3.0	mg/kg
	Arsenic	20/0.67	1.0	mg/kg
	Copper	2960	2.0	mg/kg
	Iron	NA	20.0	mg/kg
	Lead	250	2.0	mg/kg
	Zinc	24000	2.0	mg/kg
	Tin	NA	10.0	mg/kg

TABLE A-7. REPORTING LIMITS FOR EXPLOSIVE RESIDUES

Parameter/Method	Analyte	MTCA Method A/B (mg/kg)	Soil	
			RL	Unit
Explosive Residues EPA 8330	1,3,5- TNB	21400	0.25	mg/kg
	1,3- DNB	8	0.25	mg/kg
	2,4,6- TNT	NA	0.25	mg/kg
	2,4-DNT	1600	0.25	mg/kg
	2,6-DNT	80	0.26	mg/kg
	HMX	NA	2.2	mg/kg
	m-Nitrotoluene	800	0.25	mg/kg
	Nitrobenzene	40	0.26	mg/kg
	o-Nitrotoluene	800	0.25	mg/kg
	p-Nitrotoluene	800	0.25	mg/kg
	RDX	9.09	1.0	mg/kg
	Tetryl	NA	0.05	mg/kg
	2,4/2,6 Dinitrotoluenes	1.47	0.05	mg/kg

TABLE A-8. METHOD QC LIMITS EPA METHOD 6000 SERIES

Metals	Blank Spike Recovery %
Pb, As, Cu, Sb, Zn, Fe, Sn	80-120

Metals	Matrix Spike Recovery %
Pb, As, Cu, Sb, Zn, Fe, Sn	75-125

Metals	Duplicate RPD
Pb, As, Cu, Sb, Zn, Fe, Sn	< = 25 %

TABLE A-9. METHOD QC LIMITS EPA METHOD 8330

Explosives	Blank Spike Recovery %
TNT, 2 4- DNT, RDX HMX, etc.	60-120

Explosives	Matrix Spike Recovery %
TNT, 2 4- DNT, RDX HMX, etc.	50-140

Explosives	Duplicate RPD
TNT, 2 4- DNT, RDX HMX, etc.	< = 20 %

TABLE A-10. SAMPLE REQUIREMENTS

Analytical Method	Matrix	Container, Preservation	Maximum Holding Time
Explosive Residues	Soil	1 8-oz. Clear wide mouth glass jar with Teflon lid. Cool to 4°C	40 days
TCLP – metals	Soil	1 8-oz. Clear wide mouth glass jar with Teflon lid. Cool to 4°C	180 days
XRF field-portable Analyses	Soil	Zipper-locking bag. Samples will be minimally prepared and bag analyzed.	180 days
EPA 6010/6020 – Total Metals – As, Cu, Pb, Tn, Zn, Sb, Fe (Split Samples)	Soil	1 8-oz. Clear wide mouth glass jar with Teflon lid. Cool to 4°C	180 days

TABLE A-11. SOIL SAMPLES FOR METALS [1]

Area	Matrix	Initial Sample Points	Depth (in)	Estimated Number of Samples		
				XRF	Confirmation Splits [2]	Field Duplicates
Demonstration of Method Applicability						
Berm	Soil	10	0-12	20	20	2
			12-24	20	20	2
Former Miller Hill Pistol Range AOC 4-2.2						
Berm	Soil	18	0-12	18	2	2
			12-24	18	2	2
			24-36	18	2	2
Former Evergreen Infiltration Range AOC 4-6.3						
Berm	Soil	84	0-12	64	7	7
			12-24	64	7	7
			24-36	84	8	8
Firing Points	Soil	16	0-12	16	2	2
			12-24	16	2	2
			24-36	16	2	2

[1]These numbers are presented for contracting purposes only.

[2] The initial frequency for confirmation split samples is 100% during the DMA. The frequency of confirmation splits for the remainder of the samples will be determined from the DMA.

TABLE A-12. SOIL SAMPLES FOR EXPLOSIVES RESIDUE

Site	Area Matrix	Depth (in)	Number of Samples	QC Samples
Former Evergreen Demolition Sites	Soil	0-4	9	1 duplicate, and 1 MS/MSD
		6-12	9	1 duplicate

TABLE A-13. TCLP SAMPLES

Site	Matrix	Contaminants	No. Samples
Former Evergreen Infiltration Range	Soil	Lead and Arsenic	5
Former Miller Hill Pistol Range	Soil	Lead and Arsenic	5

End of SAP Addendum

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Appendix C
Lead Separation and Stabilization Equipment & Technologies

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Soil Separation

Soil Separation Technologies include gravity separation jigging, soil, washing, and dry screening. Examples of separation and its associated equipment are shown on the following pages.

GRAVITY SEPARATION - History

The history of gravity concentrators can be traced back to very early human history. Most devices made only a brief appearance, some evolved into more modern, efficient devices and others were successful for a long period changing very little, such as sluices.

Beginning in the early 1980's Steve McAlister, founder and chairman of Falcon Concentrators, took an interest in fine gold recovery. He took the basic principle of different settling properties between lighter and heavier relative density particles at 1 G and developed a centrifugal concentrator to subject these to 300 G's. From the first simple, robust device to the line of concentrators currently produced by Falcon there were significant leaps in design and technology followed by a succession of field tests. The Falcon Concentrator is now a proven leader in fine mineral recovery technology.

1992

First centrifuge capable of fully continuous operation. Based on the batch machine it employs a series of mass flow hoppers and automatically controlled valves to meter the discharge of concentrate. The Falcon C (continuous) model is capable of recovering masses to concentrate of up to 50% while achieving high mineralogical recovery, with no process water added or rinse time needed. This derivative of the pinched sluice also de-slimes and thickens the concentrate and is used for pre-concentration, recovering values from tailings streams, and other numerous applications where rejecting variable masses of lights is advantageous.

1994

The Falcon B and McNicol bowls are combined by replacing the top 1/3rd (concentrate retention area) with a McNicol type elutriated basket to make the Falcon SB series. The resulting concentrator outperforms both parents.

FALCON SB21

1995

The first one meter (40") diameter C4000 continuous centrifuge achieves 100 TPH of feed on a footprint of only six square meters. Separations down to 0.01 mm are demonstrated, better than that of cones and spirals. Top feed size is found to be 1.5mm (10 mesh).

FALCON C400 & C4000

1995

Pressure Jig is introduced by Gekko Systems of Australia. Increased recovery of heavy coarse minerals with relatively low water consumption makes this device popular where treatment of these particles before grinding is preferable.

1997

The development of a concentrically closing concentrate discharge valve greatly enhances the controllability of the Falcon C. Precision control allows mass pulls of 1-50% and a fully automated process controlled by stream monitoring devices and PLC control.

2002

A Falcon SB capable of treating >200 TPH is introduced, making this the largest enhanced gravity concentrator in the world.

High Efficiency Separation

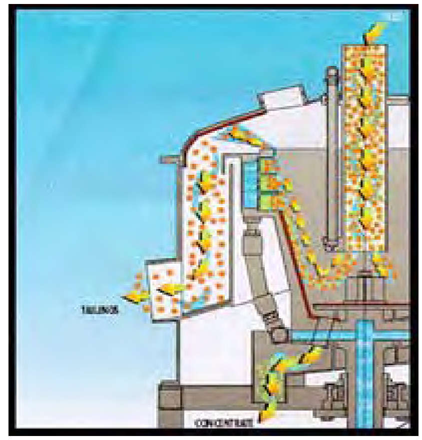
History has shown that greater centrifugal force allows better separation of fine particles of different relative densities.

Falcon's design philosophy has been to provide robust but simple user friendly centrifuges with maximum separation efficiency.

Our machines generate centrifugal forces of up to 300 G's with proven mechanical availability and low operating costs in hundreds of industrial installations worldwide.

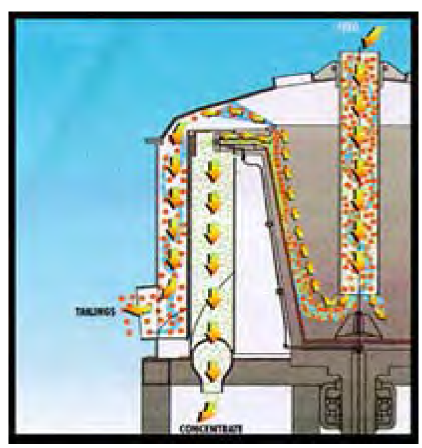
Recoveries in ranges as low as 1 micron have been performed, previously unheard of at 1 G.

Model SB Semi-Batch units are available for low weight recovery to high grade concentrates with low water requirements.



SB2500 Concentrator	Model SB

Model C Continuous units provide high weight recovery for low tails values without additional process water



C400 Concentrator	Model C

JIG RECOVERY SYSTEMS

Circular 52, April, 1995
by H. Mason Coggin, Director

Introduction

Jigging is one of the oldest processes used to separate heavy minerals from the lighter gangue. This technology was used in Cleopatra's time to separate wheat from chaff. A jigging sieve was described by Agricola in De Re Metallica in the 16th century.

How the Jig Works

The jig consists of a cell containing water with a screen on the top. Steel or stainless steel shot is placed on the screen. A rubber diaphragm located at the bottom of the cell is driven up and down by a walking beam and eccentric mechanism.

On the up, or expansion stroke, the water column is forced through the shot bed causing the shot bed to dilate and differential particle sorting to take place, based on Stokes Law of Hindered Settling. This allows the heavier particles on or near the shot bed to settle through the shot while the lighter particles are carried onto the tails. On the down stroke these heavier particles are pulled down through the bed and discharged through the hutch concentrate valve at the bottom of the cell.

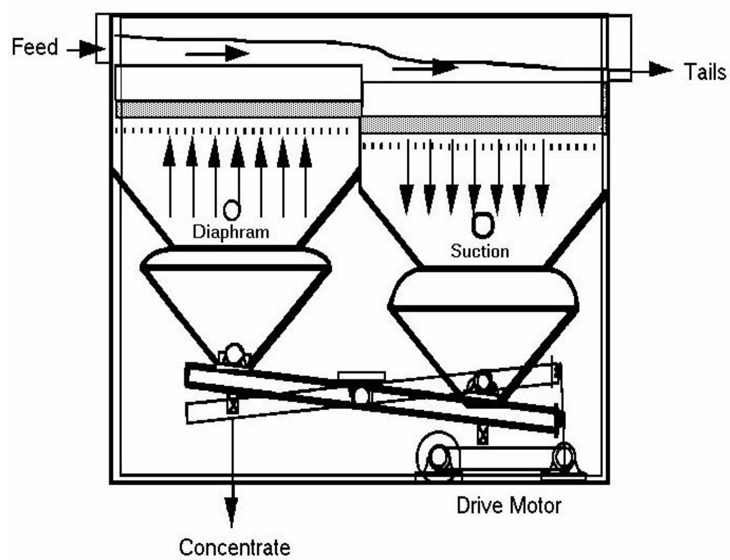


Figure 1. Section of a modern placer jig

Feed rate, depth of bed, pulsation frequency, stroke length, and make-up water are the main variables used to adjust the jig for optimum recovery. These basic features of the jig system are shown in Fgure 1.

History

Although jigs were extensively used in coal and base metal recovery at the turn of the century, it was not introduced to the gold placer mining industry until 1914. From that time until 1942 jigging became the most popular method of placer gold recovery. Beginning with the gold mine closing order of 1942, production from placer gold mining and jigging all but disappeared until the gold price was released in 1975. Gold mining has had a most remarkable revival in the last two decades, but the practice of jigging has lagged.

In 1914 J.W. Neil installed a large-scale test jig on the Yosemite dredge in California. Subsequent testing of the Neil jig by Natomas Consolidated resulted in the conversion of their sluice dredges. At first jigs were placed on the end of the sluices as a final cleanup. The next year they were moved to the head of the sluices. The following year sluices were being removed from many of the dredges and jigs were installed as the only recovery system. The improved recovery from jigging resulted in the profitable reworking of the tails from some previously mined deposits that had been considered marginal.

Conversion by other companies was slow. It was not until 1932 that the Bulolo Gold Dredging Company initiated testing. This test work resulted in the immediate conversion of their largest dredge then operating in New Guinea. The Bendalari Jigs became the dredge's sole means of primary recovery. With the success of this operation, the company began to convert all of their dredging operations to jigs.

To remedy the design and installation problems of the original Bendelari Jigs, the Bulolo engineers designed a new machine that they called the Pan-American Placer Jig. The new design, adapted for use on board a dredge, was compact and could accommodate a great deal of wave movement on a small barge operating in an active dredge pond.

The success of this new design was so great that Bulolo converted their dredges in New Guinea and Columbia. Observing the high recovery of these installations, Yuba Consolidated Goldfields, Ltd. converted all of their California Fisher and Baumhoff operations to jigging plants in 1936 and 1937.

These efforts marked the last technological advancement in gold dredging. With the L-208 closing order of WWII all placer gold mining in the U.S. was stopped. Few of the dredges survived the scrap drives of the war. When L-208 was rescinded at the end of WWII, a few of the survivors were refitted, but inflation and the fixed gold price halted the construction of new dredges for North American placer gold mining. Placer gold mining was almost forgotten until 1975 when the price of gold was allowed to float on the world market. Somehow, during this long sleep the success of the jig was forgotten.

The Cleveland Circular Jig was designed to treat the tin bearing sands off the coast of Indonesia. Feed is entered through the center and as it travels outward to the tail weir the velocity is decreased with obvious advantage. At the present time these jigs are manufactured in Europe. One manufacturer has even developed a hydraulic stroke for the diaphragm that is claimed to be superior to the mechanical eccentric drive.

Circular jigs have not been generally accepted in gold mining, probably because of their high cost, large capacities, and low (20:1) recovery ratios that were developed for the offshore tin industry.

The concentration of free gold in a gold placer is very small and a high concentration ratio is required to make an economic concentrate. There is a great deal more tin in a tin placer than gold in a gold placer. To be economic the ratio of enrichment for tin placers need only be 10 or 20 times.

One of the few modern operators using circular jigs was WestGold in their offshore operation at Nome, Alaska. These jigs were already onboard when the dredge, Bima, was purchased.

Jig Operation

Although great improvements have been made in their design, riffles have inherent metallurgical limitations. The gold must settle and be trapped behind the riffle in a swift current of water. The current's velocity must be great enough to transport crudely classified material across the riffles. The slower the velocity the better the tendency for the gold to settle and be saved. This lower velocity, however, has less carrying capacity and will allow black sand and other heavy minerals to pack behind the riffles leaving no trap for the gold. If the amount of water and the slope of the riffle are increased to provide sufficient velocity to clean the riffle, gold particles that were previously trapped will be remobilized and lost. Sudden surges in feed may also dislodge gold. If the velocity is too low during the down cycle, black sand will again pack behind the riffle.

In either case the first gold lost by the riffles is presumed to be the fine (-200 mesh) gold. Flat gold or light gold because of its poor setting ability will also be lost.

Jigging avoids these limitations. The best can be adjusted to permit settling and trapping of the gold at all times. Once trapped, the gold is removed from the stream and the losses from packing and surging are eliminated. The jig can be adjusted to remove a large percentage of black sand and the balance can be eliminated on tables or further jigging. The pulsations of the jig move material across the jig to the tail, and consequently, less water is required to move material. Conditions at the top of the jig bed are quiescent at the top and bottom of each stroke. This provides a better opportunity for the gold to settle.

The jig has few limitations, but it is a gravity machine and therefore can recover only the gold that will settle by gravity in the jig bed. Some of the finest gold will be lost, but in most deposits this loss is below the economic limits of present technology. In the majority of placer deposits the total amount of fine gold is difficult to quantify. If the deposit was formed as alluvial, colluvial or eluvial, the finest gold has already been eliminated by the poor sluicing provided by nature. There are a few exceptional deposits in which the gold has been liberated by oxidation of gold-bearing sulfides, or is still locked up within the sulfides or oxides that were deposited with the gravels of the deposit. These deposits present problems that involve milling methods and the economic advantages of a placer operation are voided.

Flotation, for example, may be applicable in the recovery of fine gold that will be lost even by jigs. Without specific research on the increased recovery from flotation and the costs involved for each specific property, it is doubtful if flotation would recover more gold values than it would cost. A 1933 installation of six full-size flotation machines, treating 300 tons per day, was made on one of the dredges operating on the American River in California. After three months of operation the recovery of gold by flotation was only 2 cents per ton on heads to the cells of 3.5 to 9 dollars per ton.

Design Considerations

Placer jigs present a different set of problems from those encountered in the concentration of base metals. The ratio of the specific gravities is higher and the feeds are not as well classified as those in hard rock milling. The hard rock jigs are generally much longer and narrower. To work with the lower specific gravities, close classification is essential and the longer jig beds provide for slower setting. With these advantages the load per square foot for the placer jig can be increased without appreciably affecting the recovery. This allows a lower cost unit to be produced per ton of material jigged.

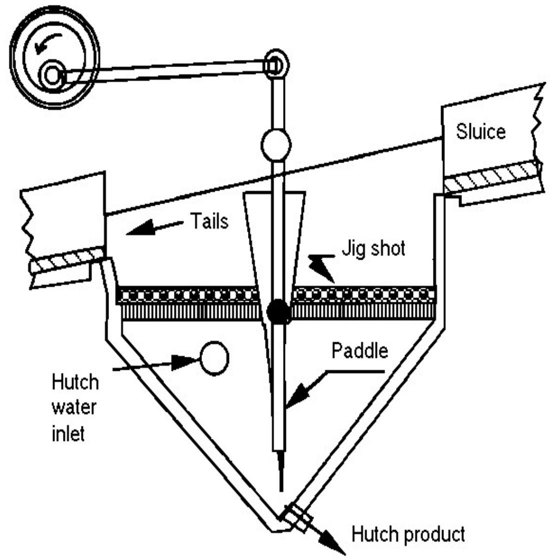


Figure 2. Neil jig, about 1907 (after Taggart)

When jigs were first considered for placer mining, several different designs were available from coal washing and base metal operations. These jigs were heavy, cumbersome, and occupied considerable space. On a dredge, floor space is a critical design consideration. The Neil Jig, was modified to take up no more floor space than the actual jigging surface.

The Bendelari Jig, which followed the Neil design, was actuated by a plunger sealed with a rubber diaphragm located below the jigging surface. This allowed the floor space requirement to be defined by the jigging surface.

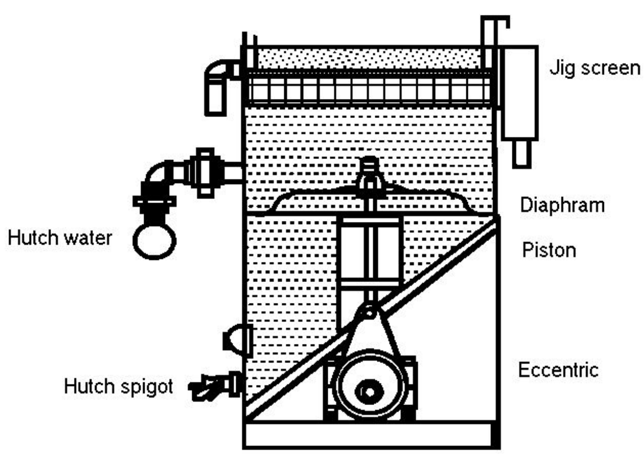


Figure 3. Bendelari jig (after Taggart)

Pan-American Placer Jig

In the Pan-American Jig, the hutch is an inverted cone that moves by means of an eccentric cam and a walking beam. A rubber diaphragm between the cone and the jigging screen provides a positive displacement of the hutch water to insure jig bed pulsations. Concentrates discharge freely through the metered outlet in the bottom of the cone. A large volume of water is added in the hutch to provide an upward flow through the screen during the up stroke while maintaining the flow of concentrate out the bottom. This provides a zone in the hutch, below the screen, where the flow is neither up nor down. Gold particles settling through this zone are accelerated by the velocity of the flow to the discharge.

Hutch water flow also aids in the suspension of the pulp as it passes over the screen providing for additional separation in the ragging. In the final design, the weight and volume of the machine was cut to a minimum for further cost reduction and volume efficiency.

The Pan American Placer Jig is designed to hold a certain volume of steel shot on the screen as bedding. The restriction, through the spaces between the shot, reduces the amount of concentrate and provides for maximum recovery at a high concentration ratio.

The 42" x 42" duplex cell arrangement has become a de facto standard in the industry. In this arrangement two cells are set in series with a drop between the cells. The rollover of the material as it passes over this drop between the cells further increases gold recovery. Material, which may have been riding on the top in the first cell, is rolled to the bottom of the flow and adjacent to the bedding. The effectiveness of this toss is demonstrated at each jig screen cleaning. Particles of coarse gold that escaped the first cell will be found in the first few trays of the second cell.

Testing Tailing Losses

Nowhere in the art and science of sampling are results harder to obtain and less reliable than in the sampling of gold placer tails. The volume of material is so great and the effect of one small gold particle so dramatic, that only relative results can be obtained. The following example will illustrate this point.

For a placer operation with average heads of $3.00 and recovery of 90 percent, the tail will carry $0.30 in gold. This is equivalent to about 500 minus 80 mesh particles per yard. An 80 mesh particle is smaller than a speck of ground pepper and has a value of about $0.0005. If three of these particles were found in a single pan of tails, the loss would be reported as $0.30 per yard.

Summary

The jig is again a popular choice for processing placer gold deposits. Operators who have experimented with sluices, spirals, cones, and centrifuges are now changing to jigs. One reason for this may be the great number of manufacturers who are answering the demand for jigs. In most cases these manufacturers have acquired one of the original Pan American Jigs and have copied them as original patents ran out years ago. These designs have proven to be efficient and effective collectors of gold. Innovations in jig design that were tried during the first half of the century are being tested again. Some new and better technology may be developing, but for the present, the old designs are still the best.

SOIL STABILIZATION

Soil stabilization with binders is a field- proven technique for reducing metals concentrations and improving engineering qualities of soils. Typical soil stabilization equipment used to mix stabilizers with site soils are shown below. A summary of a site specific application of a commercial stabilizer is also included.

Soil Stabilizer Used to Mix Reagents for Stabilization

Stabilization of Refinery Sludge and RCRA Cell Construction

A Pugmill Mixing Contaminated Soil with Fly Ash to Reduce Total Leachable Lead Concentrations

Soil Mixer - Pulverizer

Soil Mixer - Pulverizer

Binder Spreader and Soil Decompactor

Solidification/Stabilization at the Massachusetts Military Reservation, Training Range and Impact Area, Cape Cod, Massachusetts

Site Name:
Massachusetts Military Reservation, Training Range and Impact Area

Location:
Cape Cod, MA

Period of Operation:
February 1998 through June 1998

Cleanup Authority:
CERCLA
- Administrative Order issued April 10, 1997

EPA Remedial Project Manager:
Mike Jasinski
U.S. EPA Region 1
1 Congress Street, Suite 1100
Boston, MA 02203-2211
Telephone: (617) 918-1352
Fax: (617) 918-1291
E-mail: jasinski.mike@epa.gov

Purpose/Significance of Application:
Use of a proprietary stabilization technology to treat lead in both *in situ* and *ex situ* soils

Cleanup Type:
Full scale

Contaminants:
Heavy Metals
- Lead was the primary contaminant, with total lead concentrations in soil ranging as high as 12,200 mg/kg and TCLP leachable lead as high as 734 ug/L

Waste Source:
Training/firing ranges

Site Lead:
Ben Gregson, Assistant Project Officer
Army National Guard
Building 2816, Room 228
Camp Edwards, MA 02542
Telephone: (508) 968-5821
Fax: 508-968-5286

Technology Vendor:
Mike Lock or Chris Rice
Sevenson Environmental Services, Inc.
8270 Whitcomb Street
Merrillville, IN 46410
Telephone: (219) 756-4686
Fax: (219) 756-4687
E-mail: sevensonmw@aol.com

Technology:
Stabilization using MAECTITE®
- MAECTITE® is a proprietary technology that applies a liquid reagent to the soil to react with the lead and produce a geochemically stable synthetic mineral crystal; information was not provided on the type of chemicals in the liquid reagent
- Contaminated soil from sixteen small arms ranges was treated with MAECTITE® technology in both *ex situ* and *in situ* applications
- Berm soil was excavated and treated *ex situ* when a visual analysis showed the presence of recoverable bullet fragments
- Soil remaining in the berms that did not contain bullet fragments but still had a TCLP lead concentration of greater than 5.0 mg/L was treated *in situ.*

Type/Quantity of Media Treated:
Soil
- 23,168 cubic yards of soil; consisting of 17,788 cubic yards treated *ex situ* (27,952 tons), and 5,380 cubic yards treated *in situ*
- Soil was classified as sandy and included stones and other oversize materials captured on 6-inch, 2-inch, and number 4 screens, and had a pH ranging from 5.0 to 6.5

Regulatory Requirements/Cleanup Goals:
- The Administrative Order contained several requirements, including removing the maximum amount of lead munitions from the soil; recycling the removed lead munitions, as appropriate; and use of soil modifiers to minimize prospective bullet corrosion and lead migration
- A cleanup goal was established as TCLP leachable lead concentration in soil of <5.0 mg/L

Results:
- 17,788 cubic yards of soil were treated *ex situ* in 56 batches (each consisting of 500 tons of soil). All batches met the cleanup goal, with no retreatment required. In addition, 96% of the samples of *ex situ* treated soil had a TCLP leachable lead concentration of <0.5 mg/L (one order of magnitude lower than the cleanup goal).
- 5,380 cubic yards of soil were treated *in situ* with 29 samples analyzed after *in situ* treatment of soil. All locations met the cleanup goal, with no retreatment required. In addition, 97% of the samples of *in situ* treated soil had a TCLP leachable lead concentration of <0.5 mg/L (one order of magnitude lower than the cleanup goal).

Solidification/Stabilization at the Massachusetts Military Reservation, Training Range and Impact Area, Cape Cod, Massachusetts

Costs:

- The capital cost for MAECTITE® treatment of 23,168 cubic yards of contaminated soil was $3.5 million, with a calculated unit cost of $151 per cubic yard of soil treated
- The costs included *ex situ* and *in situ* treatment of berms, as well as mobilization, work plan preparation, negotiation support, meetings and briefings, reports, survey of berms, berm reconstruction, and decontamination
- *In situ* treatment was used at those berms and portions of berms which did not contain recoverable bullet fragments, thus limiting the amount of soil that was required to be excavated and treated on an *ex situ* basis.

Description:

The Massachusetts Military Reservation (MMR), founded by the Commonwealth of Massachusetts in 1935 as a National Guard training camp and federalized in 1940 to prepare for World War II, currently houses Otis Air National Guard Base, U.S. Coast Guard Air Station Cape Cod, and Army National Guard Camp Edwards. MMR covers 34 square miles of upper Cape Cod (approximately 22,000 acres), and borders the towns of Bourne, Falmouth, Mashpee and Sandwich, Massachusetts. MMR was placed on EPA's Superfund National Priority List in 1989, and has 78 pollution source areas currently identified and 10 major groundwater pollution plumes moving at approximately 1.5 to 2 feet per day. The reservation sits atop the recharge area for the sole source groundwater aquifer from which all of upper Cape Cod draws its drinking water. The Training Range and Impact Area includes 16 small arms firing ranges (training ranges). Berms constructed behind targets at the ranges to capture bullets and fragments of bullets behind targets became contaminated with lead.

MAECTITE®, a proprietary stabilization technology, was used on both an *ex situ* and an *in situ* basis to treat lead-contaminated soil in the berms at the 16 small arms ranges. A total of 23,168 cubic yards of soil were treated (17,788 cubic yards *ex situ* and 5,380 cubic yards *in situ*). All samples met the cleanup goal of <5.0 mg/L of TCLP leachable lead, and soil was not required to be retreated. The treatment vendor reported that the factors that affect cost and performance for the MAECTITE® technology include heavy metal constituents of concern, level of heavy metal contamination, reduction in concentrations of leachable metal, volume of material to be treated, whether *in situ* or *ex situ* methods are used, material sizing requirements, final disposition of treated material (i.e., on site or off site), reporting requirements, waste matrix complexities, site configuration, prevailing labor rates, and taxes.

Appendix D
Evergreen Infiltration Range Treatability Studies

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Skeet and Evergreen Small Arms Firing Ranges
Fort Lewis, Washington

Treatment Findings and Implementation Cost Estimates

In August 2003, ERDC, AMEC, and Brice Environmental Services (Brice) collected soil samples from four former small arms firing ranges as well as from a lead-based paint site located at Fort Lewis, Washington. Soil testing was conducted to evaluate physical treatment and secondary treatment using emulsion encapsulation. The physical treatment study was conducted at Brice's test facility located in Fairbanks, Alaska, while the emulsion encapsulation testing was conducted at the ERDC facility located in Vicksburg, Mississippi.

In March 2004, AMEC, Brice, and Corps of Engineers personnel revisited Fort Lewis to collect samples from the Evergreen Small Arms Firing Range Impact-Berm and Skeet Range. Sampling was limited to the Impact Berm area based on site work conducted by the Corps of Engineers, who in 2003 extensively tested soils at both the Evergreen Range and Skeet Range. Composite 5-gallon samples were collected from the following locations at the Evergreen Range:

- Evergreen **Impact Berm** Face. Sample composite consisting of soil from 3 locations equally spaced across the mid-line of the Impact Berm.
- **Toe Area** in front of the berm. Sample composite consisting of soil from 3 locations equally spaced across the front of the Impact Berm, approximately 10 feet out from the slope.
- **Backside** of the impact berm. Sample composite consisting of soil from 3 locations equally spaced across the mid-line of the Berm Backside.
- **Floor** behind the impact berm. Sample composite consisting of soil from 2 locations approximately 25 to 30 feet out from the Berm Backside.

As described in the field sampling report contained in Appendix A, 5-gallon composite samples were collected to depths generally extending to 3-feet below grade. Soils were subjected to testing following the procedures described in the report entitled *"Physical Treatment Study, Fort Lewis,"* dated September, 2003. Results for the 5-gallon composite samples are summarized below in the first two tables of results.

First round results clearly indicated that sample depths were insufficient for removing soils exceeding 250 mg/kg total lead in the minus #10 mesh. Consequently, a second round of field sampling was conducted for the purpose of delineating excavation depths and forecasting soil quantities requiring treatment. Both the Evergreen and Skeet Range were resampled.

A small excavator was used to trench in locales on the Impact Berm Face, Backside, and Floor. A tape measure was used to measure depths and a sample was then collected from the floor of the trench. Each excavation limit sample was subsequently density treated and screened at #10 mesh. Both the plus and minus fractions were crushed prior to total lead analysis via EPA Methods. These results are shown below following the first round 5-gallon composite results.

Two important sets of results are presented in the Lead Distribution tables for each location. The first column shows residual total lead by fraction and the last column shows calculated plus and minus #10 mesh results.

Evergreen Range Results

Particle Distribution – Berm Toe @ 3'

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (%)			
Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	10,144	24	-	37.5	0.1	-	37.5
+3/8	5,007	5	-	18.5	0	-	56.0
+4	3,460	-	-	12.8	0	-	68.8
+8	1,535	-	-	5.7	0	-	74.5
+20	3,149	-	-	11.6	0	-	86.2
+50	3,123	-	-	11.5	0	-	97.7
+100	182	-	-	0.7	0	-	98.4
+200	69	-	-	0.3	0	-	98.7
-200	364	-	-	1.3	0	-	100
Totals	27,034	29		99.9%	0.1%		100.0%

Note: - denotes no material

Lead Distribution – Berm Toe @ 3'

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Conc. (mg/kg)
+3/4	4	-	-	1.50	-	-	
+3/8	6	-	-	1.12	-	-	
+4	8	-	-	1.05	-	-	
+8	39	-	-	2.20	-	-	7.9
+20	31	-	-	3.64	-	-	276
+50	57	-	-	6.53	-	-	
+100	435	-	-	2.93	-	-	
+200	1,865	-	-	4.78	-	-	
-200	3,899	-	-	52.49	-	-	

Note: Highlighted values denote minus #10 mesh soil fractions with lead concentrations exceeding 250 mg/kg following density treatment. Estimated plus and minus #10 mesh residual soil lead concentrations are also highlighted using the #8 mesh screen size.

No excavation limit sampling was performed at this locale.

Particle Distribution - Impact Berm Face @ 3'

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (%)			
Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	3,583	70	-	26.8	0.5	-	28.2
+3/8	2,847	-	123	21.3	0	0.9	50.5
+4	1,401	-	122	10.5	0	0.9	61.6
+8	582	88	10	4.3	0.7	0.1	66.1
+20	1,745	62	12	13.0	0.5	0.1	79.8
+50	1,344	154	8	10.0	1.2	0.1	90.4
+100	427	-	4	3.2	-	-	93.8
+200	191	-	3	1.4	-	-	95.3
-200	602	-	-	4.5	-	-	100.0
Totals	12,722	374	426	95.1%	2.8%	2.1%	100.0%

Lead Distribution – Impact Berm Face @ 3'

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Conc. (mg/kg)
+3/4	117	-	-	31.45	-	-	
+3/8	366	-	700,000	77.87	-	6,422.29	
+4	368	-	700,000	38.54	-	6,361.58	
+8	2,226	47,315	700,000	96.82	309.61	516.53	389
+20	3,677	-	700,000	479.81	-	604.44	8,224
+50	4,636	-	700,000	465.75	-	428.61	
+100	12,193	-	700,000	389.54	-	184.21	
+200	24,405	-	700,000	347.57	-	130.83	
-200	21,465	-	-	966.68	-	-	

Excavation Limit Results – Impact Berm Face

Depth (Feet below Grade)	Wgt. Plus #10	Wgt. Minus #10	Plus #10 Total Lead (mg/kg)	Minus #10 Total Lead (mg/kg)	Plus #10 Dup. Total Lead (mg/kg)
3.5'	743	172	344	8,335	358
4'	784	225	18	309	
5'	877	307	65	593	
6'	1364	279	172	326	

Particle Distribution – Berm Backside @ 3'

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (%)			
Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	10,210	-	-	38.0	-	-	38.2
+3/8	6,830	-	-	25.4	-	-	63.8
+4	3,792	-	40	14.1	-	0.15	77.9
+8	1,443	44	11	5.4	0.2	0.04	83.3
+20	1,436	29	4	5.3	0.1	0.01	88.7
+50	2,102	22	-	7.8	0.1	-	96.6
+100	352	15	-	1.3	0.1	-	97.9
+200	66	-	-	0.2	-	-	98.1
-200	499	-	-	1.9	-	-	100
Totals	26,729	110	55	99.4%	0.4%	0.2%	100.0%

Lead Distribution – Berm Backside @ 3'

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Conc. (mg/kg)
+3/4	40	-	-	15.19	-	-	
+3/8	59	-	-	15.05	-	-	
+4	87	-	500,000	12.29	-	745.53	
+8	1,315	-	500,000	70.57		204.25	297
+20	2,218	-	500,000	118.37	-	68.08	1,664
+50	883	-	-	69.04	-	-	
+100	1,331	-	-	17.39	-	-	
+200	3,673	-	-	9.00	-	-	
-200	6,431	-	-	119.41	-	-	

Excavation Limit Results – Berm Backside

Depth (Feet below Grade)	Wgt. Plus #10	Wgt. Minus #10	Plus #10 Total Lead (mg/kg)	Minus #10 Total Lead (mg/kg)	Minus #10 Dup. Total Lead (mg/kg)
3.5'	474	354	46	581	
5.5'	478	337	2	437	426

Particle Distribution – Floor @ 3' (25' Back)

MATERIAL DISTRIBUTION (Grams) / MATERIAL DISTRIBUTION (%)

Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	10,144	-	-	36.1	-	-	36.9
+3/8	5,007	70	-	17.8	0.2	-	55.1
+4	3,460	-	-	12.3	-	-	67.7
+8	1,621	275	-	5.8	1.0	-	73.6
+20	3,324	110	-	11.8	0.4	-	85.6
+50	3,297	156	-	11.7	0.6	-	97.6
+100	192	-	-	0.7	-	-	98.3
+200	73	-	-	0.3	-	-	98.6
-200	385	-	-	1.4	-	-	100
Totals	27,503	610	-	97.8%	2.2%	-	100.0%

Lead Distribution – Floor @ 3' (25' Back)

FRACTIONAL TOTAL LEAD RESULTS / FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)

Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Concs. (mg/kg)
+3/4	25	-	-	9.02	-	-	
+3/8	50	560	-	8.91	1.39	-	
+4	63	-	-	7.76	-	-	
+8	876	560	-	50.48	5.47	-	105
+20	527	1,101	-	62.35	4.30	-	512
+50	295	1,292	-	34.58	7.15	-	
+100	1,559	-	-	10.67	-	-	
+200	1,347	-	-	3.51	-	-	
-200	1,563	-	-	21.39	-	-	

Excavation Limit Results – Floor @ 30' Back From Impact Berm

Depth (Feet below Grade)	Wgt. Plus #10	Wgt. Minus #10	Plus #10 Total Lead (mg/kg)	Minus #10 Total Lead (mg/kg)	Plus #10 Dup. Total Lead (mg/kg)
3'	762	259	9	13	10
4'	443	291	9	52	

Excavation Limit Results – Floor @ 80' Back From Impact Berm

Depth (Feet below Grade)	Wgt. Plus #10	Wgt. Minus #10	Plus #10 Total Lead (mg/kg)	Minus #10 Total Lead (mg/kg)	Minus #10 Dup. Total Lead (mg/kg)
1'	250	240	19	50	
2'	571	211	15	26	23
3.5'	368	287	9	17	

Excavation Limit Results – Floor @ 130' Back From Impact Berm

Depth (Feet below Grade)	Wgt. Plus #10	Wgt. Minus #10	Plus #10 Total Lead (mg/kg)	Minus #10 Total Lead (mg/kg)	Plus #10 Dup. Total Lead (mg/kg)
Surface	206	225	10	13	
6"	340	187	36	42	40
1.5'	369	253	160	23	

A #10 mesh screen was not used for the 5-gallon sample testing because at the time it was not known that the State of Washington definition of soil as being #10 mesh minus would be both the excavation and treatment driver for "soil." The #8 mesh screen was used to estimate #10 mesh cut-point lead concentrations. Although slightly larger than #10 mesh, the #8 mesh works well for this determination due to the low amount of material between #8 and #10 mesh.

Lead Leachability

Minus #10 mesh excavation limit samples from the Impact Berm Face and Berm Backside were combined and tested for lead TCLP. The recombined soil showed a lead TCLP of 98 mg/L, which is considerably higher than the 5 mg/L allowable standard.

ECOBOND™ and Apatite II were evaluated for their ability to mitigate leachability at low dosage rates on an individual basis, and in conjunction. Results are presented below.

Raw Soil = 98 mg/L

- 1.2% ECOBOND™ and 1.3% Apatite II = 36 mg/L
- 3% ECOBOND™ = 12 mg/L
- 5% ECOBOND™ = 3.9 mg/L
- .95% Apatite II = 92 mg/L
- 2.4% Apatite II = 37 mg/L
- 5% Apatite II = 12 mg/L

ECOBOND™ appears to be more effective at mitigating lead leachability. Results indicate that a dosage rate of 5% will be required to reduce the leachability to less than 5 mg/L in the minus #10 mesh fraction.

Skeet Range

In August 2003 one sample was collected from the Skeet Range for evaluation. The sample was of a 1 foot by 1 foot by 1 inch deep area located near Corps of Engineers sample point ST88. Those results are shown below.

Particle Distribution – Skeet Range @ 1"

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (%)			
Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	1,513	0	0	16.9%	0.0%	0.0%	16.9%
+4	4,728	502	0	52.9%	5.6%	0.0%	69.8%
+20	986	14	190	11.0%	0.2%	2.1%	80.8%
+50	427	23	6	4.8%	0.3%	0.1%	85.6%
+100	118	50	0	1.3%	0.6%	0.0%	86.9%
+200	19	212	0	0.2%	2.4%	0.0%	87.1%
-200	157	0	0	1.8%	0.0%	0.0%	88.9%
Totals	7,948	801	196	88.9%	9.0%	2.2%	100.0%

Lead Distribution – Skeet Range @ 1"

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Concs. (mg/kg)
+3/4	253	0	0	43	0	0	
+4	451	0	0	238	0	0	
+20	93	9,506	900,000	10	15	19,117	179
+50	1,435	11,702	100,000	69	30	67	3,065
+100	3,586	0	0	47	0	0	
+200	6,262	0	0	13	0	0	
-200	6,718	0	0	118	0	0	
Soil Total Lead by Source				538	45	19,184	

Estimated #10 mesh soil results clearly indicated that a shallow surface scrap to remove lead pellets and lead contaminated soil would leave behind high-lead soils. Additional sampling was thus performed at the site. Two samples were collected to 1-foot and evaluated separately. One sample was taken adjacent to the 1-inch deep sample collected in August 2003 (near ST88) and another was collected closer to the firing line near COE sampling point ST24.

Particle Distribution – Treeline Skeet Range @ 1' (Near ST88)

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (%)			
Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	2,294	-	-	28.6%			28.6%
+3/8	2,467	-	-	30.7%			59.3%
+4	1,160	-	-	14.5%			73.8%
+10	535	101	38.9	6.7%	1.3%	0.5%	80.5%
+20	356	253	0.4	4.4%	3.2%	0.0%	84.9%
+50	398		-	5.0%			89.9%
+100	137			1.7%			91.6%
+200	73		-	0.9%			92.5%
-200	210			2.6%			95.1%
Totals	7,630	354	39	95.1%	4.4%	0.5%	

Lead Distribution – Treeline Skeet Range @ 1' (Near ST88)

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Conc. (mg/kg)
+3/4	18	-		5	0	0	
+3/8	22	-		7	0	0	
+4	32	-		5	0	0	
+10	93	522	950,000	6	7	4,606	28
+20	46	1430	950,000	2	45	47	412
+50	306			15	0	0	
+100	772			13	0	0	
+200	804			7	0	0	
-200	862			23	0	0	

The raw soil total lead concentration was 4,788 mg/kg.

Particle Distribution – Midfield Skeet Range @ 1' (Near ST24)

MATERIAL DISTRIBUTION (Grams)				MATERIAL DISTRIBUTION (%)			
Particle Size (inches or mesh)	Soil (gr.)	Vegetation (gr.)	Particulate Metal (gr.)	Soil (%)	Vegetation (%)	Particulate Metal (%)	Soil Cumulative Retained (%)
+3/4	4,298	-	-	37.6%	0.0%	0.0%	37.6%
+3/8	2,777	-	-	24.3%	0.0%	0.0%	61.9%
+4	1,052	-	-	9.2%	0.0%	0.0%	71.1%
+10	525	-	2.7	4.6%	0.0%	0.0%	75.7%
+20	223	-	12.8	2.0%	0.0%	0.1%	77.7%
+50	1,387	-	-	12.1%	0.0%	0.0%	89.8%
+100	418	-	-	3.7%	0.0%	0.0%	93.5%
+200	477			4.2%	0.0%	0.0%	97.6%
-200	256			2.2%	0.0%	0.0%	99.9%
Totals				99.9%	0.0%	0.1%	

Lead Distribution – Midfield Skeet Range @ 1' (Near ST24)

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Conc. (mg/kg)
+3/4	13			5	0	0	
+3/8	18			4	0	0	
+4	22			2	0	0	
+10	42		950,000	2	0	224	22
+20	60		950,000	1	0	1,064	185
+50	21			3	0	0	
+100	339			12	0	0	
+200	330			14	0	0	
-200	662			15	0	0	

The estimated raw soil concentration was 1,346 mg/kg total lead.

Lead Leachability

Minus #10 mesh excavation limit samples from the Skeet Range were tested for lead TCLP. The **Treeline** minus #10 mesh soil showed a lead TCLP of 2.9 mg/L, and the **Midfield** minus #10 mesh soil showed a lead TCLP of 0.8 mg/L lead.

Results indicate that soils from the Skeet Range will not require stabilization following density treatment.

FINDINGS AND CONCLUSIONS

Soils from the Evergreen Range and Skeet Range were evaluated to determine the viability of employing physical treatment for reducing total lead concentrations. Soils were sampled at various depths to derive a basis for predicting soil volumes requiring excavation. TCLP testing was performed to determine post density treatment lead leachability levels for the minus #10 mesh fraction.

Evergreen Range

Results indicate the following:

1) Soils approximately 10 feet in front of the Impact Berm were sampled and evaluated. Results indicate that **Berm Toe** soils contain high lead at depths exceeding 3 feet below grade. The estimated minus #10 mesh soil fraction following density treatment contained a residual lead concentration of 276 mg/kg. No additional excavation limit sampling was conducted in this area but it may be assumed that to remove all soil exceeding the 250 mg/kg standard, approximately 4 feet of soil needs to be excavated from this locale.

2) Soils comprising the Impact Berm are heavily contaminated with lead. The age of the site, combined with rain and highly porous soil has resulted in lead contamination migrating well into the soil column. Results show that lead contamination of the berm proper extends well beyond the 3-foot depth. EPA Method analytical test results for the minus #10 mesh soil taken from 6-feet into the **Impact Berm Face** contained 325 mg/kg total lead. Results taken 5.5-feet into the **Berm Backside** were 437 mg/kg total lead. These results indicate that excavation limits for the berm proper are likely to be around 8 feet on the Impact Berm Face and Berm Backside.

3) Soils immediately behind the berm contain lead, which is consistent with other sites due to particulate lead splatter over the Impact Berm. Results taken to 3 feet deep at two locations approximately 25 feet behind the berm on the **Floor** contained 512 mg/kg in the minus #10 mesh fraction following density treatment. Results indicate that approximately 6 feet of soil requires removal out at least 25 feet from the Berm Backside.

4) At distances further than 25 behind the berm limited sampling results suggest that lead concentrations rapidly decrease. Samples taken 30, 80 and 130 feet behind the berm showed lead concentrations well below the standard of 250 mg/kg for the minus #10 mesh soil fraction. These samples were only from single locations however, and thus provide only limited information.

5) Fine vegetation in the soil column sorbs lead dissolved in rainwater. Results of fine soil vegetation from the Evergreen Range indicate that the material contains high lead concentrations. Like the particulate lead, soil vegetation will be removed from the soil for disposition.

6) The minus #10 soil fraction from the Impact Berm contains high levels of leachable lead. Results indicate that a dosage rate for ECOBOND™ of 5 percent will be required to reduce lead leachability to less than 5 mg/L. Apatite II appears less effective at similar dosage rates.

7) Particulate lead removal dramatically reduces overall lead concentrations. This results in a high percentage of soil that can be treated to less than 250 mg/kg. Results indicate that the plus #10 mesh soil fraction from all locales sampled to depth will be less than 250 mg/kg and as such, may be reused without restriction. Under a mass excavation scenario involving removal of soils exceeding 250 mg/kg in the minus #10 mesh soil fraction, results indicate that the volume reduction percentage with density treatment will average around 75 percent.

Skeet Range

Initial sample results of the Skeet Range in August 2003 revealed residual minus #10 mesh soil concentrations well above the State of Washington standard of 250 mg/kg in the 1-inch soil horizon. Follow-up sampling of two locations to 1 foot below grade indicate the following:

1) **Treeline** soil taken near COE sample point ST88 contained more shot and thus higher soil contamination. Most of the shot was plus #10 mesh in size with only a small percentage finer than #10 mesh. It appears that more heavily charged loads firing larger pellets have resulted in a fallout pattern well beyond the fallout for rounds containing smaller shot. The raw soil lead concentration was 3,982 mg/kg. Treeline soil to 1 foot below grade showed a minus #10 mesh soil concentration of 412 mg/kg. Results thus indicate that increasing the excavation depth to 2 feet will be required to remove minus #10 mesh soil greater than 250 mg/kg in some areas.

2) The **Midfield** soil sample taken near COE sample point ST24 contained less shot and thus less soil contamination. Most of the shot was smaller, at minus #10 mesh in size with only a small percentage larger than #10 mesh. The raw soil lead concentration was 1,120 mg/kg. Midfield soil to 1 foot below grade showed a minus #10 mesh soil concentration of 185 mg/kg total lead. Results thus indicate that a 1 foot excavation depth may be sufficient for this part of the range.

3) TCLP testing of the minus #10 mesh soil from both sites showed low lead leachability. Stabilization does not appear to be required for these soils following density treatment.

4) Density treatment dramatically reduces soil total lead concentrations by recovering the lead pellets. Results indicate that if soils are excavated to a depth where the minus #10 mesh fraction exceeding 250 mg/kg is removed, then with density treatment the plus #10 mesh fraction as well as a majority of the minus #10 fraction could be less than 250 mg/kg total lead.

RECOMMENDATIONS

Evergreen Range

1) Proceed with particle separation and volume reduction treatment of Evergreen Range soil. Results show that with particulate metal recovery, upwards of 75 percent of Evergreen Range soils will be less than 250 mg/kg total lead and could be returned to the site or reused elsewhere without restriction.

2) Utilize the excavation limit sampling results to establish soil volumes requiring treatment from each locale. For the Evergreen Range results indicate the following quantities of contaminated soil in each locale:

   Berm Toe Area – 30' x 4' x 330' = 39,600CF (1,466 cubic yards, or 2,200 tons)

   Impact Berm Face – 45' x 8' x 330' = 118,800CF (4,400 cubic yards, or 6,600 tons)

   Berm Backside – 45' x 8' x 330' = 118,800CF (4,400 cubic yards, or 6,600 tons)

   Floor – 25' x 6' x 330' = 49,500CF (1,833 cubic yards, or 2,750 tons)

   Excavation limit data indicates that approximately 18,150 tons of soil at the Evergreen Range contains lead exceeding the 250 mg/kg standard. ~12k cy

3) Some uncertainty exists regarding the actual volume of contaminated soil at the Evergreen Range. Final contaminated soil depths in the Impact Berm cannot be known with certainty until mass excavation begins with follow-up excavation limit sampling. Likewise, some uncertainty exists regarding where the boundary between contaminated soil and uncontaminated soil actually lies in the Floor area behind the Impact Berm as well as the Toe area between the Impact Berm Face and the road. Results indicate that establishing 20,000 tons as the amount of soil requiring excavation and processing provides a realistic base quantity for costing purposes.

4) Results indicate that Impact Berm minus #10 mesh soil will exceed the lead TCLP standard of 5 mg/L and require stabilization treatment. ECOBOND™ appears to mitigate against leachability at lower dosages than Apatite II. Results indicate that a dosage rate of 5 percent will be required

for minus #10 mesh Impact Berm soil. Stabilization should thus be included as part of the treatment process for soils from the Evergreen Range.

Skeet Range

1) Proceed with particle separation and volume reduction treatment of Skeet Range soil. Results show that following lead pellet recovery, 75 to 100 percent of Skeet Range soils will be less than 250 mg/kg total lead and could be returned to the site or reused elsewhere without restriction. Density treated soils do not appear to require stabilization.

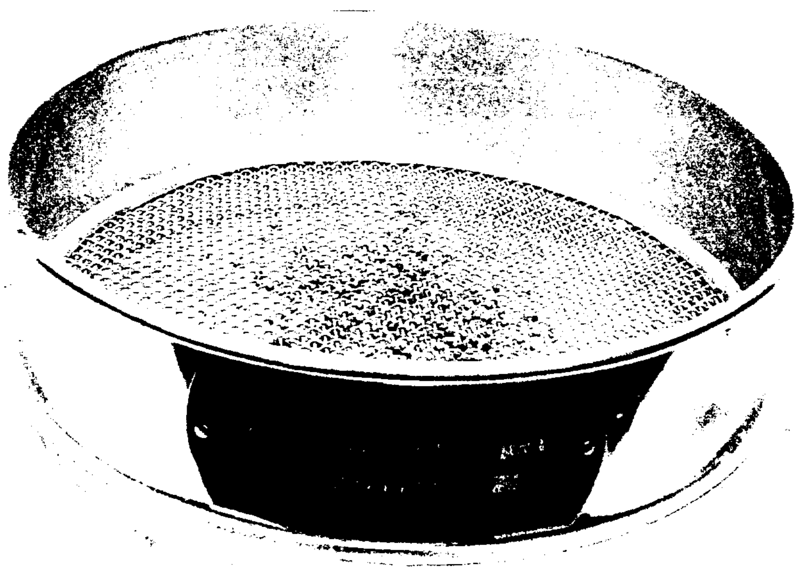
2) Utilize the excavation limit sampling results as an initial basis for estimating soil volumes requiring treatment from each locale and tie soil volumes to shotfall information for standard ranges practices. The Treeline Sample was taken from a spot approximately 400 feet from the firing line while the Midfield Sample was taken from a spot approximately 200 feet from the firing line.

   As discussed in the January 2003 Interstate Technology Regulatory Council (ITRC) document entitled *"Characterization and Remediation of Soils at Closed Small Arms Firing Ranges"* a fan-shaped shotfall zone is created, with the areas of maximum shotfall occurring generally between 350 and 550 feet out from the firing line.

   Treeline results indicate that areas of heavy shotfall will require excavation to 2-feet. The high percentage of lead shot indicates that the sample point is within a zone of heavy shotfall. Heavy shotfall in this area supports the ITRC information for fan-shaped patterning out at this distance. An unknown factor concerns existing trees and if tall trees were present when the range was used. If tall trees were present then they would have served as a "curtain" for airborne shot, resulting in higher shot accumulation around the bases of the trees.

   COE results from 0" to 3" indicate a zone of high lead out from the firing line in the fan-shaped area of heavy fallout. The 0" to 6" COE results show elevated lead levels well out from the firing line to support the fan-shaped shotfall zone. The COE computer generated maps showing lead concentrations however show marked breaks indicating contamination extending beyond areas sampled. In addition, we understand that COE did not take into account plus #10 mesh shot when determining soil total lead concentrations. Of particular interest are the COE results for 12" to 24" that show elevated lead in a far left locale at an angle that it does not fit normal firing practices in relation to the existing firing line location. It may have been that soils from the baseball diamond were moved and used as fill in the far left area where lead contamination from 12" to 24" was found. This makes sense given that at the same angle from the firing line heading to the right COE results showed no lead. High lead soils in the far left region of the site may be indicative of a second firing line in front of the baseball diamond that has been removed.

The photograph below show lead pellets from the Skeet Range retained on a #10 mesh sieve.



For the Skeet Range, by scrutinizing our results combined with COE results and guidance from the ITRC document we believe that soil quantities requiring removal from the site will be at least 20,000 tons; however, actual soil volumes exceeding the 250 mg/kg standard are unknown. A minimum treatment quantity of 20,000 tons appears to be a realistic base quantity for excavation and treatment .

For Both Sites

An integral factor for both sites will be excavation limit sampling and analysis. For the Evergreen Range, results justify the estimated excavation limits and soil volumes for areas where high lead has been found. Once these depths have been reached follow-up sampling should be performed to confirm removal of high lead soils. An issue for the Evergreen Range is the soil behind the berm. We suggest extending the clearing and grubbing limits well out behind the berm to facilitate additional sampling to ensure that areas containing high lead are not missed.

contamination is all particulate. The 1 lb. sample contains 3,084-mg/kg total lead (1.4gr./454-gr. = .308% or 3,084 mg/kg). Now suppose that an analyst weighs out triplicate 2-gr. subsamples for total lead analysis following the EPA method:

- Sample #1 - there was 1 piece of lead in the sample. If the lead completely digested the analytical result would be .07/2-gr. = 3.5% lead or 35,000-mg/kg lead

- Sample #2 - there was no particulate lead in the sample. The analytical result would be 0-mg/kg total lead.

- Sample #3 - there are 2 pieces of lead in this sample (statistically unlikely but not beyond the level of probability). The analytical result would be .14/2-gr. = 7% lead or 70,000-mg/kg total lead.

When particulate lead is not removed and accounted for separately this example shows that the EPA Method alone will <u>never</u> generate the true value of 3,084 mg/kg. Either a value of 0 mg/kg will be generated or a result much higher than the true value.

A pre-EPA Method step involving particulate metal removal and accounting on a mass basis is therefore crucial for determining the actual total lead in the soil. If this is not performed then all results from areas containing particulate metal will be inaccurate.

Spikes can also result from contaminated soil vegetation. So a density step to remove particulate metal and vegetation and separate accounting of lead from those materials as well as soil lead is the only way to derive the true soil total lead.

Step 2: Following Density Treatment, Crush Prior to EPA Method Total Lead Testing.
Individual soil grains contain differing lead concentrations as noted in results from the Impact Berm Face:

Lead Distribution – Impact Berm Face @ 3'

FRACTIONAL TOTAL LEAD RESULTS				FRACTIONAL TOTAL LEAD CONTRIBUTIONS (WGT. AVERAGED)			
Particle Size (inches or mesh)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Soil (mg/kg)	Vegetation (mg/kg)	Particulate Metal (mg/kg)	Est. #10 Mesh Cut-Point Concs. (mg/kg)
+3/4	117	-	-	31.45	-	-	
+3/8	366	-	700,000	77.87	-	6,422.29	
+4	368	-	700,000	38.54	-	6,361.58	
+8	2,226	47,315	700,000	96.82	309.61	516.53	389
+20	3,677	-	700,000	479.81	-	604.44	8,224
+50	4,636	-	700,000	465.75	-	428.61	
+100	12,193	-	700,000	389.54	-	184.21	
+200	24,405	-	700,000	347.57	-	130.83	
-200	21,465	-	-	966.68	-	-	

The lab analyst will use a small spatula to take soil for weighing and subsequent digest as per the EPA Digest Method. Typically, only the fine soil material will be taken as anything larger rolls off the spatula. As a result, the soil gradation weighed out for digest differs from the gradation of the soil in the field. Bias is thus introduced when soil grains contain differing amount of lead. If the analyst takes more minus #200 mesh soil than he will get a higher total lead value than if he takes more plus #200 mesh soil and so forth. Conversely, XRF method testing of a subsample containing more #200 mesh soil than #100 mesh soil will be higher than actual for the complete matrix.

The key is to ensure that the gradation of samples analyzed is the same as the actual soil gradation and the only way to insure this is to crush the sample to make a homogenous mix. Primary and duplicate sample results then show a higher degree of correlation using both EPA Method and XRF analytical procedures.

REPORT ON TREATMENT OF FORT LEWIS SOIL, EVERGREEN RANGE

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Background

The Evergreen Range, at Fort Lewis (WA), was formerly used for machinegun training exercises. The range is dominated by a berm, about 15 ft high. 0.30 Caliber bullets have been identified in the area. Because of planned construction, the Evergreen Range may need to be removed. One possible treatment method would be to use stabilization techniques, which do not remove lead from the soil, but rather bind it into the soil, preventing its migration.

Methods

Sample Collection

A five-gallon bucket of soil was collected from various points on and around the berm by AMEC, and sent to ERDC.

Treatments

Soils were first sieved using a number 10 mesh. The material passing the screen was then homogenized. The soils were then treated as follows:

- 3% by weight Apatite II (Apatite II is in the form of processed fish bones. More information can be found at www.pimsnw.com).
- 5% Apatite II
- 8% Apatite II
- 1% Enviro 50:50 (Enviro 50:50 is a form of EnviroBlend. It is a phosphate-based product. More information can be found at www.enviroblend.com).
- 3% Enviro 50:50
- 5% Enviro 50:50

Up to 5% by weight water was added to facilitate mixing. Each treatment was vigorously mixed and then the soils were compacted into cylinder molds and allowed to set for 24 hours. Each treatment was performed in triplicate.

Total Lead and TCLP Extractions, and Sample Analysis

Total lead was extracted using microwave digestion, EPA method number 3051a (USEPA 1997). TCLP extraction was conducted using EPA method 1311 (USEPA 1995). Analyses were performed using Inductively Coupled Plasma Spectrophotometry.

Results

Table 1 summarizes the results of the study. The total lead of the soil was over 12,000 mg/kg and the TCLP of the untreated soil was >3000 mg/L. The three Apatite II treatments substantially decreased the lead extractable using TCLP. However, the resulting values were still greater than 5 mg/L, which was the goal of the project as based on Federal Resource Conservation and Recovery Act Characteristic Waste requirements (Title 40 Code of Federal Regulations, Chapter 1, Subchapter 1, Part 261).

Each of the Enviro treatments reduced the TCLP extractable lead. The 1% treatment reduced the TCLP concentration by about 1/3rd, but was still over 1000 mg/L. The 3% treatment was less than 1.25 mg/L. Both the 5 and 10% treatments yielded similar results, less than 0.5 mg/L.

TABLE A-1 - SUMMARY OF EVERGREEN RANGE DATA

Evergreen	Concentration	Deviation
Total Lead (mg/kg)	12790.00	788.86
TCLP Untreated (mg/L)	3157.00	379.90
3% Apatite (TCLP mg/L)	12.16	6.79
5% Apatite (TCLP mg/L)	7.55	0.65
8% Apatite (TCLP mg/L)	11.95	5.69
1% Enviro (TCLP mg/L)	1141.00	78.89
3% Enviro (TCLP (mg/L)	1.22	0.52
5% Enviro (TCLP mg/L)	0.39	0.04
10% Enviro (TCLP mg/L)	0.44	0.12

Conclusion

Of the treatments tested, Enviro 50:50 at concentrations of 3% or greater proved to meet the treatment goal of <5 mg/L. Apatite II also substantially reduced the TCLP extractable lead, but did not meet the goal. It should be noted that these experiments did not address long-term stability issues.

References

USEPA. 1995. Test Methods for Evaluating Solid Wastes. Washington DC. 20460. EPA-SW-846.

USEPA. 1997. Method 3051a: Microwave Assisted Acid Dissolution of Sediments, Sludges, Soils, and Oils. Washington DC. 20460.

Disclaimer

ERDC does not endorse any product or vendor.