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Work Plan for the Ex Situ Biological Remediation Treatability Study on Explosives-contaminated Soils

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Approved by:

[signature] 3-15-99

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Date

ABSTRACT

This work plan provides the technical details and procedures (or references to supporting documents containing same) for conducting the ex situ biological remediation treatability study of soils contaminated with explosive materials at the INEEL. This treatability study supports Operable Unit 10-04 remedial activities, and constitutes a small-scale field demonstration of soil cleanup using composting combined with solvent pretreatment to facilitate more efficient biodegradation of explosive materials in soil. The Environmental Protection Agency's Guide for Conducting Treatability Studies under Comprehensive Environmental Response, Compensation, and Liability Act (EPA/540/R-92/071a) served as guidance for preparing this work plan and designing the treatability study.

CONTENTS

FIGURES

TABLES

ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRP	Community Relations Plan
DOE	U.S. Department of Energy
DQOs	Data Quality Objectives
EDF	Engineering Design File
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FTL	Field Team Leader
FSP	Field Sampling Plan
HASP	Health and Safety Plan
HPLC	High Performance Liquid Chromatography
INEEL	Idaho National Engineering and Environmental Laboratory
IRC	INEEL Research Center
LMITCO	Lockheed Martin Idaho Technologies Company
MCP	Management Control Procedure
NOAA	National Oceanic and Atmospheric Administration
OU	Operable Unit
PI	Property Index
PPE	Personnel Protective Equipment
ppm	parts per million
QAPjP	Quality Assurance Project Plan
RDX	Royal Demolition Explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine; cyclotrimethylene trinitroamine)
SMO	Sample Management Office
TNT	Trinitrotoluene (2,4,6-trinitrotoluene)

TS	Treatability Study
WAG	Waste Area Group

Work Plan for the Ex Situ Biological Remediation Treatability Study on Explosives-contaminated Soils

1. OVERVIEW

This work plan provides the general strategy for conducting the Idaho National Engineering and Environmental Laboratory (INEEL) Operable Unit (OU) 10-04 RDX (cyclotrimethylene trinitroamine; hexahydro-1,3,5-trinitro-1,3,5-triazine; Royal Demolition Explosive)/TNT (2,4,6-trinitrotoluene) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Treatability Study (TS). Additional supporting documents include the Field Sampling Plan (FSP), Quality Assurance Project Plan (QAPjP), the Health and Safety Plan (HASP), and other documents as cited. These plans have been prepared pursuant to the National Oil and Hazardous Substances Contingency Plan, (Environmental Protection Agency [EPA] 1990), and guidance from the EPA. This work plan describes the activities that will occur as part of the treatability study, while the QAPjP details the processes and programs that will be used to ensure that the data generated are suitable for their intended uses.

1.1 Treatability Study Plan Statement

The purpose of this TS is to guide the overall execution of the field, laboratory, and analytical work performed as components of the field activity using soils from areas on the INEEL that have been subjected to activities such as test firing and high-altitude bombing, which have led to the contamination of soils by high explosives. The INEEL has multiple areas containing unexploded ordnance (UXO) and ordnance explosive (OE) waste as a result of activities performed at the Naval Proving Grounds (NPG) prior to the existence of the INEEL. Before 1949, the U.S. Navy conducted aerial bombing practice, naval gun-barrel testing, explosive storage magazine testing, safe separation distance testing, and ordnance disposal. Activities over the last 4 years have involved the cleanup of UXO and OE waste in high-priority areas.

RDX/TNT soil areas currently have a wide range of contaminants and a very diverse spatial distribution of high explosives. In order to reduce excess cancer risk to 1 in 100,000 (usually considered acceptable in the CERCLA process), a calculated 44-ppm TNT and 18-ppm RDX level of contamination must be met. These levels differ from the OU 10-05 Interim Action PRGs of 44 ppm and 180 ppm to include and protect ecological receptors. The explosives-contaminated soils at the INEEL contain fragments of solid explosives. These fragments were found to range from large particles of bulk high explosive to microscopic particles. Because of the diversity in size of explosives particles at the INEEL, and hence, the inherent range of physical and chemical properties of the particles, screening was found to be an ineffective process.

Biological treatment of explosives-contaminated soils has been previously shown to be effective during bench scale tests on INEEL soils, but not in soil containing solid explosive particles. Lockheed Martin Idaho Technologies Company (LMITCO) has developed a pretreatment (original invention disclosure filed as LIT-PI-313), which renders INEEL soil containing solid explosive particles amenable to biological remediation. The goal of this CERCLA treatability study is to assess the integration of the LMITCO pretreatment with INEEL soil and standard biological remediation systems, and provide baseline information on the suitability of composting to remove explosives from INEEL soils. To accomplish this, several treatment technologies will be brought together: minimal solvent pretreatment (dissolving solid particles of explosive to enhance bioremediation), explosives composting (a well-accepted bioremediation process for use with explosives-contaminated soils), and biofiltration (to mitigate any potential release of solvent vapors).

Current remedial alternatives for soils contaminated with explosives include incineration and/or screening/removal of explosive particles from the soil for detonation. It is currently estimated that over 10,000 cubic yards of INEEL soils are contaminated with explosives. As much of the explosives found in the soil will not be economically amenable to removal through a mechanical screening process it is likely that a significant volume would require incineration to meet remedial action objectives. Successful demonstration of bioremediation technology through performance of this TS will allow for its inclusion in the WAG 10 remedial alternative analysis. The fact that earlier bench scale studies have been successful illustrates the potential of this technology to achieve remedial action objectives in a cost-effective manner in comparison to incineration or screening for particle removal.

1.2 Historical Data

1.2.1 Activities Producing Explosives-contaminated Soils

The OU 10-05 Records Search Report[1] identified former Navy and former Army Air Corps activities as the source of unexploded ordnance and explosives-contaminated soils at INEEL. Ordnance explosives commonly used by the military included TNT and RDX. The former military activities in the Naval Proving Ground (NPG) area included artillery testing, bombing practice, and explosives storage bunker testing. TNT and RDX contamination of the soil is a consequence of the soil having been exposed to explosives scattered by incomplete detonations, or from breached unexploded ordnance.

1.2.2 Previous Explosives-contamination Investigations at the INEEL

Historical information and the results of soil screening analyses, characterization analyses, and remedial actions performed during the OU 10-05 Interim Remedial Action[3] have been used to define the source, nature, and extent of the contamination in the three major contaminated areas: OU 10-01, OU 10-05, and OU 10-03. Detailed descriptions of the methods, procedures, and quality assurance techniques used during the interim action can be found in the OU 10-05 Interim Remedial Action project documentation.[1-5] The distribution of areas known to contain explosives-contaminated soils across the INEEL site is presented in a map found in the Field Sampling Plan.

1.3 Previous Bioremediation Studies

1.3.1 Minimal Solvent Pretreatments

The explosives-contaminated soils at the INEEL contain fragments of solid explosives. These fragments were found to range from large particles closely associated with unexploded ordnance to microscopic particles. Because of the diversity of explosives particles at the INEEL, and hence the inherent range of physical and chemical properties of the particles, screening was found to be an undesirable process. A minimal solvent pretreatment was subsequently developed (LIT-PI-313). Experimental data supporting LIT-PI-313 are presented in manuscript format as Appendix A.

1.3.2 Effect of Unevaporated Minimal Solvent Pretreatments on Biological Remediation

The effect of acetone on the biological removal of explosives from INEEL soils was investigated. In summary, the potential deleterious effects of residual acetone were determined to be minimal on compost systems.

2. TREATMENT TECHNOLOGY DESCRIPTION

Several treatment technologies will be brought together in this TS. The technologies of minimal solvent pretreatment, explosives composting, and biofiltration will be used in series.

2.1 Minimal Solvent Pretreatment

Minimal solvent pretreatment was evaluated in the laboratory in response to the finding that the explosive particles (mostly TNT) within contaminated soil at the INEEL responded poorly to bioremediation. The objective of solvent pretreatment in the context of this TS is to *dissolve the explosive materials particles greater than 1 mm* to the point that subsequent complete, efficient bioremediation of the site is possible, while keeping the amount of solvent used to a minimum.

An objective of this TS is to determine minimum amounts of acetone that may be used to dissolve particles of explosives, resulting in subsequent complete biodegradation. The data generated from these activities will be instrumental in determining the feasibility of using solvent pretreatment combined with composting and in future scale-up.

2.2 Composting

Composting explosives-contaminated soils is a well developed[5,6] and effective[7] technology. In the process of composting explosives, soil is mixed in with typical compost starting materials and formed into windrows. The piles function best if they are remixed and turned often—up to twice per day. Composts heat up during the incubation period from massive biological activity. The same biological activity degrades the explosives within the soil matrix. Compost mediated bioremediation of explosives-contaminated soil results in a large fraction of inextractable, bound material, presumed to be humified into a covalent attachment to natural organic polymers.[8]

Laboratory studies at the INEEL, and communications with firms performing commercial remediation of explosives-contaminated soils using composting indicate that solid particles of TNT are not effectively degraded if present. Conventional approaches rely on screening of these particles away from soil before or after composting and incinerating or detonating the solid explosives. These physical approaches are costly and can be hindered by the presence of large, nonexplosive particles (such as organic debris, small rocks and gravel). For this reason, a means of dissolving the explosive particles prior to composting has previously been investigated at the INEEL. The results indicated that such an approach was feasible, and serve as a foundation for this treatability study. Supporting experimental work found that the presence of a solvent does not significantly hinder the process of composting explosives-contaminated soil (Appendix A).

2.3 Biofiltration of Solvent Vapors

Biofiltration uses organisms within a solid matrix to degrade volatile organics. Biofiltration is a mature technology and has been shown to be effective on ketones[9–11] and odors.[10,12–14] Acetone has been found to degrade quickly using biofiltration, over twice as fast as ethanol or 2-propanol (rubbing alcohol).[16] Passive biofiltration will be used to prevent/minimize the release of acetone from the finished compost pile and also for odor control. The application of biofiltration will be to add a cover of a moistened, mature, finished compost to the explosives-contaminated windrows.

3. TEST OBJECTIVES

3.1 Project Objective Statement

The overall objective of the treatability study project is to successfully bioremediate approximately 1 cubic yard of explosives-contaminated soil, and provide information to assess the nine CERCLA decision criteria. The criteria for assessing the success of this objective is to produce a finished compost that:

- Is below established cleanup levels for explosives-contaminated soils under OU 10-04 (47 mg/kg TNT and 18 mg/kg RDX, or 10% of the initial soil concentration, whichever is larger and corrected for dilution)
- Has no "hot spots" of contamination
- Has no remaining particles of explosives after pretreatment (determined by visual *and microscopic inspection)*
- Contains no residual solvent (as measured analytically)
- Supports vegetation by seeded and native plants
- Is economically and technically feasible
- Is accomplished in accordance with the CERCLA process
- Establishes the feasibility of the treatment for use at the INEEL.

3.2 Phase Objectives

There are four phases of this TS designed to ensure that the TS provides meaningful, concise, and accurate data for the scaleup, and that it documents the cost and feasibility of the technologies. These four phases are as follows:

- Phase 1: Excavation of Soil
- Phase 2: Pretreatment Mixing
- Phase 3: Compost generation
- Phase 4: Compost Maturation.

3.2.1 Pretreatment Mixing

The thorough dissolution of particle explosives within a soil matrix is pivotal to this TS because it is essential for the success of the bioremediation system. A major goal of this TS is, therefore, to identify the minimum amount of acetone, appropriate intensity of mixing, and time of mixing required to achieve dissolution of the particle explosives. Particle dissolution will be evaluated by visual and microscopic evaluation in the field.

3.2.2 Compost Generation

Compost generation is a well developed technology. However, the use of acetone as performed in this TS is novel. The biotreatment system has been found effective in laboratory studies (Appendix A). The objective for this phase is to create a working field composting system while minimizing environmental and safety risks. This working system would involve the construction of a facility which met secondary containment regulations if it is determined that acetone pretreatment would be used in the remediation process.

3.2.3 Compost Maturation (Bioremediation)

Compost maturation is the time-dependent process by which natural organic addenda (manure, leaf matter, straw, wood chips, and other common compost constituents) degrade through a period of intense biological activity (heat is generated within the compost to average temperatures of 55°C). During the course of this maturation, organic contaminants (in this case explosive compounds) are concurrently degraded. The objective for this phase will be to monitor the remediation process through measurement of compost temperature, explosive concentrations, residual solvent concentration, and microscopic inspection of the compost to determine "decrease in size" or "elimination" of TNT/RDX particles.

4. EXPERIMENTAL DESIGN AND PROCEDURES

The experimental design for this TS was developed to provide accurate and quantifiable data for the application of bioremediation to explosives-contaminated soils at the INEEL. The scheme for generating the compost is presented in Figure 1.

4.1 Excavation of Soil

The explosives-contaminated soils to be used in this treatability study will be obtained from a non radiologically contaminated area near the Experimental Field Station. The TS itself will also be performed at the Experimental Field Station. However, soils from the National Oceanic and Atmospheric Administration (NOAA) Grid area can be used interchangeably and this study may be performed at that location should this prove logistically easier. If a second site is selected, all necessary approvals will be obtained prior to initiating work.

Soil will be moistened with a water spray to reduce fugitive dusts and the chance of an explosion or deflagration due to static electricity discharge or friction. Soil will then be excavated by hand using nonsparking tools. With the understanding that solid particles of explosives may be present, care will be exercised when excavating the soil. Soils will be placed in a rotary cement mixer.

An external review of this treatability study was performed by the U.S. Naval Ordnance Center, Indian Head, MD staff, who determined that additional safety precautions were unnecessary provided explosives concentrations in soil remain below 7% by weight (letter dated July 28, 1997). In order to examine the effects of solvent pretreatment on explosive particles of differing sizes, some of the soil will be sieved manually to recover particles ranging from 1–5 mm in width.

4.2 Pretreatment Mixing

Pretreatment mixing will be carefully examined in order to determine the amount of solvent (acetone), and the duration and intensity of the mixing process required for complete dissolution of solid explosive materials into the soil/solvent matrix.

The approach to investigate the concentration, the mixing intensity, and the mixing time (which make up the "triangle," see Figure 2), is designed to provide these data efficiently during the compost assembly process. Laboratory tests have shown that with a saturated acetone/soil slurry (0.38 mL/g-soil), it took 30 seconds for adequate dissolution of TNT particles to occur, when mixing by hand.

A specially-modified rotary cement mixer with the mixing bowl sealed with epoxy to prevent solvent leakage will be used to mix the acetone with the soil. The mixer will be fitted with a lid designed to minimize solvent vapor evaporation. The motor will be physically separated from the bowl to eliminate the potential for motor sparking to ignite any fugitive solvent vapors—The mixer will be operated remotely while the motor is energized. After a measured volume of soil is place into the mixer the acetone will be added incrementally to a maximum concentration of .38 mL/g.

Samples taken before and after each acetone addition will provide data that indicate the effects of increasing acetone volume on TNT dissolution, while samples taken between solvent addition (during mixing periods) will provide insight to the time required to physically homogenize and dissolve explosive particles in the soil. Sample analyses will include visual/microscopic examination (to estimate particle distribution) and chemical analysis for TNT and RDX using EPA Method 8330.

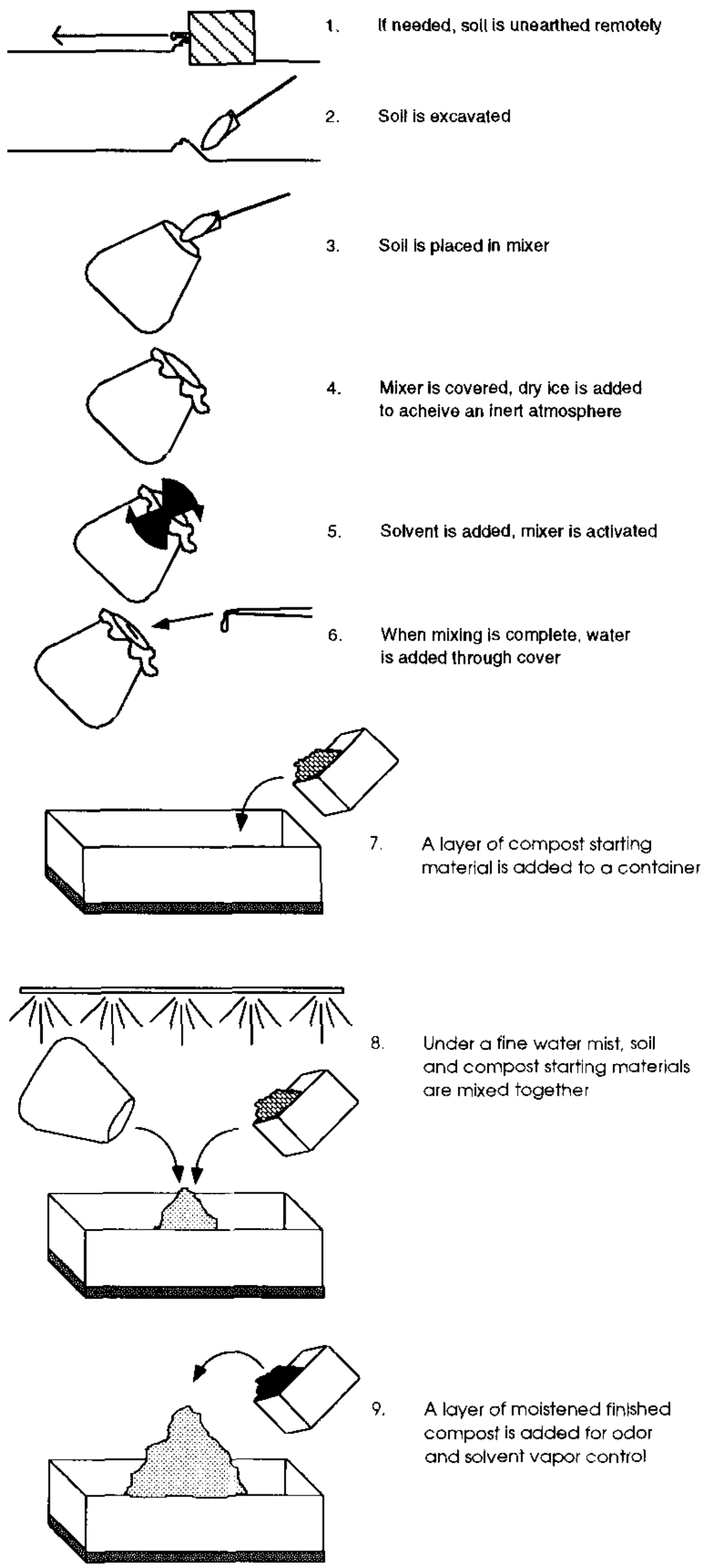

Figure 1. TS schematic.

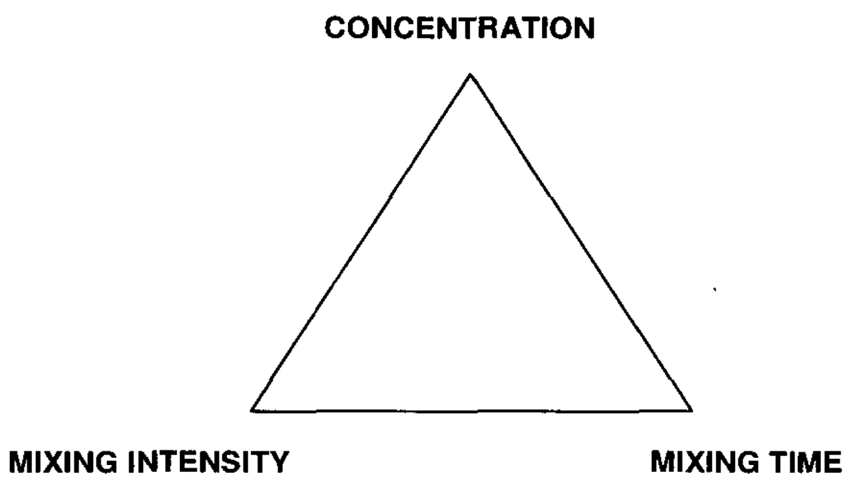

Figure 2. Conceptual relationship of concentration, mixing intensity, and mixing time.

4.3 Compost Generation

The end product of the minimal solvent pretreatment phase is an acetone/soil slurry in the cement mixer. Water will next be added in a volume equal to the amount of acetone added during the pretreatment. This will serve to precipitate some of the explosives out of solution in a very fine aqueous powder, and also to slightly repress the volatilization of the acetone into the surrounding air. A measured volume of pelletized corn cob pith and chaff will then be added to the acetone/soil/water slurry to absorb the free liquid. The pelletized pith and chaff breaks apart when it absorbs liquid and becomes an easily mixed material with soil. This will also serve to reduce the volatilization of acetone into the surrounding air.

The compost will be prepared in a large rectangular impermeable polyethylene tub. An initial layer of preshredded compost starting material will be added to the bottom of the container to support the explosives-contaminated compost pile. This starting material contains hay, chicken and cow manure, sawdust, and either potato or pressed sugar beet waste. These materials will be obtained from local suppliers and brought on site.

The contents of the cement mixer will then be blended by hand at a volumetric rate of 1:4 with dried compost starting material. A fine water spray will be in place over the compost as it is mixed, preventing appreciable losses of solvent to the atmosphere. When the mixture is homogenous, the compost pile will be shaped by hand using a nonsparking shovel. Temperature probes will then be inserted into the pile. A commercial agricultural finished compost will then be added to the air-facing sides of the compost to facilitate odor quenching and passive acetone biofiltration. To prevent mixing the biofilter with the composite a geomembrane will be placed on the composite prior to the adding of the biofilter material.

4.4 Compost Maturation

The finished pile will be monitored for temperature and oxygen content over time using probes. Daily samples of the internal spaces within the compost will also be analyzed for acetone. When the acetone within the internal spaces falls below the flash point for acetone, the compost will be mixed by hand using a nonsparking shovel. These samples will be analyzed at the IRC using head-space gas chromatography. Soil samples taken of the compost will be analyzed for nitroaromatics by high-performance liquid chromatography (HPLC) at the INEEL Research Center (IRC) until contaminant levels meeting acceptance criteria are achieved. Additional samples will be collected for an acetone and nitroaromatics for analysis at an off-Site laboratory. These samples will be taken as described in the field sampling plan.

4.5 Compost Spreading and Re-Seeding at Excavation Site

At the end of the composting phase, the finished compost will be spread to a depth of 6 in., seeded with crested wheatgrass, watered, and left unattended. After 1 year has passed, the site will be inspected visually for crested wheatgrass growth and development, as well as colonization by native plant species.

4.6 Parallel Studies

A microcosm system of Dewar flasks[16] will be run in parallel with the TS. The microcosm system may provide useful data regarding scale-up. This microcosm system was recommended by the U.S. Environmental Protection Agency (EPA) Region 10 and was successfully used at the INEEL for determining the effects of acetone on compost bioremediation of explosives in soil (Appendix A).

5. EQUIPMENT AND MATERIALS

The following materials and equipment will be used in all phases of the TS:

- Portable water sprayer
- Potable water
- Camera and film (35 mm)
- Logbook and pens—need to ensure that indelible ink pen is used.
- Demarking tape or twine
- Signing
- Global Positioning System (GPS) receiver
- Water displacement measuring system (for measuring volume of explosive particles)
- Sampling supplies
- Portable decontamination station
- Labels
- Cellular phone
- Duct tape
- Spill kit
- Personnel protective equipment (PPE)
- Used PPE container
- First aid kit (including emergency eyewashes, etc.)
- Thermometer
- Gloves
- Safety glasses with side-shields.
- Fire extinguisher
- Shovel.

5.1 Excavation Equipment and Materials

The following equipment and materials that will be used in the excavation-of-soil phase of the TS:

- Floating stakes
- Nonsparking shovel
- Plastic tarp
- Steel cable (if remote excavation is required)
- Steel blade (if remote excavation is required)
- Vehicle capable of pulling blade (if remote excavation is required)
- Analytical balance (small)
- Analytical balance (large).

5.2 Minimal Solvent Pretreatment Equipment and Materials

The following equipment and materials will be used in the minimal solvent pretreatment testing phase of the TS:

- Rotary portable cement mixer
- Dry ice
- Acetone
- Sampling supplies
- Flexible nonpermeable membrane
- Portable oxygen monitoring device
- Timer
- Plastic tarp
- Portable water sprayer
- Water
- Generator
- Extension cord

- Electrical switch or timer
- Duct tape.

5.3 Composting Equipment and Materials

The following equipment and materials that will be used in the composting-of-soil phase of the TS:

- Portable shredder
- Plastic bags
- Rectangular polyethylene tub
- Portable water sprayer
- Water
- Sampling supplies
- Nonsparking shovel
- Compost starting materials
- Commercial agricultural finished compost
- Duct tape.

6. SAMPLING AND ANALYSIS

This section addresses general details of sampling tests and analysis methods that will be used to support the TS. Comprehensive details are provided in the supporting FSP and *Quality Assurance Project Plan (QAPjP) for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, and 10.*[17] The standard explosives analysis as performed by the INEEL at the IRC is outlined below. This method provides relatively quick and accurate data collection of the parent and metabolic fate of TNT, the primary contamination expected. The Sample Management Office (SMO) certified laboratory will use EPA SW-846 8330, which is another HPLC method for the detection of explosives in soil and groundwater.

6.1 Sampling Strategy

The sampling strategy for this TS is driven by the goals of the overall bioremediation effort. In general, samples will be taken before and after every unit operation and twice per day during the final composting. As outlined by the EPA,[18] screw top sample containers will be not be used. All sampling will be performed in triplicate using whirl-pak bags and sealed with evidence tape prior to preservation and transportation.

6.1.1 Data Quality Objectives

There are two primary data quality objectives (DQOs) for this TS. The first DQO is to provide data of adequate quality to provide meaningful interpretation pertaining to scale-up of the technology. The second DQO is to allow for data of sufficient quality as to ensure that the final product (compost) generated by the bioremediation activities will allow for closure of the ordnance-contaminated site if applied to the entire area. A Validation Level of A is assigned for all data that will be sent off-site to an approved SMO Laboratory. All data is to be considered 'definitive' as defined in the QAPjP.[17] The sampling data quality objectives for each phase of the TS are detailed in Table 1.

6.1.2 Soil Excavation Sampling Strategy

A total of six samples will be collected prior to initiating the TS. The samples will be collected to establish background conditions and to ensure that concentration levels exceed remedial action objectives when the dilution effect of the composting process is considered. Three samples will be analyzed at the IRC and three will be analyzed at an off-Site laboratory.

6.1.3 Pretreatment Sampling Strategy

The sampling strategy for the minimum solvent pretreatment portion of the TS will be governed by the specific phase objectives, using Reference 17 for guidance. Although microscopy can be performed to assist in the identification of explosives fragments within the soil matrix, a more quantifiable approach involves analyzing several subsamples within a sample set and determining the variability of explosives concentrations measured within the subsamples.

6.1.4 Composite Generation Strategy

Samples will be taken daily and analyzed at the IRC for acetone until it is determined the concentration is below flash. The compost pile will then be mixed and three samples collected for nitroaromatic concentrations to establish background concentrations in the compost.

Table 1. TS sampling methodology.

TS Phase	Objective	Number (100-g Samples)	Analytes	Sample Method	Precision/ Accuracy	Comments
Excavation of Soil	Establish background concentrations	10	Nitroaromatics	Random (Nonsparking Shovel)	Duplicate samples/spike recovery	Sample to be collected at select site. Three samples for SMO approved lab.
Pretreatment mixing	Establish volume of solvent required to dissolve explosive particles	7 per event	Nitroaromatics Acetone	Random (Nonsparking sample spoon)	Duplicate samples/spike recovery	Each time mixer is stopped for acetone addition.
Compost generation	Establish background concentrations	TBD 6	Acetone Nitroaromatics	Random (Nonsparking sample spoon)	Duplicate samples/spike recovery	Acetone samples collected and analyzed at IRC lab daily until it is determined that concentrations are below flash point. Nitroaromatic samples will be taken after final compost pile is constructed and acetone concentrations are below flash point. Three samples for SMO approved lab for Nitroaromatics.
Compost maturation	Establish degradation rates	3 per event	Nitroaromatics	Random (Nonsparking sample spoon)	Duplicate samples/spike recovery	Incubation sampling events will be performed twice daily for a total of 6 samples per day.
Compost cover	Hazardous Waste determination	3	Acetone	Random (Nonsparking sample spoon)	Duplicate samples/spike recovery	Three samples for SMO approved lab.
Compost end	Determine effectiveness of treatment and for hazardous waste determination	10	Nitroaromatics Acetone	Random (Nonsparking sample spoon)	Duplicate samples/spike recovery	Seven samples for IRC analysis; 3 for IRC analysis; and 3 samples for SMO approved lab.

6.1.5 Compost Maturation Sampling Strategy

At the end of the study seven samples will be collected for analysis at the IRC and three for analysis at an off-Site laboratory.

6.2 Sampling Method

Samples will be taken at all phases of the experimental process. Sampling intensity will be roughly two times that needed with all sample storage by air drying and freezing until the utility of the samples are deemed unimportant, or 90 days after the final report of the particular unit operation that the samples were taken under, whichever comes first. Samples will be taken by hand with a grounded stainless steel sampling spoon and placed into prelabeled whirl-pak bags approved by the LMITCO SMO. Capped samples will be taped with evidence tape and placed in a cooler for transportation.

Confirmation samples will initially be run of only the first and last sample sets taken. Pending sufficiently low or undetectable levels of contamination in the final sample set, samples taken earlier will be subsequently analyzed. Performing the sampling and analysis in this fashion will result in a minimal amount of analyses, while allowing for complete reporting during pertinent times.

6.3 IRC Extraction Methodology

In general, the IRC extraction procedure for both soil and compost used in this TS follows the bath sonication method described by Jenkins et al.[19] An outline of the procedure is as follows:

1. Air-dry the soil overnight in a hood at room temperature (about 23°C).
2. Measure 10 g of soil (within four decimal places). Place the soil in a new borosilicate glass scintillation vial. Use 5 g of compost versus 10 g of soil (compost is considerably less dense than soil).
3. Measure 15 mL of methanol into the vial using a new glass serological pipette.
4. Cap the vial with a Teflon-lined screw cap and shake it by hand to ensure that all internal surfaces are wetted with solvent.
5. Place the vial in a sonication bath containing approximately 2 in. of nanopure water.
6. Sonicate the vial for 2 hours.
7. Take 1 mL from the vial with a Pasteur pipette and place it in a prelabeled plastic Eppendorf conical centrifuge tube. Centrifugation reportedly helps deter the potential problem of compounds binding to filters.[6]
8. Centrifuge the tube for 5 minutes at 2,000 g.
9. Extract and analyze the supernatant directly by HPLC if no dilution is required.
10. If needed, perform dilutions gravimetrically using an analytical balance (record to four decimal places past the gram).

6.4 HPLC Analyses

6.4.1 HPLC Conditions

The HPLC conditions described in EPA method 8330[20] will be used by the SMO-certified laboratory for determining explosives concentrations in confirmation soil samples. Samples analyzed at the IRC will be run using an Alltech mixed mode C-18/Anion, 150-mm 5-µ, Alltech #7260 column with a 50:50 methanol water isocratic phase at 1 mL/min and a Supelco C-18 guard column and detected with a Waters photodiode array detector at 254 nm.

6.4.2 Retention Times

The results of using a Waters HPLC in the configuration described in Section 6.4.1 are listed below in Table 2.

Table 2. HPLC analytes of TNT metabolites and their corresponding retention times.

Compound	Retention Time (Minutes)	Found in INEEL Studies
methanol (void volume)	3.07	
2,4-diaminotoluene	4.373	
2,4,6-triaminotoluene	4.632	
2,6-diamino-4-nitrotoluene	5.598	x
2,4-diamino-6-nitrotoluene	6.392	x
trinitrobenzene	7.80	x
o-toluidine	7.878	
p-toluidine	8.027	
2,4,6-trinitrobenzene	11.707	x
nitrobenzene	13.037	
1,3-dinitrobenzene	13.147	
2,6-dinitrobenzene	17.505	
2-nitrotoluene	19.375	
2,4-dinitrotoluene	19.722	
4-nitrotoluene	20.733	
3-nitrotoluene	22.145	
5 4-amino-2,6-dinitrotoluene	29.633	x
2-amino-4,6-dinitrotoluene	35.96	x

6.4.3 Standard Curves

A six-point standard curve will be run weekly in an independent sample set. Three- or four-point standard curves are added randomly within each experimental set. A regression is generated from the internal standards in every experimental run and used for evaluating experimental data. The instrument is therefore recalibrated for every experimental set. The maximum number in a set is 21, as limited by the autosampler capacity.

7. DATA MANAGEMENT

The TS is an important component of the remedial investigation/feasibility study process. It verifies the effectiveness of a selected and/or developed technology to meet the expected remediation goals for the site. A data management plan either provides or references procedures and requirements necessary to develop a data base of relevant information that can be readily accessible and accurately maintained. The plan describes the data flow process, data custodianship, and organizational and individual responsibilities associated with data management. The plan also provides project file and reporting requirements and identifies extensive data base capability requirements to allow selective data sorting, analysis, formatting, and reporting.

The Data Management Plan for the Idaho National Engineering Laboratory Environmental Restoration Program[21] will function as the data management plan for this TS.

Specific DQOs will be established to support test objectives listed in Section 3. MCP-205, "Records Management" will assist in ensuring that information is available when needed, protected as appropriate, and properly dispositioned. In addition, a number of LMITCO internal management control procedures (MCPs) also apply to this TS. The applicable MCPs include:

1. MCP-227, "Sampling and Analysis Process for EM-Funded Activities"
2. MCP-230, "Environmental Restoration Document Control Center Interface"
3. MCP-231, "Logbooks"
4. MCP-232, "Engineering Design File"
5. MCP-233, "Producing ER Reports"
6. MCP-240, "Internal/Independent Review of Documents"
7. MCP-241, "Fieldwork"
8. MCP-242, "Obtaining Laboratory Services for EM-Funded Activities"
9. MCP-244, "Chain-of-Custody, Sample Handling, and Packaging for Comprehensive Environmental Response, Compensation, and Liability (CERCLA) Activities"
10. MCP-328, "Test Plans"
11. MCP-452, "Treatability Studies"
12. MCP-2864, "Sample Management"
13. MCP-540, "Assignment of Quality Levels."

8. DATA ANALYSIS AND INTERPRETATION

Upon completing the TS, the data must be summarized and evaluated to determine their validity and to assess the performance of the stabilization process. To accomplish this goal, results will be reduced to a useful form in accordance with the data uses defined in Sections 3 and 4. Test results are to be interpreted on the ability to implement the remediation technology and to analyze its effectiveness and safety. These in turn influence the technology's overall cost. At the end of each specific test, the raw data and test results will be summarized in engineering design files (EDFs) by project personnel. These EDFs will provide the key information needed for complete data analyses and interpretations in the TS report.

The data will be both qualitative and quantitative. The qualitative data will include photographic records of major events, visual observations, logbook entries, descriptions, etc. Quantitative data will include temperature and other weather recordings during the process, temperature of the various processes, and chemical concentration measurements. Data of sufficient quality will be obtained to perform a full-scale operations estimate, which includes such items as cost, manpower requirements, and time. The analysis and interpretation of the data generated by the tests will be performed by LMITCO personnel. Samples requiring off-Site analyses will be sent to approved SMO-related laboratories.

9. HEALTH AND SAFETY

A task-specific Health and Safety Plan (HASP), INEEL/EXT-98-00741, has been developed to cover the Bioremediation of Explosives-Contaminated Soil Treatability Study. This HASP establishes the procedures and requirements that will be used to minimize health and safety risks to persons working on the TS. This HASP is intended to meet the requirements of the Occupational Safety and Health Administration (OSHA) standard, 29 Code of Federal Regulations (CFR) 1910.120. It contains information about the hazards involved with performing the work and the specific actions and equipment that may be used to protect persons working at the site.

9.1 Personnel Health and Safety

Since personnel from several organizations will participate in the Bioremediation of Explosives-Contaminated Soils effort, the HASP will cover all work in the control zone. Any work or effort outside the control zone boundary requires compliance with the ordnance safety engineer.

9.2 Subcontractor Health and Safety

All subcontractor work is governed by the HASP. Each subcontractor will agree to comply with the requirements outlined in the HASP.

10. WASTE MANAGEMENT

Waste management for this TS will be guided by the Waste Certification Plan for the Environmental Restoration Program.[22] This document provides the requirements to ensure that CERCLA project-generated waste submitted to the Waste Experimental Reduction Facility for on-Site or off-Site treatment or to the Radioactive Waste Management Complex for disposal satisfies the DOE-ID Reusable Property, Recyclable Materials, and Waste Acceptance Criteria. This plan also defines program policies and applications for the INEEL ER CERCLA area of contamination compliance issues, investigative-derived waste, land disposal restrictions, and CERCLA TS.

Waste that will be generated during the TS includes sanitary waste (PPE, wipes etc) and decontamination water and the compost pile. Sanitary waste will be managed through process knowledge to determine if it meets F-003 waste criteria. All sanitary waste determined type require management as F-003 waste and the decontamination water will be sent to the Waste Experimental Reduction Facility for disposal. Sampling equipment and the soil mixer will be decontaminated and recycled.

In the event that the TS is unsuccessful with respect to acetone (F-003 listed waste) being above land disposal restrictions and risk based concentrations, it has been determined that it can be accepted for disposal at a Chem Waste Management disposal facility (J. Espinosa, Lotus Note 6/4/98, attached to this document and the FSP). However, if the compost meets land disposal restrictions and risk based concentration levels for acetone it will be returned to the excavation site and identified in the WAG 10 Record of Decision. Residuals developed analytically in the IRC will be handled through the existing explosives waste stream IFF-603-3-006T-H-LS at IRC (Environmental Coordinator D. McDonald or alternate C. Stander).

11. COMMUNITY RELATIONS

The community relations task is designed to ensure community understanding of actions taken during the TS and to obtain community input on the TS program. Community relations are an integral part of any CERCLA action whether or not the action is at a federal facility. At the INEEL, all CERCLA actions will be subject to both CERCLA and National Environmental Policy Act community involvement requirements. The INEEL public affairs group of LMITCO has prepared a programmatic Environmental Restoration Program Community Relations Plan (CRP),[23] which covers the WAG 10 Remedial Investigation/Feasibility Study process. This CRP was issued as a DOE document representing "the process established by mutual agreement between the DOE, EPA, and State of Idaho to address environmental restoration concerns at the INEEL." This CRP will guide the actions taken to ensure appropriate public involvement in agency decision-making and will serve as the CRP for this TS.

12. REPORTS

During the course of the TS, open lines of communication are essential to ensure smooth and accurate flow of information to all parties directly or indirectly involved with the project. The following sections identify the necessary TS documentation.

12.1 Weekly Reports

Work package managers are responsible for submitting weekly reports updating the progress of the TS project. At a minimum, the weekly reports will be distributed to the project manager. The project manager, as appropriate, will then forward the weekly reports or relevant information to the program manager, the DOE-ID project manager, and the control account managers. The weekly reports should include but not be limited to the following:

1. Accomplishments of work performed for the week
2. Anticipated work to be performed the following week
3. Any problems or issues encountered and the actions taken
4. Schedule.

12.2 Monthly Reports

The monthly reports shall be prepared by the control account manager and will be distributed to the program manager and the DOE-ID project manager. Monthly reports, as a minimum, will contain the following:

1. A summary of project work progress
2. A summary of work completed
3. Planned work to follow
4. Problems or issues encountered and the actions taken
5. Results of any Change Control Board or Internal Change Board actions
6. Key position changes
7. Contracts awarded, completed, and terminated
8. Audits performed
9. Safety, health, and environment assessment of work performed for the month
10. Schedule and any variances
11. Cost and any variances
12. Earned Value reports.

12.3 Occurrence Reporting

During the TS process, unusual events may occur that fall within the scope of DOE Order 5000.3b and DOE Order 232.1. If such events occur, notifications will be made in accordance with LMITCO MCP-190, "Event Investigation and Occurrence Reporting," which addresses the requirements of this order. Unusual events that fall outside the scope of DOE Order 5000.3b and MCP-190 will be reported as follows:

1. Minor problems that can be field corrected will be reported to the field team leader (FTL) or site supervisor. The FTL or site supervisor will ask the radiation control technicians, industrial hygienists, or safety representative for assistance as appropriate.

2. Problems that could stop work for more than one shift or cause a schedule change of greater than 2 days, or a budget change greater than $1,000, will be reported to the appropriate work package manager by the FTL or site supervisor. The work package manager will report these problems to the control account manager, project managers, and program managers as appropriate.

12.4 Engineering Design Files

Interim reports such as EDFs will provide a means of determining whether to proceed to the next tier of activities. The data and observations from specific tests will be combined into the EDFs. The EDFs will summarize results and conclusions drawn from intermediate or supporting activities to the TS.

12.5 Final TS Report

At the completion of the TS activities, a TS report will be prepared documenting project activities, results, conclusions, and recommendations. Complete and accurate reporting is essential, as decisions about the bioremediation option for full-scale remediation of the site will be made pending the outcome of this TS. The TS report will be prepared following EPA's Guide for Conducting Treatability Studies under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA/540/R-92/071a.

13. SCHEDULE

The working schedule for this ex situ Bioremediation Treatability Study is contingent upon getting the preliminary paperwork in place. The first ground-breaking study is planned to begin in the Spring of 1999.

14. MANAGEMENT AND STAFFING

All field personnel will receive the required training before field activities begin, including the health and safety training required by the HASP. In order for personnel to enter the exclusion zone unescorted, the following training is required:

- DOE Ordnance Training
- Environmental Safety and Health Training (blue card).

Depending on job functions, additional training may be required. The HASP will outline the specific job training requirements.

The following list identifies the key project personnel necessary to conduct the overall TS. The team has been assembled to include persons who have remediation experience in similar TS activities.

DOE-ID Team Members

- Project Line Manager — Kathleen Hain
- WAG 10 Manager (EM-40 Representative) — Patti C. Kroupa

LMITCO Team Members

- Project Manager/Control Account — Dan M. Smith
- Principal Investigator — Dr. Frank F. Roberto
- Quality Engineer — R. Leo Herbert
- ER Director — Kathleen L. Falconer
- ER WAG 10 Manager — Thomas M. Stoops
- ER ES&H Manager — Charlie Chebul
- Ordnance Safety Engineer — Hanceford E. Clayton

15. BUDGET

Bioremediation of the explosives-contaminated soils at the INEEL has been found to be a cost-effective alternative to incineration.[25] Treatability studies are a necessary part of implementing technology to nontypical conditions, such as those present at the INEEL.

The scope and funding levels for this TS are defined in LMITCO ADS #ID06MW75 (41-EG), work breakdown structure 1.1.10.1.1.B.1.

16. REFERENCES

1. Wyle Laboratories, Interim Ordnance Cleanup Program Record Search Report, Revision 2, OU 10-05, April 30, 1993.

2. Wyle Laboratories, Interim Ordnance Cleanup Program Remedial Action Work Plan, Revision 3, June 1993.

3. Wyle Laboratories, Interim Ordnance Cleanup Program Remedial Design, Revision 2, April 5, 1993.

4. Wyle Laboratories, Remedial Action Report for the Interim Action to Cleanup Unexploded Ordnance Locations at the INEL (Operable Unit 10-05), Revision 2, April 1994.

5. Weston, Windrow Composting Demonstration for Explosives-Contaminated Soils at the Umatilla Depot Activity, Hermiston, Oregon, Report No. CETHA-TS-CR-93043, U.S. Army Environmental Center.

6. J. Breitung, D. Bruns-Nagel, K. Steinbach, L. Kaminski, D. Gemsa, and E von Low, "Bioremediation of 2,4,6-trinitrotoluene-Contaminated Soils by Two Different Aerated Compost Systems," Applied Microbiology and Biotechnology, Vol. 44, 1996, pp. 795–800.

7. P. G. Thorne and D. C. Leggett, "Hydrolytic Release of Bound Residues from Composted Soil Contaminated with 2,4,6-trinitrotoluene," Environmental Toxicology and Chemistry, Vol. 16, No. 6, 1997, pp. 1132–1134.

8. W. H. Griest, R. L. Tyndall, A. J. Stewart, J. E. Caton, A. A. Vass, C.-H. Ho, and W. M. Caldwell, "Chemical Characterization and Toxicological Testing of Windrow Composts from Explosives-contaminated Sediments," Environmental Toxicology and Chemistry, Vol. 14, No. 1, 1995, pp. 51-59.

9. M. A. Deshusses and G. Hamer, "The Removal of Volatile Ketone Mixtures from Air in Biofilters," Bioprocess Engineering, Vol. 9, 1993, pp. 141–146.

10. T. O. Williams and F. C. Miller, "Odor Control Using Biofilters," Biocycle, October 1992, pp. 72-77.

11. H. Bohn, "Consider Biofiltration for Decontaminating Gases," Chemical Engineering Progress, April, pp. 34–40.

12. R. Kapahi and M. Gross, "Biofiltration for VOC and Ammonia Emissions Control," Biocycle, February 1995, pp. 87–90.

13. R. H. Forbes, T. C. Mendenhall, L. O. Young, and J. D. Schwisow, "Combined Strategies for Odor Control," Biocycle, August 1994, pp. 49–54.

14. G. Leson and A. M. Winer, "Biofiltration: An Innovative Air Pollution Control Technology for VOC Emissions," Journal of Air and Waste Management Association, Vol. 41, No. 8, 1991, pp. 1045–1054.

15. S. P. Ottengraf, "Biological Systems for Waste Gas Elimination," Trends in Biotechnology, Vol. 5, 1987, pp. 132–136.

16. W. Brinton, M. Droffner, and E. Evans, "Standardized Test for Evaluation of Compost Self Heating," Biocycle, November 1995.

17. LMITCO, Quality Assurance Project Plan for Waste Area Groups 1, 2, 3, 4, 5, 6, 7, and 10, INEL-95/0086, Revision 4, March 1995.

18. EPA, Field Sampling and Selecting On-Site Analytical Methods for Explosives in Soil, EPA/540/R-97/501.

19. T. F. Jenkins and C. L. Grant, "Comparison of Extraction Techniques for Munitions Residues in Soil," Analytical Chemistry, Vol. 59, 1987, pp. 1326–1331.

20. EPA, SW846, METHOD 8330.

21. LMITCO, Data Management Plan for the Idaho National Engineering Laboratory Environmental Restoration Program, INEL-95/0257, June 1995.

22. LMITCO, Waste Certification Plan for the Environmental Restoration Program, INEL-96/0043, April 1996.

23. LMITCO, Community Relations Plan for the Idaho National Engineering Laboratory Environmental Restoration Program, no document number, May 1995.

24. MK-Ferguson of Idaho, Engineering Evaluation/Cost Analysis for a Non-Time Critical Removal Action of TNT- and RDX-Contaminated Soil at the Idaho National Engineering Laboratory, DOE Document Number 10.03.2.121.02, Revision 2, June 1994.