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SUPERFUND TREATABILITY CLEARINGHOUSE

Document Reference:

PEI Associates, Inc. "CERCLA BDAT SARM Preparation and Results of Physical Soils Washing Experiments (Final Report)." Prepared for U.S. EPA. Approximately 75 pp. October 1987.

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SUPERFUND TREATABILITY CLEARINGHOUSE ABSTRACT

Treatment Process:	Physical/Chemical - Soil Washing
Media:	Soil/Generic
Document Reference:	PEI Associates, Inc. "CERCLA BDAT SARM Preparation and Results of Physical Soils Washing Experiments (Final Report)." Prepared for U.S. EPA. Approximately 75 pp. October 1987.
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Site Name:	BDAT SARM - Manufactured Waste (Non-NPL)
Location of Test:	ORD - Edison, NJ

BACKGROUND: This study reports on the results of work preparing 30,000 lbs of SARM or synthetic analytical reference matrix, a surrogate Superfund soil containing a wide range of contaminants. It also reports the results of bench scale treatability experiments designed to simulate the EPA developed mobile soil washing system, where various SARM samples were physically washed to determine the efficiency of using chelating reagent, and surfactants to remove contaminants from the SARMs. This work supports the EPA's Superfund Best Demonstrated Available Technology (BDAT) program.
OPERATIONAL INFORMATION: SARMs were developed to support testing of various cleanup technologies in support of the Superfund BDAT program. Superfund sites were surveyed to evaluate the type of soils present and the concentrations of contaminant in the soils. The final soil composition selected consists of 30% clay, 25% silt, 20% sand, 20% topsoil and 5% gravel. A prescribed list of chemicals was added to the soils. The contaminants include volatile and semi-volatile organics, chlorinated organic compounds and the metals Pb, Zn, Cd, As, Cu, Cr and Ni. Four different SARM formulations were prepared containing high and low levels of metals and organics. They will be used by the EPA in subsequent treatability studies.

Different solutions containing SARM samples were tested in bench scale shaker tests to determine the ability of a chelant (EDTA), a surfactant (TIDE) and plain water solvent to remove various contaminants from the fine and coarse fractions of soils. The degree of contamination in both the coarse and fine fraction was determined by TCLP tests and total waste analysis (SW-846, 3rd edition). A QA/QC discussion is contained in the report and a complete QA/QC plan is appended.

PERFORMANCE: After samples were treated on the bench scale shaker table the SARM soils were put through a wet sieve to separate fine from coarse materials and the fractions were analyzed using TCLP tests and total analysis. Tap water was as effective in removing the VOC as the other solutions. The pH and temperature had very little effect on VOC reduction. The semi-volatile organics were removed slightly better by the 0.5% TIDE than plain tap water. A chelant concentration of 3 moles of EDTA to total metals was most effective in removing metals. Chelant reaction time for removal was 15 to 30 minutes. Arsenic and chromium showed the poorest removal efficiencies while Cd, Zn, Cu and Ni were easily chelated by EDTA. The soil is divided into three particle size classes > 2 mm, 2 mm to 250 um and < 250 um. The washes removed contaminants from the two larger classes of soils to levels below the proposed TCLP limits. These soil classes comprise 42% by weight of the SARM and could potentially be classified as non-hazardous and be returned to the site. The contaminated fines could be stabilized and treated further. This study revealed the SARM could be cleaned by soils washing and the contaminated soil volume could be reduced. This report contains an excellent bibliography of soil washing papers.

CONTAMINANTS:

Analytical data is provided in the treatability study report. The breakdown of the contaminants by treatability group is:

Treatability Groups	CAS Number	Contaminants
W01-Halogenated Nonpolar Aromatic Compounds	108-90-7	Chlorobenzene
W03-Halogenated Phenols, Cresols, Ethers, and Thiols	87-86-5	Pentachlorophenol
W04-Halogenated Aliphatic Compounds	107-06-2	1,2-Dichloroethane
	127-18-4	Tetrachloroethene
W07-Simple Nonpolar Aromatics and Heterocyclics	100-42-5	Styrene
	1330-20-7	Xylenes
	100-41-4	Ethylbenzene
W08-Polynuclear Aromatics	120-12-7	Anthracene
W09-Other Polar Organic Compounds	117-81-7	Bis(2-ethylhexyl)phthalate
	67-64-1	Acetone
W10-Non-Volatile Metals	7440-50-8	Copper
	7440-02-0	Nickel
	7440-47-3	Chromium
W11-Volatile Metals	7439-92-1	Lead
	7440-66-6	Zinc
	7440-43-9	Cadmium
	7440-38-2	Arsenic

NOTE: Quality assurance of data may not be appropriate for all uses.

CERCLA BDAT SARM PREPARATION AND RESULTS OF PHYSICAL SOILS WASHING EXPERIMENTS (FINAL REPORT)

VOLUME I

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Work Assignment No. 0-7

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DISCLAIMER

The information in this document has been funded, wholly or in part, by the U.S. Environmental Protection Agency under Contract No. 68-03-3413 (Task No. 0-7) to PEI Associates, Inc. It has been subject to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of solid and hazardous wastes. These materials, if improperly dealt with, can threaten both public health and the environment. Abandoned waste sites and accidental releases of toxic and hazardous substances to the environment also have important environmental and public health implications. The Hazardous Waste Engineering Research Laboratory assists in providing an authoritative and defensible engineering basis for assessing and solving these problems. Its products support the policies, programs, and regulations of the U.S. Environmental Protection Agency (EPA); the permitting and other responsibilities of State and local governments; and the needs of both large and small businesses in handling their wastes responsibly and economically.

The 1984 RCRA Hazardous Substances Waste Act prohibits the continued land disposal of untreated hazardous wastes beyond specified dates. The statute requires EPA to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized."

The current RCRA schedule is to promulgate best demonstrated available technology (BDAT) treatment levels for the first third of the RCRA listed hazardous wastes and Superfund soil and debris by August 1988. This project was divided into two phases; the first involved the identification and preparation of representative standard analytical reference matrix (SARM) samples, and the second involved the evaluation of soil washing technologies for volumetric reduction. These results will be utilized to provide contaminant pretreatment levels for Superfund wastes prior to land disposal.

Thomas R. Hauser
Director
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ABSTRACT

The RCRA Hazardous and Solid Waste Amendments of 1984 prohibit the continued land disposal of untreated hazardous wastes beyond specified dates. The statute requires EPA to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized." The legislation sets forth a series of deadlines at which times further disposal of particular waste types is prohibited if the Agency has not set treatment standards under Section 3004(m) or determined, based on a case-specific petition, that there will be no migration of hazardous constituents for as long as the wastes remain hazardous.

In addition to addressing future land disposal of specific listed wastes, the RCRA land disposal restrictions address the disposal of soil and debris from CERCLA site response actions as well. Sections 3004(d)(3) and (e)(3) of RCRA state that the soil/debris waste material resulting from a Superfund financed response action or an enforcement authority response action implemented under Sections 104 and 106 of CERCLA, respectively, will not be subject to the land ban until November 8, 1988.

Because Superfund soil/debris waste often differs significantly from other types of hazardous waste, the U.S. EPA is developing specific RCRA Section 3004(m) standards or levels for treatment of these wastes. These standards will establish Best Demonstrated and Available Treatment (BDAT) levels through the evaluation of five readily available treatment technologies; namely, soil washing, chemical treatment (KPEG), thermal desorption, incineration, and stabilization/fixation. After November 8, 1988, Superfund wastes in compliance with these regulations may be deposited in land disposal units; wastes exceeding these levels will be banned from land disposal unless a variance is issued.

This report details part of the initial work conducted from April to October 1987 under the Superfund BDAT testing program. In this segment of the program, a surrogate Superfund soil bearing a wide range of chemical contaminants typically occurring at Superfund sites was prepared for use across the board in the BDAT tests (Task 1) and experimental bench tests on physical washing of the soil surrogate were conducted (Task 2).

The surrogate soil is referred to throughout the text as SARM, which is an acronym for Synthetic Analytical Reference Matrix. Under Task 1, more than 30,000 pounds of clean SARM were prepared after considerable research

into the types of soils found at Superfund sites nationwide. The final composition selected consisted of 30 percent by volume clay (a mixture of montmorillinite and kaolinite), 25 percent silt, 20 percent sand, 20 percent topsoil, and 5 percent gravel. The components were air dried to minimize moisture and then mixed together in two 15,000-lb batches using a standard truck-mounted 6-yd^3 cement/concrete mixer.

A prescribed list of chemicals found to be widely and frequently occurring at Superfund sites was then added to the clean SARM in a series of smaller-scale mixing operations using a 15-ft^3 mortar mixer. Organic chemicals added included ethyl benzene, xylene, 1,2-dichloroethane, perchloroethylene, acetone, chlorobenzene, styrene, anthracene, pentachlorophenol, and bis(2-ethylhexyl) phthalate. Salts or oxides of the following metals were also added: lead, zinc, cadmium, arsenic, copper, chromium, and nickel. Because contaminants occur in soils at a wide range of concentrations, four different SARM formulas containing either high or low levels of organics and metals were prepared and delivered to the EPA for use in subsequent treatability tests using the five BDAT technologies noted above. Reserves of each SARM were also packaged and archived for future use. The archived samples are being stored at EPA's R&D facility in Edison, New Jersey.

Under Task 2, samples of each SARM were physically washed in a series of bench-scale experiments designed to simulate the EPA-developed Mobile Soils Washing (MSW) System. This system is capable of extracting certain contaminants from soils, resulting in a volume reduction of the contaminated portion of the soils. Different wash solutions that were evaluated during the bench-scale shaker-table experiments included 1) a chelant solution (tetrasodium salt of EDTA-Dow Chemical Versene 100®) and 2) an anionic surfactant solution (phosphated formulation from Procter and Gamble, Institutional Formula TIDE®). Different pH and temperature conditions were evaluated for the wash solutions. Following the shaker-table wash, the soil solutions were put through a wet sieve to separate the fines from the coarse material. The resulting soil fractions were analyzed to determine the effectiveness of the soil-washing technique in separating a clean coarse fraction from a contaminated fine fraction. The degree of contamination of both fractions was ultimately determined by toxicity characteristic leaching procedure (TCLP) tests and total waste analyses (according to SW-846, 3rd edition). The results indicate that tap water was as effective at removing volatile organics as any of the other wash solutions, pH and temperature variations had little effect on the volatile contaminant reduction efficiencies. Reduction efficiencies for the TCLP volatile organics of up to 99.2 percent were achieved for particles greater than 0.25 mm in diameter. The semivolatile organics were removed slightly better by a 0.5 percent solution of TIDE®, with no pH or temperature adjustments, than by tap water alone. The TCLP semivolatile contaminants were reduced by up to 93.2 percent for soil particles greater than 0.25 mm, after a 0.5 percent surfactant wash. The same particle size class achieved a TCLP semivolatile contaminant reduction of up to 92.9 percent using tap water alone. A chelant concentration of 3:1 moles of EDTA to total moles of metals, without pH or temperature adjustment, proved most effective in reducing the TCLP metal contamination. Reduction efficiencies for the TCLP metals of up to 93.5 percent were achieved for particles greater than 0.25 mm. Since 42 percent of the SARM is greater than 0.25 mm in diameter, a 42 percent reduction (by weight) in contaminated material was achieved through the bench scale soil washing experiments of the SARMS.

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ACKNOWLEDGMENT

This report was prepared by PEI Associates, Inc., Cincinnati, Ohio, as part of the work conducted for the U.S. EPA Hazardous Waste Engineering Research Laboratory (HWERL) under Contract No. 68-03-3413, Work Assignment No. 7. Mr. Richard Traver, of HWERL's Releases Control Branch in Edison, New Jersey, was the EPA Technical Project Monitor.

PEI's S. Robert Cochran and M. Pat Esposito were responsible for managing this project and preparing this report under the direction of Mr. Jack S. Greber, Director of PEI's Waste Management Division. Principal investigators and coauthors included Mr. Cochran and Ms. Esposito, as well as several key individuals, namely Ms. Claudia Furman, Ms. Barbara Locke, Ms. Judy Hessling, Mr. Doug Bailey, Mr. Lou Bruck, and Mr. William Parker.

PEI is very grateful for the technical support and guidance given throughout the course of the work by Mr. Richard Traver of EPA-Edison-HWERL; Mr. John Cunningham, Mr. Jim Antizzo, and Ms. Jennifer Haley of EPA-HQ-OERR; Mr. Robert Thurnau of EPA-Ci-HWERL; Ms. Joan Knapp, Ms. Trish Kenney, and Mr. James Nash of Camp, Dresser and McKee; and Ms. Murial Waller of Converse Environmental. The assistance provided by these professionals is sincerely acknowledged and appreciated.

SECTION 1

INTRODUCTION

The 1984 RCRA Hazardous Substances Waste Act prohibits the continued land disposal of untreated hazardous wastes beyond specified dates. The statute requires EPA to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized."

The legislation sets forth a series of deadlines with hammer provisions. At the deadlines, further disposal of the particular waste is prohibited if the Agency has not set treatment standards under Section 3004(m) or determined, based on a case-specific petition, that there will be no migration of hazardous constituents for as long as the wastes remain hazardous.

The current RCRA schedule is to promulgate best demonstrated available technology (BDAT) treatment levels for the first third of the listed hazardous wastes by August 1988 (all F & K wastes). Since these wastes (and associated constituents) will be subject to the Land Ban at the time Superfund exemption expires in November 1988, they should be included within the scope of Superfund BDAT testing.

Some wastes generated through CERCLA responses are known to be similar to wastes regulated under RCRA; in view of this, the RCRA BDAT research and

results will be directly applicable to these CERCLA wastes and additional research of treatability of these wastes is not included in this effort. However, much of the waste generated during CERCLA responses consists of contaminated soil and debris which is significantly different in nature than most RCRA wastes. Consequently, an evaluation of BDAT for contaminated soil and debris material is necessary for the purposes of CERCLA/SARA compliance with the proposed 1988 Land Ban. These BDAT "treatability" levels are intended to provide the user community with performance information on five technologies: incineration, low-temperature desorption, chemical treatment, physical (washing) treatment, and solidification/stabilization. These target clean levels are reported in toxic contaminant leaching potential (TLCP) format.

1.1 OBJECTIVES

Task 1 of this Work Assignment was to prepare a means for comparison of the five BDAT treatment technologies for contaminated soil and debris, thus allowing an evaluation of BDAT efficiencies and the determination of their treatability levels. In order to accomplish this objective, a reference material "representative of Superfund wastes" was to be prepared. Due to the wide variability of wastes found at Superfund sites, it was determined that for the initial treatability studies four different SARMs would be prepared to more realistically evaluate the technologies that may be used to treat certain types of wastes.

Task 2 of this Work Assignment was to evaluate, using the new SARMs, the EPA-developed Mobile Soils Washing System technology as a means of treating (or pretreating) Superfund site contaminated soils. This BDAT evaluation was

to be conducted using bench-scale components and was to determine the validity of the four assumptions that underlie the volume reduction approach of soils washing, specifically that:

1. A significant fraction of the BDAT SARM contaminants are attached to the silt, humus, and clay particles.

2. The contaminated silt and clay are attached to the sand and gravel by physical processes (primarily compaction/adhesion).

3. Physical cleaning/scrubbing of the sand/gravel/rock fraction will effectively remove the contaminated very fine sand, silt and clay sized (0.1 to 0.002 mm) material from the coarse material.

4. The contaminants will be removed to the same extent that the silt and clay are separated (i.e., increasing the efficiency of the scrubbing process will directly increase the removal efficiency for the majority of the BDAT contaminant mix).

5. Water, with minor additives (i.e., pH, chelates, and surfactants to aid fines migration, etc.) would be the only solvent necessary for this volume reduction.

1.2 SUMMARY OF APPROACH

The technical approach for completion of Task 1 under the Superfund BDAT project is best summarized in terms of the following three subtask work areas:

1) CERCLA data base review and literature search
2) Bench-scale study
3) Full-scale operations

The initial steps of the project involved an extensive research effort and data base review to collect information on soil conditions that are typically found at CERCLA sites, and to identify those chemical contaminants and their concentrations most frequently detected in these soils. With this information, the project peer review team decided on what the composition of the clean soil matrix would be, along with the representative chemicals that would be blended with this soil and their concentrations.

The next step in the approach for Task 1 involved conducting a bench-scale study to 1) determine the specific soil components and their quantities needed to manufacture a clean soil matrix that met the criteria of a "typical" Superfund site soil, and 2) determine the quantities of the representative chemicals that would have to be blended with the soil to reach predesignated SARM contaminant levels.

The final step of Task 1 was the implementation of the full-scale operations during which time 30,000 lb of SARM were blended, packaged, and shipped to several different predetermined locations.

The primary objective of Task 2 is to conduct a bench-scale physical soil washing of the SARM which simulates the EPA-developed Mobile Soil Washing System (MSWS). Therefore, the primary considerations in the design of the physical soil-washing experiments are the operating conditions of the MSWS. PEI, in conjurction with EPA, designed a series of bench-scale shaker-tube experiments which simulate the main components of the MSWS. The bench-scale soil-washing experiments utilized a shaker tube to simulate the drum washer agitation and contact mechanism. This provided the soil-to-solution contact and agitation necessary to mobilize the fines. The soil solution was then poured through a wet sieve containing 10- (2-mm) and 60-mesh (250-μm) screens, and rinsed with a high-pressure water sprayer. This effectively simulated the drum screen and water knife present in the MSWS which provides for maximum physical soil separation. Each soil size (+10-mesh, 10- to 60-mesh, and less than 60-mesh) was then analyzed to determine the level of contaminant removal. The MSWS utilized a 10-mesh screen only; however, the 60-mesh screen was also used in these experiments to determine whether a larger volume reduction can be realized by using a smaller screen.

The analytical plan provides for both prewash and post-wash analysis of all contaminants present in the SARM in each of the three soil size classifications. These analyses will determine the effectiveness of the soil-washing technique for reducing the volume of contaminated material. Furthermore, all three soil size classifications will undergo TCLP analysis to further evaluate the appropriateness of landfilling (over otherwise treating) the soil-washing residues.

SECTION 2

SARM RESEARCH AND PROJECT DEVELOPMENT BACKGROUND

An extensive literature review and compilation of data were performed, as part of this project, to identify those soil types and hazardous constituents that most frequently occur at uncontrolled hazardous waste sites. As part of this background research, the contractor utilized information that had already been collected and reported by EPA/OERR as part of another, ongoing RCRA BDAT development project. The following section discusses the overall research effort conducted in support of the BDAT SARM work, and identifies the basic information and data that were used to develop procedures for both the bench and full-scale operations utilized in preparing the SARM.

2.1 SARM SOIL MATRIX

The background research associated with development of the "clean" soil matrix focused on identifying 1) the critical soil characteristics which would impact removal or treatment efficiencies, and 2) a range of values for those parameters that would meet the objectives of the project. In working toward these goals, the contractor worked closely with EPA/OERR in assessing data that had already been compiled on soil groups found at NPL sites. In addition, the contractor reviewed numerous other sources of CERCLA site information for the purpose of supplementing EPA/OERR's data and conclusions. The following reports and information sources were reviewed:

- "Progress Report for Superfund BDAT Development" (CDM March 1987)

- The Effects of Clay Mineralogy on the BDAT Surrogate Soil Matrix" (CDM April 1987)
- Treatment of Contaminated Soils with Aqueous Surfactants-Interim Report" (Ellis and Payne 9/1985)
- Records of Decision for 151 CERCLA sites
- U.S. Department of Agriculture, Soil Conservation Service data base
- "Cleaning Contaminated Excavated Soil Using Extraction Agents" (Foster Wheeler Corp. 9/1986)
- "Most Frequently Identified Compounds/Metals at Hazardous Waste Sites" (CDM 1987)
- "Patterns of Soil Contamination and Composition on NPL Sites - Draft Summary" (EPA date unknown)

Ten soil parameters were examined and assessed in terms of their quantitative values in real and typical Superfund site soils, and in terms of their potential affect on the five candidate treatment technologies. These parameters were as follows:

- Texture
- Mineralogy
- Cation exchange capacity
- TOC
- pH
- Moisture content
- Permeability
- Porosity
- Density
- Structure

The result of this assessment was the identification of those soil parameters that would be most critical in the SARM development. Once these critical parameters were identified, quantitative values for them were established based on real-world conditions and individual technology capabilities. The following parameters and associated values and/or descriptions served as criteria in the selection of a soil type to be used in the development of the SARM:

- Grain size distribution (texture)
  - 25 to 40 percent sand (mix of fine, medium and coarse)
  - 25 to 40 percent silt
  - 25 to 40 percent clay
  - 5 to 10 percent pebbles and cobbles (no particle to exceed 2-inch diameter)
  - 10 to 15 percent top soil (organic matter included)
- Mineralogy
  - Sands (siliceous) - Clay (either montmorillonite, kaolinite, montmorillonite, kaolinitic, illite)
  - Silt (mixture of sand and clay compositions)

- Cation exchange capacity (CEC): moderate, 30 to 50 meq/100 g
- Total organic carbon (TOC): 3 to 6 percent
- pH: 5.0 to 8.0
- Moisture content: 10 to 20 percent on completion of blending

It should be noted that the grain size distribution criteria presented above were modified during the bench-scale study from percentages by weight to percentages by volume. This modification changed the target soil component distribution to the following:

- 15 to 25 percent sand
- 15 to 25 percent silt
- 20 to 35 percent clay
- 10 to 20 percent topsoil
- 5 to 10 percent gravel

2.2 SARM CHEMICAL CONTAMINANTS

The background research associated with the identification of indicator chemicals or analytes and the target concentrations for use in the SARM's development was conducted by EPA/OERR. The objective of this effort was to identify contaminant groups, and indicator chemicals for those groups, that were most representative of CERCLA/SARA wastes.

The three basic contaminant groups identified as being frequently found in Superfund site soil and debris are volatile organics, semivolatile organics, and metals. The selection of representative analytes for each group was based on an analysis of the physical and chemical properties of each compound. The physical properties examined to aid in selecting representative organic compounds include the following:

- Molecular structure
- Vapor pressure
- Heat of vaporization
- Heat of combustion
- Solubility
- Henry's Law constant

- Partition coefficient
- Soil absorption coefficient

Based on the previously listed properties as defined by EPA/OERR and records of contaminants encountered at Superfund sites, a listing was developed of 48 substances occurring most frequently at Superfund sites.

The next step in the research effort was to evaluate each of the 48 substances and their associated physical properties relative to the affect each would have on the performance of the five selected treatment technologies. The result was a proposed list of compounds that represented the most frequently occurring hazardous compounds at Superfund sites, and that also provided a challenging test matrix for all five treatment technologies. The final list of chemical contaminants chosen for the SARM studies is as follows:

Volatile Organics

Ethylbenzene
Xylene
1,2-Dichloroethane
1,1,2,2-Tetrachloroethylene
Acetone
Chlorobenzene
Styrene

Semi-Volatile Organics

Anthracene
Pentachlorophenol
Bis (2-ethylhexyl) phthalate

Metals

Lead
Zinc
Cadmium
Arsenic
Copper
Chromium
Nickel

Four contaminant formulations or "blends" were then selected for the development of the four SARMs to accommodate the technology limitations and performance of the five selected BDAT technologies:

(1) High organics, low metals
(2) Low organics, low metals
(3) Low organics, high metals
(4) High organics, high metals

The final step in this research process was to examine the levels at which these chemicals have been found at Superfund sites and select concentrations that are representative of contaminated soils and debris. EPA/OERR compiled average concentrations and maximum concentrations of each selected chemical and calculated the percentage of each compound within its group. From these data, target contaminant concentrations for the SARM development were devised. Table 2-1 presents the selected target levels used for the purpose of preparing the four SARMs outlined below:

SARM 1: High levels of organics (20,000 ppm volatiles plus 10,000 ppm semivolatiles) and low levels of metals (1,000 ppm total metals).

SARM 2: Low levels of organics (2,000 ppm volatiles plus 1,000 ppm semivolatiles) and low levels of metals (1,000 ppm total metals).

SARM 3: Low levels of organics (2,000 ppm volatiles plus 1,000 ppm semivolatiles) and high levels of metals (50,000 ppm total metals).

SARM 4: High levels of organics (20,000 ppm volatiles plus 10,000 ppm semivolatiles) and high levels of metals (50,000 ppm total metals).

TABLE 2-1. TARGET CONTAMINANT CONCENTRATIONS FOR SARMS

Contaminant	Ratio, percent	Hi (ppm)	Low (ppm)
Volatiles			
Ethylbenzene	16	3,200	320
Xylene	41	8,200	820
1,2-Dichloroethane	3	600	60
1,1,2,2-Tetrachloroethylene	3	600	60
Acetone	34	6,800	680
Chlorobenzene	2	400	40
Styrene	1	200	20
	100	20,000	2,000
Semivolatiles			
Anthracene	65	6,500	650
PCP	10	1,000	100
Bis (2-ethylhexyl) phthalate	25	2,500	250
	100	10,000	1,000
Metals			
Pb	28	14,000	280
Zn	45	22,500	450
Cd	2	1,000	20
As	1	500	10
Cu	19	9,500	190
Cr	3	1,500	30
Ni	2	1,000	30
	100	50,000	1,000

SECTION 3

BENCH-SCALE SARM BLENDING STUDIES AND RESULTS

A series of bench-scale experiments were conducted at PEI's laboratories to determine 1) the specific component formula for the clean SARM soil, 2) the quantities of contaminants that would have to be added to the clean SARM soil to achieve detectable levels of the contaminants at the designated levels, and 3) the procedures by which the contaminants would be added to the clean SARM during full-scale blending operations. Details of the experiments can be found in Appendix A. Highlights of the studies are presented in this section.

Supplies of various soil components (sand, gravel, silt, top soil, and a variety of clay samples) and target chemicals were brought to PEI's Cincinnati laboratory for the bench-scale studies. Several small batches of synthetic soil were prepared using various proportions of the above materials and analyzed for physical properties such as particle size distribution, cation exchange capacity (CEC), X-ray diffraction, clay composition, total organic carbon (TOC), percent moisture, and pH. Based on the results of these experiments and extensive discussions with EPA and others, the formula shown in Table 3-1 for the clean SARM soil was chosen because it best fit the set of characteristics typified by most Superfund soils.

TABLE 3-1. CLEAN SARM SOIL COMPOSITION

Soil component	Volume %	Weight %
Sand	20.0	31.4
Gravel (No. 9)	5.0	5.7
Silt	25.0	28.3
Top soil	20.0	19.8
Clay	30.0	14.8
- Montmorillonite	(7.5)	(5.4)
- Kaolinite	(22.5)	(9.4)
	100.0	100.0

Analysis of bench-scale preparation of the clean SARM formula shown in Table 3-1 showed the following set of physical properties:

Cation exchange capacity (Na), meq/100 g	30.9, 30.0, 34.5
Grain size distribution,	
weight % sand	48, 48
weight % gravel	7, 6
weight % silt	33, 33
weight % clay	12, 13
TOC, mg/kg	2.7, 3.4
pH	8.0, 8.2
Moisture content	Not analyzed, expected to be less than or equal to 5%

Using small quantities (i.e., 750-g batches) of the clean SARM soil, a series of spiking experiments were conducted to determine the optimum dosages for each contaminant to achieve the desired target levels. This was done largely because of concerns over potential volatile losses during full-scale mixing, and also because of potential inabilities to achieve 100 percent recoveries during analysis. Three samples were spiked at 100 percent of the theoretical target dose, three at 120 percent, and three at 140 percent, for a total of nine samples.

The results of the spiked sample analyses, presented in Table 3-2, indicated that most of the organics would need to be added to the SARM soil at 120 to 140 percent of the theoretical dosage to achieve the desired residual target levels. Acetone would need to be dosed at about 175 percent of theoretical, and 1,2-dichloroethane at 167 percent of theoretical to achieve the desired levels.

Most of the residual metal concentrations were close to target at 120 to 140 percent of theoretical dosage, with two exceptions. Nickel residuals measured only 40 to 50 percent of the desired level, regardless of dosage, and chromium was only detectable at very low ppm levels. This poor result for chromium was believed to be due to the form in which Cr was added (i.e., as Cr_2O_3 anhydrous, and insoluble in the acid digestion procedure used in sample preparation). To correct this situation, a more soluble Cr salt $Cr(NO_3)_3 \cdot 9H_2O$ was purchased for full-scale spiking. No cause for the low nickel residual was determined.

The data also indicated that the styrene target level needed to be increased from 200 to 1000 ppm at the high level and 20 to 100 ppm at the low level. This was necessary to make the styrene detectable during analysis. Apparently, the sample dilution necessary for analysis of the relatively high levels of xylene in the SARM made the styrene undetectable during analysis.

Based on the data in Table 3-2, the doses for each chemical to be added to the clean SARM during full-scale operations were selected. See Table 3-3.

The third phase of the bench-scale experiments was focused on determining the order of addition of chemicals to the clean SARM. Using solubility and compatibility data as guidelines, a series of premixing tests revealed that all of the organics could be premixed together before addition to the

TABLE 3-2. SPIKED SOIL SAMPLE ANALYSIS RESULTS (ppm)

Contaminant	Sample identification and dosage batches									Hi-Hi target levels (100%)
	100% dosage			120% dosage			140% dosage			
	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	
Volatiles										
Ethylbenzene	2,300	2,100	2,800	4,100	3,300	2,100	4,500	6,300	4,500	3,200
Xylene	3,500	3,200	4,400	6,300	5,100	3,300	6,900	9,700	6,900	8,200
Tetrachloro-ethylene	240	210	290	420	330	200	490	690	460	600
Chlorobenzene	200	180	240	360	290	180	400	560	400	400
Acetone	2,700	2,500	2,000	2,300	2,300	1,900	3,500	3,800	3,700	6,800
1,2-dichloro-ethane	180	130	170	280	190	120	350	470	340	600
Styrene	<63	<63	<100	<100	<100	<100	<120	<170	<170	200
Semivolatiles										
Anthracene	5,800	3,800	6,000	5,500	4,600	4,500	4,400	4,400	4,600	6,500
Bis (2-ethyl-hexyl) phthal-ate	610	1,600	1,500	1,100	1,600	1,800	2,300	2,500	2,800	2,500
Pentachloro-phenol	320	560	550	470	630	790	790	730	790	1,000
Metals										
Lead	13,700	11,100	10,800	14,400	15,200	15,400	15,200	14,700	21,500	14,000
Zinc	18,100	16,300	15,500	21,500	22,100	22,400	23,600	22,900	24,500	22,500
Cadmium	880	598	543	863	1,760	862	852	779	871	1,000
Arsenic	393	270	274	232	446	420	466	428	428	500
Copper	9,870	5,920	5,220	9,010	9,250	8,790	8,200	7,720	8,420	9,500
Nickel	524	367	336	549	550	537	516	483	521	1,000
Chromium	7	6.6	6.8	5.5	6.9	7.4	7.2	13.6	7.9	1,500

TABLE 3-3. FULL-SCALE CHEMICAL DOSES

Chemical	Dose % (of theoretical)
Ethylbenzene	120
Xylene	120
Tetrachloroethylene	140
Chlorobenzene	140
Acetone	175
1,2-dichloroethane	167
Styrene	500
Anthracene	100
Bis(2-ethylhexyl)phthalate	140
Pentachlorophenol	100
Pb (as $PbSO_4$)	120
Zn (as ZnO)	120
Cd [as $3Cd(SO_4)\cdot 8H_2O$]	130
As (as As_2O_3)	150
Cu (as $CuSO_4$)	140
Ni [as $Ni(NO_3)\cdot 6H_2O$]	120
Cr [as $Cr(NO_3)_3\cdot 9H_2O$][a]	100

[a] Changed form of Cr from Cr_2O_3 to $Cr(NO_3)_3$ because Cr_2O_3 was virtually insoluble during the analytical procedure and only detectable at very low ppm levels

SARM, except for the anthracene, which would have to be added in its dry powder form. The soluble metal salts of nickel nitrate, copper sulfate, cadmium sulfate, and chromium nitrate could be predissolved in water and added as a solution to achieve optimal distribution throughout the SARM. However, the insoluble metals compounds of arsenic trioxide, lead sulfate, and zinc oxide would have to be added in dry form as powders.

Another series of bench-scale tests were conducted to determine the optimal mixing order for preparing the SARM. That is, we wanted to know:

- Whether chemicals should be added to the soils, or soils added to the chemicals
- Whether chemicals should be applied to certain soil fractions (e.g., to the sand or clay fraction) before being blended with the remainder of the soil matrix
- The method of chemical application to the soil (e.g., sprayed, poured)
- The order of application (e.g., organics first, followed by metals, or visa versa)

The results of this series of bench tests led to the following conclusions for full-scale mixing procedures:

1) Chemicals would be added to the soil (not visa versa) as the mixing blades turned.
2) Liquids would be slowly added as a spray or in small droplets, to avoid a "balling-up" effect on the soil.
3) Dry chemicals would be added first and allowed to mix thoroughly.
4) The inorganic liquid chemical mixtures would be added next and allowed to mix thoroughly.
5) The liquid organic mixture would be added last, and the mixing time following addition of the liquid organics would be held to a minimum (e.g., about 2 minutes for subsequent small, bench-scale preparations of SARM, and 5 to 15 minutes for full scale).

Following completion of the bench-scale tests, a procedures plan for full-scale SARM preparation was written and submitted to the TPM for approval. It was closely followed throughout the full-scale operations, although some alterations had to be made. The procedures manual can be found in Appendix E.

SECTION 4

FULL-SCALE SARM PREPARATION

4.1 OBJECTIVE AND SUMMARY

The objective of the full-scale SARM blending operation was to prepare the following quantities of SARMs for use by the five EPA-selected BDAT technologies and archiving for possible future use (Table 4-1).

TABLE 4-1. QUANTITIES AND USE OF SARM SAMPLES

BDAT	(SARM 1) High organics,[a] low metals[b] (lb)	(SARM 2) Low organics,[c] low metals (lb)	(SARM 3) Low organics high metals[d] (lb)	(SARM 4) High organics high metals (lb)
Incineration	12,000	12,000	0	0
Stabilization	100	100	100	100
Thermal desorption	50	50	50	50
Chemical treatment	50	50	50	50
Physical treatment	50	50	50	50
Archive	500	500	500	500
Other reserve	<250	<250	<250	<250
Totals	13,000	13,000	1000	1000

[a] 20,000 ppm volatile organics plus 10,000 ppm semivolatile organics.

[b] 1,000 ppm total metals.

[c] 2,000 ppm volatile organics plus 1,000 ppm semivolatiles organics.

[d] 50,000 ppm total metals.

The full-scale operations were conducted in two phases:

- Phase I - Mixing of Clean Soil Matrix
- Phase II - Blending of SARM Samples

Phase I included mixing a total of 30,710 pounds of soil components into a homogeneous soil matrix. This was done at the Oeder Sand and Gravel Company, located in Morrow, Ohio on July 4 and 5, 1987. The clean soil mix was packaged in clean, epoxy-lined 55-gallon, open-head steel drums (500 ±0.5 pounds of soil each) and shipped to EPA's Center Hill Research Facility, where Phase II was conducted. Phase II entailed the blending of the clean soil matrix with the selected chemical contaminants, yielding the four SARMs. This work was completed over a 4-week period (July 13 through August 10, 1987). The procedures plan (Appendix E) developed under the bench-scale phase of this project was closely followed over the course of full-scale operations, although some adjustments were necessary, as described in the following subsections.

4.2 PHASE 1 - MIXING OF CLEAN SOIL MATRIX

A total of 30,710 pounds of soil matrix components were mixed together to form the soil matrix that was used for the preparation of the SARM samples. Table 4-2 indicates the source and quantity of each soil component that was used in the full-scale soil mixing. A cement mixer, having a rated capacity of 6 cubic yards, was used to blend the soil in two identical 15,355-lb batches (subsequently referred to as Batches 1 and 2).

For each 15,355-pound batch the components were either weighed using a commercial truck scale (±20 pounds) or preweighed by the supplier (commercially-prepared and bagged clays). Bulk materials (sand, gravel and top soil) were transferred into the cement mixer by means of a conveyor-belt

lift. The clay components were added directly to the mixer from 50-lb bags. The soil components were then mixed, by normal rotation of the mixer, for approximately 1 hour. Following the thorough mixing, the clean soil matrix was dispensed into 55-gallon drums to 500 ±0.5 pounds net weight.

TABLE 4-2. SOIL COMPONENT QUANTITIES FOR FULL-SCALE

Soil component	Total quantity[a] (lb)	Quantity per batch	Source/location
Gravel (No. 9)	1,760	880	Oeder Sand & Gravel Co./Morrow, OH
Sand	9,680	4,840	Oeder Sand & Gravel Co./Morrow, OH
Silt	8,680	4,340	Oeder Sand & Gravel Co./Morrow, OH
Clay			
- Bentonite	1,650	825	American Colloid Co./Skokie, IL[b]
- Kaolinite	2,900	1,450	Charles B. Chrystal & Co./Brooklyn, NY[c]
Topsoil	6,400	3,020	Oeder Sand & Gravel Co./Morrow, OH
	30,710	15,355	

[a] Quantities based on the following recipe: gravel - 5.7%; sand - 31.47%; silt - 28.29%; bentonite clay - 5.37%; kaolinite clay - 9.35%; top-soil - 19.81%. Recipe finalized by peer review committee on 6/16/87.

[b] Actual source of bentonite is Mississippi.

[c] Actual source of kaolinite is Georgia.

Representative samples of clean soil were collected for analysis to confirm homogeneity of the physical and chemical characteristics of the soil mix. Five samples were collected at random from each batch (for a total of 10 samples) and analyzed for cation exchange capacity (CEC); three of the five samples collected at random from each batch (a total of six samples) were also analyzed for grain size distribution, TOC, and pH. The results of these analyses are presented in Table 4-3. One of the samples was analyzed

for the hazardous substance list (HSL) to identify any contaminants that may have been present in the soil prior to the SARM blending operation. Results of this analysis are presented in Appendix E. Organic analyses showed no volatile or semivolatile compounds at the µg/kg level; metals analysis showed appreciable quantities of iron, potassium, aluminum, calcium, and magnesium (as would be expected), but no substantial amounts of the more toxic metals (e.g., chrome, nickel, lead, zinc). In other words, the clean SARM is free of anthropogenic contamination.

TABLE 4-3. RESULTS OF CLEAN SOIL MATRIX HOMOGENEITY ANALYSES

Sample	1	2	3	4	5	6	7	8	9	10
Batch No.	1	2	2	1	1	2	2	1	1	2
CEC meq/100 g	117.5	152.5	150	150	77.5	150	155	80	147.5	147.5
TOC %	3.2	3.9	3.0	3.8	2.8	2.7	-[a]	-	-	-
pH S.U.	8.0	9.0	8.5	8.5	9.0	8.0				
Grain size distribution %										
Gravel	3	2	4	3	2	3	-	-	-	-
Sand	55	57	58	54	56	57	-	-	-	-
Silt	29	30	27	30	28	27	-	-	-	-
Clay	13	11	11	13	14	13	-	-	-	-

[a] "-" = Sample not analyzed for parameter

4.3 PHASE 2 - BLENDING OF SARM

4.3.1 Preparation Activities

Phase 2 of the full-scale operation involved the blending of various amounts of chemicals with the clean soil matrix to form the four different SARM blends. Prior to the actual blending operations, facilities and equipment were made ready during the weeks preceding the July 13, 1987 starting date. A containment shed was constructed to provide shelter from the elements, security for the equipment, and containment of chemicals and contaminated materials. See Figure 4-1 for a floor plan of the containment shed and

surrounding area. A 16-cubic-foot mortar mixer was delivered to the site and modified by installing a 5-horsepower explosion-proof electric motor, amd mounted on an elevated stationary foundation; the grated cover was replaced with a solid, hinged cover. Work benches were built inside the shed, a custom fume hood was constructed around the mixer, and explosion-proof wiring installed and inspected. An exhaust fan (100 ft^3/min) and activated carbon filter were installed to ventilate the fume hood and clean the air of fugitive volatile and dust emissions from the mixer. The fume hood was completely lined with polyethylene film to facilitate decontamination at decommissioning of the site. The floor of the shed was covered with vinyl flooring and all joints and edges were sealed, to aid in containment in the event of a spill.

Two drums of clean sand were brought to the site and used in a "dry run" of the mixing procedure. The results of this test identified certain changes that were necessary before attempting the first SARM preparation. Among these were the installation of masonite sheeting over the vinyl flooring, to provide physical protection from the drums and the drum-handling equipment, a change in the planned drum-handling procedure, and a reduction of the anticipated number of batches to be completed each day.

The clean soil matrix (Phase 1, Section 4.2) was delivered to the Center Hill, facility in 55-gallon drums on July 7. A licensed hazardous waste transport trailer (Tonawanda Tank Transport) was delivered to the site to be used for temporary storage of the SARMs and eventual shipment of 24,000 pounds of SARMs to the John Zink Co. incineration facility in Tulsa, Oklahoma. A front-end loader (CASE 1835), to be used for handling drums outside the shed, was rented for the duration of Phase 2. Chemicals necessary to begin

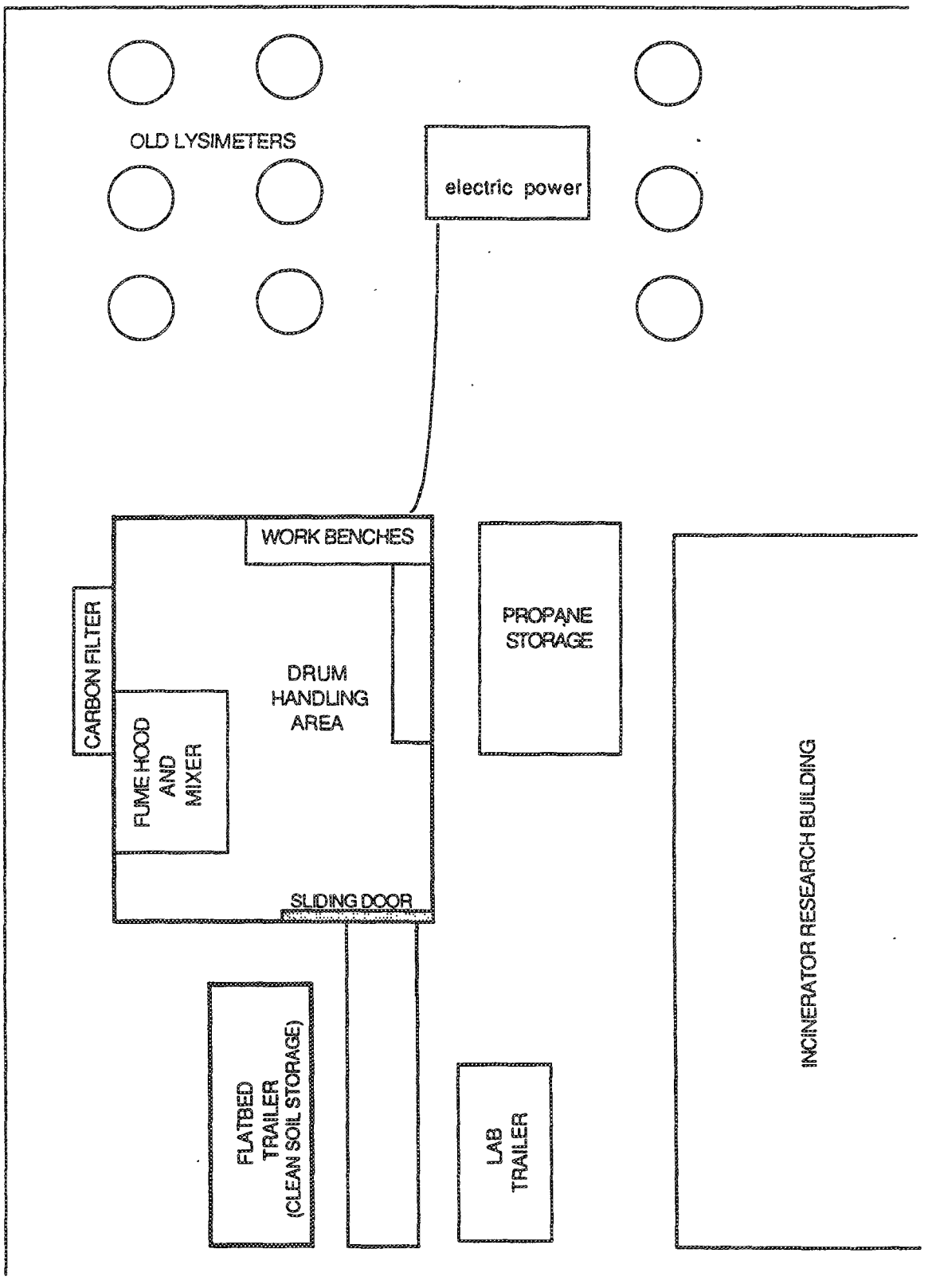


Figure 4-1. SARM Site Diagram.

SARM blending were in storage at Center Hill from the beginning of bench-scale development.

4.3.2 Full-Scale Chemical Quantities and SARM Mixing Time

Table 4-4 indicates the target high and low contaminant concentrations for the SARM samples [reflecting revised (increased) styrene target levels]. The quantities of each chemical that were added to each 500-pound batch to achieve the target concentrations of the four SARMs (as determined through bench-scale testing) are presented in Table 4-5. Section 4.3.3 discusses the various premixtures of chemicals that were prepared before being added to the soil, and the specific blending procedures that were followed over the course of the full-scale operation.

The mixing time necessary to achieve a homogenous blend of soil and chemicals was determined during the preparation of the first SARM batch (SARM-IV-1). This determination was made based on the results of analyses of a series of samples collected at mixing-time intervals of 6, 12, and 18 minutes following the addition of all contaminants. Six samples were collected after each 6 minutes of mixing and analyzed for copper, lead, and purgeable organic carbon (POC).

The analytical results obtained for the 6-, 12-, and 18-minute samples (Table 4-6) indicated no statistically significant difference between the sets and 12 minutes was selected as the mix duration for all remaining SARM batches. A summary of this statistical analysis is presented in Appendix B.

4.3.3 SARM Blending Activities

The chemicals used during the full-scale SARM blending operations were transferred from the designated flammable materials storage vault (located at the Center Hill facility) to the mixing shed for premixing prior to their addition to the soil matrix. As determined during the bench-scale SARM

TABLE 4-4. TARGET HIGH AND LOW CONTAMINANT CONCENTRATIONS FOR SARM SAMPLES

Contaminant	Proportions (%)	High (ppm)	Low (ppm)
Volatiles			
Ethylbenzene	15	3,200	320
Xylene	39	8,200	820
1,2-Dichloroethane	3	600	60
1,1,2,2-Tetrachloroethylene	3	600	60
Acetone	33	6,800	680
Chlorobenzene	2	400	40
Styrene[a]	5	1,000	100
	100	20,800	2,080
Semivolatiles			
Anthracene	65	6,500	650
PCP	10	1,000	100
Bis (2-ethylhexyl)Phthalate	25	2,500	250
	100	10,000	1,000
Metals			
Lead (Pb)	28	14,000	280
Zinc (Zn)	45	22,500	450
Cadmium (Cd)	2	1,000	20
Arsenic (As)	1	500	10
Copper (Cu)	19	9,500	190
Chromium (Cr)	3	1,500	30
Nickel (Ni)	2	1,000	30
	100	50,000	1,000

[a] Styrene levels were increased five-fold at the recommendation of PEI's analytical lab to make styrene detectable during analysis. The relatively high levels of xylene were masking styrene GC peaks at the previously recommended levels of 200 and 20 ppm. See Page 3-3.

TABLE 4-5. CHEMICALS ADDED PER 500-POUND MIX

Contaminant	High concentrations	Low concentrations
	(SARM I, IV)	(SARM II, III)
Volatiles		
Acetone	3,408 ml	341 ml
Chlorobenzene	115 ml	12 ml
1,2-Dichloroethane	181 ml	18 ml
Ethylbenzene	1,005 ml	100 ml
1,1,2,2-Tetrachloroethylene	119 ml	12 ml
Styrene	249 ml	25 ml
Xylene	2,595 ml	260 ml
Semivolatiles		
Anthracene	1,475 g	147 g
Bis(2-ethylhexyl)phthalate	806 ml	81 ml
Pentachlorophenol	227 g	23 ml
	(SARM III, IV)	(SARM I, II)
Metals		
As_2O_3	225 g	4.5 g
$3CdSO_4 \cdot 8H_2O$[a]	670 g	13.4 g
$CuSO_4 \cdot 5H_2O$	11,875 kg	237.5 g
$Cr(NO_3)_3 \cdot 9H_2O$[a]	2,620 g	52.4 g
$Ni(NO_3)_2 \cdot 6H_2O$[a]	1,345 g	26.9 g
$PbSO_4 \cdot PbO$	4,835 g	96.7 g
ZnO	7,635 g	152.5 g

[a] Water-soluble compound.

TABLE 4-6. SOIL MIXING TIME RESULTS

	Zinc, mg/kg Mixing time - min.			Copper, mg/kg Mixing time - min.			Total organic compounds, µg/g[a] Mixing time - min.		
	6	12	18	6	12	18	6	12	18
	16,083	15,801	18,262	9,589	9,799	9,744	2,490	13,300	9,390
	12,766	18,481	14,010	8,412	11,191	8,238	3,010	2,410	9,930
	11,876	14,373	16,956	6,923	9,326	9,678	1,350	3,965	7,260
	17,463	17,150	12,896	9,974	10,105	7,583	3,540	9,540	14,000
	16,555	15,738	15,842	10,707	10,001	9,694	2,080	6,160	3,590
	10,725	11,974	16,276	7,100	7,113	9,752	5,470	3,690	5,155
Mean	14,245	15,586	15,374	8,784	9,589	9,115	2,990	6,511	8,221
Standard deviation	2,802	2,254	1,570	1,562	1,360	956	1,430	4,163	3,727
Coefficient of variation	0.197[b]	0.145	0.102	0.178	0.142	0.105	0.478	0.639	0.453
Overall mean		15,068			9,163			5,907	
Standard deviation		2,254			1,317			3,330	
Coefficient of variation		0.150			0.144			0.564	

[a] As purgeable organic carbon (POC). POC of uncontaminated (clean) soil was 10.7 µg/g.

[b] Coefficient of variation (CV) = standard deviation ÷ mean.

NOTE: Metal analyses were done by EPA-Cincinnati; POC by PEI Laboratory.

activities, chemicals could be premixed as three contaminant mixtures and one, single chemical additive. These four additives were as follows:

Additive No. 1 - a dry mixture of insoluble metal powders consisting of arsenic trioxide (As_2O_3), lead sulfate ($PbSO_4$), and zinc oxide (ZnO)

Additive No. 2 - anthracene (insoluble dry solid)

Additive No. 3 - an aqueous solution of nickel nitrate [$Ni(NO_3)_2 \cdot 6H_2O$)], copper sulfate [$CuSO_4 \cdot 5H_2O$], cadmium sulfate [$3CdSO_4 \cdot 8H_2O$], and chromium nitrate [$Cr(NO_3)_3 \cdot 9H_2O$]

Additive No. 4 - a mixture of organic liquids consisting of ethylbenzene, xylene, 1,2-dichloroethane, 1,1,2,2-tetrachloroethylene, acetone, (mono) chlorobenzene, styrene, bis(2-ethyhexyl)phthalate and dissolved pentachlorophenol.

Using the quantities presented in Table 4-5, Additive Nos. 1, 3, and 4 were prepared prior to beginning each SARM batch. Additive No. 2 required no preblending.

These premixes were prepared in a number of different ways during the course of SARM preparation. Each method is believed to yield equivalent results and merely reflect lessons of time/motion management and practical application learned during the mixing operations.

The metal oxide mixtures (Additive No. 1) were exclusively prepared by weighing out the appropriate amount of each compound for each 500-pound batch. These compounds were then added to the dry soil prior to the addition of any liquid component. Similarly, anthracene (Additive No. 2) was weighed and added to the dry soil.

Initially, dry soil was placed in the mixer and the mixer turned on. With the mixer turning the dry soil, all dry chemical additives were placed into the mixer and allowed to distribute themselves. This procedure proved to be devastating to the mortar mixer (designed to mix wet components) and was not followed during any subsequent batches.

The aqueous metal solutions (Additive No. 3) were prepared by dissolving the appropriate mass of each water soluble ingredient in a minimal amount of water in an appropriately sized container (55 gallons for high metal, 1/2 gallon for low metal batches). The contents were stirred and water added, as necessary, until the salts were completely dissolved. During the first few batches, this aqueous metal solution was added to the dry soil (and metals) already in the mixer. It was later determined that this was also detrimental to the equipment by creating binding and another change in procedure was effected.

Alternately, solid soluble salts for low-metal SARM were added directly to approximately 10 gallons of water already in the mortar mixer and allowed to dissolve in it with the aid of agitation by the turning mixer blades. Following sufficient time to dissolve the metal salts, the dry soil/dry chemical mixture was slowly added to the mixer and homogenized.

Additive No. 4, the liquid organic mixture, was prepared by combining the appropriate amounts of acetone, bis(2-ethylhexyl)phthalate, styrene, ethylbenzene, monochlorobenzene, xylene, dichloroethane, and 1,1,2,2-tetrachloroethylene to which the solid pentachlorophenol was lastly added and dissolved. The organic premixes (No. 4) for low organic SARM were premixed in assembly-line fashion, measuring and placing the appropriate volume (converted from mass by density) of each chemical in a number of 1/2 gallon glass jars (usually 6 to 12). The entire contents of one jar was then added to each 500-pound batch.

The organic premixes for "high-organic" SARM were prepared by measuring an appropriate amount of each chemical to complete a specified number of 500-pound batches and placing them in a closed end 55-gallon drum. Following

thorough mixing by agitation of the drum, the necessary weight of premix No. 4 was pumped out of the drum and placed, temporarily, in a 5-gallon pail. The premixed, preweighed portion of organic chemicals were then poured into the mixer at the appropriate time.

4.4 SARM PACKAGING AND SHIPPING

A total of 28,000 pounds of SARM samples were prepared over the course of the full-scale blending operation. Twenty-seven thousand pounds were packaged for BDAT testing and archiving. The remaining 1000 pounds were packaged and shipped to a RCRA permitted facility for disposal.

Following the blending of contaminants with the soil fraction, each SARM batch was placed into various packages appropriate for shipment to the testing locations and to the archive storage facility. Twenty-four thousand pounds of SARM I and II (12,000 pounds each) were packaged in 48, 55-gallon epoxy-lined open-head steel drums (500 lb per drum). One thousand pounds of SARM were packaged in 20 5-gallon steel pails and 2000 pounds of SARM were packaged in 400 half-gallon glass jars.

The modified mortar mixer has a pour-spout that facilitated dumping the SARM directly into the 55-gallon drums. Drums were immediately closed, sealed, and labeled. When staged drums were filled, the SARM-filled drums were moved to the storage/shipping trailer and drums of clean soil were moved into the mixing shed in preparation for mixing the next set of SARM batches.

The pour-spout of the mixer was used to fill a few of the 5-gallon pails; however, a shovel was subsequently used to fill these, either directly from the mixer or from a 55-gallon drum.

The 400 5-pound SARM archive samples were placed in sample containers either by hand or by using stainless-steel and plastic scoops. The jars were then cleaned, closed with Teflon-lined lids, labeled, and sealed. One hundred, 0.5-gallon jars were filled with each SARM type. These samples were shipped to EPA's research facility in Edison, New Jersey, where archiving and distribution will be controlled.

Transportation, consignee, and amounts of SARM samples to be shipped to testing locations and archiving are presented in Table 4-7.

TABLE 4-7. LOCATIONS, QUANTITIES TO BE SENT, AND TRANSPORTATION OF SARMs

SARM destination	Number	Size	Transport mode
Incineration			
Jake Cambell John Zink Co. Tulsa, OK	48	55 gal	Contract trucking
Stabilization	8	5 gal	PEI special delivery
Acurex Corp. Leo Weitzman Durham, NC			
Thermal desorption	4	5 gal	PEI special delivery
Robert Fox IT Corp. 312 Directors Road Knoxville, TN			
Chemical treatment	4	5 gal	PEI special delivery
Dr. Thomas O. Tiernan Brehm Laboratory Wright State University Dayton, OH			
Physical treatment	4	5 gal	PEI special delivery
Ms. Barb Locke PEI Associates Edison, NJ			Common Carrier
Archiving	400	0.5 gal	PEI special delivery
Ric Traver EPA-HWERL Edison, NJ			

4.5 COMPLICATIONS AND FINAL MIXING PROCEDURE

During the startup of full-scale mixing procedures, much of the work was of a novel nature and the untested procedures used to accomplish the SARM preparation were understood, from the outset, to be flexible. Some of the complications encountered during the early phases of full-scale mixing have been mentioned earlier. Details of these and other complications are presented in the remainder of this section along with the changes in procedure that overcame the problems.

During the initial "dry run," sand was used to test the power of the mortar mixer's electric motor and belt-drive mechanism. One-thousand pounds of sand were slowly added to the running mixer, which easily turned the full charge of sand. The mixer was then turned off, allowed to come to a complete stop, then switched on again, to determine if it could be started from a dead stop. This was found to be possible and the initial SARM batch was planned for a 1000-pound mix.

One-thousand pounds of dry soil was placed into the mixer, the dry metal oxides and anthracene were added and the mixer was turned on. The mixer turned easily and the chemical addition proceeded with the metal salts in aqueous solution. The solution was pumped from a 55-gallon drum to a holding tank mounted on the wall beside the fume hood (Figure 4-1), from which it flowed through a Teflon tube, and into a spray-bar mounted on the inside of the mixer lid. A leak became apparent, caused by the spray striking the underside of the mixer cover and running to its edge, from where it dripped to the floor behind the mixer. The mixer was turned off to reposition the spray bar and when the mixer was turned on again, it would not turn the now-wet soil. The mixer was emptied of more than half its load and turned

on, again with no restart. The mixer was then completely emptied and preparations were made to complete the initial 1000-pound mix as two 500-pound mixes. One 500-pound mix was completed without further difficulty including the use of the injection spray-bar and holding tank for the addition of the organics solution.

The second 500-pound mix was begun and the spray bar promptly clogged with scale believed to be caused either by corrosion by the metals solution or from galvanic plating of metals from the solution. Upon further inspection of the feed system, most other components had either been severly corroded, plated, or attacked by the high-concentration metals solution or the aggressive solvent mixture passed through it. The decision was made to add the solutions manually, rather than risk a major leak or spill resulting from deteriorating materials.

During the second 500-pound batch, the mixer encountered mechanical problems. These problems were attributed to misalignment of chain, gears, and pulleys, believed to have been loosened during the first 1000-pound mix attempt. The gears were realigned and the mix completed. The decision to limit further mixing to 500-pound batches was reached, owing to the damage done to the mixer during the first mix as identified during mechanical repair of the mixer.

The soils and dry chemical had been added to the mixer, prior to the addition of any liquids, in both batches completed thus far. Dry soil and chemicals were added to the mixer for the third batch and the mixer turned on. The mixer turned freely for approximately 10 minutes then seized promptly upon the addition of 2 gallons of the aqueous metal solution. The mixer

was emptied by hand and a dry, hard scale of silty dirt was found to be packed against the rear of the mixer tub. The scale had obvious rubber burns from the pads on the mixer blades and the blades were twisted around the square center-axle of the mixer, indicating the extreme torque that had been applied to the blades. This condition was attributed to the fact that the mixer was designed for mixing wet materials, and the low moisture content of the low metals SARM was insufficient for the mixer to work properly.

The decision was made to first place approximately 7 to 10 gallons of water in the mixer tub, which was then used to dissolve the metal salts for each SARM batch. To this solution, the soil from one drum and the premixed dry chemicals for a 500-pound batch were slowly added, yielding a wet slurry that the mixer was capable of turning. To this slurry was added the organic solution, the mixer lid and fume-hood doors closed, and the 12-minute count begun. This procedure continued through the remainder of full-scale mixing with the exception of two 1000-pound batches that were completed using the most recent procedure. It was determined that too much stress was placed on both the equipment and personnel, and no more 1000-pound batches were made.

Although work typically began at 5:00 a.m., ambient temperatures during the work day averaged above 90 degrees and work often continued until mid to late afternoon. The physical and mental stress of working long hours in Levels B and C protective clothing, breathing supplied air or wearing air-purifying respirators, and the labor necessary to move, lift, dump and pack 500-pound batches of chemically-hazardous materials kept productivity to a maximum of 3,500 pounds per day. A number of days were spent producing only 500 to 1,500 pounds and on a few days no SARM samples were produced at all.

4.6 WASTE HANDLING PRACTICES

Contaminated waste materials generated during the full-scale blending activities were containerized in DOT 17E open-head drums over the course of the operation. Upon completion of the full-scale field activities, all containerized waste materials; e.g., spill cleanup materials, absorbents, protective clothing, decontamination materials, spilled chemicals, etc., were labeled as hazardous waste, and arrangements are being made for its proper disposal.

4.7 SITE DECOMMISSIONING

During the preparation of the SARMs, there were no spills or accidents of significance. Minor spills occurring during measuring or addition of SARM chemicals were either immediately contained in selected containment areas or devices or were cleaned up using sorbent materials, scoops and shovels. These containment and cleanup materials were codisposed with other contaminated materials generated during the SARM preparation. Prepared SARM spilled during transfer from mixer to containers was immediately picked up and placed either back into the mixer or into the SARM containers. Minor amounts of leftover SARM was placed in waste drums for disposal along with other hazardous wastes.

The site (including shed, entry portal, trailer parking areas, electrical supply, etc.) will be returned to its original condition. This will entail removal, packaging, manifesting, and disposal of contaminated building and cleanup materials. The mixer has been decontaminated by removing gross contamination followed by water and solvent rinses; it was then reattached to its

trailer mounting for further use by EPA staff at the Center Hill facility. Demolition of the building should proceed in a manner such that reusable portions will be saved; all other materials that are either unusable, impractical, or impossible to decontaminate will be disposed of as solid waste and/or hazardous waste, as appropriate.

Final inspection of the site will be requested of Center Hill Research Facility officials to assure that the cleanup and decommissioning is to their reasonable satisfaction.

4.8 ANALYTICAL PROFILE OF FULL-SCALE SARM PRODUCTS

Under the BDAT testing program, samples of the various SARMs are being analyzed for contaminant concentrations, TCLP, moisture content, and other parameters. Most of these results are not yet available; they will be added to this section at a later date.

An analysis of moisture content of the SARM samples provided for soil washing BDAT testing yielded the following results:

SARM	Dean Stark Distillation, % water (H_2O)	Oven dry % moisture (H_2O + volatile organics)
I	19.6	22.9
II	6.2	7.2
III	18.6	20.6
IV	-	30.1

The low moisture content for the SARM II sample provided to the soil washing test program is believed to be accurate because this sample was taken from Batch 1 of SARM II, to which only a small amount of water was added (i.e., only enough to dissolve the low level of metal salts). All subsequent batches of SARM II were prepared using a higher water content, similar to that added to the other SARM formulas.

Data generated as part of the Superfund BDAT test program on the four SARMs are given in Tables 4-8 through 4-11.

These limited data suggest that the metal levels achieved were reasonably close to the targets. Many of the organic levels were lower than desired; reasons for the low organic results may include poor recovery efficiencies, analytical detection limitations or error, losses of volatiles during SARM preparation and storage, or low spiking initially in preparation of the SARM. Further conclusions as to the validity and representativeness of the available organic data are reserved pending the full receipt of data on the untreated SARMs from the BDAT technologies.

TABLE 4-8. ANALYTICAL PROFILE OF SARM I, MG/KG

Analyte	Target	R. Thurnau[a] (thermal desorption)	E. Barth[b] (stabilization)	R. Thurnau[c] (incineration)	C. Rogers[d] (KPEG)
Volatiles					
Acetone	6800	5450	2700, 3600	3300, 2700, 6000	
Chlorobenzene	400	355	330, 260	340, 360, 240	
1,2-dichloroethane	600	390	400, 360	450, 340, 140	
Ethylbenzene	3200	3600	3600, 3100	3600, 4000, 2400	
Styrene	1000	695	770, 650	770, 810, 580	
Perchloroethylene	600	470	650, 560	ND, 350, 260	
Xylene	8200	5850	3800, 4500	5800, 6000, 4000	
Semivolatiles					
Anthracene	6500	4300	780, 1100		
Phthalate	2500	2800	460, 740		
Pentachlorophenol	1000	220	160, 110		
Metals					
Arsenic	10	13		17, 17, 20	20
Cadmium	20	22		26, 25, 27	45
Chromium	30	26		24, 33, 39	30
Copper	190	242		244, 268, 261	349
Lead	280	239		261, 296, 292	304
Nickel	30	24		28, 30, 27	68
Zinc	450	458		459, 551, 526	1028

[a] Data generated under EPA Contract No. 68-03-3389, Task 5, R. Thurnau Project Officer, PEI Contractor, IT Corporation Subcontractor (lab) - data given is on wet weight basis.

[b] Data generated under EPA Contract No. 68-03-3241, Task 2-18, E. Barth Project Officer, Acurex Contractor and Hittman-Ebasco (lab) under EPA Contract No. 68-01-7280, R. Thurnau, P.O.

[c] Data generated under EPA Contract No. 68-03-3389, Task 7, R. Thurnau, P.O., PEI Contractor, Radian Corporation (lab).

[d] Organic data generated under EPA Contract No. 68-03-3413, Task 6, C. Rogers, P.O., PEI Contractor, Wright State Subcontractor (lab) - data given is on wet weight basis.

Metals data generated under EPA Contract No. 7C3072 YAWE, Subcontract No. 4-87-1-0275, T. D. Ferguson, P.O., Analytical Enterprises, Inc. Subcontractor - data given is on wet weight basis.

TABLE 4-9. ANALYTICAL PROFILE OF SARM II, MG/KG

Analyte	Target	R. Thurnau[a] (thermal desorption)	E. Barth[b] (stabilization)	R. Thurnau[c] (incineration)	C. Rogers[d] (KPEG)
Volatiles					
Acetone	680	430	180, 250, 260	680, 570, 270	
Chlorobenzene	40	6.6	9.2, -, -	22, 6.9, 30	
1,2-dichloroethane	60	1.3	3.2, 4.2, 4.2	13, 3.5, 28	
Ethylbenzene	320	82.5	56, 150, 15	240, 84, 330	
Styrene	100	ND	17, 31, 31	51, 16, 67	
Perchloroethylene	60	4.4	13, 18, 18	29, 8.5, 36	
Xylene	820	155	100, 270, 260	120, 150, 520	
Semivolatiles					
Anthracene	650	350	270, 280		
Phthalate	250	150	30, 37		
Pentachlorophenol	100	29	4.2, 120		
Metals					
Arsenic	10	15		19, 19, 18	20
Cadmium	20	30		26, 26, 26	59
Chromium	30	35		30, 27, 27	33
Copper	190	292		282, 250, 255	376
Lead	280	287		328, 301, 302	379
Nickel	30	32		30, 28, 28	70
Zinc	450	625		548, 508, 158	1725

[a] Data generated under EPA Contract No. 68-03-3389, Task 5, R. Thurnau Project Officer, PEI Contractor, IT Corporation Subcontractor (lab) - data given is on wet weight basis.

[b] Data generated under EPA Contract No. 68-03-3241, Task 2-18, E. Barth Project Officer, Acurex Contractor and Hittman-Ebasco (lab) under EPA Contract No. 68-01-7280, R. Thurnau, P.O.

[c] Data generated under EPA Contract No. 68-03-3389, Task 7, R. Thurnau, P.O., PEI Contractor, Radian Corporation (lab).

[d] Organic data generated under EPA Contract No. 68-03-3413, Task 6, C. Rogers, P.O., PEI Contractor, Wright State Subcontractor (lab) - data given is on wet weight basis.

Metals data generated under EPA Contract No. 7C3072 YAWE, Subcontract No. 4-87-1-0275, T. D. Ferguson, P.O., Analytical Enterprises, Inc. Subcontractor - data given is on wet weight basis.

TABLE 4-10. ANALYTICAL PROFILE OF SARM III, MG/KG

Analyte	Target	R. Thurnau[a] (thermal desorption)	E. Barth[b] (stabilization)	R. Thurnau[a] (incineration)	C. Rogers[c] (KPEG)
Volatiles					
Acetone	680		220		
Chlorobenzene	40		8.9		
1,2-dichloroethane	60		3.1		
Ethylbenzene	320		100		
Styrene	100		24		
Perchloroethylene	60		13		
Xylene	820		150		
Semivolatiles					
Anthracene	650		240, 290		
Phthalate	250		89, 190		
Pentachlorophenol	100		13, 16		
Metals					
Arsenic	500				359
Cadmium	1000				3488
Chromium	1500				1163
Copper	9500				11,678
Lead	14,000				14,451
Nickel	1000				2,409
Zinc	22,500				24,262

[a] Did not evaluate this SARM in thermal desorption or incineration studies.

[b] Data generated under EPA Contract No. 68-03-3241, Task 2-18, E. Barth Project Officer, Acurex Contractor and Hittman-Ebasco (lab) under EPA Contract No. 68-01-7280, R. Thurnau, P.O.

[c] Organic data generated under EPA Contract No. 68-03-3413, Task 6, C. Rogers, P.O., PEI Contractor, Wright State Subcontractor (lab) - data given is on wet weight basis.

Metals data generated under EPA Contract No. 7C3072 YAWE, Subcontract No. 4-87-1-0275, T. D. Ferguson, P.O., Analytical Enterprises, Inc. Subcontractor - data given is on wet weight basis.

TABLE 4-11. ANALYTICAL PROFILE OF SARM IV, MG/KG

Analyte	Target	R. Thurnau[a] (thermal desorption)	E. Barth[b] (stabilization)	R. Thurnau[a] (incineration)	C. Rogers[c] (KPEG)
Volatiles					
Acetone	6800		13,000		
Chlorobenzene	400		270		
1,2-dichloroethane	600		830		
Ethylbenzene	3200		2500		
Styrene	1000		540		
Perchloroethylene	600		540		
Xylene	8200		3700		
Semivolatiles					
Anthracene	6500		580, 970		
Phthalate	2500		370, 630		
Pentachlorophenol	1000		100, 55		
Metals					
Arsenic	500				338
Cadmium	1000				6148
Chromium	1500				1407
Copper	9500				10,928
Lead	14,000				17,175
Nickel	1000				2448
Zinc	22,500				23,414

[a] Did not evaluate this SARM in thermal desorption or incineration studies.

[b] Data generated under EPA Contract No. 68-03-3241, Task 2-18, E. Barth Project Officer, Acurex Contractor and Hittman-Ebasco (lab) under EPA Contract No. 68-01-7280, R. Thurnau, P.O.

[c] Organic data generated under EPA Contract No. 68-03-3413, Task 6, C. Rogers, P.O., PEI Contractor, Wright State Subcontractor (lab) - data given is on wet weight basis.

Metals data generated under EPA Contract No. 7C3072 YAWE, Subcontract No. 4-87-1-0275, T. D. Ferguson, P.O., Analytical Enterprises, Inc. Subcontractor - data given is on wet weight basis.

SECTION 5

SOIL WASHING (BDAT PHYSICAL TREATMENT)

5.1 INTRODUCTION

The primary objective of Task 2 was to conduct bench-scale operations that simulate the EPA Mobile Soils Washing System (MSWS) for the evaluation of the BDAT SARM samples. The MSWS has been designed for onsite removal of a broad range of hazardous materials and associated fine fractions from excavated soils. This system is expected to be an economic alternative to the current practice of hauling contaminated soils offsite to a landfill and replacing the excavated volume with fresh soil on site. This system is capable of extracting certain contaminants from soils and thereby enabling operators to perform an economic volumetric reduction of the waste site material.

Specifically, this project was designed to simulate the drum screen washer segment of the MSWS as described by J.S. Shum (1987) in the Operation and Maintenance Manual. This segment of the MSWS separates the +2-mm soil fraction from the -2-mm soil fraction (fines) by use of a rotary drum screen. A high-pressure water knife operates at the head of the system to break up soil lumps and strip the contaminants off the soil particles. Both the design of the MSWS and the design of the bench-scale experiments to simulate the MSWS for cleanup of the SARMS samples operate on the following assumptions, which underlie the volume reduction approach of physical soils washing:

1. A significant fraction of the contaminants (BDAT SARM) are attached to the silt, humus, and clay particles.

2. The silt and clay are attached to the sand and gravel by physical processes (primarily compaction/adhesion).

3. Physical washing of the sand/gravel/rock fraction will effectively remove the fine sand, silt, and clay sized (less than 0.25 mm) materials from the coarse material.

4. The contaminants will be removed to the same extent that the silt and clay are separated (i.e., increasing the efficiency of the washing process will directly increase the removal efficiency for the majority of the BDAT contaminant mix).

To meet these objectives, different wash solutions were evaluated in bench-scale shaker table experiments. Water with minor additives (i.e., acids, bases, chelants, and surfactants for fines migration) was the only solvent investigated. Organic solvents and oxidizing agents were considered but found not to be viable soil washing solutions because of material handling problems associated with these compounds, especially when used in a field situation. Following the shaker-table wash, the soil was wet sieved to separate the fines from the coarse material. Although the EPA MSWS only separates the soil into +2-mm and -2-mm size fractions, three size fractions (+2-mm, 250-μm - 2-mm, and -250-μm) were investigated in this study to determine if the middle fraction (medium to fine sand) could be cleaned effectively, thereby increasing the volume reduction achievable. To determine the effectiveness of the soil washing techniques for reducing the volume of contaminated material, the resulting soil fractions were subsequently analyzed for total organics and metals per standard GC/MS and ICAP techniques (SW-846, 3rd ed.) and for leachable constituents per the toxicity characteristic leaching procedure (TCLP).

The soil washing was conducted at EPA's Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) facility in Leonardo, New Jersey.

The facility is equipped with a 40-foot mobile laboratory trailer, which was specially designed to handle highly toxic materials. The semi-trailer has a ventilation system providing 15 air changes per hour in a single pass-through configuration. Furthermore, the trailer is completely self-contained, which aided in the prevention of cross contamination by other nonrelated operations involving hazardous materials.

5.2 PROJECT SCOPE

5.2.1 Literature Review

An abbreviated literature search was conducted to identify candidate wash solutions for the BDAT SARM samples. The emphasis of the search was on work recently completed in the area of soil washing with special emphasis on the development and subsequent pilot-scale demonstrations of the EPA MSW system. The search included a review of previously prepared EPA research reports (in-house and publicly disseminated), recent articles on treatment of contaminated soils, and other readily obtainable documents.

Soil washing bench-scale shaker table experiments were reviewed to identify the most significant experimental variables (wash solution, pH, temperature, etc.) with respect to this study. Much of the data reported in the literature were generated in direct support of in situ soil washing. Although some of the variables in these studies relate specifically to in situ treatment (such as contaminant transport through a soil column), many of the variables pertain more generally to mobilization of contaminants and, therefore, are applicable to this study. Tables 5-1 and 5-2 summarize the literature review of these experiments. Table 5-1 lists studies in which organic contaminant removal was of primary interest, and Table 5-2 lists those studies in which inorganic (mostly metals) removal was evaluated.

TABLE 5-1. SUMMARY OF SHAKER-TABLE SOILS WASHING EXPERIMENTS FOR SOILS WITH ORGANIC CONTAMINATION

Variable	Study					
	Ellis, Payne, and McNabb 1985	Mason Hanger[a]	Alperin 1983	Scholtz and Milanowski 1983	Exner et al. 1985	Nash and Johnson 1982
1. Temperature	NE[b]	Normal (65°F) and elevated (120°F)	NE	NE	NE	Room temperature and 50°C
2. pH	NE	Normal (7-8) and elevated (11.5)	NE	NE	NE	NE
3. Reaction time	1 hour	ND[e]	4 hours	3 hours	4 hours	1 to 4 minutes
4. Surfactant type and concentration	1.5 to 3.0% total Adsee 799[c] and Hyonic NP-90[d]	0.15% Tide[f]	1 to 6% total Adsee 799 and Hyonic NP-90	0.1 to 10% Tween 80[g] 1% MYRJ 52[g]	Solvents used instead of surfactants: Toluene with 20% isopropyl alcohol Cyclohexane with 20% isopropyl alcohol	0.15 to 4.0% Tide, ethylene glycol, fuel oil, and other extract-ants
5. Solution-to-soil ratio	2:1	ND	3:1	20:1 and 40:1	3:1	1:1 and 2:1
6. Number of rinses	None	Four following initial wash	Three sequential surfactant washes followed by one water rinse	None	Three sequential solvent extractions	ND

[a] Study conducted for the U.S. Environmental Protection Agency, Hazardous Waste Engineering Research Laboratory, Releases Control Branch by Mason & Hanger - Silas Mason Co., Inc.; personal communication from J. Nash, Mason & Hager, on May 13, 1987.

[b] Not evaluated.

[c] Manufactured by Witco Chemical.

[d] Manufactured by Diamond Shamrock.

[e] Cannot be determined from available information.

[f] Manufactured by Procter and Gamble.

[g] Manufactured by ICI, Inc.

TABLE 5-2. SUMMARY OF SHAKER-TABLE SOILS WASHING EXPERIMENTS FOR SOILS WITH METAL CONTAMINATION

Variable	Study[a]						
	Castle 1985	*Rayford, Evangelista,* and Ungers 1986	PEI 1986a	PEI 1986b	Ellis 1985	Connick 1985	Fox 1984
1. Temperature	NE[b]	NE	NE	NE	NE	NE	NE
2. pH	ND[c]	7	12.5 to 13.0	10.8 and 12.2	6	9 to 10	8.5 and 6.0
3. Reaction time	2 hours	5 to 45 minutes	10 minutes to 8 hours, 55 minutes	30 minutes and 60 minutes	Overnight	15 minutes to 48 hours	30 minutes
4. Chelant concentration	10% EDTA	15 - 20% EDTA	0.43:1 to 6.13:1[d]	0.7, 1.4, and 2.4% EDTA	0.1 Molar EDTA (+ hydroxylamine hydrochloride and citrate buffer)	0.144 Molar EDTA	0.861 and 0.337 Molar EDTA
5. Solution-to-soil ratio	7:3 and 3:2	11:9 and 3:1	2:1	2:1	10:1	10:1	2:1 and 8.8:1
6. Number of rinses	3 to 4	4	None	2	2	ND	3

[a] Where bench-scale and full-scale data were available, bench-scale data were used in preparation of this table.

[b] Not evaluated.

[c] Cannot be determined from available information.

[d] Expressed as molar ratio of EDTA:metal.

Based on the literature review summarized in Table 5-1 and 5-2, it was determined that a number of variables are important in maximizing the effectiveness of the soil washing procedure. Due to budgetary and time constraints, however, it was decided to minimize evaluation of variables that had either not been tested or were not critical to the overall soil washing process, as determined through previous research. Furthermore, variables that were considered impractical to implement in a field demonstration (i.e., very high temperatures, extremely low or extremely high pH values, etc.) also were not evaluated.

5.2.2 Selection of Variables

This section presents a brief discussion of the experimental variables chosen for evaluation of physical soil washing of the SARM samples. The discussion is divided into two parts, critical parameters for reduction of organic contamination in soils, and critical parameters for reduction of metal contamination. Although all of the SARM samples contain both organic and metal contamination, the variables in this study were optimized for either organic or inorganic contaminant removal or both, depending on which SARM sample was being tested. (Refer to Section 5.5 for more detail on the Experimental Test Design.)

Critical Parameters for Reduction of Organic Contamination--

1. Temperature - Elevated temperatures may reduce the required reaction times; however, they may also volatilize a significant portion of the organics. VOC emissions can be treated in the field with an activated-carbon air filtration system. Two temperatures that are attainable in the field were evaluated.

   Experimental Variable - Ambient temperature (60° to 80°F) and elevated temperature (120°F).

2. pH - For some organics, pH is a useful variable for improving the mobility of the contaminant into solution (Dietz et al. 1986). Three pH's that are attainable in the field were evaluated.

   Experimental Variable - pH 5, ambient pH of tap water, and pH 12.

3. Reaction Time - Reaction time, which affects treatment performance, will be determined during a preliminary run. Reaction times beyond 30 minutes are not considered economical to scale up and were not be evaluated.

   Experimental Variable - 5, 15, and 30 minutes.

4. Surfactant Concentration - Industrial Formula Tide (manufactured by Procter and Gamble) was chosen as the test surfactant because it is biodegradable, inexpensive, easily obtainable, and has proven successful in previous soil washing experiments (Nash 1982). The literature search indicated an optimum range of surfactant concentrations between 1 and 10 percent; however, concentrations over 1.5 percent are likely to result in material handling problems and were not evaluated.

   Experimental Variable - 0.1, 0.5, and 1.5 percent (by weight) of Tide.

5. Solution:Soil Ratio - The solution-to-soil ratio should be kept to a minimum to facilitate dewatering and to minimize production of wastewater. However, based on the available literature, solution-to-soil ratios below 10:1 may not allow adequate soil-solution contact.

   Experimental Variable - Fixed at 10:1.

6. Number of Rinses - Following contact with the wash solution, the soil should be rinsed with either clean solution or plain water to enhance removal of solubilized contaminants; excessive rinsing, however, will generate additional wastewater. According to the literature, a minimum of two rinses appears to be required. Tap water wash was chosen as the rinse solution to more closely simulate actual field operation.

   Experimental Variable - Fixed at 2 (1 liter each).

Critical Parameters for Reduction of Metal Contamination--

1. Temperature - Temperature has a negligible effect on chelation of most metals (Dietz et al. 1986). However, some data suggest that an elevated temperature may be necessary for rapid chelation of chrome III (Dow 1985). Therefore, both elevated and ambient temperatures were evaluated.

   Experimental Variable - Ambient temperature (70° to 80°F) and elevated temperature (120°F).

2. pH - pH is one of the most critical parameters. Both metal cations and chelating agents are influenced by hydrogen ions; therefore, any change in pH affects the equilibrium of the system (Dietz et al. 1986). Based on research performed by Dow Chemical (supplier of the chelating agent), the metals under study should be most effectively chelated at a pH of 8 to 12.

   Experimental Variable - pH 8 and pH 12.

3. Reaction Time - Reaction time, which affects treatment performance, will be determined during a preliminary run. Reaction times beyond 30 minutes are not considered economical to scale up and were not be evaluated.

   Experimental Variable - 5, 15, and 30 minutes.

4. Chelant Concentration - Versene 100 (tetrasodium salt of EDTA manufactured by Dow Chemical) was chosen as the test chelating agent because it chelates a variety of metals over a broad pH range, is completely miscible with water, will not chelate univalent metal ions, and is readily available. Based on calculations provided by Dow Chemical, a molar concentration of 1:1 to 3:1 Versene 100 to total metal ions present in the SARM samples should chelate all of the metals present (with the possible exception of arsenic).

   Experimental Variable - 1:1 and 3:1 Molar ratio of Versene 100:total metal ions present in SARMS.

5. Solution:Soil Ratio - The solution-to-soil ratio should be kept to a minimum to facilitate dewatering and to minimize production of wastewater. However, based on the available literature, solution-to-soil ratios below 10:1 may not allow adequate soil-solution contact.

   Experimental Variable - Fixed at 10:1.

6. Number of Rinses - Following contact with the wash solution, the soil should be rinsed with either clean solution or plain water to enhance removal of solubilized contaminants; excessive rinsing, however, will generate additional wastewater. According to the literature, a minimum of two rinses appears to be required. Tap water wash was chosen as the rinse solution to more closely simulate actual field operation.

   Experimental Variable - Fixed at 2 (1 liter each).

5.3 CONCLUSIONS

The results of the bench scale physical soil washing experiments conducted on the SARMS lead to a number of conclusions concerning the contaminant reduction efficiencies attainable on the SARM or similar soil and the feasibility of using a volume reduction approach to soil washing of Superfund soils.

5.3.1 Contaminant Reduction Efficiencies

The volatile organic contaminants exhibited the highest removal efficiencies of any of the contaminants. The tap water and 0.5 percent surfactant washes proved essentially equal in their ability to remove the total volatile organics contaminants from the top two soil fractions (+2-mm and 2-mm to 250-μm) at an average of 99.4 and 99.0 TCLP percent reduction, respectively. Temperature and pH adjustments did not improve volatile contaminant reduction efficiencies. It is believed that some of the high reductions in volatile organic concentrations can be attributed to loss during handling (i.e., sampling, agitation with wash solution on shaker-table, and wet sieve followed by Ro-Tap). Volatile organics lost to the air were not collected, a total mass balance was beyond the scope of this project. Therefore, the amount of volatiles lost to the air was not quantified.

Contaminant reduction efficiencies were variable but generally high for the semivolatiles. None of the wash solutions obtained consistently better results than any of the other solutions in removing semivolatiles. The best results obtained were an average of 95.6 percent reduction for the TCLP semivolatiles in the top two size classes, after a 0.5 percent surfactant

wash, and 94.2 percent reduction after a tap water wash. The third best result (93.2 percent reduction of TCLP semivolatiles in the top 2 soil fractions) was obtained after at 3:1 molar EDTA to total metals wash. Therefore, the primary mechanism of semivolatile organic removal appears to be an effective physical washing of the soil resulting in separation of the clean coarse material from the fines, where the semivolatiles are concentrated.

Consistently higher metal contaminant reduction efficiencies were obtained for the chelant wash (3:1 molar concentration of EDTA to total metal ions present in the SARM) than for any of the other washes. Temperature and pH variations had a negligible effect on the overall metal concentration reductions. The best results obtained were an average of 93.4 percent reduction for the TCLP metals in the top two size classes (+2-mm and 2-mm to 250-μm) after the chelant wash of SARM II (low organic, low metal contamination), and 91.1 percent reduction of the same soil fractions after the chelant wash of SARM III (low organic, high metal contamination). Generally, arsenic and chromium showed the poorest removal efficiencies, while cadmium, zinc, copper and nickel all appeared to be easily chelated by the EDTA and exhibited overall the highest removal efficiencies under chelant wash conditions.

SARM I (high organic, low metal contamination) and SARM IV (high organic, high metal contamination) exhibited overall the highest removal efficiencies for all the contaminants subjected to the TCLP analysis. This is partially attributable to some results from SARMS II (low organic, low metal contamination) and III (low organic, high metal contamination) which appear to be outliers and cause the contaminant reduction efficiencies for the volatile

and semivolatile organics of these SARMS to be unusually low or even negative. Furthermore, these low organic contaminated soils (SARM II and III) show less conclusive results because the concentrations are often at or near the detection limits. When numbers are this low, a slight change in concentration can exaggerate the resulting effect on removal efficiencies.

As expected, the +2-mm soil fraction frequently exhibited lower contaminant concentrations than the 2-mm to 250-μm soil fraction. The overall average of all TCLP contaminant reduction efficiencies (throwing out those outliers discussed above) was 91 percent for the +2-mm soil fraction and 78 percent for 2-mm to 250-μm soil fraction. In general, there are no apparent differences between the water wash, the 3:1 molar chelant wash, and the 0.5 percent surfactant wash for cleaning of the +2-mm soil fraction. As hypothesized, the silt and clay particles appear to be attached to the sand and gravel primarily by physical processes, such as compaction and adhesion. These physical attractions are often related to the age of the soil and the contact time between the contaminants and soil particles. Because the SARM is a synthetic waste, the forces of attraction are relatively weak, a condition more typical of a spill site soil than an older, abandoned CERCLA site soil. Consequently, the water wash was as effective in cleaning the +2-mm soil fraction as the other water plus additive solutions.

5.3.2 Contaminated Soil-Volume Reduction

During initial bench scale experiments, it was determined that the SARMS were approximately 13 percent by weight +2-mm soil size, 29 percent were 2-mm to 250-μm, and 58 percent were less than 250-μm. Therefore, using the TCLP reduction efficiencies provided in the previous section, 13 percent of the

SARM realized an average TCLP contaminant reduction of 91 percent and 29 percent realized an average TCLP reduction of 78 percent. Together the top two soil size classes make up approximately 42 percent of the soil by weight, and the overall TCLP contaminant reduction obtained in these experiments for these top two size classes was 82 percent.

Furthermore, many of the washes resulted in either the +2-mm or the 2-mm to 250-μm (or both in some cases) soil size fractions to be under the proposed TCLP regulatory limits. These soils could then potentially be classified as non-hazardous. Specifically, SARM I (high organic, low metal contamination) realized a 42 percent weight reduction in "hazardous waste" classified soil after the tap water wash (both top soil fractions were below the TCLP limits), and a 13 percent weight reduction (+2-mm soil fraction) after the surfactant wash. SARM II (low organic, low metal contamination) was below all TCLP limits prior to washing. However, SARMS III (low organic, high metal contamination) and IV (high organic, high metal contamination) both contained cadmium (with lead and tetrachloroethylene in some cases) slightly over the 1.0 mg/l TCLP limit in all the soil sizes after washing.

During the prewash analysis of the SARMS, it was discovered that washing the soil may not be necessary to reduce the volume of contaminated soil. All four SARMS were wet-sieved and analyzed to determine where the contaminants were located (which size fraction) prior to washing. Separation of the SARM by wet sieving into the three particle sizes proved effective in concentrating the contaminants in the fines (less than 250 μm) and subsequently removing a significant portion of the contamination from the +2-mm and 2-mm

to 250-μm particle size fractions. The result of this prewash (or wet sieve only) experimental run was to show that for soils which have hot aged (such as the SARMS or spill site soils), particle size separation only, eliminating or minimizing the use of wash solutions, appears to be an efficient means of achieving a significant volume reduction of the contaminated soil.

After nearly all the washes, the contaminants were concentrated in the fines (<250-μm soil fraction). These fines contain humus, silt, clay, and very fine sand. The separation of the fines from the coarse material and subsequently, the concentration of the contaminants in the fine soil fraction is one of the main processes critical to the volume reduction approach to soil washing. However, these fines will have to undergo further treatment prior to disposal. As indicated in Section 5.4, soil washing is well suited to be part of a treatment train. For example, the contaminated fines from soil washing could be stabilized, incinerated, or sent to a chemical treatment facility, while the coarse clean material could be returned to the site, thus reducing the volume of contaminated material requiring further processing.

5.4 RECOMMENDATIONS

The mix of contaminants in Superfund soils lends itself to an extraction or washing treatment technology such as that demonstrated in this study. Although promising results have already been achieved at the pilot scale at a number of lead-contaminated Superfund sites, additional research is needed to demonstrate the cost-effectiveness of soil washing for full-scale treatment of a wide range of metal- and organic-contaminated soils. Specifically, most of the research conducted to date has involved demonstration of equipment

unit operations for pretreatment and extraction of the contaminants from the soil as well as post-treatment of the extractant. However, the effective separation of the wash solution from the soil, recycle of the regenerated wash solution, and concentration/destruction of the contaminants have not been demonstrated at a large-scale pilot facility (Dietz et al. 1986). The following list delineates areas in which laboratory research data are lacking, particularly with respect to development of soil washing as a full-scale viable treatment option for Superfund soils. Specific projects are recommended within these research areas.

1. Laboratory Feasibility Study for Evaluating Removal of SARM Contaminants From Wash Water - Treatment of the wash water remaining after contact with and separation from the contaminated soil was not part of the physical soil-washing experiments described in this report. However, if soil washing is to be an economical approach to cleaning contaminated soils, the wash water must be economically treated to reduce its contamination level and to recover/recycle the chelant or surfactant, if used. The objective of this wash water treatment study would be to establish the optimum process for recirculation of the wash solution, including the concentration and removal of any solubilized contaminants; the separation and dewatering of suspended clay, humus, and colloidal material; and the addition of new stripping agents.

2. Physical Soil Washing Laboratory-Scale Study Utilizing Actual Superfund Soils Containing a Mix of Metal and Organic Contamination - The principal reason for the high removal efficiencies observed in this study was that the SARMS had not aged. Dietz et al. (1986) indicate that metal-soil binding changes with time until an equilibrium is established; therefore preadsorbed soils (such as the SARMS) may not be representative of "mature" Superfund soils. Typically, both organic and metal contaminants are converted over time to more insoluble forms by inclusion in the organic and metal oxide matrices of the soil (Ellis and Fogg 1985). Therefore, a "mature" aged Superfund soil may be more difficult to clean via physical soil washing, and volume reduction of a Superfund soil may not be as easily achieved as it was for the SARMS.

3. Evaluation of Sequential Wash Solutions for Reducing Combined Organic and Metal Contamination - This study examined the effectiveness of surfactant and chelant wash solutions in reducing the level of organic and metal contamination, respectively, of a mixed waste. The evaluation of sequential washes for reducing the total level of contamination, however, was beyond the scope of this project. Most of the currently available published data on soil washing are applicable to either metal- or organic-contaminated soils. However, many Superfund soils contain both metals and organics together in high enough concentrations to warrant evaluation of physical soil washing. Both metal and organic contaminants are held in the soil fines, as shown in this study; therefore, the volume reduction approach to soil washing should be effective as a treatment technology for a combined contaminant soil matrix.

4. Additional Pilot-Scale Studies Utilizing the EPA Mobile Soil-Washing System (MSWS) - The MSWS has been demonstrated at only a few lead-contaminated waste sites. The objective of this study would be to obtain engineering information on the unit cost, personnel requirements, and performance of the MSWS for treatment of the SARMS or an actual mixed Superfund waste.

5. Bench-Scale Feasibility Study for Evaluating Stabilization/Solidification (S/S) Effectiveness as a Treatment Train Option for the Concentrated Fines - The most efficient full-scale use of physical washing will probably be as part of a treatment train, since this technology has proven effective in removing contamination from the +2-mm soils fraction but has met with limited success in cleaning the -2-mm soils. The objective of this study would be to evaluate soil washing for volume reduction followed by S/S of the fines (-2-mm fraction) where the contaminants are concentrated. An evaluation of dewatering methods prior to S/S would also have to be conducted.

6. Evaluation of Feed Stock Preparation Methods for the EPA MSWS - The objective of this study would be to evaluate different pretreatment options that will optimize the operating conditions and ultimate treatment efficiencies of the MSWS. Grinding, crushing, and other physical unit operations would be evaluated in addition to chemical pretreatment options (air stripping for organics, etc.) on a bench scale as part of an overall soil washing treatment train.

5.5 EXPERIMENTAL TEST DESIGN

The physical washing of the SARMS was conducted in two phases. Phase I involved the evaluation of wash solutions at different concentrations under varying conditions of pH and temperature. SARM I (high organic/low metal contamination) and SARM III (low organic/high metal contamination) were

evaluated in Phase I to determine the optimum conditions under which organic and metal contamination, respectively, would be effectively reduced.

All four SARMS were subsequently washed during Phase II under optimum conditions for both the organic and metal contaminant reduction. Prior to initiating Phase I, the reaction times for the chelant and surfactant washes were determined as described in Section 5.6.2. These experiments targeted metal and organic contaminants, respectively, without regard for nontarget contaminants. The evaluation of a universal wash solution and the use of sequential washes for targeting both organic and metal contaminants were beyond the scope of this study. Table 5-3 presents the Phase I experimental test design. The results from Phase I screening tests were then used to design Phase II. Phase II further evaluated those variables and associated process conditions that were determined to be optimum in Phase I.

The Phase II experimental test design is shown in Table 5-4. This test design is based upon the results obtained in Phase I (see Section 5.7), which indicated that ambient pH and temperature combined with a molar ratio of 3:1 EDTA to total metal concentration was most effective in removing metals from SARM III. The results also indicated that ambient pH and temperature combined, with a surfactant concentration of 0.5 percent proved slightly more effective than any of the other conditions in removing organic contaminants from SARM I. Three parameters were held constant for both Phases I and II: reaction time (15 minutes for water and chelant washes, 30 minutes for surfactant washes) solution-to-soil ratio (10:1 by weight) and the number of rinses following soil sieving (2 1-liter rinses with tap water).

TABLE 5-3. PHASE I EXPERIMENTAL TEST DESIGN

SARM I
(high organic/low metal contamination)
Reaction time - 30 minutes
Solution-to-soil ratio - 10:1

Run	pH[a]	Temperature,[b] °F	Surfactant concentration (weight %)	Objective
1	6.7	78	Water	Establish baseline
2	9.2	78	1.5	Study effect of surfactant concentration
3	9.6	78	0.5	Study effect of surfactant concentration
4	10.7	78	0.1	Study effect of surfactant concentration
5	Low - 5.0	78	0.5	Study effect of pH
3	9.6	78	0.5	Study effect of pH
6	High - 12.0	78	0.5	Study effect of pH
2	9.2	78	0.1	Study effect of temperature
7	9.2	High - 120	0.1	Study effect of temperature

SARM III
(low organic/high metal contamination)
Reaction time - 15 minutes
Solution-to-soil ratio - 10:1

Run	pH[a]	Temperature,[b] °F	Chelant ratio (moles of EDTA to total moles of metal)	Objective
1	6.7	78	Water	Establish baseline
2	12.0	78	1:1	Study effect of chelant molar ratio
3	12.0	78	3:1	Study effect of chelant molar ratio
2	12.0	78	1:1	Study effect of pH
4	Low - 8.0	78	1:1	Study effect of pH
2	12.0	78	1:1	Study effect of temperature
5	12.0	High - 120°F	1:1	Study effect of temperature

[a] All pH values given are ambient values of the wash solutions, unless noted otherwise. Those values listed as low and high were adjusted to the given pH.

[b] All temperature values given are ambient values of the wash solutions, unless noted otherwise. Those values listed as low and high were adjusted to the given temperature.

TABLE 5-4. PHASE II EXPERIMENTAL TEST DESIGN

Run	SARM	pH[a]	Temperature,[b] °F	Wash solution
1	I	6.7	78	Water
2		9.6	78	0.5% surfactant
1	II	6.7	78	Water
2		12.0	78	3:1 molar ratio chelant
3		9.6	78	0.5% surfactant
1	III	6.7	78	Water
2		12.0	78	3:1 molar ratio chelant
1	IV	6.7	78	Water
2		12.0	78	3:1 molar ratio chelant
3		9.6	78	0.5% surfactant

[a] All pH values given are ambient values of the wash solutions.

[b] All temperature values given are ambient values of the wash solutions.

The optimum conditions for reducing organic and metal contamination were applied to all four SARMs and compared with a baseline plain water wash for each SARM. The results of Phase I are discussed in more detail in Section 5.7. Phase II results are presented in Section 5.8.

5.6 EXPERIMENTAL PROCEDURES

5.6.1 Size Classification of Soil for Prewash Analysis

To determine where the contaminants were distributed in the soils before treatment, each of the four SARMs was classified by wet sieving into three size fractions--greater than 2-mm (+10 mesh), less than 2-mm but greater than 250-μm (10 to 60 mesh), and less than 250-μm (-60 mesh). A representative sample of soil was placed on the top sieve and alternately sprayed with water and screened by shaking the nested sieves in a sieve shaker (Ro-Tap) to

effect the separation. A minimum amount of water was used in the wet sieving process to minimize any soluble contaminant transport between size fractions. (Dry sieving was attempted; however, the SARM samples were generally too wet to be effectively dry sieved.) The three size fractions were submitted for total analysis.

5.6.2 Determination of Reaction Time

Optimum reaction times for all Phase I and Phase II runs were determined experimentally by washing representative samples of SARM I and SARM III with dilute solutions of Tide (0.1 percent by weight) and Versene 100 (1:1 molar ratio of EDTA to total metals), respectively, at ambient temperature and pH per the method described in Section 5.6.3. Sample aliquots were extracted after 5, 15, and 30 minutes and allowed to settle. After settling, the supernatant from each sample was vacuum filtered (for the chelant wash solution) or centrifuged (for the surfactant wash solution) to separate the solids, and the remaining liquid was submitted for chemical analysis. Concentrations of the target analytes present in the liquid were plotted versus time for determination of the time at which the reactions were essentially complete. (See Section 5.7 for a discussion of these results.) The optimum reaction times, as determined from these tests, were adopted for all Phase I and II experimental runs.

5.6.3 Soil Washing

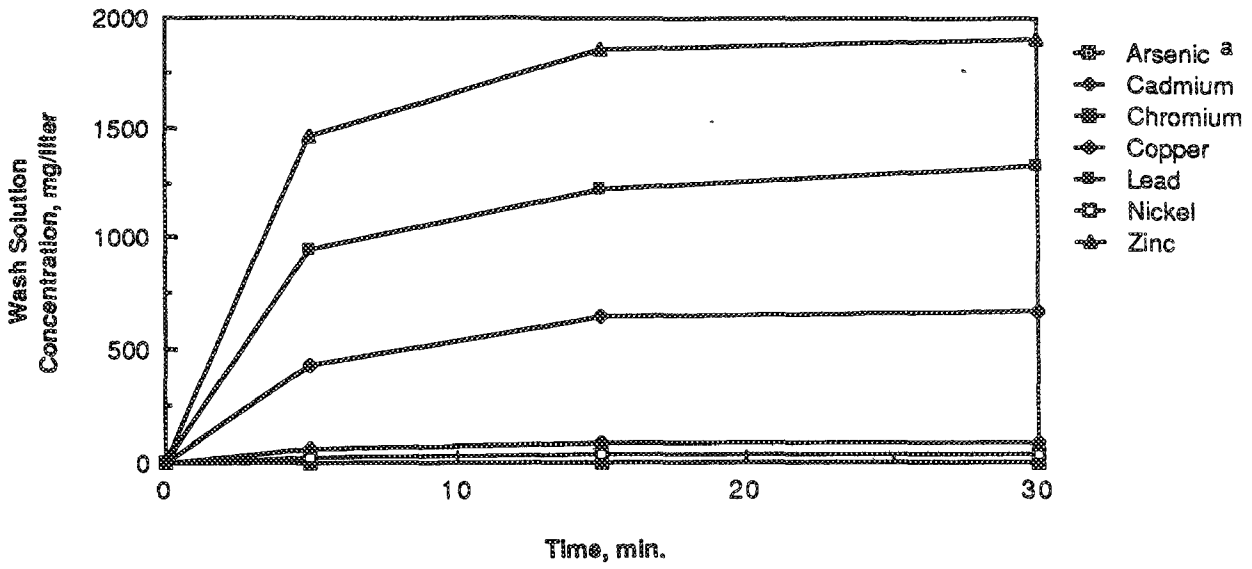
The Phase I and Phase II soil washing experiments involved contacting the soil with the wash solution by agitating the mixture on a laboratory shaker for a sufficient time period, as determined from the reaction time tests, and wet sieving the treated soil into three size fractions: coarse (+10 mesh or +2-mm), medium-grained (10 to 60 mesh or 2-mm to 250-μm), and

fine (-60 mesh or less than 250-μm). A representative sample of soil was mixed with the chelant or surfactant solution of the desired concentration at a 10:1 solution-to-soil ratio. The temperature of the wash solution was controlled at the tap by using cold or hot water. The pH of the wash solution was adjusted as necessary by titrating it with 10 N sulfuric acid (H_2SO_4) or 10 N sodium hydroxide (NaOH). After agitating, the mixture was poured onto the top sieve and alternately rinsed with water (two 1-liter rinses) and screened by shaking the rested sieves in a Ro-Tap to effect the separation. In the Phase I experiments, only the coarse and medium-grained fractions were submitted for chemical analysis. In the Phase II experiments, all three size fractions were submitted for both total analysis and TCLP analysis.

5.7 PHASE I RESULTS

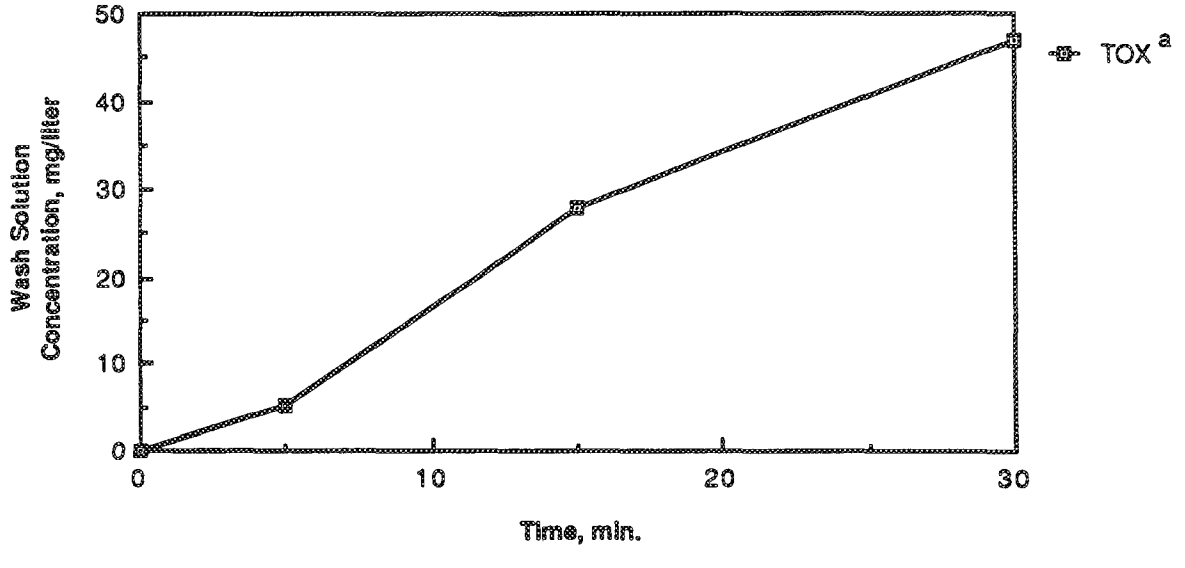
Figures 5-1 and 5-2 present the reaction time results for a 1:1 molar chelant wash of SARM III and for a 0.1 percent weight surfactant wash of SARM I, respectively. As can be seen from Figure 5-1, no significant additional metal chelation occurs after 15 minutes for any of the six metals. Therefore, a 15-minute reaction time was chosen for the chelant washes. As shown in Figure 5-2, no similar completion of reaction was evident for the organic contaminants (as total organic halogens) whose concentration in the wash water continued to increase over the entire 30-minute interval. Therefore, 30 minutes was chosen as the reaction time for the surfactant washes on the basis of scale-up considerations.

Tables 5-5 and 5-6 summarize the results of Phase I soil washing for SARM III (high metal/low organic concentration), and Table 5-7 summarizes the results for SARM I (low metal, high organic concentration). Contaminant



a Arsenic and nickel overlap in this figure.

Figure 5-1. Reaction time - 1:1 molar chelant wash, SARM III



a Total organic halogens

Figure 5-2. Reaction time - 0.1% surfactant wash, SARM I

reduction efficiencies were not calculated because the results are on a wet-weight, as-received basis. The Phase I chemical analyses were designed to be a comparison tool for use in selecting the best conditions for further evaluation in Phase II.

Phase I results for the SARM III +2-mm soil fraction, as shown in Table 5-5, do not differ by enough margin to conclude that any of the experimental runs was superior in removing the contaminants. The contaminants appear to be adhered to the coarse particles primarily through a physical mechanism; therefore, the tap water wash (Run 1) was as effective as the other washes in separating the contaminated finer particles from the coarse (+2-mm) particles. The data contained in Table 5-6, however, are slightly more conclusive. The medium-grained material (250-μm to 2-mm soil fraction) is more difficult to physically clean because of its smaller size and greater specific surface area for adsorption of contaminants. The removal of metals from this soil size fraction seems to be a combination of physical and chemical processes, since water alone (Run 1) does not appear to be as effective as water plus EDTA. Experimental Run 3, which is ambient pH and temperature and a 3:1 molar ratio of EDTA to total metals, resulted in the lowest concentration of all metals except arsenic. Run 3 was chosen as the optimum set of variables for reduction of metal contamination and was further evaluated in the Phase II soil washing experiments.

Table 5-7 shows the Phase I results for SARM I. These data are not as extensive as the Phase I results for SARM III because of problems encountered in identifying an appropriate screening analysis for organic contaminants. Total organic carbon (TOC) and total organic halogens (TOX) were both tried as possible screening analyses but were rejected because the results obtained

TABLE 5-5. PHASE I RESULTS: SARM III, >2-mm SIZE FRACTION

Run[a]	Concentration, mg/kg (wet weight)						
	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Untreated soil[b]	604	756	868	8830	12,776	674	23,840
Run 1	54	165	2.2	52	76	14	325
Run 2	40	150	1.8	47	66	14	335
Run 3	40	130	2.7	44	63	14	315
Run 4	38	155	1.6	42	78	12	330
Run 5	36	155	3.1	48	58	14	350

[a] Refer to Table 5-3 for explanation of runs.

[b] Unscreened sample.

TABLE 5-6. PHASE I RESULTS: SARM III, 250-μm to 2-mm SIZE FRACTION

Run[a]	Concentration, mg/kg (wet weight)						
	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
Untreated soil[b]	604	756	868	8830	12,776	674	23,840
Run 1	62	145	9.8	165	275	26	1,060
Run 2	71	110	11.5	165	265	30	1,600
Run 3	52	80	6.0	90	145	21	500
Run 4	74	140	9.3	160	220	29	1,250
Run 5	40	130	9.0	175	320	34	1,550

[a] Refer to Table 5-3 for explanation of runs.

[b] Unscreened sample.

TABLE 5-7. PHASE I RESULTS: SARM I, 250-μm to 2-mm SIZE FRACTION

Run[a]	Concentration, mg/kg (wet weight)				
	Acetone	Styrene	o-Xylene	Chlorobenzene	Ethylbenzene
Untreated soil[b]	6800	1000	8200	400	3200
Run 1	>570	3	4	19	9
Run 2	<50	3	5	19	9
Run 3	<50	3	5	19	14
Run 4	<50	4	7	28	14
Run 5	<50	3	5	19	9
Run 6	<50	3	5	22	10
Run 7	<50	4	7	28	14

[a] Refer to Table 5-3 for explanation of runs.

[b] Unscreened sample.

were not reproducible. A carbon tetrachloride extraction followed by IR analysis was also attempted; however, all analytical results were below the detection limit of 80 ppm total hydrocarbons. The nondetectable levels were attributed to incomplete extraction of the organics by the carbon tetrachloride. Finally, GC analysis for five of the organic contaminants was settled on. Because of budgetary and time constraints, only the medium grained fraction (2-μm to 250-mm), which had shown better differentiation between variables for SARM III, was submitted for analysis. Generally, Table 5-7 shows that significant reductions were achieved for most organic constituents. Comparison among runs is inconclusive. None of the variables appear to have a more significant effect on organic contaminant reduction than any of the others. Based on the present knowledge of surfactants and the lack of sufficient data for basing conclusions, Run 3 (0.5 percent surfactant by weight, ambient pH and temperature) was chosen for further evaluation in Phase II. Run 3 showed slightly better results than Run 4 (0.1 percent surfactant by weight, ambient pH and temperature), and Run 2 (1.5 percent surfactant by weight, ambient pH and temperature) did not result in significant additional contaminant reduction over Run 3 to justify the higher surfactant concentration.

5.8 PHASE II RESULTS

5.8.1 TCLP Results

TCLP analyses were performed on the raw soil and on each of the three soil size fractions after soil washing according to the method described in the Federal Register, Volume 51, No. 216, November 7, 1986. The TCLP was developed as a means of determining if mismanagement of a waste has the potential to pose a significant hazard to human health or the environment because of its propensity to leach toxic compounds. The TCLP analysis is

intended to model codisposal of industrial waste with refuse in a sanitary landfill, which represents a worst-case mismanagement scenario.

Tables 5-8 through 5-11 present the results of the TCLP analyses for each of the four SARMS. These tables also contain the TCLP regulatory level for all compounds as proposed in the Federal Register, Volume 51, No. 114, June 13, 1986. The discussion of results relates the TCLP Regulatory Levels to those levels achieved through the bench-scale soil washing experiments described in this report.

The TCLP results from soil washing of SARM I (high organic, low metal contamination) are shown in Table 5-8. The untreated SARM I sample falls below the regulatory levels for all metals and above the regulatory levels for all volatile and semivolatile organics. For both Run 1 (water wash) and Run 3 (surfactant wash), the +2-mm soil fractions were below all of the proposed TCLP limits. Furthermore, for Run 1, the 2-mm to 250-µm fraction and the -250-µm fraction were also below all of the proposed TCLP limits. As described previously, the SARM was determined to be composed of approximately 13 percent by weight coarse material (+2 mm), 29 percent by weight medium-grained material (2 mm to 250 µm), and 58 percent by weight fines (-250 µm). Therefore, the water wash resulted in a 100 percent reduction (by weight) of contaminated material, and the surfactant wash resulted in a 13 percent reduction (by weight). In Run 3, tetrachloroethylene was the only organic constituent in the 2-mm to 250-µm size fraction that did not fall below the TCLP levels. Although the SARM was theoretically homogeneous, the sample drawn for Run 3 may not have been representative (i.e., it may have had a higher concentration of tetrachloroethylene). Similarly, the unexpectedly low concentration of contaminants in the fines from Run 1 appear to support the idea of a nonhomogeneous mix.

TABLE 5-8. PHASE II TCLP RESULTS: SARM I (HIGH ORGANICS, LOW METALS) (ppm)

Contaminant	TCLP regulatory level (mg/l)[a]	Untreated SARM I	Run 1, water wash			Run 2, 3:1 molar chelant wash[b]			Run 3, 0.5% surfactant wash		
			>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm
Volatile organics											
Acetone	-	110	1.30[c]	0.74[c]	0.62[c]				1.80	0.65	1.00
Chlorobenzene	1.4	5.2	0.04[c]	0.04[c]	0.02[c]				0.06	0.12	0.54
1,2-Dichloroethane	0.40	76	0.05[c]	0.05[c]	0.05[c]				0.03	0.03	0.06
Ethyl benzene	-	27	0.40[c]	0.33[c]	0.16[c]				0.44	0.97	5.40
Styrene	-	9.0	0.12[c]	0.10[c]	0.04[c]				0.13	0.25	1.40
Tetrachloroethylene	0.1	3.3	0.02[c]	0.02[c]	0.05[c]				0.03	0.10	0.64
Xylene	-	62	1.20[c]	0.91[c]	0.45[c]				1.00	2.20	12.00
Semivolatile organics											
Anthracene	-	0.07	0.01	0.10	2.1				0.01	0.02	0.30
Bis(2-ethylhexyl) phthalate	-	0.10	0.04	0.04	0.2				0.10	0.10	5.5
Pentachlorophenol	3.6	7.6[d]	0.06	1.10	1.5				0.04	0.41	2.07
Inorganics											
Arsenic	5.0	0.15	0.15	0.15	0.15				0.05	0.15	0.36
Cadmium	1.0	0.53	0.15	0.40	0.93				0.12	0.26	0.70
Chromium	5.0	0.01	0.01	0.01	0.01				0.01	0.01	0.74
Copper	-	0.61	0.04	0.28	1.87				0.06	0.18	3.60
Lead	5.0	0.49	0.15	0.22	1.05				0.15	0.15	1.06
Nickel	-	0.27	0.04	0.09	0.39				0.04	0.06	0.73
Zinc	-	9.2	0.88	3.25	10.7				0.85	1.90	15.4

[a] As proposed in the Federal Register, Volume 51, No. 114, June 13, 1986.

[b] Test run not conducted - See Table 5-4, Experimental Design.

[c] Analysis performed after 14 days holding time expired.

[d] Estimated value, calibration problem.

Table 5-9 presents the TCLP results from soil washing of SARM II (low organic, low metal contamination). The untreated soil sample was below the regulatory levels for all contaminants; therefore, this soil may not require any treatment if found at these contamination levels at a Superfund site. For Runs 1, 2, and 3, the top two soil fractions (+2 mm and 250 μm to 2 mm) were below all of the proposed TCLP limits, with the exception of the Run 1, +2-mm fraction for tetrachloroethylene. The values for this data set, which showed consistently higher results than the untreated sample for all volatile organics are estimated values above the value of the highest standard used to quantify the samples. Unusually high surrogate recoveries were also observed for this data set. Although the data are presented for completeness sake, they are considered to be outliers and have not been used to draw conclusions concerning the effectiveness of the water wash.

SARM III (low organic, high metal contamination) TCLP results are shown in Table 5-10. The untreated SARM III sample exceeds the regulatory levels for all contaminants except chlorobenzene, pentachlorophenol, and chromium. (Generally, chromium was not detected over 0.06 mg/l in any of the untreated soil sample TCLP extracts, even though the high-metal SARMS were spiked at a concentration of 1500 ppm. These low levels are attributable to the fact that chromium was added as Cr III, which is relatively insoluble, even under acidic conditions.) For both Run 1 (water wash) and Run 2 (chelant wash), the +2-mm and the 250-μm to 2-mm fractions were below the proposed TCLP limits for all of the volatile and semivolatile organics, with the exception of the Run 1, 250-μm to 2-mm fraction for tetrachloroethylene. However, these fractions exceeded all the TCLP limits for cadmium and/or lead. Overall, the chelant wash was more effective in reducing metal

TABLE 5-9. PHASE II TCLP RESULTS: SARM II (LOW ORGANICS, LOW METALS)
(ppm)

Contaminant	TCLP regulatory level (mg/l)[a]	Untreated SARM II	Run 1, water wash			Run 2, 3:1 molar chelant wash			Run 3, 0.5% surfactant wash		
			>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm
Volatile organics											
Acetone	-	0.92	3.40[b]	0.05	0.16[c]	0.10	0.10	0.10	0.10	0.10	0.10
Chlorobenzene	1.4	0.05	0.91[b]	0.05	0.05[c]	0.01	0.05	0.02	0.02	0.05	0.05
1,2-Dichloroethane	0.40	0.05	0.25[b]	0.05	0.05[c]	0.05	0.05	0.05	0.05	0.05	0.05
Ethyl benzene	-	0.12	9.11[b]	0.05	0.08[c]	0.07	0.06	0.24	0.17	0.25	0.10
Styrene	-	0.03	2.32[b]	0.22	0.02[c]	0.02	0.05	0.06	0.05	0.07	0.02
Tetrachloroethylene	0.1	0.05	0.97[b]	0.02[b]	0.05[c]	0.01	0.05	0.02	0.01	0.02	0.05
Xylene	-	0.30	17.82[b]	3.90[b]	0.17[c]	0.13	0.15	0.55	0.40	0.64	0.23
Semivolatile organics											
Anthracene	-	0.01	0.02	0.01	0.01	0.01	0.02[d]	0.02	0.01[d]	0.02[d]	0.01[d]
Bis(2-ethylhexyl) phthalate	-	0.22	0.02	0.02	0.03	0.04	0.03[d]	0.02	0.01[d]	0.02[d]	0.02[d]
Pentachlorophenol	3.6	0.90	0.01	0.05	0.46	0.01	0.16	0.24	0.04	0.21[e]	0.61[e]
Inorganics											
Arsenic	5.0	0.15	0.15	0.15	0.18	0.15	0.15	0.15	0.15	0.15	0.60
Cadmium	1.0	0.73	0.07	0.32	1.68	0.05	0.07	0.17	0.03	0.23	1.17
Chromium	5.0	0.01	0.01	0.01	0.01	0.01	0.01	0.53	0.01	0.01	0.80
Copper	-	0.89	0.04	0.32	4.49	0.10	0.12	4.12	0.05	0.10	7.15
Lead	5.0	0.70	0.06	0.68	3.44	0.15	0.15	2.32	0.15	0.15	4.53
Nickel		0.40	0.15	0.12	0.89	0.04	0.11	0.73	0.12	0.09	0.92
Zinc	-	14.6	0.47	6.17	28.2	0.42	0.75	11.7	0.11	3.77	38.4

[a] As proposed in the Federal Register, Volume 51, No. 114, June 13, 1986.

[b] Estimated values, values greater than highest standard and high surrogate recovery.

[c] Analysis performed after 14 days holding time expired.

[d] Estimated value, identification uncertain.

[e] Estimated value, calibration problem.

TABLE 5-10. PHASE II TCLP RESULTS: SARM III (LOW ORGANICS, HIGH METALS)
(ppm)

Contaminant	TCLP regulatory level (mg/l)[a]	Untreated SARM III	Run 1, water wash			Run 2, 3:1 molar chelant wash			Run 3, 0.5% surfactant wash[b]		
			>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm
Volatile organics											
Acetone	-	7.10	0.45[c]	6.10	0.40	0.38	0.25	0.25			
Chlorobenzene	1.4	0.38	0.05[c]	1.10	0.03	0.04	0.02	0.02			
1,2-Dichloroethane	0.40	0.50	0.05[c]	0.31	0.05	0.05	0.05	0.05			
Ethyl benzene	-	4.60	0.04[c]	9.50	0.32	0.34	0.25	0.19			
Styrene	-	0.50	0.05[c]	2.80	0.09	0.08	0.06	0.06			
Tetrachloroethylene	0.1	0.33	0.05[c]	0.89	0.02	0.03	0.02	0.03			
Xylene	-	11.00	0.10[c]	30.0	0.90	0.82	0.73	0.55			
Semivolatile organics											
Anthracene	-	0.01	0.01	0.01	0.04[e]	0.01	0.01	0.01			
Bis(2-ethylhexyl) phthalate	- 3.6	0.09 0.34[e]	0.02 0.17	0.02 0.93[d]	0.02[e] 2.2[e]	0.02 0.03[d]	0.02 0.40[d]	0.02 0.27			
Pentachlorophenol											
Inorganics											
Arsenic	5.0	6.39	0.86	1.75	8.00	0.64	0.55	8.12			
Cadmium	1.0	33.1	4.95	7.79	19.16	3.67	2.15	5.1			
Chromium	5.0	0.01	0.01	0.04	0.03	0.01	0.01	1.16			
Copper	-	80.7	1.32	6.39	144.0	1.15	1.39	52.6			
Lead	5.0	19.9	6.46	11.67	19.85	5.27	1.56	64.8			
Nickel	-	17.5	1.26	1.56	18.5	1.32	0.94	8.6			
Zinc	-	358.5	50.0	52.9	320.1	46.2	26.8	216.4			

[a] As proposed in the Federal Register, Volume 51, No. 114, June 13, 1986.

[b] Test run not conducted - See Table 5-4 Experimental Design.

[c] Analysis performed after 14 days holding expired.

[d] Estimated value, calibration problem.

[e] Estimated value, poor surrogate recoveries.

contamination than was the water wash. Assuming the values reported for cadmium and lead in the Run 2 coarse and medium-grained fractions are not significantly greater than the regulatory limits for these metals, the chelant wash resulted in a 42 percent reduction (by weight) of contaminated material. The water wash and surfactant wash did not achieve any volume reduction for SARM III.

Table 5-11 presents the TCLP results for SARM IV (high organic, high metal contamination). The untreated soil sample exceeds the regulatory levels for all contaminants except chromium. For Runs 1, 2, and 3 the top two soil fractions (+2 mm and 250 μm to 2 mm) were below the TCLP limits for all of the volatile and semivolatile organics. However, these fractions all exceeded the TCLP limits for cadmium and/or lead. Overall, the chelant wash was more effective in reducing metal contamination than was the water wash or surfactant wash. Assuming the value reported for cadmium in the Run 2 coarse fraction is not significantly greater than its regulatory limit, the chelant wash resulted in a 13 percent reduction (by weight) of contaminated material. The water wash and surfactant wash did not achieve any volume reduction of SARM IV.

Tables 5-12 through 5-15 present contaminant percent reduction efficiencies, which were calculated from the TCLP data contained in Tables 5-8 through 5-11. In general, the highest reduction efficiencies were obtained for SARM I (high organic, low metal contamination) and SARM IV (high organic, high metal contamination). Normally, higher removal efficiencies can be expected with higher initial contaminant concentrations. For most washes, the +2-mm soil fraction exhibited the highest percentage of contaminant reduction. This observation upholds our primary assumptions of the soil

TABLE 5-11. PHASE II TCLP RESULTS: SARM IV (HIGH ORGANICS, HIGH METALS)

Contaminant	TCLP regulatory level (mg/l)[a]	Untreated SARM IV	Run 1, water wash			Run 2, 3:1 molar chelant wash			Run 3, 0.5% surfactant wash		
			>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm
Volatile organics											
Acetone	-	130	NF[b]	NF[b]	0.47	0.78	0.67	1.40	1.80	0.81	1.50
Chlorobenzene	1.4	6.7	0.04	0.09	0.69	0.07	0.09	1.50	0.02	0.10	0.17
1,2-Dichloroethane	0.40	13	0.02	0.03	0.36	0.04	0.01	0.21	0.02	0.04	0.05
Ethyl benzene	-	47	0.24	0.94	7.33	0.50	0.92	15.0	0.12	0.78	2.00
Styrene	-	11	0.07	0.17	1.52	0.14	0.23	4.20	0.03	0.22	0.46
Tetrachloroethylene	0.1	4.5	0.03	0.07	0.84	0.03	0.09	1.90	0.05	0.08	0.18
Xylene	-	100	0.44	1.57	13.23	1.20	2.20	36.0	0.23	1.80	5.00
Semivolatile organics											
Anthracene	-	3.4	0.02	0.01	0.01	0.01[d]	0.25	0.01	0.11	0.01	0.11
Bis(2-ethylhexyl) phthalate	-	3.0	0.02	0.04	1.0	0.01	0.22	0.21	0.11	0.10	0.10
Pentachlorophenol	3.6	3.8[c]	0.58[c]	1.60[c]	1.9[c]	0.37[c]	0.52[c]	8.5[c]	0.05	1.28	1.24
Inorganics											
Arsenic	5.0	9.58	0.94	2.09	10.94	0.75	1.91	5.81	0.97	2.91	12.8
Cadmium	1.0	35.3	2.98	9.05	14.7	1.62	5.54	10.6	4.87	9.60	25.2
Chromium	5.0	0.06	0.01	0.08	0.03	0.01	0.01	0.65	0.01	0.25	2.19
Copper	-	159.9	3.01	14.52	210.8	1.61	9.88	118.4	1.94	15.06	192.0
Lead	5.0	70.4	0.35	25.20	55.43	0.40	4.59	151.3	0.50	28.79	13.4
Nickel	-	26.8	1.23	2.95	19.2	0.99	2.52	12.2	1.06	2.73	21.95
Zinc	-	395.9	79.1	175.4	326.4	41.0	136.9	165.6	42.5	150.0	412.8

[a] As proposed in the Federal Register, Volume 51, No. 114, June 13, 1986.

[b] Not found due to interference from methylene chloride.

[c] Estimated value, calibration problem.

[d] Estimated value, identification uncertain.

TABLE 5-12. CONTAMINANT PERCENT REDUCTIONS AS TCLP[a]
SARM I (HIGH ORGANICS, LOW METALS)

Contaminant	Run 1 - water wash		Run 3 - surfactant wash	
Volatile organics	>2 mm	250 µm - 2 mm	>2 mm	250 µm - 2mm
Acetone	98.8	99.3	98.4	99.4
Chlorobenzene	99.2	99.2	99.8	97.7
1,2-dichloroethane	99.9	99.9	>99.9	>99.9
Ethyl benzene	98.5	98.8	98.4	96.4
Styrene	98.7	98.9	98.6	97.2
Tetrachloroethylene	99.4	99.4	99.1	97.0
Xylene	98.1	98.5	98.4	96.4
Overall volatile organic reduction[c]	98.9	99.2	98.8	98.5
Semivolatile Organics				
Anthracene	85.7	NR[b]	85.7	71.4
Bis (2-ethylhexyl phthalate)	60.0	60.0	NR	NR
Pentachlorophenol	99.2	85.5	99.5	94.6
Overall semivolatile organic reduction[c]	98.6	84.0	98.1	93.2
Inorganics				
Arsenic	NR	NR	66.7	NR
Cadmium	71.7	24.5	77.4	50.9
Chromium	NR	NR	NR	NR
Copper	93.4	54.1	90.2	70.5
Lead	69.4	55.1	69.4	69.4
Nickel	85.2	66.7	85.2	77.8
Zinc	90.4	64.7	90.8	79.3
Overall metal reduction[c]	87.4	60.9	88.6	75.9

[a] Calculated from data contained in Table 5-8.

[b] NR = no reduction.

[c] Overall reduction efficiencies calculated from total TCLP contaminant levels in untreated soil versus total TCLP contaminant levels in treated soil.

TABLE 5-13. CONTAMINANT PERCENT REDUCTIONS AS TCLP[a]
SARM II (LOW ORGANICS, LOW METALS)

Contaminant	Run 1 - water wash		Run 2 - chelant wash		Run 3 - surfactant wash	
Volatile organics	>2 mm	250 µm - 2 mm	>2 mm	250 µm - 2 mm	>2 mm	250 µm - 2mm
Acetone	NR[b]	94.6	89.1	89.1	89.1	89.1
Chlorobenzene	NR	NR	80.0	NR	60.0	NR
1,2-dichloroethane	NR	NR	NR	NR	NR	NR
Ethyl benzene	NR	58.3	41.7	50.0	NR	NR
Styrene	NR	NR	33.3	NR	NR	NR
Tetrachloroethylene	NR	60.0	80.0	NR	80.0	60.0
Xylene	NR	NR	56.7	50.0	NR	NR
Overall volatile organic reduction[c]	NR	NR	74.3	66.4	47.4	22.4
Semivolatile Organics						
Anthracene	NR	NR	NR	NR	NR	NR
Bis (2-ethylhexyl phthalate)	90.9	90.9	81.8	86.4	95.4	90.9
Pentachlorophenol	98.9	94.4	98.9	82.2	95.5	76.7
Overall semivolatile organic reduction[c]	95.6	92.9	94.7	81.4	94.7	77.9
Inorganics						
Arsenic	NR	NR	NR	NR	NR	NR
Cadmium	90.4	56.2	93.2	90.4	95.9	68.5
Chromium	NR	NR	NR	NR	NR	NR
Copper	95.5	64.0	88.8	86.5	94.4	88.8
Lead	91.4	3.0	78.6	78.6	78.6	78.6
Nickel	62.5	70.0	90.0	72.5	70.0	77.5
Zinc	96.8	57.7	97.1	94.9	99.2	74.2
Overall metal reduction[c]	94.6	55.5	94.7	92.2	96.4	74.2

[a] Calculated from data contained in Table 5-9.

[b] NR = no reduction.

[c] Overall reduction efficiencies calculated from total TCLP contaminant levels in untreated soil versus

TABLE 5-14. CONTAMINANT PERCENT REDUCTIONS AS TCLP[a]
SARM III (LOW ORGANICS, HIGH METALS)

Contaminant	Run 1 - water wash		Run 2 - chelant wash	
Volatile organics	>2 mm	250 µm - 2 mm	>2 mm	250 µm - 2mm
Acetone	93.7	14.1	94.6	96.5
Chlorobenzene	86.8	NR	89.5	94.7
1,2-dichloroethane	90.0	38.0	90.0	90.0
Ethyl benzene	99.1	NR	92.6	94.6
Styrene	90.0	NR	84.0	88.0
Tetrachloroethylene	84.8	NR	90.9	93.9
Xylene	99.1	NR	92.5	93.4
Overall volatile organic reduction[c]	96.8	NR	92.9	94.3
Semivolatile Organics				
Anthracene	NR	NR	NR	NR
Bis (2-ethylhexyl phthalate)	77.8	77.8	77.8	77.8
Pentachlorophenol	50.0	NR	91.2	NR
Overall semivolatile organic reduction[c]	54.5	NR	86.4	2.3
Inorganics				
Arsenic	86.5	72.6	90.0	91.4
Cadmium	85.0	76.5	88.9	93.5
Chromium	NR	NR	NR	NR
Copper	98.4	92.1	98.6	98.3
Lead	67.5	41.3	73.5	92.2
Nickel	92.8	91.1	92.4	94.6
Zinc	86.0	85.2	87.1	92.5
Overall metal reduction[c]	87.4	84.1	88.7	93.5

[a] Calculated from data contained in Table 5-10.

[b] NR = no reduction.

[c] Overall reduction efficiencies calculated from total TCLP contaminant levels in untreated soil versus total TCLP contaminant levels in treated soil.

TABLE 5-15. CONTAMINANT PERCENT REDUCTIONS AS TCLP[a]
SARM IV (HIGH ORGANICS, HIGH METALS)

Contaminant	Run 1 - water wash		Run 2 - chelant wash		Run 3 - surfactant wash	
Volatile organics	>2 mm	250 µm - 2 mm	>2 mm	250 µm - 2 mm	>2 mm	250 µm - 2mm
Acetone	NF[b]	NF	99.4	99.5	98.6	99.4
Chlorobenzene	99.4	98.6	98.9	98.6	99.7	98.5
1,2-dichloroethane	99.8	99.8	99.7	99.9	99.8	99.7
Ethyl benzene	99.5	98.0	98.9	98.0	99.7	98.3
Styrene	99.4	98.4	98.7	97.9	99.7	98.0
Tetrachloroethylene	99.3	98.4	99.3	98.0	98.9	98.2
Xylene	99.6	98.4	98.8	97.8	99.8	98.2
Overall volatile organic reduction[d]	99.7	99.1	99.1	98.6	99.3	98.8
Semivolatile Organics						
Anthracene	99.4	99.7	99.7	92.6	96.8	99.7
Bis (2-ethylhexyl phthalate)	99.3	98.7	96.7	92.6	96.3	96.7
Pentachlorophenol	84.7	57.9	90.3	86.3	98.7	66.3
Overall semivolatile organic reduction[d]	93.9	83.8	96.2	90.3	97.3	86.4
Inorganics						
Arsenic	90.2	78.2	92.2	80.1	90.0	69.6
Cadmium	91.6	74.4	95.4	84.3	86.2	72.8
Chromium	83.3	NR[c]	83.3	83.3	83.3	NR
Copper	98.1	90.9	99.0	93.8	98.8	90.6
Lead	99.5	64.2	99.4	93.5	99.3	59.1
Nickel	95.4	89.1	96.3	90.6	96.1	89.8
Zinc	80.1	55.7	89.6	65.4	89.3	62.1
Overall metal reduction[d]	87.4	67.1	93.3	76.9	92.6	70.0

[a] Calculated from data contained in Table 5-11.

[b] Not found.

[c] NR = no reduction.

washing process: 1) that a significant fraction of the contaminants are attached to the smaller particles (silt, humus, and clay); and 2) that a physical washing of the sand/gravel/rock fraction will effectively remove the finer particles, and thus most of the contaminants, from the coarse material.

In general, the volatile organics exhibited high percent reductions. This is partially attributable to their nature (i.e., many of the volatile organics were probably lost to the air during the sampling and soil washing process). Furthermore, volatiles were generally removed from the SARM with water as efficiently as they were removed with a surfactant or chelant solution. This is particularly evident in Tables 5-12 and 5-15 where the reduction efficiencies have been calculated for the high-organic-contaminated soils (SARM I and IV). The low organic contaminated soils (SARM II and III) show less conclusive results because the concentrations are often at or near the detection limits. When the numbers are this low, a slight change in concentration can exaggerate the resulting effect on removal efficiencies.

The semivolatile organics showed a wide variation in removal efficiencies. Again, the best removal efficiencies for the semivolatiles were obtained with SARM I and SARM IV (high-organic-contaminated soils). However, as in the case of the volatiles, none of the wash solutions obtained consistently better results than any of the other solutions. As indicated in Tables 5-8 through 5-11 (and in Section 5-10), many of the semivolatile organic results are estimated values because of equipment calibration problems, compound identification uncertainties, and low surrogate recoveries. Therefore, it is inappropriate to draw definitive conclusions relative to the removal efficiencies of different wash solutions with respect to the semivolatiles.

Contaminant reduction efficiencies for the metals were consistently higher for the chelant wash than for the water or surfactant washes. The water and surfactant washes showed similar results in terms of metal concentration reduction. However, the overall removal efficiencies for metals in the top two soil size fractions (+2-mm and 250-μm to 2-mm) were higher with the chelant wash. The greatest difference in contaminant reduction efficiencies can be seen in the 250-μm to 2-mm soil size fraction. The overall average percent reduction for all metals in the 250-μm to 2-mm soil fraction for water and surfactant washes was 66.9 and 73.4 percent, respectively, whereas the average metal percent reduction in the same soil size class for the chelant wash was 87.5 percent. The +2-mm soil size class showed a similar pattern of metals removal. However, the differences in overall removal efficiencies for water, surfactant, and chelant washes (89.2, 92.5, and 92.2 percent, respectively) were less pronounced than for the middle soil fraction.

5.8.2 Total Waste Analysis Results

A total waste analysis for the 17 spiked compounds was performed on each of the three size fractions according to the methods contained in SW-846, 3rd edition. To ensure accuracy of the data, all Phase II analyses were run in duplicate. Consequently, all values reported in this section are averages of the duplicate analyses. The raw analytical data from Phase II are contained in Appendix D of this report.

Tables 5-16 through 5-19 present the results of the prewash analysis for each SARM. The experimental procedure for the prewash is described in Section 5.6.1. This portion of the bench-scale soil-washing evaluation was designed to show how the contaminants were distributed among the size fractions prior to soils washing of the SARMS. As can be seen from the data in

TABLE 5-16. PHASE II PREWASH RESULTS
SARM I (HIGH ORGANIC, LOW METAL CONTAMINATION)

Contaminant	SARM I target contaminant level, ppm	Untreated soil,[a] ppm		
		>2 mm	250 μm-2 mm	<250 μm
Volatile organics				
Acetone	6800	33	51	180
Chlorobenzene	400	<0.015	1.4	22
1,2-Dichloroethane	600	<0.016	0.11	<0.94
Ethylbenzene	3200	0.038	11	200
Styrene	1000	0.029	ND	34
Tetrachloroethylene	600	ND[b]	0.78	42
Xylene	8200	0.097	26	300
Semivolatile organics				
Anthracene	6500	38	3,800	720
Bis(2-ethylhexyl)phthalate	2500	8.2	1,400	1,200
Pentachlorophenol	1000	25	110	63
Metals				
Arsenic	10	3.5	4.3	18.4
Cadmium	20	4.8	11.2	26.4
Chromium	30	2.8	2.3	40.2
Copper	190	10.3	30.6	358
Lead	280	11.4	28.4	370
Nickel	30	5.3	6.8	32.6
Zinc	450	35.6	151	678

[a] Wet-sieved only.

[b] ND = not detected.

TABLE 5-17. PHASE II PREWASH RESULTS

SARM II (LOW ORGANIC, LOW METAL CONTAMINATION)

Contaminant	SARM II target contaminant level, ppm	Untreated soil,[a] ppm		
		>2 mm	250 µm-2 mm	<250 µm
Volatile organics				
Acetone	680	2.1	2.4	3.8
Chlorobenzene	40	0.002	<0.26	0.034
1,2-Dichloroethane	60	ND[b]	0.024	<0.021
Ethylbenzene	320	0.010	1.9	0.23
Styrene	100	0.016	<0.050	0.26
Tetrachloroethylene	60	ND	<0.11	<0.026
Xylene	820	0.026	4.0	0.87
Semivolatile organics				
Anthracene	650	ND	60	760
Bis(2-ethylhexyl)phthalate	250	34	50	460
Pentachlorophenol	100	<6.0	7.2	12
Metals				
Arsenic	10	5.2	4.6	27.2
Cadmium	20	3.2	11.8	45.4
Chromium	30	<1.1	5.8	56.5
Copper	190	8.6	41.7	495
Lead	280	8.8	53.0	516
Nickel	30	<2.4	9.4	47.3
Zinc	450	19.4	257	1,100

[a] Wet-sieved only.

[b] ND = not detected.

TABLE 5-18. PHASE II PREWASH RESULTS
SARM III (LOW ORGANIC, HIGH METAL CONTAMINATION)

Contaminant	SARM III target contaminant level, ppm	Untreated soil,[a] ppm		
		>2 mm	250 µm-2 mm	<250 µm
Volatile organics				
Acetone	680	1.8	2.7	7.6
Chlorobenzene	40	0.014	0.28	0.64
1,2-Dichloroethane	60	0.001	0.023	<0.28
Ethylbenzene	320	0.066	0.88	12
Styrene	100	<0.020	ND[b]	2.4
Tetrachloroethylene	60	0.006	0.31	1.5
Xylene	820	1.0	2.0	24
Semivolatile organics				
Anthracene	650	12	510	1,200
Bis(2-ethylhexyl)phthalate	250	4.0	13	880
Pentachlorophenol	100	4.0	44	45
Metals				
Arsenic	500	60.8	88.1	1,040
Cadmium	1,000	321	288	682
Chromium	1,500	8.6	19.4	2,240
Copper	9,500	107	278	11,500
Lead	14,000	200	480	28,800
Nickel	1,000	24.5	46.6	1,360
Zinc	22,500	612	1,200	46,900

[a] Wet-sieved only.

[b] ND = not detected.

TABLE 5-19. PHASE II PREWASH RESULTS
SARM IV (HIGH ORGANIC, HIGH METAL CONTAMINATION)

Contaminant	SARM IV target contaminant level, ppm	Untreated soil,[a] ppm		
		>2 mm	250 μm-2 mm	<250 μm
Volatile organics				
Acetone	6,800	4.0	5.0	300
Chlorobenzene	400	<0.016	0.30	300
1,2-Dichloroethane	600	<0.016	0.090	48
Ethylbenzene	3,200	0.030	2.1	4,000
Styrene	1,000	<0.028	ND	750
Tetrachloroethylene	600	ND[b]	0.22	520
Xylene	8,200	0.087	4.4	3,400
Semivolatile organics				
Anthracene	6,500	6.4	2,900	8,300
Bis(2-ethylhexyl)phthalate	2,500	2.6	58	5,700
Pentachlorophenol	1,000	18	140	440
Metals				
Arsenic	500	68.4	110	929
Cadmium	1,000	320	291	652
Chromium	1,500	3.7	54.4	2,180
Copper	9,500	96.8	743	22,000
Lead	14,000	116	1280	23,800
Nickel	1,000	21.0	113	1,320
Zinc	22,500	586	7420	36,000

[a] Wet-sieved only.

[b] ND = not detected.

Tables 5-16 through 5-19, size classification of the SARMS by wet-sieving proved effective in physically separating the contaminants from the coarse and medium-grained materials (+250-μm size fraction) and concentrating them in the fines (-250-μm size fraction). These results support the basic assumptions underlying the volume-reduction approach to soils washing (i.e., that a significant fraction of the contaminants are attached to the fines, and that the coarse material can be cleaned by physically separating and concentrating the fines).

Although this prewash analysis was originally intended to serve as a baseline by which to judge the effectiveness of the various washing solutions, it is clear that the contaminants were effectively mobilized by simple water rinses during the wet sieving procedure. This demonstrates that for soils that have contacted contaminants for only a short period of time (such as the SARMS or spill site soils), particle size separation techniques may significantly reduce the volume of contaminated soil. In preliminary bench-scale experiments, it was determined that the SARM is approximately 13 percent by weight coarse material, 29 percent by weight medium-grained material, and 58 percent by weight fines. Therefore, the data presented in Tables 5-16 through 5-19 indicate that for the SARMS, at least a 13 percent reduction and possibly a 42 percent reduction (by weight) of the volume of contaminated soil can be achieved by an efficient particle size separation.

Tables 5-20 through 5-23 present the results from Phase II soil washing of each SARM. In general, there are no apparent differences between the water wash, the 3:1 molar chelant wash, and the 0.5 percent surfactant wash for cleaning of the +2-mm soil fraction. As hypothesized, the silt and clay particles appear to be attached to the sand and gravel primarily by physical

TABLE 5-20. PHASE II RESULTS: SARM I (HIGH ORGANICS, LOW METALS)
(ppm)

Contaminant	Target contaminant level, ppm	Run 1, water wash			Run 2, 3:1 molar chelant wash[a]			Run 3, 0.5% surfactant wash		
		>2 mm	250 μm-2 mm	<250 μm	>2 mm	250 μm-2 mm	<250 μm	>2 mm	250 μm-2 mm	<250 μm
Volatile organics										
Acetone	6800	10	20	140				22	8.0	50
Chlorobenzene	400	0.028	0.28	160				0.30	1.0	31
1,2-Dichloroethane	600	<0.023	0.18	24				0.15	0.32	6.0
Ethyl benzene	3200	0.13	1.4	2300				2.3	8.5	680
Styrene	1000	ND[b]	ND	400				<0.17	ND	96
Tetrachloroethylene	600	0.009	0.12	250				0.20	0.81	49
Xylene	8200	0.38	3.2	1800				4.0	14	820
Semivolatile organics										
Anthracene	6500	6.5	3200	1400				3.3	2500	2700
Bis(2-ethylhexyl) phthalate	2500	4.0	92	1600				<6.1	100	1600
Pentachlorophenol	1000	66	26	53				8.4	4.6	ND
Inorganics										
Arsenic	10	3.0	5.2	18.6				4.5	5.8	19.1
Cadmium	20	7.3	11.3	28.8				6.9	11.0	26.2
Chromium	30	1.5	2.6	43.4				3.0	3.0	46.8
Copper	190	10.6	30.5	387				11.8	34.6	384
Lead	280	11.1	28.8	402				10.1	40.1	420
Nickel	30	3.2	7.8	35.1				5.1	6.8	31.6
Zinc	450	44.8	106	726				47.9	101	647

[a] Test not conducted - See Table 5-4 Experimental Design.

[b] ND = not detected.

TABLE 5-21. PHASE II RESULTS: SARM II (LOW ORGANICS, LOW METALS)
(ppm)

Contaminant	Target contaminant level, ppm	Run 1, water wash			Run 2, 3:1 molar chelant wash			Run 3, 0.5% surfactant wash		
		>2 mm	250 μm-2 mm	<250 μm	>2 mm	250 μm-2 mm	<250 μm	>2 mm	250 μm-2 mm	<250 μm
Volatile organics										
Acetone	680	0.50	0.31	0.50	0.58	1.2	2.7	0.46	0.75	1.8
Chlorobenzene	40	0.002	0.013	<0.23	<0.004	0.006	0.020	0.002	0.002	ND
1,2-Dichloroethane	60	ND[a]	<0.004	ND	ND	0.003	0.003	ND	0.004	ND
Ethyl benzene	320	0.014	0.082	0.14	0.005	0.058	0.13	0.009	0.015	0.62
Styrene	100	0.016	0.13	0.25	<0.006	0.066	0.12	0.010	<0.013	0.28
Tetrachloroethylene	60	ND	<0.004	<0.22	ND	<0.004	0.009	ND	ND	<0.30
Xylene	820	0.040	0.31	0.52	0.021	0.20	0.44	0.028	0.040	1.3
Semivolatile organics										
Anthracene	650	3.2	180	830	8.8	210	660	1.6	120	700
Bis(2-ethylhexyl) phthalate	250	27	46	370	40	44	260	28	32	160
Pentachlorophenol	100	ND	6.8	4.6	ND	5.1	ND	2.4	7.8	ND
Inorganics										
Arsenic	10	2.5	4.2	24.8	3.9	4.4	12.6	3.0	3.6	27.8
Cadmium	20	6.0	10.2	55.6	2.0	4.0	7.5	4.8	9.4	37.7
Chromium	30	<0.88	4.0	90.4	1.6	3.4	69.7	2.7	3.5	56.6
Copper	190	5.0	25.4	652	8.2	15.6	238	9.0	28.6	478
Lead	280	4.0	69.0	710	6.2	12.6	110	8.5	31.8	511
Nickel	30	4.0	7.2	68.6	4.2	7.0	43.0	3.2	6.8	41.8
Zinc	450	21.0	107	1380	28.3	63.6	546	25.8	112	906

[a] ND = not detected.

TABLE 5-22. PHASE II RESULTS: SARM III (LOW ORGANICS, HIGH METALS) (ppm)

Contaminant	Target contaminant level, ppm	Run 1, water wash			Run 2, 3:1 molar chelant wash			Run 3, 0.5% surfactant wash[a]		
		>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm	>2 mm	250 µm-2 mm	<250 µm
Volatile organics										
Acetone	680	0.74	1.7	16	0.96	2.6	3.3			
Chlorobenzene	40	0.008	0.16	1.6	0.011	0.23	1.2			
1,2-Dichloroethane	60	<0.004	0.024	0.084	0.002	0.034	<0.050			
Ethyl benzene	320	0.040	1.3	34	0.054	2.0	20			
Styrene	100	0.026	<0.30	6.4	ND[b]	0.55	3.0			
Tetrachloroethylene	60	0.002	0.16	3.0	0.006	0.23	2.2			
Xylene	820	0.10	2.6	58	0.091	3.6	31			
Semivolatile organics										
Anthracene	650	<5.6	480	1,800	1.7	540	1800			
Bis(2-ethylhexyl) phthalate	250	2.2	7.4	1,100	3.4	9.4	790			
Pentachlorophenol	100	9.2	40	59	<6.6	13	<96			
Inorganics										
Arsenic	500	54.6	102	1,160	36.6	51.0	243			
Cadmium	1,000	372	276	746	290	116	110			
Chromium	1,500	3.8	14.8	2,590	3.2	9.2	1940			
Copper	9,500	68.4	264	20,800	38.6	104	2250			
Lead	14,000	122	491	30,600	98.1	171	1470			
Nickel	1,000	18.6	42.2	1,570	17.5	28.2	472			
Zinc	22,500	558	1010	48,200	500	519	6760			

[a] Test run not conducted - See Table 5-4 Experimental Design.

[b] ND = not detected.

TABLE 5-23. PHASE II RESULTS: SARM IV (HIGH ORGANICS, HIGH METALS) (ppm)

Contaminant	Target contaminant level, ppm	Run 1, water wash			Run 2, 3:1 molar chelant wash			Run 3, 0.5% surfactant wash		
		>2 mm	250 μm-2 mm	<250 μm	>2 mm	250 μm-2 mm	<250 μm	>2 mm	250 μm-2 mm	<250 μm
Volatile organics										
Acetone	6800	5.8	5.8	120	16	21	180	14	15	53
Chlorobenzene	400	0.020	1.5	68	0.012	1.4	99	0.076	0.94	22
1,2-Dichloroethane	600	0.028	<0.34	<8.6	<0.004	<0.54	40	0.10	<0.30	4.4
Ethyl benzene	3200	0.080	15	2,000	0.051	12	1000	0.52	7.4	300
Styrene	1000	ND[a]	<2.8	150	<0.026	ND	200	0.17	ND	54
Tetrachloroethylene	600	<0.017	2.3	120	0.006	1.4	170	0.048	1.1	45
Xylene	8200	0.18	25	3,200	0.11	23	1700	0.86	26	460
Semivolatile organics										
Anthracene	6500	28	2700	5,200	40	1700	3300	2.4	1800	5,800
Bis(2-ethylhexyl) phthalate	2500	5.8	34	3,100	9.6	70	2800	<5.6	26	1,500
Pentachlorophenol	1000	23	39	360	8.4	22	<180	38	42	100
Inorganics										
Arsenic	10	126	110	924	63.4	91.7	180	30	110	538
Cadmium	20	348	286	643	279	210	107	308	336	739
Chromium	30	7.7	29.0	2,180	6.4	29.8	1480	5.9	32.5	1,500
Copper	190	148	467	18,400	80.6	332	1990	63.1	446	11,100
Lead	280	168	1260	23,900	103	272	1360	68.4	818	15,000
Nickel	30	29.8	56.4	1,240	19.4	70.7	284	14	62.9	618
Zinc	450	873	3320	36,200	558	4730	5160	462	3040	25,400

[a] ND = not detected.

processes, such as compaction and adhesion. These physical attractions are often related to the age of the soil and the contact time between the contaminants and soil particles. Because the SARM is a synthetic waste, the forces of attraction are relatively weak, a condition more typical of a spill site soil than an older, abandoned CERCLA site soil. Consequently, the water wash was as effective in cleaning the +2-mm soil fraction as the other water plus additive solutions.

Removal of contaminants from the medium-grained fraction (250-μm to 2-mm) appears to entail both physical and chemical processes. By nature, this middle soil fraction, which is composed of medium to fine sand, does not absorb contaminants to the degree that clays and silts do. In comparison of the water wash and the 3:1 molar chelant wash, a marked reduction in the residual concentration of metals can be seen. This trend is particularly apparent in the data for SARM III (Table 5-22) and is also evident in the data for SARM IV (Table 5-23). The organics show less variation between experiment runs in this soil size class. For the most part, water is as effective as the surfactant wash for reducing the level of contamination. The one anomaly is anthracene, which shows particularly high levels in the medium soil class. It appeared that anthracene was not fully dissolved prior to addition into the SARM; flakes of what was believed to be anthracene were observed on the 60-mesh screen during the washing experiments.

Reduction of contaminants in the fine soil fraction (less than 250 μm) appears to be more affected by the use of different wash solutions than in the other soil fractions. The chelant wash (Run 2) significantly reduced metal contamination in the fine soil fraction, as can be seen in Tables 5-21 through 5-23. This reduction is particularly evident in Tables 5-22 and 5-23, in which high metal contamination was originally present. Although the

spent wash water was not analyzed, it can be assumed that chelation effectively mobilized metals into solution. Similarly, the surfactant wash (Run 3) significantly reducted the organic contamination in the fine soil fraction, as evident in Tables 5-20 and 5-23 for the high-organic-content SARMS. Again, the wash water was not analyzed; however, it can likewise be assumed that the surfactant successfully mobilized organics into solution.

5.9 SCALE-UP CONSIDERATIONS

The EPA Mobile Soil Washing System was selected as a model to scale-up the results of the Phase II soil washing experiments and project these results into terms of processing rates and costs.

Although a pilot scale unit, and not in commercial use, the MSWS has the components of mineral/mining process streams. More importantly, its performance has been quantified for use as a corrective action technology for contaminated soils (Shum, 1987). Its functions have also been incorporated into a computer model (Nash, 1987).

The Mobile Soil Washing System (MSWS) consists of two principal pieces of trailer mounted hardware. The first is the drum screen unit (DSU) schematically shown in the upper portion of Figure 5-3. The second unit is a froth flotation unit shown in the lower half of Figure 5-3. Both of these units require support equipment to operate. Earth moving equipment is needed to bring the soil to the drum screen and a wastewater treatment system is required to allow the recycling of the spent wash fluid.

Contaminated soil is fed into the system through a soil feed meter on the drum screen. In order for the meter to work, cobbles larger than one

inch in diameter must be screened out of the soil. This is done using a one inch by two inch grate to cover the loading hopper of the MSWS. The soil meter is then able to deliver soil to the first screen at a controlled rate.

The drum screen separates the soil into two particle classifications -- greater than two millimeters (+2 mm) and less than two millimeters (-2 mm). The +2-mm particles are tumbled and washed in the drum section. This process starts inside the first cylindrical screen. While the screen rotates the soil is tumbled and broken-up by high pressure streams of water from "water knives". Soil that is fine enough to pass through the screen becomes part of a slurry that is pumped to the froth flotation unit.

The +2-mm particles (gravel) are tumbled into the drum over baffles. The drum, as well as both screens, are operated on an incline. It is this incline in combination with the rotation that causes the gravel to move down the drum. The residence time in the drum is approximately fifteen minutes depending on the incline and speed of rotation. During this washing, additional material that is less than two millimeters is removed from the gravel.

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A second screen at the discharge end of the drum allows for a final separation of the two sizes. A dilute slurry of the fine particles under the

momentum of water from a second set of water knives passes through the screen and is pumped to the nozzles of the first screen, as shown on Figure 5-3. Meanwhile, the gravel is given a final rinse with sprays of clean wash fluid before discharge into bins or directly back to the ground.

The slurry created in the sump of the first screen is pumped from the drum screen to the first cell of the four chamber froth flotation unit. In this cell, as in each of the other three 200 gallon capacity cells, the slurry is agitated and sparged. If a froth is formed by this action it is skimmed from the surface by a rotating paddle wheel. The non-frothed slurry is pumped to a hydrocyclone.

The function of a hydrocyclone is to remove solid particles from a liquid slurry. Depending on the density, size, and shape of the particles a hydrocyclone will be more or less effective. In general, soil particles with a density of 2.6 grams/cubic centimeter and less than 0.075 millimeters in diameter (pass through a #200 mesh screen) will not be removed from the wastewater stream. These particles, with the majority of the liquid (called the overflow,) will pass out of the top of the hydrocyclone. The solids, that are concentrated by the hydrocyclone pass out the bottom (the apex) along with liquid. This material is called the underflow. In order to keep working properly, the underflow cannot have more than 10 percent suspended solids. This characteristic of the hydrocyclone is the controlling factor in the MSWS processing rate when the soil has more then 20 percent -2-mm particles.

There are four hydrocyclones on the froth flotation unit. Referring to Figure 5-3, the concentrated slurry underflow of each hydrocyclone is

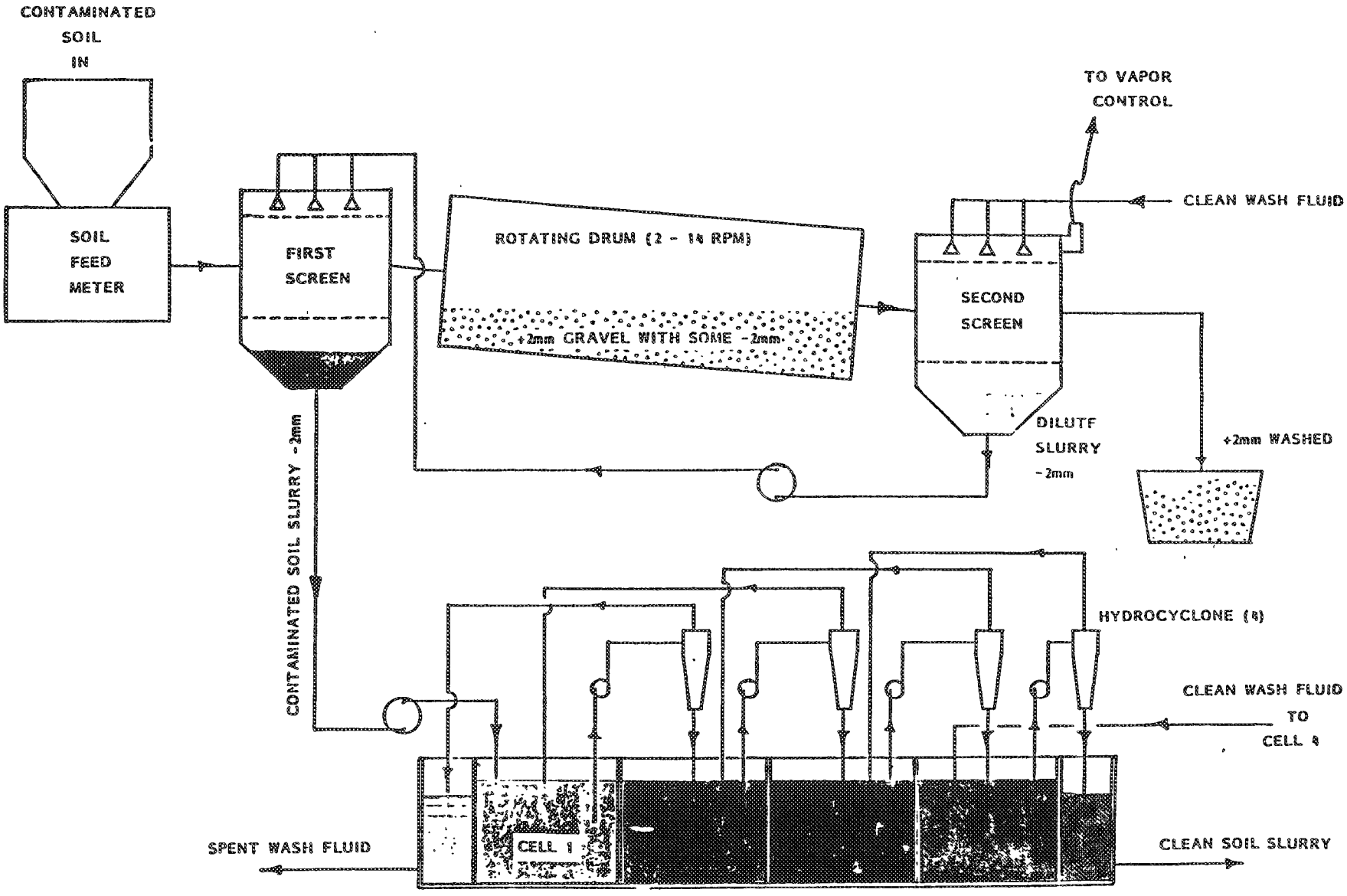

Figure 5-3. Schematic of the Mobile Soil Washing System.

deposited in the cell to the right of the hydrocyclone's feed source. The overflow is deposited to the left of the hydrocyclone's feed source. This countercurrent process results in two effluent streams from the froth flotation unit. They are: 1) the majority of the soil in a concentrated slurry that is considered the clean soil, and 2) the majority of the spent wash fluid along with the finer fractions of the soil. Because of this countercurrent process, the froth flotation unit is generally referred to as the countercurrent unit (CCU).

In considering scale-up from the bench scale experiments conducted in this study to use of the mobile soil washer, the treatment of the residuals from the countercurrent unit must be taken into account in evaluating the MSWS as an economical technology alternative. For the purpose of identifying an over all expected performance and because of this study's findings that "none of the variables appear to have a more significant effect on organic contaminant reduction than any of the others" all of the data was analyzed as coming from equivalent treatments. Expected process wastewater stream concentrations were calculated based on the difference between initial and final contaminant levels for SARM I and II. Final concentrations of the soil were determined by mathematically reconstituting the soil using the total waste analyses for the three size fractions and the weight percent distribution of the uncontaminated SARM soil. The waste stream flow coming away from the MSWS was calculated from the 10:1 washing ratio used in the study.

Depending on the soil, SARM I, II, III, or IV and the washing process the effluent streams from the MSWS could contain the following in pounds per day:

	Volatiles	Semi-volatiles	Metals
High value	700-800	200-300	300-500*
Low value	100-120	30-40	30-40

*Projection based on low metals value.

According to the EPA Treatability Manual (EPA, 1983) the waste stream would require a combination of vapor stripping and vapor recovery, carbon absorption, and chemical precipitation with sedimentation or filtration. Precipitation/coagulation data given in the manual for heavy metals indicate a 100 to 200:1 ratio for such things as ferric sulfate, alum, lime and sodium hydroxide to the heavy metal present. The technologies required to support soil washing (i.e., treatment of the MSWS residuals, -2-mm soil) of a SARM IV type soil would be significant; the closest industrial situation would be industries involved in metal processing and finishing. There are no treatability studies that could be found to evaluate this process waste water stream. However, based on the treatability of the metals, some of the treatment chemicals would rival or exceed the quantity of contaminants present in the original soils.

Based on the computer model, the cost of washing soil in a way compatible with the BDAT Phase II lab study would cost between $260 and $280 per cubic yard. This is based on $0.50 per pound washing additive, a $0.02 per gallon wastewater treatment cost and doing the work near Cincinnati Ohio. The processing rate calculates out to 18 cubic yards per twelve hour day, for a 4400 cubic yard job. It should be noted that the model is positively biased and that field trials have only shown instantaneous rates predicted by the model. Due to a number of factors, shift rates are 50 percent of best

instantaneous rates. This cost does not include the cost of landfilling the contaminated residuals.

5.10 QUALITY ASSURANCE/QUALITY CONTROL

All total waste analyses were performed in duplicate to ensure that any variation in sampling and analytical methods would be minimized. All values reported in Tables 5-16 through 5-23 are average values calculated as an arithmetic mean from the individual results, which can be found in Appendix D. Matrix spikes (MS) and matrix spike duplicates (MSD) were analyzed on selected samples to calculate precision and accuracy for the data set. Tables 5-24 through 5-29 show the results of the MS/MSD analysis for the middle soil fraction (2-mm to 250-μm) of SARM II and SARM IV. All MS/MSD analyses can be found in Appendix D. The middle size fraction was chosen for inclusion in this section because it represents neither unusually high nor unusually low contaminant concentrations.

Tables 5-24 and 5-25 present the MS/MSD for metals in SARM II and SARM IV, respectively. In Table 5-24, lead and zinc were both spiked at less than two times their native concentrations; therefore, lead was not recovered and zinc showed an elevated precision (relative percent difference, RPD). Where appropriate spike levels were used, precision and accuracy were within the QA/QC objectives of less than 20 and 75 to 125, respectively, as shown in Table 5-25.

The results for volatile organic MS/MSD are shown in Tables 5-26 and 5-27. Again, where the spike was added at less than 2 times the native analyte concentration (Table 5-19), QA/QC objectives were not met as often. Furthermore, the soil sampled for the QA/QC analysis appears to be variable in concentration. Many times, native analyte concentrations could not be

TABLE 5-24. SARM II EXPERIMENTAL RUN 1, 2 mm TO 250 µm SOIL FRACTION SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR METALS[a,b]

Compound	Concentration spike added MS	Concentration spike added MSD	Sample result	Concentration MS	Percent recovery	Concentration MSD	Percent recovery	RPD[c]
Arsenic	43.8	47.1	4.1	43.3	90	44.1	85	5.7
Cadmium	43.8	47.1	9.3	48.7	90	49.1	85	5.7
Chromium	43.8	47.1	4.2	37.2	75	38.9	74	1.3
Copper	43.8	47.1	24.2	66.9	97	58.2	72	30
Lead	43.8	47.1	103	67.4	0[d]	59.8	0[d]	0
Nickel	43.8	47.1	6.7	40.7	78	41.5	74	5.3
Zinc	43.8	47.1	78.6	223	130[d]	116	79	123

[a] Concentration units are mg/kg (ppm) on a dry weight basis.

[b] MS = Matrix spike, MSD = Matrix spike duplicate.

[c] RPD = Relative percent difference.

[d] Spike added is approximately 2 times less than native analyte.

TABLE 5-25. SARM IV EXPERIMENTAL RUN 3, 2 mm TO 250 µm SOIL FRACTION SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR METALS[a,b]

Compound	Concentration spike added MS	Concentration spike added MSD	Sample result	Concentration MS	Percent recovery	Concentration MSD	Percent recovery	RPD[c]
Arsenic	516	563	105	600	96	707	107	11
Cadmium	2,060	2,250	311	2,230	93	2,390	92	1.1
Chromium	516	563	30.2	489	89	536	90	1.1
Copper	2,060	2,250	390	2,610	108	2,640	100	7.7
Lead	2,060	2,250	657	2,430	86	3,130	102	17
Nickel	516	563	52.1	523	91	595	96	5.3
Zinc	10,300	11,300	1980	12,600	103	14,300	109	5.7

[a] Concentration units are mg/kg (ppm) on a dry weight basis.

[b] MS = Matrix spike, MSD = Matrix spike duplicate.

[c] RPD = Relative percent difference.

TABLE 5-26. SARM II EXPERIMENTAL RUN 1, 2 mm TO 250 µm SOIL FRACTION SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR VOLATILE ORGANICS[a,b]

Compound	Concentration spike added	Sample result	Concentration MS	Percent recovery	Concentration MSD	Percent recovery	RPD[c]
Acetone[d]	120	310	440	108	460	125	14
1,2-Dichloroethane	120	ND[e]	130	108	130	108	0
Tetrachloroethene	120	ND	130	108	130	108	0
Ethyl benzene	120	54	170	97	180	105	7.9
Chlorobenzene	120	8	130	102	130	102	0
Styrene	120	96	250	128	230	112	13
Xylenes	120	220	370	125	330	92	30

[a] Concentration units are µg/kg (ppm) on a dry weight basis.

[b] Quantitation limit = 6.

[c] RPD = Relative percent difference.

[d] This compound has a quantitation limit of 2 times that listed.

[e] ND = Not detected.

TABLE 5-27. SARM IV EXPERIMENTAL RUN 3, 2 mm TO 250 µm SOIL FRACTION, SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR VOLATILE ORGANICS[a,b,c]

Compound	Concentration spike added	Sample result	Concentration MS	Percent recovery	Concentration MSD	Percent recovery	RPD[d]
Acetone	15,000	6,600	12,000	36	13,000	43	18
1,2-Dichloroethane	3,100	<310 (140)[e]	3,300	102	3,200	99	3.0
Tetrachloroethane	3,100	1,900	5,200	106	6,300	142	5.6
Ethyl benzene	7,400	17,000	28,000	149	36,000	257	53
Chlorobenzene	3,100	1,800	4,900	100	5,700	126	23
Styrene	3,100	5,100	8,900	123	11,000	190	43
Xylenes	3,100	32,000	38,000	194	51,000	613	104

[a] Concentration units are µg/kg (ppm) on a dry weight basis.

[b] Quantitation limit = 310.

[c] Moisture = 19.27.

[d] RPD = Relative percent difference.

[e] < = Detected but at a level less than the quantitation limit. Values in parentheses are estimated.

TABLE 5-28. SARM II EXPERIMENTAL RUN 1, 2 mm TO 250 µm SOIL FRACTION SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR SEMIVOLATILE ORGANICS[a,b]

Compound	Concentration spike added	Sample result	Concentration MS	Percent recovery	Concentration MSD	Percent recovery	RPD[c]
Pentachlorophenol	14,000 (MS) 15,000 (MSD)	5,100	4,300	-5.7	5,600	3.3	750
Anthracene	56,000 (MS) 61,000 (MSD)	100,000	120,000	36	200,000	164	130
Bis(2-ethylhexyl) phthalate	28,000 (MS) 31,000 (MSD)	44,000	49,000	18	63,000	61	110

[a] Concentration units are µg/kg (ppm) on a dry weight basis.

[b] Percent moisture = 19.12.

[c] RPD = Relative percent difference.

TABLE 5-29. SARM IV EXPERIMENTAL RUN 3, 2 mm TO 250 µm SOIL FRACTION SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY FOR SEMIVOLATILE ORGANICS[a,b,c]

Compound	Concentration spike added	Sample result	Concentration MS	Percent recovery	Concentration MSD	Percent recovery	RPD[d]
Pentachlorophenol	145,000	71,000	67,000	0	70,000	0	-
Anthracene	579,000	1,400,000	680,000	0	410,000	0	-
Bis(2-ethylhexyl) phthalate	289,000	25,000	180,000	54	190,000	57	5.4

[a] Concentration units are µg/kg (ppm) on a dry weight basis.

[b] Percent moisture = 19.27.

[c] Quantitation limit = 12,000.

[d] RPD = Relative percent difference.

estimated or anticipated to fall within a certain range prior to preparation of the spike standard. This situation is particularly evident in the semivolatile organic MS/MSD results presented in Tables 5-28 and 5-29. In general, both the precision, expressed as relative percent difference, and the accuracy, expressed as percent recovery, are low for the semivolatile organic data. Therefore, caution should be used in interpreting the semivolatile organic data, especially in drawing detailed conclusions concerning contaminant removal efficiencies from the soil-washing experiments.

The TCLP analyses were performed under separate contract, and therefore, a full QA/QC discussion of the TCLP data will be included in a separate report which will cover all the TCLP data from the five technologies that tested the SARMS (soil washing, thermal desorption, incineration, KPEG or chemical treatment, and stabilization/solidification). Matrix spikes, duplicate analyses, laboratory blank analyses, and extraction blank analyses were performed on the TCLP samples. The results of these QA/QC analyses can be found in Appendix D of this report.

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CERCLA BDAT SARM PREPARATION AND RESULTS OF PHYSICAL SOILS WASHING EXPERIMENTS (FINAL REPORT)

VOLUME II

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APPENDIX A

BENCH-SCALE EXPERIMENTS ON SARM BLENDING

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BENCH-SCALE EXPERIMENTS ON SARM BLENDING

The overall objective of the bench-scale SARM blending was four-fold:

1) To "fine-tune" the clean soil matrix to meet specified criteria
2) To determine a methodology for bench-scale SARM blending;
3) To determine the clay mineralogy of the clean soil matrix; and
4) To determine procedures for full-scale blending.

The "fine-tuning" of the clean soil matrix was accomplished through the preparation of a series of soil mixes and analyses of critical soil characteristics (identified in Subsection 2.1). The determination of the bench-scale SARM blending methodology involved identification of mixing apparatus and establishing the order in which the chemical contaminants/analytes would be mixed together and then blended with the soil. Selection of the clay mineralogy was based on the results of blending the contaminants with several clay types and observation of the changes that occurred such as alteration of cation exchange capacity.

Once the first three objectives were met, an effort to meet the fourth objective of determining the full-scale blending procedures was begun. The order and method(s) of mixing chemicals and soil components, and determining the quantity of each chemical necessary to reach the target contaminant/analyte levels was determined at this time.

BENCH-SCALE IMPLEMENTATION

The soil mixing, chemical and soil blending, and sample preparation associated with the four objectives of the bench-scale study were conducted

in PEI's laboratory in Cincinnati, Ohio. The actual analyses of the soil samples that were prepared over the course of the bench-scale study were performed by the laboratories of:

- Soil and Material Engineers (SME), Fairfield, Ohio
- H.C. Nutting Company, Cincinnati, Ohio
- University of Cincinnati, Cincinnati, Ohio
- Bowser-Morner, Inc., Dayton, Ohio
- Western Research Institute (WRI) Laramie, Wyoming
- U.S. EPA Center Hill Facility, Cincinnati, Ohio

Equipment, supplies, and materials necessary to complete the bench-scale activities are presented in Table A-1, including the source of each item.

The chemicals to be used for the bench- and full-scale operations were purchased and (with the exception of PCP) were delivered by their respective suppliers directly to the U.S. Environmental Protection Agency, Center Hill Research Facility (Table A-2). Upon delivery, all chemicals were immediately placed in a flammable materials storage cabinet designated for this project by Center Hill staff. The metal compounds were not initially intended to be placed in the storage cabinet, but after determining that there was sufficient space, all chemicals were stored in this locked cabinet. Once all the necessary chemicals had arrived, the quantity of each chemical needed for bench-scale work (Table A-2) was measured out and placed in containers for transport to the PEI laboratory. The portions of organic chemicals brought to the laboratory were placed in a flammable materials storage cabinet where

TABLE A-1. LIST OF EQUIPMENT AND LABORATORY APPARATUS

Item	Quantity	Source
Analytical balance (0.01 and 0.001 g)	2	PEI
EP toxicity extraction mixing apparatus	1	PEI
500-g glass sample containers with Teflon seals and lids	35	Fisher Scientific, Cincinnati, Ohio
Fume hood	1	PEI
Glass spray bottles	5	PEI
Pipettes	20	PEI
2.5-gallon glass jars with lids	2	PEI
1-gallon plastic jars	10	PEI
Glass rods	5	PEI
Graduated cylinders	2	Fisher Scientific, Cincinnati, Ohio
Scupulas	10	PEI
Soil scoops	3	PEI
Fireproof waste receptacle	1	Fisher Scientific, Cincinnati, Ohio
55-gallon steel drum	1	Queen City Barrel, Cincinnati, Ohio
1-gallon PVC buckets with lids	10	PEI
- Laboratory tissue (Kimwipes)	1 box	PEI
- Vermiculite	5-gallon container	PEI
- Spill pads	2 boxes	PEI
Organic vapor analyzer (OVA) equipped with portable GC	1	PEI
Flammable materials storage cabinet	1	PEI
Health and safety personal protective gear and associated equipment	a	PEI
Alconox[b]	0.5 gallon	Fisher Scientific, Cincinnati, Ohio
Bottle brush	1	PEI
Deionized water supply	-	PEI

[a] Discussed and itemized in Subsection 3.2.6.

[b] Detergent used for decontaminating equipment and laboratory apparatus.

TABLE A-2. CHEMICAL QUANTITIES FOR BENCH SCALE

Chemical[a]	Approximate quantity[b] (grams)	Source
Volatiles		
Ethylbenzene	15	Kodak
Xylene	38	Herbert-Verkamp-Calvert
1,2-Dichloroethane	2	Kodak
1,1,2,2-Tetrachloroethene	2	Herbert-Verkamp-Calvert
Acetone	31	Herbert-Verkamp-Calvert
Chlorobenzene[c]	0	Herbert-Verkamp-Calvert
Styrene	1	Kodak
Semivolatiles		
Anthracene	60	Ruetgers Nease
Pentachlorophenol	9	Sigma or Curtin Matheson
Bis (2-ethylhexyl)phthalate	23	Kodak
Metals		
Lead ($PbSO_4$)	184	Eagle Picher
Zinc (ZnO)	252	Herbert-Verkamp-Calvert
Cadmium ($CdSO_4$)	21	Aldrich
Arsenic (As_2O_3)	6	Aldrich
Copper ($CuSO_4$)	335	Herbert-Verkamp-Calvert
Chromium (Cr_2O_3)	20	Aldrich
Nickel [$Ni(NO_3)_2$]	28	Aldrich
Total	1027	

[a] All organic chemicals to be used in the bench-scale studies will be stored in a flammable materials storage cabinet and used only in a fume hood equipped with a single-pass exhaust system.

[b] Chemical quantities shown here represent 2 times the amount of each chemical that is expected to be used during bench-scale activities. The extra quantities will serve as reserves. All unused chemicals will be returned to the Center Hill facility, to the full-scale stock, upon completion of the bench-scale operation.

[c] Chlorobenzene was not available for bench-scale study.

they were stored for the duration of the bench-scale operation. The metal compounds were stored in a designated storage area in close proximity to the work area.

Extreme care was taken at all times in handling chemicals during the bench-scale activities in order to minimize the potential for chemical releases to the surrounding laboratory facilities. Appropriate chemical release prevention and response procedures, and health and safety protocol was followed, and no spills or exposures were incurred during bench-scale activities.

All wastes generated during the bench-scale operation, e.g., contaminated wipes, contaminated soil, expendable protective equipment, etc., were placed in a fireproof waste receptacle. At the completion of the bench-scale work, the accumulated wastes were transported to the Center Hill facility, where they were containerized along with wastes from the full-scale operation. All quantities of chemicals not used during bench-scale work were transported back to the Center Hill facility for use during full-scale blending operations.

The prevention of chemical releases during the bench-scale operation required special chemical handling procedures. Of particulate concern was the potential for releases of organic vapors within the organic prep laboratory (extraction/preparation area of the PEI laboratory) where the bench-scale fume hood is located. A release of this nature could potentially have contaminated laboratory facilities and other samples that were being analyzed in other areas of the laboratory. To minimize the potential of this occurring and to facilitate a quick response if it did occur, air monitoring was conducted on a continuous basis during the bench-scale operation.

A Century Model 128 Organic Vapor Analyzer (OVA, GC-equipped FID) was used to monitor organic vapor concentrations both inside and outside the fume hood. Initial background readings were obtained in the organic prep laboratory prior to beginning work each day. The OVA was used in survey mode to monitor ambient laboratory air continuously with periodic readings being obtained from within the fume hood. If the OVA readings had ever increased significantly above the initial background level the instrument would have been switched to GC mode and a strip chart of the GC output would have been recorded. An attempt would have then been made to determine if the SARM organic compounds being used were the cause of the increased readings. All such measurements would have been summarized and submitted to the Laboratory Manager at the end of the bench-scale study. In the event of a vapor release, the Laboratory Manager would have been notified immediately, at which time the appropriate response would have been taken.

In addition to air monitoring, transport of chemicals within the laboratory was minimized by storing the organics in a flammable materials storage cabinet located in close proximity to the fume hood. The inorganics were also stored in close proximity to the fume hood. In this way, transport of the chemicals through the laboratory complex was minimized, decreasing the potential for releases. All chemicals that were transported to and from the bench-scale work area were carried in secondary containment vessels

Staff conducting the bench-scale activities wore Level C protective clothing, including Tyvek coveralls, safety glasses, and chemical-resistant gloves suitable for the materials being handled (viton and/or butyl rubber). Air purifying respirators equipped with combination high-efficiency particulate/organic vapor cartridges (replaced once each day, at a minimum) were kept on hand for use when necessary.

The following subsections discuss the design and implementation of each of the four phases used to meet the objectives of the bench-scale operation.

Phase 1 - Preparation of Clean Soil Matrix

The initial step (Phase 1) of the bench-scale work was the "fine-tuning" of the clean soil matrix to meet the criteria identified during the background research effort (see Subsection 2.1). The "fine-tuning" involved numerous mixing exercises and laboratory analyses to determine the inherent soil characteristics (grain size, TOC, pH, cation exchange capacity, and mineralogy) of each soil sample differing in clay mineralogy and attempted grain size distribution.

Eighty pounds of soil matrix components were delivered to PEI's analytical laboratory for use during the bench-scale activities. Table A-3 indicates the source and quantity of each soil component.

TABLE A-3. SOIL COMPONENT QUANTITIES FOR BENCH SCALE

Soil component	Approximate quantity, lb	Source/location
Sand	20	Oeder Sand & Gravel Co./Morrow, OH
Silt	20	Oeder Sand & Gravel Co./Morrow, OH
Clay	18	
- Ca - Montmorillonite	(6)	American Colloid Co./Skoky, IL[a]
- Kaolinite	(6)	Charles B. Crystal & Co./ Brooklyn, NY[b]
- Illite (Warren County)	(6)	Oeder Sand & Gravel Co./Morrow, OH
Topsoil	10	Oeder Sand & Gravel Co./Morrow, OH
Gravel (No. 9)	4	Oeder Sand & Gravel Co./Morrow, OH

[a] Actual source location of montmorillonite is the State of Mississippi.

[b] Actual source location of kaolinite is the State of Georgia.

Based on the soils analyses that were performed, the following clean soil recipe was selected for use during the next three phases of the bench-scale study:

- Sand - 25 percent
- Silt - 25 percent
- Clay - 40 percent
- Topsoil - 10 percent

The gravel component was omitted from the bench-scale recipe because it was found to cause severe problems with the mechanics of any bench-scale mixing apparatus tested.

Four 1000-g batches of tested soil were prepared using the above recipe. Each soil was prepared using a different clay mineral (mix) for the clay fraction. The four clay mineralogies were:

1) Illite
2) Montmorillonite
3) Kaolinite
4) Montmorillonite/kaolinite.

In addition to these four soils, 1000 g of sand and 1000 g of the illitic clay were placed in two separate, labeled jars. Having done this, the four soils and two soil components were transferred to the laboratory fume hood area, where all remaining bench-scale work was conducted.

Phase 2 - Determination of SARM Blending Methodology

Phase 2 of the bench-scale study was divided into four steps: 1) identification of the soil/chemical blending apparatus to be used in the laboratory, 2) determination of the physical compatibility of the chemical contaminants being used and how they would be blended with the soil material, 3) determination of the overall methodology for blending (e.g., whether the chemicals would be added to the soils or vice versa, the order and method of chemical application, etc.), and 4) determination of blending equipment and methods to be used for full-scale soil mixing.

Step 1: The device selected for blending soils and contaminants during bench-scale study was the mixing apparatus for the EP Toxicity extraction

procedure. Figure A-1 shows a schematic diagram of this mixing device. It consisted of a 2-liter stainless-steel canister, retrofitted with a plexiglass cover, and a motorized, vertical shaft to which two stainless-steel blades were attached.

Step 2: The chemicals that could be premixed together were identified based on solubility and compatibility, and the order that mixtures of chemicals could be blended into the soil material was determined. This was accomplished by reviewing the compatibility and solubility of the chemicals being used (Tables A-4 and A-5), followed by determining whether compatible chemicals could be mixed together to form a homogenous mixture. The quantity of each chemical used in this mixing exercise was proportional to the total quantity of each chemical that would be used in the soil/chemical blending exercises during the later phases of bench-scale testing.

The results of this work indicated that there would be four separate chemical additives to be blended with the soil material: three mixtures (two liquid and one dry) and one single, dry chemical. These four additives were as follows:

- An aqueous solution of nickel nitrate [$Ni(NO_3)$], copper sulfate ($CuSO_4$), and cadmium sulfate ($CdSO_4$).
- A dry mixture of arsenic trioxide (As_2O_3), lead sulfate ($PbSO_4$), zinc oxide (ZnO), and chromic oxide (Cr_2O_3).
- A solution of ethylbenzene, xylene, 1,2,-dichloroethane, 1,1,2,2-tetrachloroethylene, acetone, styrene, pentachlorophenol, and bis(2-ethylhexyl)phthalate; and
- Anthracene, as a dry additive.

The next portion of Phase 2 of the bench-scale work was conducted to determine:

- Whether chemicals should be added to the soils, or soils added to the chemicals

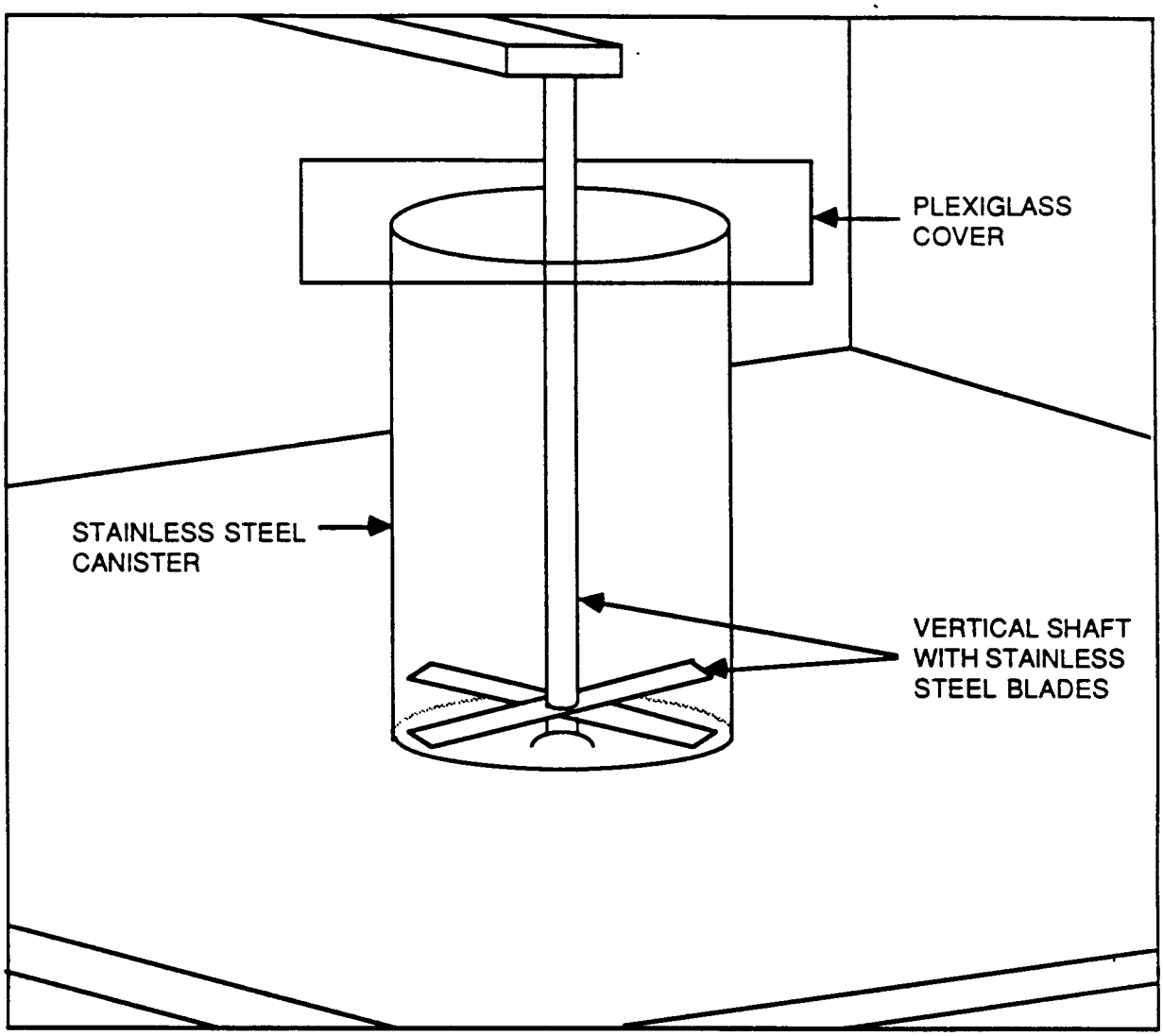


Figure A-1. Bench-scale SARM sample blending apparatus.

TABLE A-4. BDAT SARM SAMPLE CHEMICAL COMPATIBILITIES

	Classification (RGN)	Semivolatiles	Anthracene	Pentachlorophenol	Bis(2-ethyl-hexyl)phthalate	Volatiles	Ethylbenzene	Xylene	1,2 Dichloroethane	1,1,2,2 Tetrachloroethene	Acetone	Chlorobenzene	Styrene	Metals	$PbSO_4$ (Pb)	ZnO (Zn)	$3CdSO_4 \cdot 8H_2O$ (Cd)	As_2O_3 (As)	$CuSO_4 \cdot 5H_2O$ (Cu)	Cr_2O_3 (Cr)	$Ni(NO_3)_2$ (Ni)
			16	17, 31	16		16	16	17	17	19	17	16, 28, 103						24	24	24, 101
Semivolatiles																					
Anthracene	16																				
Pentachlorophenol	17, 31		N																		
Bis(2-ethyl hexyl)phthalate	16		N	N																	
Volatiles																					
Ethylbenzene	16		N	N	N																
Xylene	16		N	N	N		N														
1,2 Dichloroethane	17		N	N	N		N	N													
1,1,2,2 Tetrachloroethene	17		N	N	N		N	N	N												
Acetone	19		N	N	N		N	N	N	N											
Chlorobenzene	17		N	N	N		N	N	N	N	N										
Styrene	16, 28, 103		N	P_H	N		N	N	N	N	N	N									
Metals																					
$PbSO_4$ (Pb)																					
ZnO (Zn)																					
$3CdSO_4 \cdot 8H_2O$ (Cd																					
As_2O_3 (As)																					
$CuSO_4 \cdot 5H_2O$ (Cu)	24		N	N	N		N	N	N	N	N	N	H_P								
Cr_2O_3 (Cr)	24		N	N	N		N	N	N	N	N	N	H_P					N			
$Ni(NO_3)_2$ (Ni)	24, 101		H_F GT	H_F GT	H_F		H_F	H_F	H GT	H GT	H F	H GT	H_{PF} GT					N	N		

N = No reaction
H = Heat generation
P = Violent polymerization
F = Fire
GT = Toxic gas generation

Source: "A Method for Determining Incompatibility of Hazardous Wastes" EPA 600/2-80-076 April 1980.

TABLE A-5. BDAT SARM SAMPLE CHEMICAL SOLUBILITIES

Chemical	Solvent[a]			
	Water	Acetone	Xylene	Alcohol
Anthracene	I	S	S	S
Pentachlorophenol	SL	S	S	S
Bis(2-ethylhexyl)phthalate	I	S	S	S
Ethylbenzene	I	S	S	S
Xylene	I	S	X	S
1,2-Dichloroethane	SL	S	S	S
1,1,2,2-Tetrachloroethene	I/SL	S	VS	VS
Acetone	S	X	S	S
Chlorobenzene	I	S	S	S
Styrene	I	S	S	S
Lead sulfate ($PbSO_4$)	SL	I	I	I
Zinc oxide (ZnO)	I	I	I	I
Cadmium sulfate ($3CdSO_4 \cdot 8H_2O$)	S	I	I	I
Arsenic trioxide (As_2O_3)	SS	I	I	I
Copper sulfate ($CuSO_4 \cdot 5H_2O$)	S	I	I	SS/I
Chromic oxide (Cr_2O_3)	I	I	I	I
Nickel nitrate [$Ni(NO_3)_2$]	S/VS	I	I	S

[a] I = Insoluble
SL = Slightly soluble
S = Soluble
V = Very soluble
X = Not applicable

Source: Based on the MERK Index, 10th edition, 1983 and the Condensed Chemical Dictionary, 10th edition, 1981.

- Whether chemicals should be applied to certain soil fractions (e.g., to the sand or clay fraction) before being blended with the remainder of the soil matrix

- The method of chemical application to the soil (e.g., sprayed, poured)

- The order of application (e.g., organics first, followed by metals, or visa versa)

This portion of the bench-scale study used water to simulate the solutions instead of using the actual chemicals. Determinations were made by following the nine-run sequence (A through I) listed below:

A. "Mixed" soil was placed in the mixing apparatus, the motor turned on, and water poured onto the soil as the blades were turning

- Results Recorded -

B. Clay component was placed in clean mixing cannister, the motor turned on, the water poured onto the clay as the blades were turning, then the remaining soil compounds added to wet clay material with the blades still turning

- Results Recorded -

C. Sand component was placed in clean cannister, the motor turned on, the water poured onto the sand as the blades were turning, then the clay added to the wet sand as the blades turned

- Results Recorded -

D. "Mixed" soil was placed in the mixing apparatus, the motor turned on, and the water applied to the soil as tiny droplets while the blades were turning

- Results Recorded -

E. Clay component placed in the clean mixing cannister, the motor turned on, the water applied to the clay as tiny droplets as the blades turned, then the sand was added to the wet clay material with the blades still turning

- Results Recorded -

F. Sand component placed in the clean cannister, the motor turned on, the water applied to sand as tiny droplets as the blades turned, then the clay was added to the wet sand as the blades turned

- Results Recorded -

G. Water placed in clean cannister, motor turned on, and mixed soil added while the blades turned.

- Results Recorded -

H. Water placed in clean cannister, the motor turned on, and the clay component added as the blades turned

- Results Recorded -

I. Water placed in clean cannister, the motor turned on, and the sand component added as the blades turned

- Results Recorded -

The results of the mixing sequence outlined above, indicated the following:

1) There was no difference in the end products between Runs A, B, and C or between D, E, or F, i.e.: it did not matter to which soil component(s) the water was added, the resulting samples were similar.

2) There was a difference in the "balling-up" effect of the soil between Runs A, B, and C and Runs D, E, and F. The soil balled-up to a much less degree when the water was applied as tiny droplets.

3) The balling-up effect was much greater during Runs G, H, and I when the soil was added to the water, than during the six other runs.

As the results of these bench-scale activities, the following blending methodology was selected:

° Chemicals would be added to the mixed soil (gravel-component not included) as blades turned

° Liquid mixtures would be applied to the soil as tiny droplets

° The inorganic chemical mixtures would be added before the liquid organics

° Each sample prepared would be mixed for approximately 2 minutes

The final portion of Phase 2 involved the test mixing of soil and gasoline in a small 3-ft^3 mortar mixer that was identical in design to the 16-ft^3 mixer that was selected for the full-scale SARM blending operation. The objective of this effort was: 1) to determine the degree of volatilization

that would occur during full-scale activities, 2) to determine the actual quantity of soil material that could be mixed per batch, and 3) to determine the consistency of the soil when mixed with different amounts of liquid. The results of this mixing exercise indicated that the mortar mixer operated well with as much as 5 percent moisture without any balling up of the soil material, as found during earlier bench-scale mixing. All OVA readings taken over the course of the day indicated that organic vapor levels inside the mixer were greater than the Lower Explosive Limit (LEL).

Phase 3 - Determination of Clay Fraction

The determination of the mineralogy of the clay fraction for the final soil matrix was based on the results of analyses of soil properties performed on both "clean" and contaminated soil samples that differed only in clay mineralogy. The four clay mineralogies that were used for the samples were as follows:

1) Warren County Clay (illite)
2) Montmorillonite (Ca-based)
3) Kaolinite
4) Montmorillonite/Kaolinite

The objective of this phase was to identify the clay mineralogy that 1) exhibited a moderate cation exchange capacity (CEC of 30 to 50 meq/100 g), and 2) whose inherent properties, in particular its crystalline structure, exhibited the least amount of change due to the application of contaminants.

The initial step of Phase 3 involved the measurement of 500-g of four "clean" soil samples, with the only variable being the clay mineralogy. Each sample was taken from the 1000-g batches prepared and stored during Phase 1 of the bench-scale work. Next, the chemical mixtures determined in Phase 2 were prepared and added to form 500 g of soil contaminated at the high contaminant levels (20,000 ppm total organics and 50,000 ppm total metals). The

individual chemical quantities needed were calculated through the use of a computer program developed specifically for the BDAT project. The program was used throughout the bench-scale work to determine the quantities of chemicals that were theoretically needed to produce desired levels of contaminants, based on soil quantities and the given chemical proportions and purities. Based on this computer program, the individual chemical quantities needed to achieve high contaminant levels in 500 g of soil were as follows:

Chemical	Quantity (grams)
As_2O_3 (As)	0.330
$3CdSO_4 \cdot 8H_2O$ (Cd)	1.141
Cr_2O_3 (Cr)	1.096
$CuSO_4 \cdot 5H_2O$ (Cu)	18.664
$PbSO_4$ (Pb)	10.244
$Ni(NO_3)_2$ (Ni)	1.556
ZnO (Zn)	14.003
Ethylbenzene	0.800
Xylene	2.050
1,2-Dichloroethane	0.150
1,1,2,2-Tetrachloroethene	0.150
Acetone	1.700
Chlorobenzene	(Not available for bench-scale work)
Styrene	0.050
Anthracene	3.250
Pentachlorophenol	0.50
Bis(2-ethylhexyl)phthalate	1.25

The above quantities of chemicals were blended with each of the four soil samples by the method determined earlier during bench-scale testing.

Once the mixing of the four samples was complete, each sample was split into two 250-g samples for subsequent physical and chemical analysis. One 250-g sample of each contaminated soil was then sent to H. C. Nutting, in Cincinnati, Ohio, for CEC analysis, while the other sample split was sent to Bowser-Morner, in Dayton, Ohio, for X-ray defraction analysis. The results of these analyses were ultimately compared to the results obtained earlier on similar "clean" samples. Upon review of the results of these analyses, the

EPA and extramural peer review committee was partial toward the montmorillonite/kaolinite clay combination; however, there was some question about the accuracy and precision of the numbers, and therefore it was decided that additional CEC analyses should be run.

At this point, the overall approach for preparing the soil material was modified as a result of a suggestion made by consultant, Ms. Muriel Waller. Initially, all the soil samples were prepared on a weight percentage basis, i.e., 25 percent sand was calculated based on the weight of the sand. The new approach included the preparation of the soil matrix by volume percentage instead of by weight. The suggestion to modify the approach for mixing the clean soil was prompted by the visual inspection of the weight percentage samples which contained a very large amount of clay because of the clay's relatively low density. The change to volume percentages decreased the amount of clay material present in the samples and produced a much more realistic soil texture. Three additional clean soil samples were prepared by volume percentages and were submitted (in triplicate) for CEC and grain size analysis.

The clean soil matrix recipe that was finally agreed upon by the project peer review committee following review of the additional analytical results is presented in Table A-6 in terms of both volume and weight percentages.

TABLE A-6. FINAL CLEAN SOIL MATRIX RECIPE

Soil component	Volume %	Equivalent wt. %
Sand	20.0	31.4
Gravel	5.0	5.7
Silt	25.0	28.3
Topsoil	20.0	19.8
Clay	30.0	14.8
- Montmorillonite	(7.5)	(5.4)
- Kaolinite	(22.5)	(9.4)

Phase 4 - Determination of Full-Scale Blending

The primary objective of Phase 4 was to determine the actual quantity of each chemical that would be required to achieve the following four SARM concentrations under full-scale conditions:

1. High levels of organics (20,000 ppm volatiles plus 10,000 ppm semivolatiles) and low levels of metals (1,000 ppm total metals).

2. Low levels of organics (2,000 ppm volatiles plus 1,000 ppm semivolatiles) and low levels of metals (1,000 ppm total metals).

3. Low levels of organics (2,000 ppm volatiles plus 1,000 ppm semivolatiles) and high levels of metals (50,000 ppm total metals).

4. High levels of organics (20,000 ppm volatiles plus 10,000 ppm semivolatiles) and high levels of metals (50,000 ppm total metals).

The target concentrations for individual chemicals can be found in Table 2-1 of the main text.

The objectives of this task were met by preparing a series of spiked soil samples using varying concentrations of the designated chemicals. Two separate series of samples were prepared under this phase of the bench-scale study. The first series consisted of six samples; three high organics/high metals samples and three low organics/low metals samples. This first series, however, was prepared before the decision had been made to modify the approach for preparing the clean soil (volume percentage vs. weight percentage). As a result, it was thought best to discard the first series and re-spike new samples consisting of the selected soil matrix.

The second series consisted of nine soil samples, all spiked to high organics/high metals levels; three at 100 percent, three at 120 percent, and three at 140 percent of the theoretical target concentration levels. Samples were prepared by the previously determined methods and submitted for analysis in triplicate to increase understanding of 1) analyte recoveries, and 2) the precision and accuracy of the laboratory results.

These samples were prepared by spiking three 750-g batches of soil at 100 percent, 120 percent, and 140 percent, respectively. Table A-7 presents the individual chemical quantities that were added to each 750-g batch of soil. Each batch was divided into three 250-g samples for analysis. Analyses were conducted at the Western Research Institute (WRI) laboratory in Laramie, Wyoming; results are shown in Table A-8. From the results of these analyses, the doses of chemicals required to formulate each of the four SARMs on the full-scale level were determined. The selected doses are presented in Table A-9. A more detailed discussion of the analytical results from this soil-spiking experiment can be found later in this Subsection.

TABLE A-7. SARM CHEMICAL QUANTITIES FOR DETERMINATION OF FULL-SCALE BLENDING PROCEDURES (grams)

Chemical	SARM (4) (hi-hi levels)[a] Batch 1[b] 100%	Batch 2[b] 120%	Batch 3[b] 140%	Target concentration (ppm) @ 100% dose
Ethylbenzene	1.200	1.44	1.68	3,200
Xylene	3.075	3.69	4.305	8,200
1,1,2,2-Tetrachloroethylene	0.225	0.270	0.315	600
Chlorobenzene	0.150	0.180	0.210	400
Acetone	2.550	3.060	3.570	6,800
1,2-Dichloroethane	0.225	0.270	0.315	600
Styrene	0.075	0.090	0.105	200
Anthracene	4.875	5.850	6.825	6,500
Bis(2-ethylhexyl)phthalate	1.875	2.250	2.625	2,500
Pentachlorophenol	0.750	0.900	1.050	1,000
Pb (as Pb SO_4)	15.366	18.439	21.512	14,000
Zn (as ZnO)	21.003	25.204	29.442	22,500
Cd [as $3Cd(SO_4)\cdot 8H_2O$]	1.710	2.052	2.394	1,000
As (as As_2O_3)	0.492	0.590	0.689	500
Cu (as $CuSO_4$)	27.990	33.588	39.186	9,500
Ni [as $Ni(NO_3)\cdot 6H_2O$]	2.334	2.801	3.268	1,000
Cr (as Cr_2O_3)	1.644	1.973	2.302	1,500

[a] Hi-hi = 20,000 ppm volatile organics, 10,000 ppm semivolatile organics, and 50,000 ppm inorganics; percentage refers to the percentage of contaminants to their predesignated proportions, that were added to the soil to theoretically meet the desired contaminant levels.

[b] Quantities based on 750-g batches.

TABLE A-8. SPIKED SOIL SAMPLE ANALYSIS RESULTS (ppm)

Contaminant	Sample identification and dosage batches									Hi-Hi target levels (100%)
	100% dosage			120% dosage			140% dosage			
	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9	
Volatiles										
Ethylbenzene	2,300	2,100	2,800	4,100	3,300	2,100	4,500	6,300	4,500	3,200
Xylene	3,500	3,200	4,400	6,300	5,100	3,300	6,900	9,700	6,900	8,200
Tetrachloro-ethylene	240	210	290	420	330	200	490	690	460	600
Chlorobenzene	200	180	240	360	290	180	400	560	400	400
Acetone	2,700	2,500	2,000	2,300	2,300	1,900	3,500	3,800	3,700	6,800
1,2-dichloro-ethane	180	130	170	280	190	120	350	470	340	600
Styrene	<63	<63	<100	<100	<100	<100	<120	<170	<170	200
Semivolatiles										
Anthracene	5,800	3,800	6,000	5,500	4,600	4,500	4,400	4,400	4,600	6,500
Bis (2-ethyl-hexyl) phthal-ate	610	1,600	1,500	1,100	1,600	1,800	2,300	2,500	2,800	2,500
Pentachloro-phenol	320	560	550	470	630	790	790	730	790	1,000
Metals										
Lead	13,700	11,100	10,800	14,400	15,200	15,400	15,200	14,700	21,500	14,000
Zinc	18,100	16,300	15,500	21,500	22,100	22,400	23,600	22,900	24,500	22,500
Cadmium	880	598	543	863	1,760	862	852	779	871	1,000
Arsenic	393	270	274	232	446	420	466	428	428	500
Copper	9,870	5,920	5,220	9,010	9,250	8,790	8,200	7,720	8,420	9,500
Nickel	524	367	336	549	550	537	516	483	521	1,000
Chromium	7	6.6	6.8	5.5	6.9	7.4	7.2	13.6	7.9	1,500

TABLE A-9. FULL-SCALE CHEMICAL DOSES

Chemical	Dose % (of theoretical)
Ethylbenzene	120
Xylene	120
Tetrachloroethylene	140
Chlorobenzene	140
Acetone	175
1,2-dichloroethane	167
Styrene	500
Anthracene	100
Bis(2-ethylhexyl)phthalate	140
Pentachlorophenol	100
Pb (as $PbSO_4$)	120
Zn (as ZnO)	120
Cd [as $3Cd(SO_4)\cdot 8H_2O$]	130
As (as As_2O_3)	150
Cu (as $CuSO_4$)	140
Ni [as $Ni(NO_3)\cdot 6H_2O$]	120
Cr [as $Cr(NO_3)_3\cdot 9H_2O$][a]	100

[a] Changed form of Cr from Cr_2O_3 to $Cr(NO_3)_3$ because Cr_2O_3 was virtually insoluble during the analytical procedure and only detectable at very low ppm levels (see Table A-13).

DOCUMENTATION AND RECORDKEEPING

All activities associated with the bench-scale study were documented and detailed records were kept for all sample analyses performed. A logbook was used to note times, procedures, problems that occurred, and solutions or changes made during the BDAT bench-scale effort. Individual files have been maintained on the six outside laboratories that were performing soil analyses over the course of the project. The project files contain laboratory-specific telephone conversation notes, scheduled analyses, discussions of any problems that arose, purchase order requisitions, and invoices.

BENCH-SCALE STUDY ANALYTICAL RESULTS

During the bench-scale study, two basic sets of analytical data were generated: 1) inherent soil characteristic data (used in determining what the constituents of the clean soil matrix would be), and 2) chemical concentration data (used to determine the quantity of each chemical needed to achieve target contaminant levels). The following section presents the analytical data generated over the course of the bench-scale study and highlights those data that significantly affected the outcome of this phase of the BDAT SARM project.

Inherent Soil Characteristics

Over the course of the bench-scale study, six different laboratories performed analyses on various mixed soils and soil components. Table A-10 identifies the type and number of analyses performed by each laboratory. A total of 59 samples were analyzed for the purpose of identifying soil components and determining the component proportions needed to formulate the desired clean soil matrix. The three most critical soil parameters examined during this effort were clay mineralogy, grain size distribution, and cation exchange capacity. Tables A-11, A-12, and A-13 present analytical results for samples of individual soil components, mixed soils prepared by weight percentages and mixed soils prepared by volume percentages, respectively. The 3-V-D sample series presented in Table A-13 represents the selected clean soil matrix composition and its inherent characteristics. The selection of the final clean soil matrix was based on review of all analytical results; however, the deciding factors in the final examination were cation exchange capacity, and the texture of the soil.

TABLE A-10. BENCH-SCALE SAMPLE ANALYSIS

Laboratory	Analysis and number of samples						
	XRD	CEC	TOC[a]	pH	Moisture content	Grain size distribution	Hit List[b]
1. Soils and Materials Engineers (SME)	-	-	4	4	2	16	-
2. H.C. Nutting Co.	-	20	-	-	-	-	-
3. University of Cincinnati	4	-	-	-	-	-	-
4. Bowser-Morner, Inc.	4	-	-	-	-	-	-
5. Western Research Institute (WRI)	-	-	-	-	-	-	9
6. U.S. EPA Center Hill Facility	-	-	-	-	-	5	-
Total	8	20	4	4	2	21	9

[a] TOC = Total organic content.

[b] The "Hit List" analysis includes analysis for only those volatiles, semivolatiles, and metals that were applied to the samples.

TABLE A-11. BENCH-SCALE ANALYTICAL RESULTS - INDIVIDUAL SOIL COMPONENT CHARACTERISTICS

Sample ID	Sample composition	Analysis performed	Laboratory[a]	Parameters					
				Gravel %	Sand %	Silt %	Clay %	CEC meg/1000 g	Mineralogy
8	Illite	Grain size[b]	SME	0	53	44	3		
8-CH	Illite	Grain size	CH	0	58	25	17		
8-RR	Illite	Grain size	SMB	2	58	31	9		
E	Illite	Na-CEC[c]	HCN					0.8	
A	Illite	XRD[d]	UC						64% illite; 19% mixed-layer; 17% chlorite
WC	Illite	Grain size	SME	8.8	32.8	50.4	8.0		
10	Ca-montmorillonite	Grain size	SME	0	11	65	24		
10-CH	Ca-montmorillonite	Grain size	SME	0	12	43	45		
B	Ca-Montmorillonite	XRD	UC						100% Ca-Smectite
F	Ca-Montmorillonite	Na-CEC	HCN					46.4	
11	Kaolinite	Grain size	SME	0	0	30	70		
C	Kaolinite	XRD	UC						94% kaolinite; 6% illite
11-CH	Kaolinite	Grain size	CH	0	0	10	9.0		
S	Silt	Grain size	SME	0	2.1	92.0	5.1		
D	Kaolinite/montmorillonite	XRD	UC						52% kaolinite; 42% smectite; 6% illite

[a] SME = Soil and Materials Engineers; CH = U.S. EPA Center Hill Facility; HCN = H.C. Nutting Co.; UC = University of Cincinnati.

[b] Grain size analysis based on weight percentages.

[c] CEC = cation exchange capacity; Na refers to it being a sodium-based ASTM analysis.

[d] XRD = X-ray defraction analysis.

TABLE A-12. BENCH-SCALE ANALYTICAL RESULTS - MIXED SOILS PREPARED BY WEIGHT PERCENTAGES

Sample ID	Sample composition	Analysis performed	Laboratory[a]	Parameters								
				Gravel %	Sand %	Silt %	Clay %	CEC meq/100 g	Mineralogy	TOC mg/kg	pH	Moisture content, %
3	30% illite, 30% silt, 20% sand, 5% gravel, 15% topsoil	Grain size, pH, TOC, moisture content	SME	0.6	36.0	52.4	11.0			3.03	7.5	10.4
		Ca-CEC Na-CEC	HCN					22.311 (Ca) 17.337 (Na)				
5	30% montmorillenite, 30% silt, 20% sand, 5% gravel, 15% topsoil	Grain size, pH, TOC, moisture	SME	0.6	32.2	51.2	16.0			3.63	8.0	12.6
		Ca-CEC	HCN					23.015				
5-CH	30% montmorillenite, 30% silt, 20% sand, 5% gravel, 15% topsoil	Grain size	CH	0	31	42	27					
6	30% kalonite, 30% silt, 20% sand, 10% gravel, 10% topsoil	Na-CEC	HCN					14.945				
7	30% kaolinite/ montmorillonite, 30% silt, 20% sand, 10% gravel, 10% topsoil	Na-CEC	HCN					37.065				
9	40% illite, 20% silt, 25% sand, 5% gravel, 10% topsoil	Grain size	SME	4	70	23	3					
9RR	40% illite, 20% silt, 25% sand, 5% gravel, 10% topsoil	Grain size	SME	1	56	35	8					
9-CH	40% illite, 20% silt, 25% sand, 5% gravel, 10% topsoil	Grain size	CH	0	58	27	15					

(continued)

TABLE A-12 (continued)

Sample ID	Sample composition	Analysis performed	Laboratory[a]	Parameters								
				Gravel %	Sand %	Silt %	Clay %	CEC meq/100 g	Mineralogy	TOC mg/kg	pH	Moisture content, %
1-B spiked)[a]	40% montmoril-lonite, 25% silt, 25% sand, 10% topsoil	Na-CEC XRD	HCN BM[b]					24.1	Clay unchanged			
2-B (spiked)	40% kaolinite, 25% silt, 25% sand, 10% top-soil	Na-CEC XRD	HCN BM					49.3	Clay unchanged			
3-B (spiked)	40% kaolinite/ montmorillanite, 25% silt, 25% sand, 10% topsoil	Na-CEC XRD	HCN BM					37.7	Clay unchanged			
4-B (spiked)	40% illite, 25% 25% silt, 25% sand, 10% top-soil	Na-CEC XRD	HCN BM					15.9	Clay unchanged			

[a] Samples 1-B through 4-B were spiked with high organics/high metals concentrations of chemicals to determine effect of chemicals on CEC and mineralogy by comparing with clean sample results; objective was to select clay for clean soil matrix.

[b] BM - Bauser-Mourner, Inc., performed XRD on contaminated samples.

TABLE A-13. BENCH-SCALE ANALYTICAL RESULTS - MIXED SOIL PREPARED BY VOLUME PERCENTAGES

Sample ID	Sample composition	Analysis performed	Laboratory[a]	Parameters						
				Gravel %	Sand %	Silt %	Clay %	CEC (meq/100g)	TOC mg/kg	pH
1-V-D-1	0.5 part gravel, 2.5 pt. sand, 2.5 pt. silt, 3.0 pt. clay (50/50; m/k) 1.5 pt. topsoil	NA-CEC	HCN					40.4		
1-V-D-2	0.5 part gravel, 2.5 pt. sand, 2.5 pt. silt, 3.0 pt. clay (50/50; m/k) 1.5 pt. topsoil	Na-CEC	HCN					29.6		
1-V-D-3	0.5 part gravel, 2.5 pt. sand, 2.5 pt. silt, 3.0 pt. clay (50/50; m/k) 1.5 pt. topsoil	Na-CEC	HCN					32.6		
1-V-D-4	0.5 part gravel, 2.5 pt. sand, 2.5 pt. silt, 3.0 pt. clay (50/50; m/k) 1.5 pt. topsoil	Grain size	SME	9	31	48	12			
1-V-D-5	0.5 part gravel, 2.5 pt. sand, 2.5. pt. silt, 3.0 pt. clay (50/50; m/k) 1.5 pt. topsoil	Grain size	SME	6	52	32	10			
2-V-D-1	0.5 pt. gravel, 1.0 pt. sand, 2.5 pt. silt, 4.0 pt. clay (25/75; m/k) 2.0 pt. topsoil	Na-CEC	HCN					61.7		
2-V-D-2	0.5 pt. gravel, 1.0 pt. sand, 2.5 pt. silt, 4.0 pt. clay (25/75; m/k) 2.0 pt. topsoil	Na-CEC	HCN					60.4		
2-V-D-3	0.5 pt. gravel, 1.0 pt. sand, 2.5 pt. silt, 4.0 pt. clay (25/75; m/k) 2.0 pt. topsoil	NA-CEC	HCN					57.8		
2-V-D-4	0.5 pt. gravel, 1.0 pt. sand, 2.5 pt. silt, 4.0 pt. clay (25/75; m/k) 2.0 pt. topsoil	Grain size	SME	10	39	37	14			
2-V-D-5	0.5 pt. gravel, 1.0 pt. sand, 2.5 pt. silt, 4.0 pt. clay (25/75; m/k) 2.0 pt. topsoil	Grain size	SME	8	40	36	16			
3-V-D-1	0.5 pt. gravel, 2.0 pt. sand, 2.5 pt. silt, 3.0 pt. clay (25/75; m/k)	Na-CEC	HCN					30.9		
3-V-D-2	0.5 pt. gravel, 2.0 pt. sand, 2.5 pt. silt, 3.0 pt. clay (25/75; m/k)	Na-CEC	HCN					30.0		
3-V-D-3	0.5 pt. gravel, 2.0 pt. sand, 2.5 pt. silt, 3.0 pt. clay (25/75; m/k)	Na-CEC	HCN					34.5		
3-V-D-4	0.5 pt. gravel, 2.0 pt. sand, 2.5 pt. silt, 3.0 pt. clay (25/75; m/k)	Grain size	SME	7	48	33	12		2.7	8.0
3-V-D-5	0.5 pt. gravel, 2.0 pt. sand, 2.5 pt. silt, 3.0 pt. clay (25/75; m/k)	Grain size	SME	6	48	33	13		3.4	8.2

[a] HCN = H.C. Nutting Laboratory, Cincinnati, Ohio.
SME = Soil and Materials Engineers Laboratory, Cincinnati, Ohio.

Spiked Soil Contaminant Levels

Nine soil samples were spiked at three different dosage levels and analyzed for the purpose of determining the quantities of each chemical that would be needed to meet the target contaminant concentration levels under full-scale conditions. The specific chemical dosage added to each of the three batches were previously presented in Table A-7, and the analytical results from analysis of the nine samples (B-1 through B-9) were presented in Table A-8. Samples B-1, B-2, and B-3 are triplicate samples prepared at 100 percent of the calculated dosage needed to theoretically achieve the desired target levels for each contaminant (see far right column for targets). Samples B-4, B-5, and B-6 were prepared at 120 percent of the theoretical dose, and samples B-7, B-8, and B-9 at 140 percent of the theoretical dosage. Based on the analytical results, the full-scale dosing procedures were developed and adjusted.

The data indicated that almost all the organics needed to be overdosed 20 to 40 percent above the theoretical dosage to achieve the desired residual target levels. Acetone needed to be dosed at roughly 175 percent of theoretical, and 1,2-dichloroethane at 167 percent of the theoretical to achieve the desired levels.

Most of the residual metal concentrations were close to target at 120 to 140 percent of theoretical dosage, with two exceptions. Nickel residuals measured only 40 to 50 percent of the desired level, regardless of dosage, and chromium was only detectable at very low ppm levels. This poor result for chromium was believed to be due to the form in which Cr was added (i.e., as Cr_2O_3 anhydrous, and insoluble in the acid digestion procedure used in

sample preparation). To correct this situation, a more soluble Cr salt $Cr(NO_3)_3 \cdot 9H_2O$ was purchased for full-scale spiking. No cause for the low nickel residual was determined.

The data also indicated that the styrene target level needed to be increased from 200 ppm to 1000 ppm at the high level and 20 to 100 ppm at the low level. This was necessary to make the styrene detectable during analysis. (WRI advised that the sample dilution necessary for analysis of the high levels of xylene made the styrene undetectable during analysis.

APPENDIX B

STATISTICAL EVALUATION OF SARM HOMOGENEITY

PEI ASSOCIATES, INC.

MEMORANDUM

TO:	Pat Esposito	**DATE:**	August 6, 1987
SUBJECT:	Statistical Analysis of Soil Mixing Time Results	**FROM:**	Charles E. Zimmer
FILE:	3741-7-1	**cc:**	

Quantities of zinc, copper and total organic compounds were added to 500 pounds of soil, and mechanically mixed for six minutes, after which six samples were drawn at random for subsequent analysis. After 12 minutes and again after 18 minutes six samples were drawn at random. Concentrations of zinc, copper and total organic compounds, as determined by the PEI Analytical Laboratory, are presented in Table 1.

STATISTICAL ANALYSIS PROCEDURES

The data in Table 1 were analyzed by Analysis of Variance to determine whether or not mixing time had an effect upon the average concentration of any compounds. Further, Bartlett's Test was used to determine whether or not the variability within sets of six samples was homogenous over the three mixing times. See Attachment 1 for an explanation of these statistical procedures.

STATISTICAL ANALYSIS RESULTS

Results of the Analysis of Variance and Bartlett's Test of Variance are presented in Table 2 and 3. Based upon Analysis of Variance, the difference between mean concentrations of zinc and copper for mixing times of 6, 12 and 18 minutes is not statistically significant. The overall mean concentrations for the batch of soil are 16,068 mg/kg for zinc and 9,163 mg/kg for copper. For total organic compounds ANOVA shows that the difference between means for the three mixing times is statistically significant.

TABLE 1. SOIL MIXING TIME RESULTS

	Zinc, mg/kg Mixing time - min.			Copper, mg/kg Mixing time - min.			Total organic compounds, µg/g[b] Mixing time - min.		
	6	12	18	6	12	18	6	12	18
	16,083	15,801	18,262	9,589	9,799	9,744	2,490	13,300	9,390
	12,766	18,481	14,010	8,412	11,191	8,238	3,010	2,410	9,930
	11,876	14,373	16,956	6,923	9,326	9,678	1,350	3,960	7,260
	17,463	17,150	12,896	9,974	10,105	7,583	3,540	9,540	14,000
	16,555	15,738	15,842	10,707	10,001	9,694	2,080	6,160	3,590
	10,725	11,974	16,276	7,100	7,113	9,752	5,470	3,690	5,160
Mean	14,245	15,586	15,374	8,784	9,589	9,115	2,990	6,511	8,221
Standard deviation	2,802	2,254	1,570	1,562	1,360	956	1,430	4,163	3,727
Coefficient of variation	0.197[a]	0.145	0.102	0.178	0.142	0.105	0.478	0.639	0.453
Overall mean		15,068			9,163			5,907	
Standard deviation		2,254			1,317			3,330	
Coefficient of variation		0.150			0.144			0.564	

[a] Coefficient of variation (CV) = standard deviation ÷ mean.

[b] As purgeable organic carbon (POC). POC of uncontaminated (clean) soil was 10.7 µg/g.

NOTE: Metal analyses were done by EPA-Cincinnati and reported verbally to P. Esposito, Project Manager; POC by PEI Laboratory (lab report attached).

TABLE 2. ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-ratio*	
		Zinc			
Between mixing times	2	6,238,837	3,199,418	0.608	N.S.
Between replicates within mixing time	15	79,999,109	5,133,274		
Total	17	83,237,946			
		Copper			
Between mixing times	2	1,964,716	982,358	0.566	N.S.
Between replicates within mixing time	15	26,015,636	1,734,375		
Total	17	27,980,352			
		TOC			
Between mixing times	2	85,363,969	42,681,984	3.84	Sig. Diff.
Between replicates within mixing time	15	166,322,042	11,088,136		
Total	17	251,686,011			

* Critical value F = 2.70 (α = 0.10 risk level)

TABLE 3. BARTLETTS TEST OF VARIANCE

Mixing time (min.)	Standard deviation		
	Zinc	Copper	Total organic compounds
6	2,802	1,562	1,430
12	2,254	1,360	4,163
18	1,570	956	3,727
Pooled	2,266	1,317	3,330
Chi-square* χ^2	1.78	1.31	5.68**

* Critical $\chi^2 = 4.61$ ($\alpha = 0.10$ risk level).

** Standard deviations for various mixing times are significantly different.

Referring again to Table 1, it appears that the TOC concentration increases with increased mixing time. Further, the variability between replicate samples, as shown by the standard deviation ranges from 1,430 to 3,727 µg/g. Note that for a 12 minute mixing time the TOC concentration varied from 2,410 to 13,300 µg/g and for 18 minutes the variation was from 3,590 to 14,000 µg/g. In discussing these large variabilities with laboratory personnel, it was stated that the analytical method used to determine the concentration of TOC is one that was developed for the analysis of water samples. In the application of this procedure to this study, the soil samples were mixed with water to form a slurry. The preparation and analysis of the slurry may have affected the reproducibility of the analytical method.

The results of Bartlett's Test of Variance showed that for zinc and copper, the difference between standard deviations for the three mixing times was not statistically significant. Referring again to Table 1, it is apparent that there is a definite tendency for the standard deviation to decrease with increased mixing time. On the other hand no such tendency is demonstrated for the TOC results.

CONCLUSION

Based upon the results of this statistical analysis, it is my recommendation that a mixing time of at least 12 minutes be used in the preparation of additional batches of soil for the further studies to be performed under this project. Because of the rather large variability (i.e., standard deviation) of an individual replicate for TOC, I would urge that further consideration be given to the selection of an alternate analytical method. The overall coefficient of variation for the TOC measurements of 0.564 is more than three times that of zinc and copper.

It is my understanding that because of time constraints a mixing time of 12 minutes was used to prepare the quantity of soil required for the field testing program. Based upon the results of this study the average concentration and 95 percent confidence interval estimate for the average concentration for six replicates would be:

	Average	95% confidence interval for average
Zn	15,068	12,694-17,426
Cu	9,163	7,781-10,545

ATTACHMENT 1

STATISTICAL PROCEDURES

ANALYSIS OF VARIANCE

In situations involving the comparison of two samples the Students "t" test is used. The extension of this procedure to situations which involve the comparison of more than two samples is referred to as the Analysis of Variance (ANOVA).[a] As with the Student "t" test, ANOVA is used to test the Null Hypothesis that the means of the several samples are identical (i.e. $\mu_1 = \mu_2 = \mu_3$). The test used with ANOVA is called the F-test. As with the Students "t" test if the F value calculated from the data exceeds the value of F for the specified degrees of freedom and risk level (α), the Null Hypothesis is rejected. If the calculated value of F is less than the value from the F distribution it is concluded that the observed difference between the sample means is not statistically significant.

Example:

Zn
mg/kg

	Mixing time - minutes			
	6	12	18	Total
	16,083	16,801	16,262	
	12,766	18,481	14,010	
	11,876	14,373	16,956	
	17,463	17,150	12,896	
	16,555	15,738	15,842	
	10,725	11,974	16,276	
Sum χ	85,468	93,517	92,242	271,227
Sum χ^2	1,256,723,040	1,482,985,911	1,430,422,636	4,170,131,587

[a] Snedecor, G. W. and W. G. Cochran "Statistical Methods," The Iowa State University Press, Ames, Iowa, 1967, Chapter 10.

$$SS_{TOT} = 4,170,131,587 - \frac{271,227}{18}$$

$$= = 83,237,946$$

$$SS_{BET} = \frac{1}{6}[(85,468)^2 + (93,517)^2 + (92,242)^2] - \frac{271,227}{18}$$

$$= 6,238,837$$

ANOVA

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-ratio*
Between mixing times	2	6,238,837	3,199,418	0.608
Between replicates within mixing time	15	79,237,946	5,133,274	
Total	17	83,237,946		

The critical value of F taken from Table A, 14, Part 1 (Snedecor and Cochran) for a risk level, $\alpha = 0.10$, is $F_{15,010} = 2.70$. Because the calculated value of F = 0.608 is less than 2.70, there is no reason to reject the Null Hypothesis and thus it is concluded that the observed difference between the means of the three samples of 14.245, 15,586 and 15,374 is not statistically significant. Therefore the best estimate of the mean concentration in the batch of soil is the average of the three or 15,068 mg/kg.

BARTLETT'S TEST FOR HOMOGENEITY OF VARIANCE

Whereas ANOVA is used to determine whether or not the difference between the means of several samples is statistically significant, Bartlett's Test[a] is used to determine whether or not the variability within samples is homogenous over several samples

[a] Snedecor, G. W. and W. G. Cochran "Statistical Methods" The Iowa State University Press, Ames, Iowa, 1967, pp. 296-298.

Example

Zn
mg/kg

Mixing time (min.)	Standard deviation S_i	Variance S_i^2	Log S_i^2
6	2,802	7,851,204	6.89494
12	2,254	5,080,516	6.70591
18	1,570	2,464,900	6.39190
Sum		15,396,620	19.99265
Mean ($\overline{S^2}$)		5,132,207	

$$M = 2.3026\ f\ (a \log \overline{S^2} - \text{Sum} \log S_i^2)$$

where

f = 6 the number of samples for each mixing time
a = 3 the number of mixing times

$$M = 2.3026(6)\ [3 \log 5{,}132{,}207 - 19.99265]$$

$$= 1.91001$$

$$C = 1 + \frac{a+1}{3af}$$

$$C = 1 + \frac{3+1}{3(3)(6)}$$

$$= 1.074$$

$$\chi^2 = \frac{M}{C}$$

$$= \frac{1.91001}{1.074}$$

$$= 1.78$$

Because the calculated value of Chi squared (χ^2) is less than the value of χ^2 for a - 1 - 2 degrees of freedom and risk level $\alpha = 0.05$ (i.e., $\chi^2_{2,0.10} = 4.61$ - Table A5 Snedecor and Cochran) there is not sufficient reason to reject the Null Hypothesis that the variance is constant over the three mixing times. It should be noted that even through Bartlett's test did not reject the Null Hypothesis, there is strong evidence that the variability within samples tends to decrease as the mixing time is increased.

Batch 1 - SARM IV
Homogeneity Tests

PEI Associates, Inc.
11499 Chester Rd.
Cincinnati, OH 45246
(513) 782-4700

Client: USEPA

Project No.: 3741-7-1
Requisition No.: T7-07-156
Date Received: 7/15/87
Sampled by: PEI
Date Reported: 8/4/87

Attn: Pat Esposito

Sample ID	PEI No.	Moisture, %	POC, ug/g
Uncon Soil	01	3.63	10.7
A	02	---	2490
B	03	---	3010
C	04	---	1350
D	05	22.6	3540
E	06	---	2080
F	07	---	5470
G	08	---	13,300
H	09	---	2410
I	10	---	3960
J	11	---	9540
K	12	---	6160
L	13	---	3690
M	14	---	9390
N	15	---	9930
O	16	---	7260
P	17	---	14,000
Q	18	---	3590
R	19	---	5160

POC = Purgeable Organic Carbon

Submitted by:
Caprice Bearden
Caprice Bearden
Inorganic Laboratory
Supervisor

APPENDIX C

RESULTS OF CHEMICAL AND PHYSICAL ANALYSES OF CLEAN SARM

PEI Associates, Inc.

CLIENT: USEPA SARM

PN NO: 3741-7
REQ NO.: T7-07-408
DATE RECD.: 7/30/87

CONTACT: DOUG BAILEY

Average of two analyses

SAMPLE ID: SOIL SAMPLE 1 & 2

PEI NO: -01

CAS Number		Ug/Kg		CAS Number		Ug/Kg	
74-87-3	Chloromethane	10	U	78-87-5	1,2-dichloropropane	5	U
74-83-9	Bromomethane	10	U	10061-02-6	Trans-1,3-dichloropropene	5	U
75-01-4	Vinyl Chloride	10	U	79-01-6	Trichloroethene	5	U
75-00-3	Chloroethane	10	U	124-48-1	Dibromochloromethane	5	U
75-09-2	Methylene Chloride	4	JB	79-00-5	1,1,2-trichloroethane	5	U
67-64-1	Acetone	10	U	71-43-2	Benzene	5	U
75-15-0	Carbon Disulfide	5	U	10061-01-5	Cis-1,3-dichloropropene	5	U
75-35-4	1,1-Dichloroethene	5	U	110-75-8	2-chloroethylvinylether	10	U
75-34-3	1,1-Dichloroethane	5	U	75-25-2	Bromoform	5	U
156-60-5	Trans-1,2-dichloroethene	5	U	108-10-1	4-methyl-2-pentanone	10	U
78-93-3	Chloroform	5	U	591-78-6	2-hexanone	10	U
107-06-2	1,2-dichloroethane	5	U	127-18-4	Tetrachloroethene	5	U
78-93-3	2-butanone	10	U	79-34-5	1,1,2,2-tetrachloroethane	2	U
71-55-6	1,1,1-trichloroethane	3	JB	108-88-3	Toluene	11	B
56-23-5	Carbon Tetrachloride	5	U	108-90-7	Chlorobenzene	5	U
108-05-4	Vinyl Acetate	10	U	100-41-4	Ethylbenzene	5	U
75-27-4	Bromodichloromethane	5	U	100-42-5	Styrene	5	U
					Total Xylenes	5	U

Data Reporting Qualifiers

Value — The result is a value greater than or equal to the detection limit.

U — Indicates compound was analyzed for but not detected. The value reported is the minimum detection limit for the sample.

J — Indicates an estimated value. This flag is used when the mass spectral data indicates the presence of a compound that meets the identification criteria, but the result is less than the specified detection limit.

B — This flag is used whenever the analyte is found in the blank as well as a sample.

PEI Associates, Inc.

SEMIVOLATILE COMPOUNDS

CLIENT: USEPA
SAPM

PROJECT: 3741-7
REQ NO: T7-07-408
DATE RECD7/30/87

ATTN: DOUG BAILEY

SAMPLE ID:SOIL SAMPLE 1 & 2

PEI NO.: -01

CAS Number		Ug/Kg		CAS Number		Ug/Kg
108-95-2	Phenol	660	U	83-32-9	Acenapthene	660
111-44-4	bis(2-chloroethyl)ether	660	U	51-28-5	2,4-Dinitrophenol	660
95-57-8	2-Chlorophenol	660	U	100-02-7	4-Nitrophenol	660
541-73-1	1,3-Dichlorobenzene	660	U	132-64-9	Dibenzofuran	660
106-47-7	1,4-Dichlorobenzene	660	U	121-14-2	2,4-Dinitrotoluene	660
100-51-6	Benzyl Alcohol	660	U	606-20-2	2,6-Dinitrotoluene	660
95-50-1	1,2-Dichlorobenzene	660	U	84-66-2	Diethyl Phthalate	660
95-48-7	2-Methylphenol	660	U	7005-72-34	Chlorophenylphenyl ether	660
39638-32-9	bis(2-chloroisopropyl)ether	660	U	86-73-7	Fluorene	660
106-44-5	4-Methylphenol	660	U	100-01-6	4-Nitroaniline	660
621-64-7	N-nitroso-di-n-propylamine	660	U	534-52-1	4,6-Dinitro2methylphenol	660
67-72-1	Hexachloroethane	660	U	534-52-1	N-Nitrosodiphenylamine(1)	660
98-95-3	Nitrobenzene	660	U	101-55-3	4bromophenylphenylether	660
78-59-1	Isophorone	660	U	118-74-1	Hexachlorobenzene	660
88-75-5	2-Nitrophenol	660	U	87-86-5	Pentachlorophenol	660
105-67-9	2,4-Dimethylphenol	660	U	85-01-8	Phenanthrene	660
65-85-0	Benzoic Acid	3300	U	120-12-7	Anthracene	660
111-91-1	bis(2-chlorethoxy)methane	660	U	84-74-2	Di-n-butyl phthalate	420
120-83-2	2,4-Dichlorophenol	660	U	206-44-0	Fluoranthene	660
120-82-1	1,2,4-Trichlorobenzene	660	U	129-00-0	Pyrene	660
91-20-3	Napthalene	660	U	85-68-7	Butylbenzylphthalate	660
106-47-8	4-Chloroaniline	660	U	91-94-1	3,3'-Dichlorobenzidine	1300
87-68-3	Hexachlorobutadiene	660	U	56-55-3	Benzo(a)anthracene	660
59-50-7	4-Chloro-3-methylphenol	660	U	117-81-7	bis-(2-ethylhexyl)phthalate	660
91-57-6	2-Methylnapthalene	660	U	218-01-9	Chrysene	660
77-47-4	Hexachlorocyclopentadiene	660	U	117-84-0	Di-n-octyl phthalate	660
88-06-2	2,4,6-Trichlorophenol	660	U	205-99-2	Benzo(b)fluoranthene	660
95-95-4	2,4,5-Trichlorophenol	3300	U	207-08-9	Benzo(k)fluoranthene	660
91-58-7	2-Chloronapthalene	660	U	50-32-8	Benzo(a)pyrene	660
88-74-4	2-Nitroaniline	3300	U	193-39-5	Indeno(1,2,3-cd)pyrene	660
131-11-3	Dimethyl Phthalate	660	U	53-70-3	Dibenzo(a,h)anthracene	660
208-96-8	Acenapthylene	660	U	191-24-2	Benzo(g,h,i) perylene	660
99-09-2	3-Nitroaniline	3300	U			

(1) Cannot be separated from diphenylamine

PEI Associates, Inc.

CLIENT: USEPA
SARM

PN NO: 3741-7
REQ NO: T7-07-408
DATE RECD: 7/30/87

CONTACT: Doug Bailey

SAMPLER: PEI

SAMPLE ID: SOIL SAMPLE 1 & 2

PEI NO: -01

CAS Number		Ug/Kg	
319-84-6	Alpha-BHC	8	U
319-85-7	Beta-BHC	8	U
319-86-8	Delta-BHC	8	U
58-89-9	Gamma-BHC (Lindane)	8	U
76-44-8	Heptachlor	8	U
309-00-2	Aldrin	8	U
1024-57-3	Heptachlor Epoxide	8	U
959-98-8	Endosulfan I	8	U
60-57-1	Dieldrin	16	U
72-55-9	4,4'-DDE	16	U
72-20-8	Endrin	16	U
33213-65-9	Endosulfan II	16	U
72-54-8	4,4'-DDD	16	U
1031-07-8	Endosulfan Sulfate	16	U
50-29-3	4,4'-DDT	16	U
72-43-5	Methoxychlor	80	U
53494-70-5	Endrin Ketone	16	U
57-74-9	Chlordane	80	U
8001-35-2	Toxaphene	16	U
12674-11-2	Aroclor-1016	80	U
11104-28-2	Aroclor-1221	80	U
11141-16-5	Aroclor-1232	80	U
53469-21-9	Aroclor-1242	80	U
12672-29-6	Aroclor-1248	80	U
11097-69-1	Aroclor-1254	160	U
11096-82-5	Aroclor-1260	150	U

PEI Associates, Inc.

CLIENT: USEPA SAFM

PN NO: 3741-7
REQ NO.: T7-07-408
DATE RECD.: 7/30/87

CONTACT: DOUG BAILEY

SAMPLE ID:

PEI NO: METHOD BLANK

CAS Number		Ug/Kg		CAS Number		Ug/Kg	
74-87-3	Chloromethane	10	U	78-87-5	1,2-dichloropropane	5	U
74-83-9	Bromomethane	10	U	10061-02-6	Trans-1,3-dichloropropene	5	U
75-01-4	Vinyl Chloride	10	U	79-01-6	Trichloroethene	5	U
75-00-3	Chloroethane	10	U	124-48-1	Dibromochloromethane	5	U
75-09-2	Methylene Chloride	4	J	79-00-5	1,1,2-trichloroethane	5	U
67-64-1	Acetone	10	U	71-43-2	Benzene	5	U
75-15-0	Carbon Disulfide	5	U	10061-01-5	Cis-1,3-dichloropropene	5	U
75-35-4	1,1-Dichloroethene	5	U	110-75-8	2-chloroethylvinylether	10	U
75-35-3	1,1-Dichloroethane	5	U	75-25-2	Bromoform	5	U
156-60-5	Trans-1,2-dichloroethene	5	U	108-10-1	4-methyl-2-pentanone	10	U
78-93-3	Chloroform	5	U	591-78-6	2-hexanone	10	U
7-06-2	1,2-dichloroethane	5	U	127-18-4	Tetrachloroethene	5	U
-93-3	2-butanone	10	U	79-34-5	1,1,2,2-tetrachloroethane	5	U
71-55-6	1,1,1-trichloroethane	5		108-88-3	Toluene	3	
56-23-5	Carbon Tetrachloride	5	U	108-90-7	Chlorobenzene	5	U
108-05-4	Vinyl Acetate	10	U	100-41-4	Ethylbenzene	5	U
75-27-4	Bromodichloromethane	5	U	100-42-5	Styrene	5	U
					Total Xylenes	5	U

Data Reporting Qualifiers

Value — The result is a value greater than or equal to the detection limit.

U — Indicates compound was analyzed for but not detected. The value reported is the minimum detection limit for the sample.

J — Indicates an estimated value. This flag is used when the mass spectral data indicates the presence of a compound that meets the identification criteria, but the result is less than the specified detection limit.

B — This flag is used whenever the analyte is found in the blank as well as a sample.

PEI Associates, Inc.

SEMIVOLATILE COMPOUNDS

CLIENT: USEPA
SAPM

PROJECT: 3741-7
REQ NO: T7-07-408
DATE RECD 7/30/87

ATTN: DOUG BAILEY

SAMPLE ID:

PEI NO.: METHOD BLANK

CAS Number		Ug/Kg		CAS Number		Ug/Kg	
108-95-2	Phenol	660	U	83-32-9	Acenapthene	660	U
111-44-4	bis(2-chloroethyl)ether	660	U	51-28-5	2,4-Dinitrophenol	660	U
95-57-8	2-Chlorophenol	660	U	100-02-7	4-Nitrophenol	660	U
541-73-1	1,3-Dichlorobenzene	660	U	132-64-9	Dibenzofuran	660	U
106-47-7	1,4-Dichlorobenzene	660	U	121-14-2	2,4-Dinitrotoluene	660	U
100-51-6	Benzyl Alcohol	660	U	606-20-2	2,6-Dinitrotoluene	660	U
95-50-1	1,2-Dichlorobenzene	660	U	84-66-2	Diethyl Phthalate	660	U
95-48-7	2-Methylphenol	660	U	7005-72-3	4Chlorophenylphenyl ether	660	U
39638-32-9	bis(2-chloroisopropyl)ether	660	U	86-73-7	Fluorene	660	U
106-44-5	4-Methylphenol	660	U	100-01-6	4-Nitroaniline	660	U
621-64-7	N-nitroso-di-n-propylamine	660	U	534-52-1	4,6-Dinitro2methylphenol	660	U
67-72-1	Hexachloroethane	660	U	534-52-1	N-Nitrosodiphenylamine(1)	660	U
98-95-3	Nitrobenzene	660	U	101-55-3	4bromophenylphenylether	660	U
78-59-1	Isophorone	660	U	118-74-1	Hexachlorobenzene	660	U
88-75-5	2-Nitrophenol	660	U	87-86-5	Pentachlorophenol	660	U
105-67-9	2,4-Dimethylphenol	660	U	85-01-8	Phenanthrene	660	U
65-85-0	Benzoic Acid	3300	U	120-12-7	Anthracene	660	U
111-91-1	bis(2-chlorethoxy)methane	660	U	84-74-2	Di-n-butyl phthalate	150	J
120-83-2	2,4-Dichlorophenol	660	U	206-44-0	Fluoranthene	660	U
120-82-1	1,2,4-Trichlorobenzene	660	U	129-00-0	Pyrene	660	U
91-20-3	Napthalene	660	U	85-68-7	Butylbenzylphthalate	660	U
106-47-8	4-Chloroaniline	660	U	91-94-1	3,3'-Dichlorobenzidine	1300	U
87-68-3	Hexachlorobutadiene	660	U	56-55-3	Benzo(a)anthracene	660	U
59-50-7	4-Chloro-3-methylphenol	660	U	117-81-7	bis-(2-ethylhexyl)phthalate	660	U
91-57-6	2-Methylnapthalene	660	U	218-01-9	Chrysene	660	
77-47-4	Hexachlorocyclopentadiene	660	U	117-84-0	Di-n-octyl phthalate	660	
88-06-2	2,4,6-Trichlorophenol	660	U	205-99-2	Benzo(b)fluoranthene	660	
95-95-4	2,4,5-Trichlorophenol	3300	U	207-08-9	Benzo(k)fluoranthene	660	
91-58-7	2-Chloronapthalene	660	U	50-32-8	Benzo(a)pyrene	660	
88-74-4	2-Nitroaniline	3300	U	193-39-5	Indeno(1,2,3-cd)pyrene	660	
131-11-3	Dimethyl Phthalate	660	U	53-70-3	Dibenzo(a,h)anthracene	660	
208-96-8	Acenapthylene	660	U	191-24-2	Benzo(g,h,i) perylene	660	
99-09-2	3-Nitroaniline	3300	U				

(1) Cannot be separated from diphenylamine

PEI Associates, Inc.

CLIENT: USEPA
SAPM

PN NO: 3741-7
PEQ NO: T7-07-408
DATE RECD: 7/30/87

CONTACT: Doug Bailey

SAMPLER: PEI

SAMPLE ID:

PEI NO: METHOD BLANK

CAS Number		ug/l g	
319-84-6	Alpha-BHC----------	8	U
319-85-7	Beta-BHC----------	8	U
319-86-8	Delta-BHC----------	8	U
58-89-9	Gamma-BHC (Lindane)------	8	U
76-44-8	Heptachlor----------	8	U
309-00-2	Aldrin----------	8	U
1024-57-3	Heptachlor Epoxide-------	8	U
959-98-8	Endosulfan I----------	8	U
60-57-1	Dieldrin----------	16	U
72-55-9	4,4'-DDE----------	16	U
72-20-8	Endrin----------	16	U
33213-65-9	Endosulfan II----------	16	U
-54-9	4,4'-DDD----------	16	U
1031-07-8	Endosulfan Sulfate-------	16	U
50-29-3	4,4'-DDT----------	16	U
72-43-5	Methoxychlor----------	80	U
53494-70-5	Endrin Ketone----------	16	U
57-74-9	Chlordane----------	80	U
8001-35-2	Toxaphene----------	16	U
12674-11-2	Arochlor-1016----------	80	U
11104-28-2	Arochlor-1221----------	80	U
11141-16-5	Arochlor-1232----------	80	U
53469-21-9	Arochlor-1242----------	80	U
12672-29-6	Arochlor-1248----------	80	U
11097-69-1	Arochlor-1254----------	160	U
11096-82-5	Arochlor-1260----------	160	U

PEI Associates, Inc.
11499 Chester Rd.
Cincinnati, OH 45246
(513) 782-4700

Client: USEPA

Project No.: 3741-7
Requisition No.: T7-07-408
Date Received: 7/30/87
Sampled by: PEI
Date Reported: 8/19/87

Attn:

Sample ID: Soil for SARM
PEI No.: 07-408-01

All results ug/g

Cyanide	<0.5
Aluminum	13,000
Antimony	<11
Arsenic	9.4
Barium	52.3
Beryllium	1.4
Cadmium	2
Calcium	131,000
Chromium	8
Cobalt	3.6
Copper	8.5
Iron	10,300
Lead	9.1
Magnesium	25,600
Manganese	670
Mercury	<0.2
Nickel	7.8
Potassium	1220
Selenium	<0.2
Silver	1.6
Sodium	198
Thallium	<14
Vanadium	15.6
Zinc	33

Submitted by:

Caprice Bearden

Caprice Bearden
Inorganic Laboratory
Supervisor

THE H. C. NUTTING COMPANY
GEOTECHNICAL AND TESTING ENGINEERS SINCE 1921
4120 AIRPORT ROAD • P.O BOX C • CINCINNATI, OHIO 45226 • 513-321-5816
912 MORRIS STREET • CHARLESTON, WEST VIRGINIA 25301 • 304-344-0821
BOX NUMBER 11 • HIGHLAND HEIGHTS, KENTUCKY 41076 • 606-261-2043

BILLING COPY

August 17, 1987

W.O. No. ~~8451.016~~ 11704
P.O. No. PE-87-1886-3741-7-1

PEI Associates, Inc.
11499 Chester Road
Cincinnati, Ohio - 45246

Attn: Mr. Douglas C. Bailey

Re: Cation Exchange Analysis

Dear Sir:

Transmitted herewith is our report covering the results of the Cation Exchange analysis performed upon ten (10) samples of soil which were prepared and submitted to our laboratory.

The analysis was performed in accordance with your letter of July 30, 1987. The results of the analysis are summarized as follows:

SAMPLE NO.	CATION EXCHANGE CAPACITY - 30
1	117.5
2	152.5
3	150.0
4	150.0
5	77.5
6	150.0
7	155.0
8	80.0
9	147.5
10	147.5

REMARKS:

The cation exchange values were determined in accordance with the procedures outlined in Enviromental Protection Agency's Technical Publication Manual No. EPA-00600-2-78-054, dated March 19, 1978.

Respectfully Submitted,

THE H. C. NUTTING COMPANY

Robert L House

Robert House,
Laboratory Director

RH/sk

S&ME

Formerly, Soil & Material Engineers, Inc.

Clean Farm Project

August 8, 1987

PEI Associates, Inc.
11499 Chester Road
Cincinnati, OH 45246

Attn: Mr. Douglas Bailey

Re: Soil Testing
S&ME Project No. 1223-87-216

Dear Mr. Bailey:

Please find attached a lab summary sheet and grain size distribution curves for the six samples you sent to us for analysis.

If you have any questions regarding this work, please contact this office at (513) 874-4111.

Respectfully submitted,

S&ME, INC.

William D. Hunt

William D. Hunt
Laboratory Manager

WDH:nr

Attachments

S&ME, Inc.
225 Corporate Court, Suite K
Fairfield, OH 45014

CLIENT: PEI, Inc.

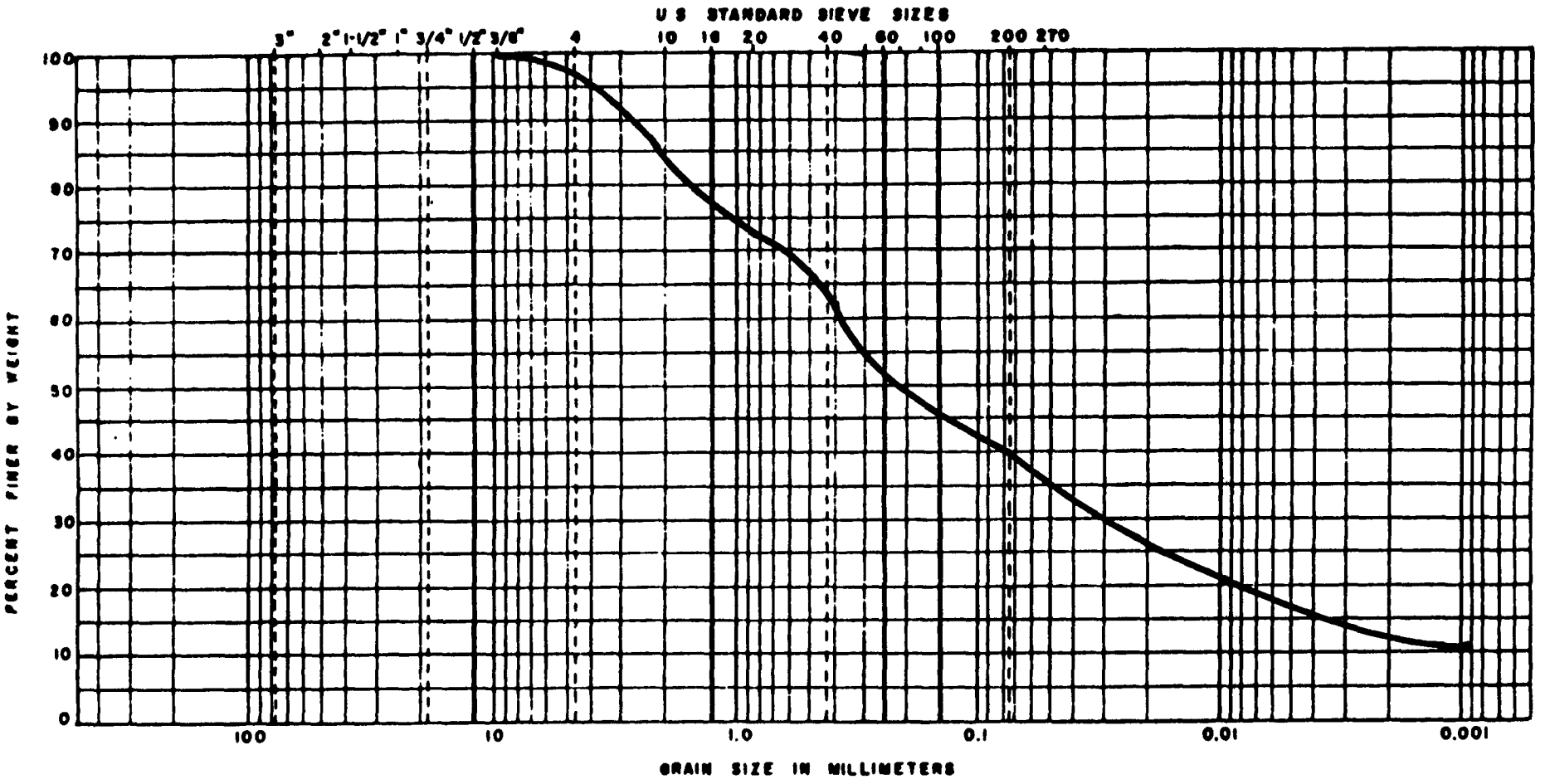
PROJECT: Soil Testing

PROJECT NO: 1223-87-216

LABORATORY TEST RESULTS

Boring No.	Sample No.	Organic Content -LOI-	Grain Size Analysis Gravel %	Sand %	Silt %	Clay %	pH
PC# 1	6	2.7	3	57	27	13	8.0
	3	3.0	4	58	27	11	8.5
	5	2.8	2	56	28	14	9.0
PC# 2	1	3.2	3	55	29	13	8.0
	2	3.9	2	57	30	11	9.0
	4	3.8	3	54	30	13	8.5

S&ME



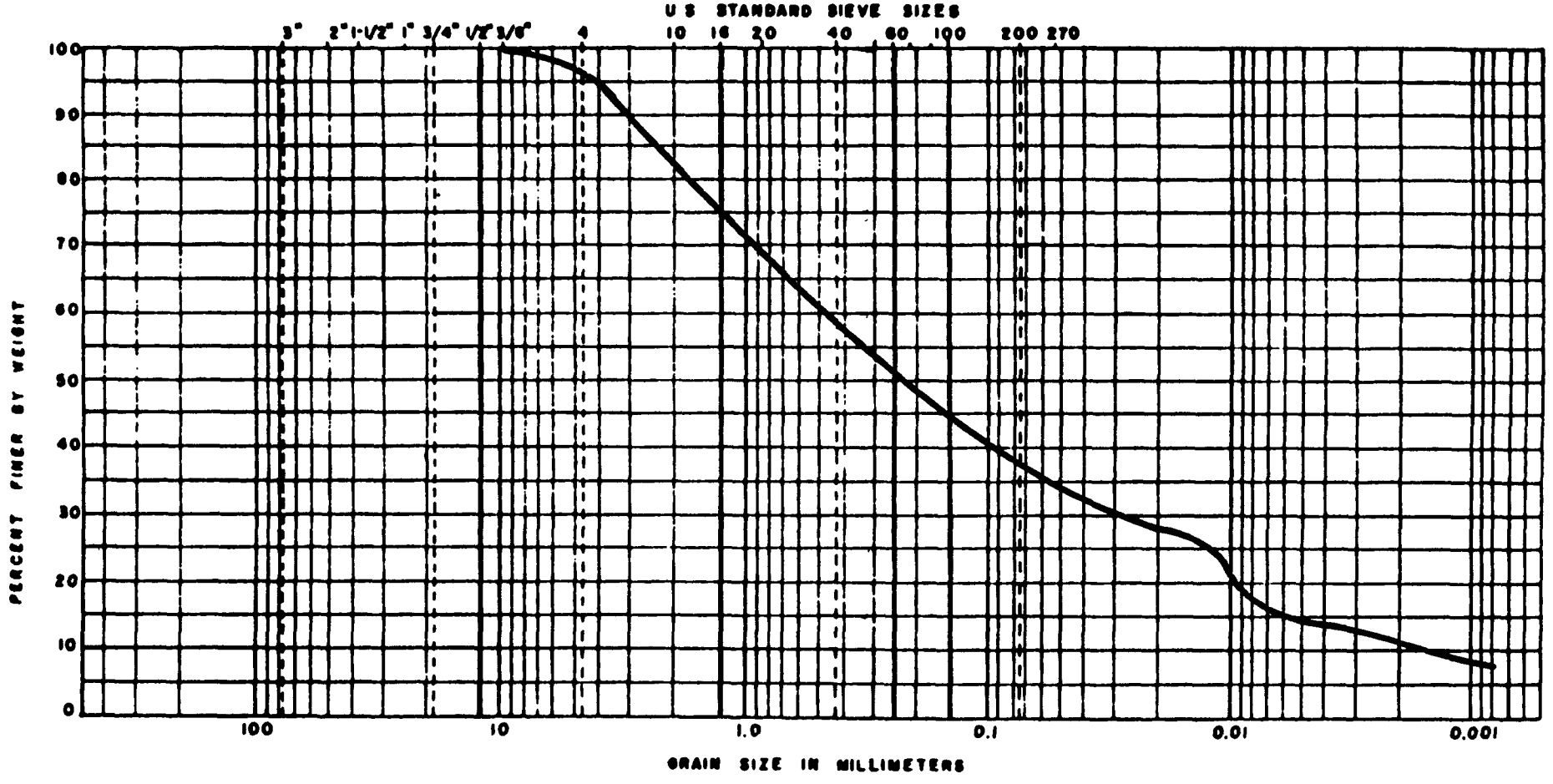
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
PC# 1, #6						

GRAIN SIZE DISTRIBUTION

JOB NO. 1223-87-216

SOIL & MATERIAL ENGINEERS, INC.



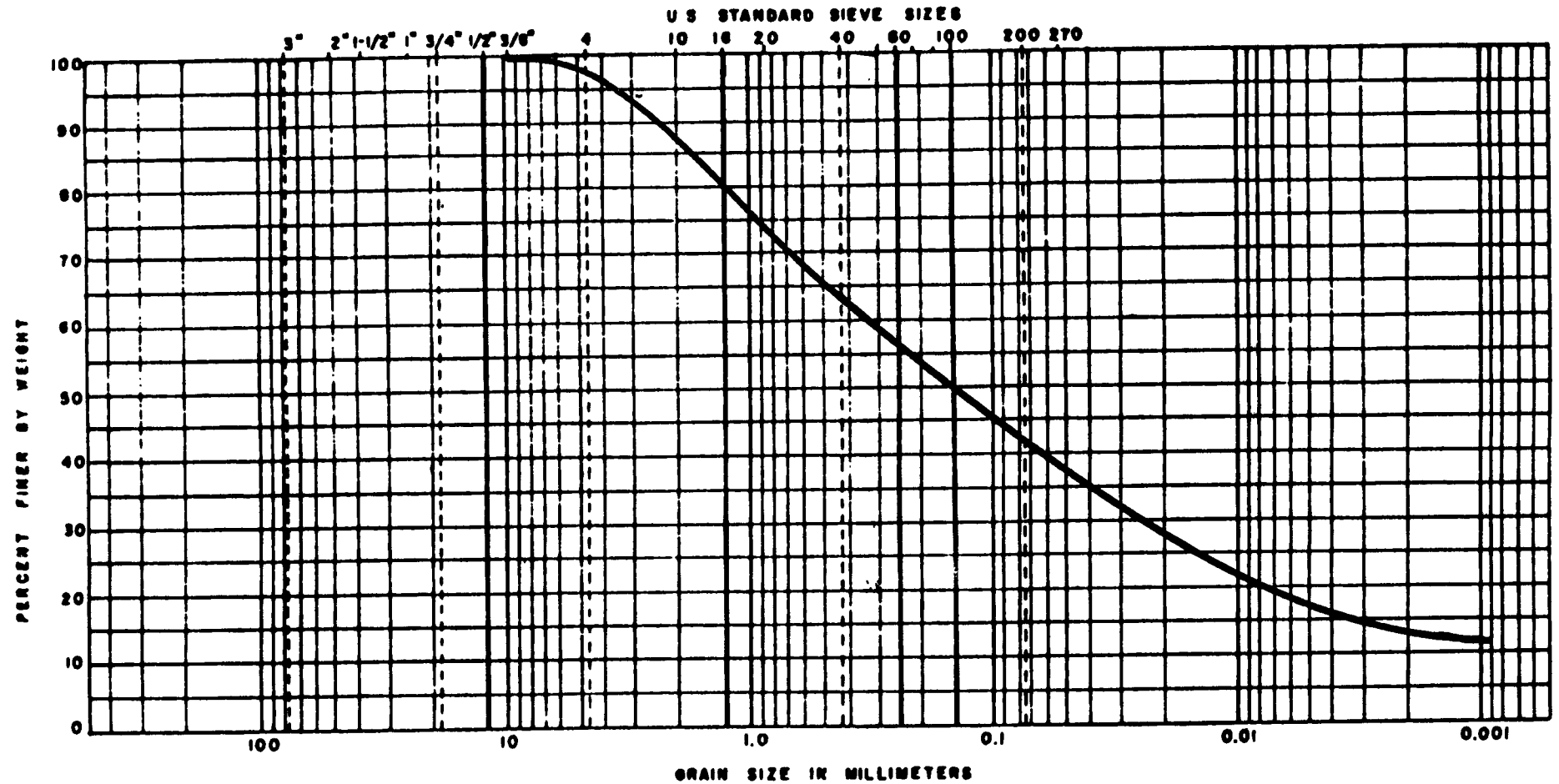
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
PC# 1, #3						

GRAIN SIZE DISTRIBUTION

JOB NO. 1223-87-216

SOIL & MATERIAL ENGINEERS, INC.



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
PC# 1, #5						

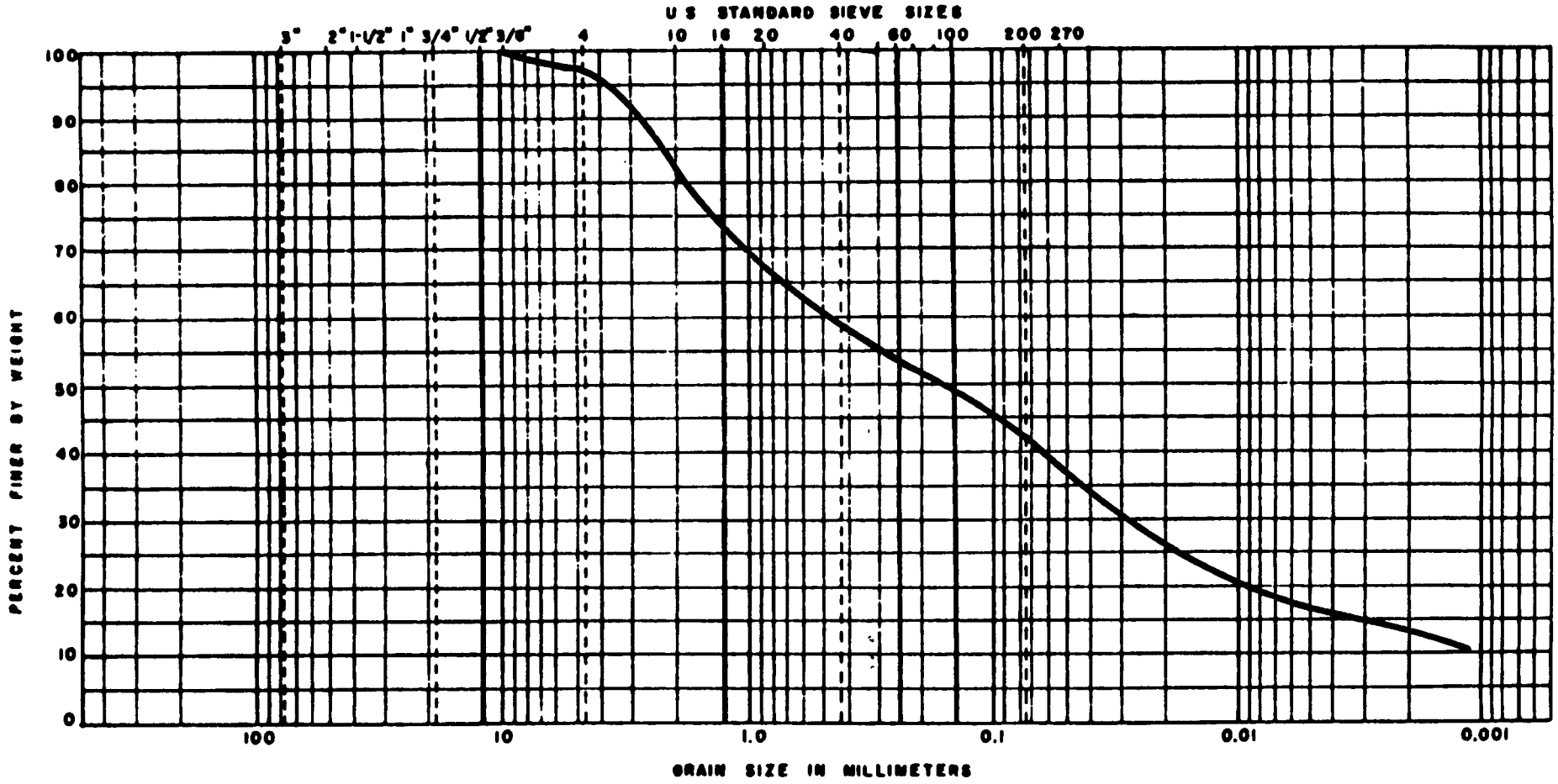
GRAIN SIZE DISTRIBUTION

JOB NO. 1223-87-216

SOIL & MATERIAL ENGINEERS, INC.

DUNCAN-PARNELL INC. RALEIGH 781

SM-19



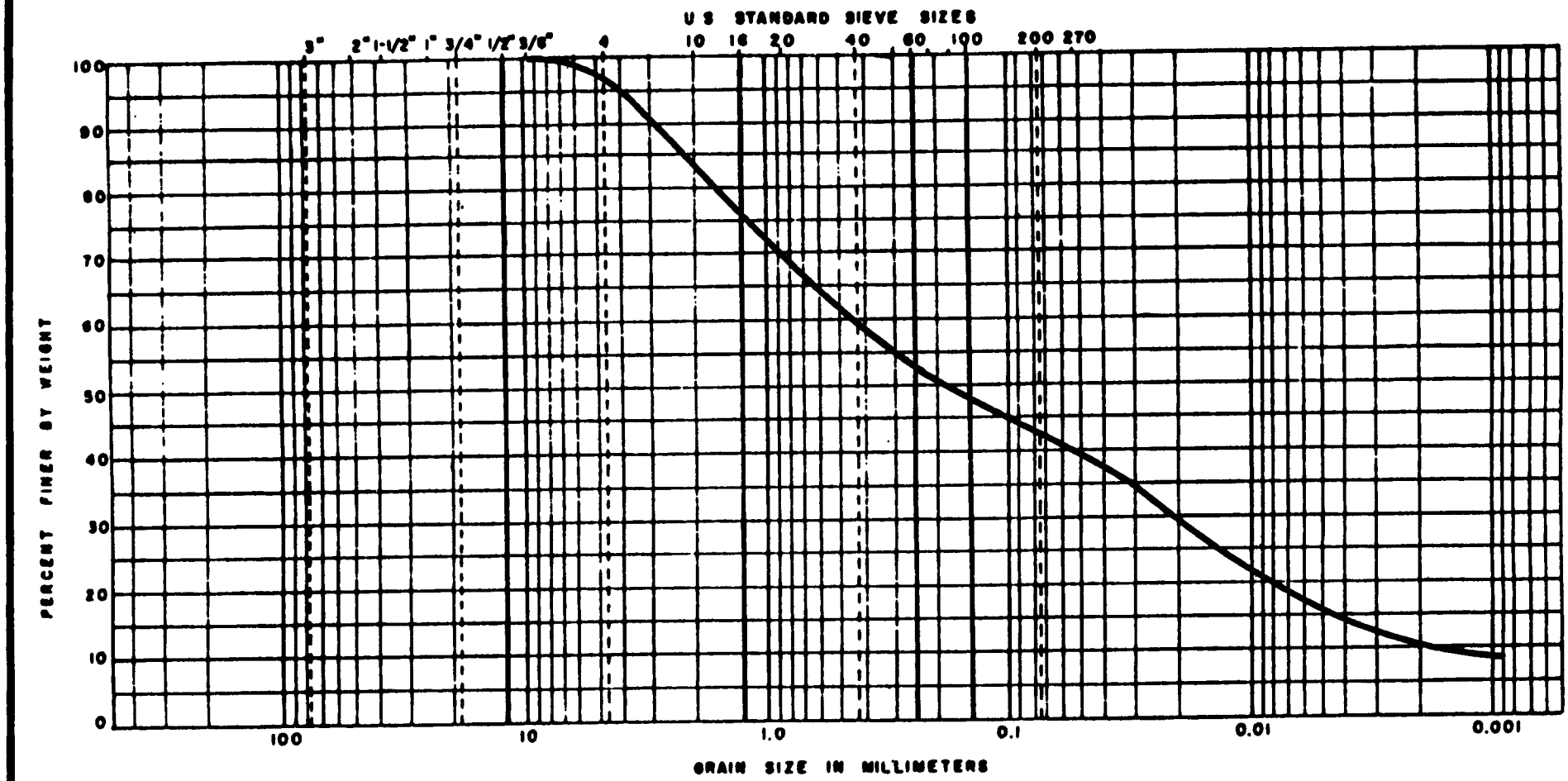
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
PC# 2, #1						

GRAIN SIZE DISTRIBUTION

JOB NO. 1223-87-216

SOIL & MATERIAL ENGINEERS, INC.



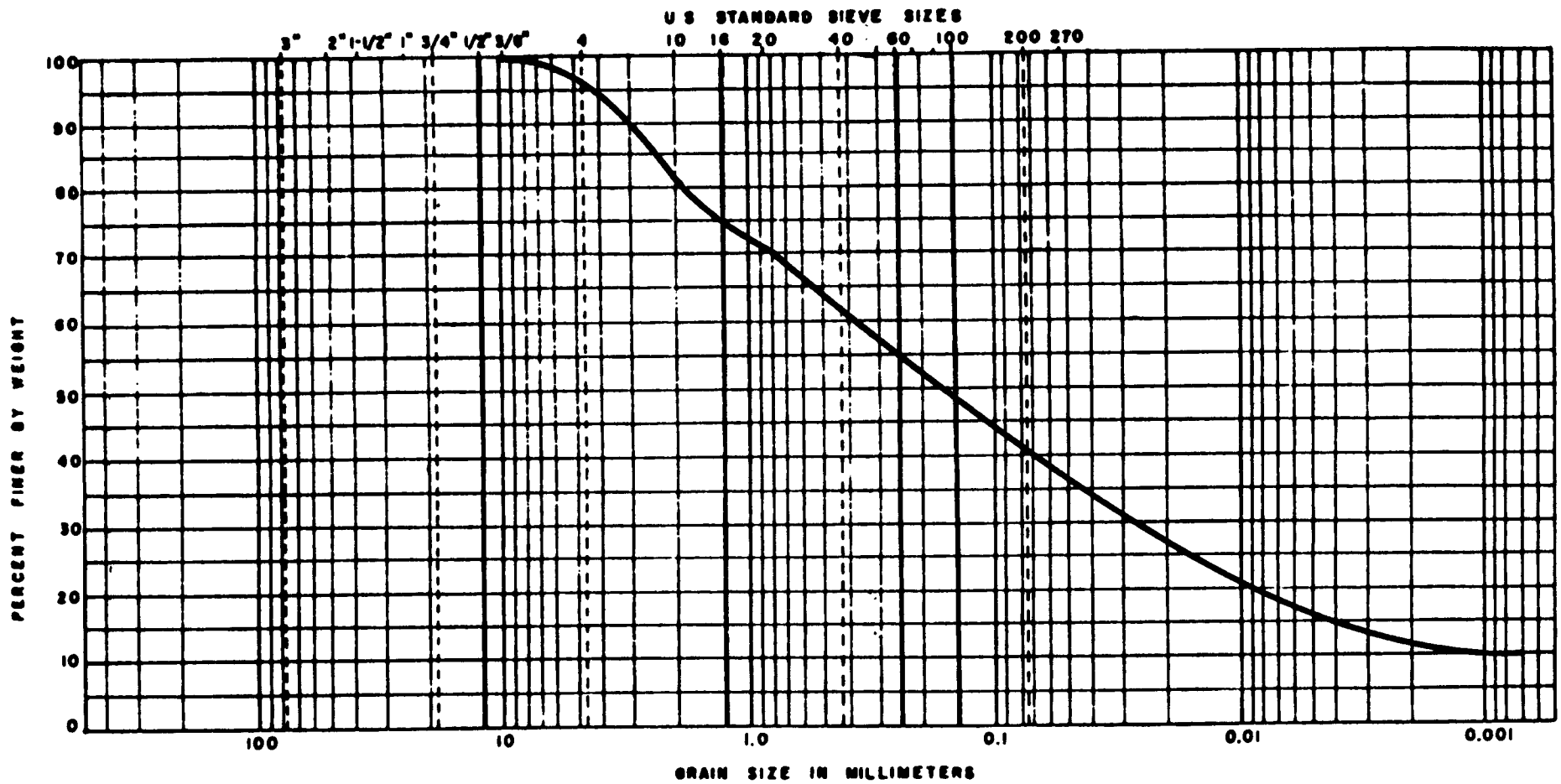
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
PC # 2, ±2						

GRAIN SIZE DISTRIBUTION

JOB NO. 1223-87-216

SOIL & MATERIAL ENGINEERS, INC.



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
PC# 2,#4						

GRAIN SIZE DISTRIBUTION

JOB NO. 1223-87-216

SOIL & MATERIAL ENGINEERS, INC.

APPENDIX D

PHASE II SOIL WASHING ANALYTICAL RESULTS

APPENDIX D

Sample ID Key - Phase II Analytical Results

A _____/ B ___ ___ ___ ___/ C ___ ___/ D _____

A = Type of wash performed

P = prewash - wet sieve only
F = final wash (Phase II)
T = final wash (Phase II) performed in duplicate for TCLP analysis

B = SARM tested

LMHO = SARMI
LMLO = SARM II
HMLO = SARM III
HMHO = SARM IV

C = Run number - type of wash

R1 = tap water wash
R2 = chelant wash
R3 = surfactant wash

D = duplicate
T = triplicate

D = Soil size fraction submitted for analysis

10 = greater than 10 mesh (+2 mm)
10-60 = less than 10 mesh, greater than 60 mesh (2 mm to 250 μm)
60 = less than 60 mesh (<250 μm)

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: Two (2) soil samples received August 7, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LML0/R1/60 & F/LML0/R1T/60	F/LML0/R1D/60
Arsenic	22.8	26.7
Cadmium	50.9	60.2
Chromium	88.6	92.3
Copper	622	681
Lead	679	741
Nickel	65.1	72.0
Zinc	1,280	1,480
% Moisture	43.46	42.37

Approved by Alyce R. Mabie
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: Four (4) soil samples received August 7, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMH0/R1/60	F/HMH0/R1D/60	F/LML0/R1/10	F/LML0/R1/10-60 & F/LML0/R1T/10-60
Arsenic	858	991	3.0	5.3
Cadmium	612	674	2.5	9.5
Chromium	2,040	2,310	<0.76	4.2
Copper	16,900	19,900	4.2	25.3
Lead	22,100	25,700	1.5	112
Nickel	1,150	1,330	4.3	7.5
Zinc	33,600	38,900	14.0	82.2
% Moisture	51.24	52.12	3.07	19.12

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: Two (2) soil samples received August 7, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LML0/R1D/10	F/LML0/R1D/10-60
Arsenic	2.0	3.0
Cadmium	9.4	11.0
Chromium	1.0	3.8
Copper	5.9	25.6
Lead	6.5	25.9
Nickel	3.7	6.9
Zinc	28.1	132
% Moisture	0.60	19.25

Approved by: Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: Four (4) soil samples received August 7, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMH0/R1/10	F/HMH0/R1/10-60	F/HMH0/R1D/10	F/HMH0/R1D/10-60
Arsenic	89.0	114	164	107
Cadmium	433	284	263	289
Chromium	7.7	26.5	7.7	31.4
Copper	158	450.	137	484
Lead	154	958	182	1,560
Nickel	37.9	53.9	21.6	58.9
Zinc	1,080	3,080	666	3,560
% Moisture	5.90	15.55	4.17	20.35

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1/60 & F/LML0/R1T/60

Concentration units are mg/kg (ppm) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Arsenic	60.5 (MS) 69.4 (MSD)	22.8	81.5	97	87.7	94	3.1
Cadmium	60.5 (MS) 69.4 (MSD)	50.9	98.9	79	111	86	8.5
Chromium	60.5 (MS) 69.4 (MSD)	88.6	133	73	150.	88	19
Copper	60.5 (MS) 69.4 (MSD)	622	688	109	783	232*	72*
Lead	60.5 (MS) 69.4 (MSD)	679	682	5*	763	121	*
Nickel	60.5 (MS) 69.4 (MSD)	65.1	113	79	125	86	8.5
Zinc	60.5 (MS) 69.4 (MSD)	1,280	1,350	116	1,490	303*	*

RPD = Relative Percent Difference
* = Sample concentration greater than 4 times spike added, therefore EPA criteria do not apply.

MS Spike Added = 40 µg/ml x 1 ml/1.17 gram ÷ 0.5654 = 60.5 µg/gram dry weight.
MSD Spike Added = 40 µg/ml x 1 ml/1.02 gram ÷ 0.5654 = 69.4 µg/gram dry weight.

% Moisture = 43.46

Approved by Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24767
ORDER NUMBER: L0118

Sample Description: F/LML0/R1/10-60 & F/LML0/R1T/10-60

Concentration units are mg/kg (ppm) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Arsenic	43.8 (MS) 47.1 (MSD)	5.3	41.4	82	41.7	77	6.3
Cadmium	43.8 (MS) 47.1 (MSD)	9.5	45.7	83	46.8	79	4.9
Chromium	43.8 (MS) 47.1 (MSD)	4.2	38.6	78	40.7	77	1.3
Copper	43.8 (MS) 47.1 (MSD)	25.3	73.4	110	63.9	82	29
Lead	43.8 (MS) 47.1 (MSD)	112	70.2	0	62.4	0	---
Nickel	43.8 (MS) 47.1 (MSD)	7.5	41.9	78	41.8	73	6.6
Zinc	43.8 (MS) 47.1 (MSD)	82.2	219	312	114	68	---

RPD = Relative Percent Difference

% Moisture = 19.12

Note: Sample was reanalyzed to confirm results. Both sets of data are provided.

Approved by: Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1/10-60 & F/LML0/R1T/10-60 (rerun)

Concentration units are mg/kg (ppm) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Arsenic	43.8 (MS) 47.1 (MSD)	4.1	43.3	90.	44.1	85	5.7
Cadmium	43.8 (MS) 47.1 (MSD)	9.3	48.7	90.	49.1	85	5.7
Chromium	43.8 (MS) 47.1 (MSD)	4.2	37.2	75	38.9	74	1.3
Copper	43.8 (MS) 47.1 (MSD)	24.2	66.9	97	58.2	72	30.
Lead	43.8 (MS) 47.1 (MSD)	103	67.4	0*	59.8	0*	0
Nickel	43.8 (MS) 47.1 (MSD)	6.7	40.7	78	41.5	74	5.3
Zinc	43.8 (MS) 47.1 (MSD)	78.6	223	330*	116	79	123

RPD = Relative Percent Difference

* = Spike added is ~2 times less than native analyte.

Approved by: Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24767
ORDER NUMBER: L0118

Sample Description: F/LML0/R1/60 & F/LML0/R1T/60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	800
chlorobenzene	ND
1,2-dichloroethane	ND
ethyl benzene	<440 (200)
styrene	<440 (400)
tetrachloroethene	ND
xylenes (total)	750

Remarks: 440 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 43.46

Approved by Alyce K. Moore
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24767
ORDER NUMBER: L0118
PAGE 9 OF 35

Sample Description: F/LMLO/R1D/60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	210
chlorobenzene	11
1,2-dichloroethane	ND
ethyl benzene	74
styrene	100
tetrachloroethene	<9 (2)
xylenes (total)	290

Remarks:
9 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 42.37

Approved by Alyce K Mack
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/HMHO/R1D/60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	100,000
chlorobenzene	86,000
1,2-dichloroethane	16,000
ethyl benzene	2,300,000
styrene	190,000
tetrachloroethene	150,000
xylenes (total)	3,600,000

Remarks: 1,300 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 52.12

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118
PAGE 10 OF 35

Sample Description: F/HMHO/R1/60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	140,000
chlorobenzene	49,000
1,2-dichloroethane	ND
ethyl benzene	1,800,000
styrene	110,000
tetrachloroethene	92,000
xylenes (total)	2,900,000

Remarks: 1,300 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 51.24

Approved by Alyce K. Nixon
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1/10 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	320
chlorobenzene	<5 (2)
1,2-dichloroethane	ND
ethyl benzene	10.
styrene	10.
tetrachloroethene	ND
xylenes (total)	29

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.07

Approved by Alyce K. Meade
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1D/10 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	690
chlorobenzene	<10. (3)
1,2-dichloroethane	ND
ethyl benzene	17
styrene	22
tetrachloroethene	ND
xylenes (total)	52

Remarks: 10. = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 0.60

Alyce K. Moore
Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1/10-60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	310
chlorobenzene	8
1,2-dichloroethane	ND
ethyl benzene	54
styrene	96
tetrachloroethene	ND
xylenes (total)	220

Remarks: 6 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.12

Approved by Laboratory Manager

Title

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DATE REPORTED September 30, 1987
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Sample Description: F/LMLO/R1D/10-60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	310
chlorobenzene	18
1,2-dichloroethane	<6 (1)
ethyl benzene	110
styrene	160
tetrachloroethene	<6 (3)
xylenes (total)	400

Remarks: 6 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.25

Approved by Alyce K. Mauze
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/HMHO/R1/10 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	7,800
chlorobenzene	<25 (22)
1,2-dichloroethane	39
ethyl benzene	86
styrene	ND
tetrachloroethene	<25 (8)
xylenes (total)	200

Remarks: 25 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 5.90

Approved by
Laboratory Manager
Title

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TO IT Corporation
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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/HMHO/R1D/10 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	3,800
chlorobenzene	<26 (18)
1,2-dichloroethane	<26 (17)
ethyl benzene	73
styrene	ND
tetrachloroethene	ND
xylenes (total)	160

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.17

Approved by Alyce K. Tiedeken
Laboratory Manager
Title

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TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/HMHO/R1/10-60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,900
chlorobenzene	610
1,2-dichloroethane	ND
ethyl benzene	6,100
styrene	ND
tetrachloroethene	820
xylenes (total)	9,600

Remarks: 300 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 15.55

Approved by Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/HMHO/R1D/10-60 (Soil) received August 7, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	8,800
chlorobenzene	2,400
1,2-dichloroethane	390
ethyl benzene	23,000
styrene	5,400
tetrachloroethene	3,800
xylenes (total)	40,000

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 20.35

Approved by
Laboratory Manager
Title

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TO IT Corporation
ATTN: Barbara Locke
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Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE. ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1/60 & F/LML0/R1T/60 (Soil) received August 7, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
acetone[1]	1,500	1,800	3,000	80.	3,100	87	-8.4
1,2-dichloroethane	1,500	ND	1,300	87	1,700	113	-26
tetrachloroethene	440	ND	420	95	410	93	2.1
ethylbenzene	440	91	490	111	490	111	0
chlorobenzene	440	<25 (18)	430	94	420	91	3.2
styrene	440	130	550	95	530	91	4.3
xylenes	440	300	720	95	680	86	9.9

Remarks: 44 = Quantitation Limit
ND = Not Detected
RPD = Relative Percent Difference
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This compound has a quantitation limit two (2) times that listed.

Note: The original sample was reanalyzed along with the matrix spike/matrix spike duplicate. The reanalysis results are reported rather than the original run.

Approved by Laboratory Manager

Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LMLO/R1/10-60 & F/LMLO/R1T/10-60 (Soil) received August 7, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
acetone[1]	120	310	440	108	460	125	-14
1,2-dichloroethane	120	ND	130	108	130	108	0
tetrachloroethene	120	ND	130	108	130	108	0
ethylbenzene	120	54	170	97	180	105	-7.9
chlorobenzene	120	8	130	102	130	102	0
styrene	120	96	250	128	230	112	13
xylenes	120	220	370	125	330	92	30

Remarks: 6 = Quantitation Limit
ND = Not Detected
RPD = Relative Percent Difference
[1] = This compound has a quantitation limit two (2) times that listed.

Approved by Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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CERTIFICATE OF ANALYSIS

TO IT Corporation
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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24767
ORDER NUMBER: L0118

Sample Description: F/LMLO/R1/60 & F/LMLO/R1T/60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,100,000
bis(2-ethylhexyl)phthalate	440,000
pentachlorophenol	<14,000 (2,600)

Remarks: 14,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 43.46

Approved by Alyce K. Madrid
Laboratory Manager
Title

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ORDER NUMBER L0118

Sample Description: F/LML0/R1D/60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	560,000
bis(2-ethylhexyl)phthalate	300,000
pentachlorophenol	<15,000 (6,500)

Remarks: 15,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 42.37

Approved by Alyce K. Moore
Laboratory Manager
Title

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TO IT Corporation
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11499 Chester Road
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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24767
ORDER NUMBER: L0118

Sample Description: F/HMHO/R1/60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	6,100,000
bis(2-ethylhexyl)phthalate	3,300,000
pentachlorophenol	390,000

Remarks: 68,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 51.24

Approved by
Laboratory Manager
Title

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PROJECT CODE: ITEC 24767
ORDER NUMBER: L0118

Sample Description: F/HMHO/R1D/60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	4,300,000
bis(2-ethylhexyl)phthalate	2,900,000
pentachlorophenol	<390,000 (330,000)

Remarks: 390,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 52.12

Approved by: Laboratory Manager
Title

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ORDER NUMBER L0118

Sample Description: F/LML0/R1/10 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,600 (3,700)
bis(2-ethylhexyl)phthalate	23,000
pentachlorophenol	ND

Remarks: 9,600 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 3.07

Approved by: Alyce K. Moore
Laboratory Manager
Title

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ORDER NUMBER L0118

Sample Description: F/LML0/R1D/10 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
anthracene	<9,300 (2,600)
bis(2-ethylhexyl)phthalate	31,000
pentachlorophenol	ND

Remarks: 9,300 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 0.60

Approved by
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118
PAGE 27 OF 35

Sample Description: F/LML0/R1/10-60 & F/LML0/R1T/10-60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	100,000
bis(2-ethylhexyl)phthalate	44,000
pentachlorophenol	<12,000 (5,100)

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 19.12

Approved by Laboratory Manager
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Sample Description: F/LML0/R1D/10-60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	250,000
bis(2-ethylhexyl)phthalate	49,000
pentachlorophenol	<12,000 (8,500)

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 19.25

Approved by Alyce K. Moore
Laboratory Manager
Title

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ORDER NUMBER L0118

Sample Description: F/HMHO/R1/10 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	40,000
bis(2-ethylhexyl)phthalate	<37,000 (7,500)
pentachlorophenol	<37,000 (25,000)

Remarks: 37,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 5.90

Approved by Laboratory Manager

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ORDER NUMBER: L0118

Sample Description: F/HMHO/R1/10-60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,200,000
bis(2-ethylhexyl)phthalate	<42,000 (26,000)
pentachlorophenol	<42,000 (36,000)

Remarks: 42,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 15.55

Approved by
Laboratory Manager
Title

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ORDER NUMBER L0118

Sample Description: F/HMHO/R1D/10 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<19,000 (16,000)
bis(2-ethylhexyl)phthalate	<19,000 (4,000)
pentachlorophenol	21,000

Remarks: 19,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 4.17

Approved by Laboratory Manager
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DATE REPORTED September 30, 1987
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ORDER NUMBER L0118

Sample Description: F/LML0/R1/60 & F/LML0/R1T/60 (Soil) received August 7, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
pentachlorophenol	91,000 (MS) 87,000 (MSD)	2,600	24,000	24	12,000	11	74
anthracene	360,000 (MS) 350,000 (MSD)	1,100,000	1,800,000	194	1,200,000	29	150
bis(2-ethylhexyl) phthalate	180,000 (MS) 170,000 (MSD)	440,000	790,000	194	620,000	106	32

RPD = Relative Percent Difference

% Moisture = 43.46

Approved by Laboratory Manager

Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/HMHO/R1D/10-60 (Soil) received August 7, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
anthracene	3,200,000
bis(2-ethylhexyl)phthalate	<45,000 (43,000)
pentachlorophenol	<45,000 (42,000)

Remarks: 45,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are less than the quantitation limit and are therefore estimated.

% Moisture = 20.35

Approved by Laboratory Manager

Title

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TO IT Corporation
ATTN: Barbara Locke
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Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER: 805018 (PEI-3741-7-2)
PAGE 1 OF 41

Sample Description: Four (4) soil samples received August 5, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/LML0/R1/60	P/LML0/R1D/60	P/LMH0/R1/60	P/LMH0/R1D/60
Arsenic	29.7	24.8	19.6	17.3
Cadmium	39.5	51.3	28.2	24.5
Chromium	44.7	68.3	42.5	37.9
Copper	408	582	385	330.
Lead	431	602	398	341
Nickel	40.6	54.0	34.6	30.7
Zinc	902	1,300	728	629
% Moisture	24.61	33.95	35.07	40.42

Allyn K. Mann
Approved by

Laboratory Manager
Title

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24767
ORDER NUMBER L0118

Sample Description: F/LML0/R1/10-60 & F/LML0/R1T/10-60 (Soil) received August 7, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	
pentachlorophenol	14,000 (MS) 15,000 (MSD)	5,100	4,300	-5.7	5,600	3.3	-
anthracene	56,000 (MS) 61,000 (MSD)	100,000	120,000	36	200,000	164	-
bis(2-ethylhexyl) phthalate	28,000 (MS) 31,000 (MSD)	44,000	49,000	18	63,000	61	-

RPD = Relative Percent Difference

% Moisture = 19.12

Approved by Alyce K. Mackie
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: Two (2) soil samples received August 5, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/LMLO/R1D/10	P/LMLO/R1D/10-60
Arsenic	8.3	6.1
Cadmium	3.7	10.9
Chromium	1.4	4.2
Copper	11.7	30.8
Lead	11.3	29.6
Nickel	3.2	8.5
Zinc	28.5	182
% Moisture	3.78	14.48

Approved by Alyce K. Tiarre
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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DATE REPORTED September 30, 1987
PROJECT CODE. ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 5, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/HMLO/R1/60	P/HMLO/R1D/60	P/LMLO/R1/10	P/LMLO/R1/10-60
Arsenic	1,070	1,000	2.2	3.0
Cadmium	702	661	2.6	12.7
Chromium	2,230	2,220	<0.86	7.5
Copper	1,880	21,200	5.4	52.6
Lead	27,400	30,300	6.4	76.5
Nickel	1,380	1,350	<1.7	10.4
Zinc	44,400	49,400	10.4	332
% Moisture	53.02	53.77	5.19	14.37

Approved by Alice L. Mace
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 5, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/HMLO/R1/10	P/HMLO/R1/10-60	P/HMLO/R1D/10	P/HMLO/R1D/10-60
Arsenic	60.0	81.6	61.5	94.6
Cadmium	333	278	309	298
Chromium	11.8	18.8	5.3	20.0
Copper	129	273	84.4	283
Lead	258	513	141	447
Nickel	28.1	46.3	20.9	47.0
Zinc	691	1,280	534	1,110
% Moisture	5.24	16.48	5.18	17.89

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 5, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/LMHO/R1/10	P/LMHO/R1/10-60	P/LMHO/R1D/10	P/LMHO/R1D/10-60
Arsenic	3.7	3.0	3.3	5.6
Cadmium	4.6	10.8	4.9	11.7
Chromium	3.9	2.9	1.8	1.7
Copper	8.9	31.6	11.7	29.6
Lead	10.0	29.6	12.7	27.3
Nickel	4.3	7.4	6.3	6.3
Zinc	29.0	202	42.3	100.
% Moisture	4.57	16.50	2.91	17.16

Alyce L. Moore
Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMLO/R1D/60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,900
chlorobenzene	44
1,2-dichloroethane	9
ethyl benzene	290
styrene	210
tetrachloroethene	20.
xylenes (total)	880

Remarks: 8 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 33.95

Approved by Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMLO/R1/60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,700
chlorobenzene	<33 (25)
1,2-dichloroethane	ND
ethyl benzene	170
styrene	320
tetrachloroethene	ND
xylenes (total)	860

Remarks: 33 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 24.61

Approved By Alyce K. Mason
Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1D/60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	210,000
chlorobenzene	5,900
1,2-dichloroethane	<2,100 (930)
ethyl benzene	94,000
styrene	21,000
tetrachloroethene	11,000
xylenes (total)	170,000

Remarks: 2,100 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 40.42

Approved by Allyce K. Mason
Laboratory Manager
Title

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Sample Description: P/LMHO/R1/60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	160,000
chlorobenzene	38,000
1,2-dichloroethane	ND
ethyl benzene	300,000
styrene	48,000
tetrachloroethene	74,000
xylenes (total)	430,000

Remarks: 960 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 35.07

Approved by Glyn K. Mann
Laboratory Manager
Title

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Sample Description: P/HMLO/R1D/60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	6,700
chlorobenzene	780
1,2-dichloroethane	ND
ethyl benzene	17,000
styrene	2,800
tetrachloroethene	2,000
xylenes (total)	36,000

Remarks: 540 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 53.77

Approved By Laboratory Manager

Title

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Sample Description: P/HMLO/R1/60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	8,400
chlorobenzene	500
1,2-dichloroethane	<53 (12)
ethyl benzene	6,600
styrene	2,000
tetrachloroethene	970
xylenes (total)	11,000

Remarks: 53 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 53.02

Approved by Alyce K. Mason
Laboratory Manager
Title

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Sample Description: P/LMLO/R1D/10 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	3,000
chlorobenzene	<5 (2)
1,2-dichloroethane	ND
ethyl benzene	10.
styrene	16
tetrachloroethene	ND
xylenes (total)	21

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.78

Approved by Alyce K. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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Sample Description: P/LMLO/R1/10 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,200
chlorobenzene	<5 (2)
1,2-dichloroethane	ND
ethyl benzene	9
styrene	15
tetrachloroethene	ND
xylenes (total)	30.

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 5.19

Approved by Alyce K. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LML0/R1D/10-60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,600
chlorobenzene	ND
1,2-dichloroethane	<29 (6)
ethyl benzene	53
styrene	72
tetrachloroethene	ND
xylenes (total)	130

Remarks: 29 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 14.48

Approved by Laboratory Manager
Title

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Sample Description: P/LML0/R1/10-60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	3,200
chlorobenzene	490
1,2-dichloroethane	41
ethyl benzene	3,700
styrene	ND
tetrachloroethene	190
xylenes (total)	7,900

Remarks: 29 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 14.37

Approved by Alyce K. Mason
Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1D/10 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	23,000
chlorobenzene	ND
1,2-dichloroethane	<26 (6)
ethyl benzene	36
styrene	25
tetrachloroethene	ND
xylenes (total)	94

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 2.91

Approved by Laboratory Manager
Title

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PROJECT CODE ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1/10 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	43,000
chlorobenzene	<26 (10.)
1,2-dichloroethane	ND
ethyl benzene	40.
styrene	33
tetrachloroethene	ND
xylenes (total)	100

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.57

Approved by Allyn R Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER. 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1D/10-60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	72,000
chlorobenzene	1,600
1,2-dichloroethane	<380 (170)
ethyl benzene	13,000
styrene	ND
tetrachloroethene	960
xylenes (total)	29,000

Remarks: 380 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 17.16

Approved By Alyce K. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1/10-60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	30,000
chlorobenzene	1,100
1,2-dichloroethane	<300 (46)
ethyl benzene	9,200
styrene	ND
tetrachloroethene	590
xylenes (total)	23,000

Remarks: 300 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 16.50

Approved by Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 22 OF 41

Sample Description: P/HMLO/R1D/10 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,700
chlorobenzene	15
1,2-dichloroethane	<5 (1)
ethyl benzene	76
styrene	ND
tetrachloroethene	7
xylenes (total)	89

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 5.18

Approved by Alyce K. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 20 OF 41

Sample Description: P/HMLO/R1/10 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,900
chlorobenzene	12
1,2-dichloroethane	<5 (1)
ethyl benzene	56
styrene	34
tetrachloroethene	<5 (4)
xylenes (total)	2,000

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 5.24

Approved by Alyce L. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/HMLO/R1D/10-60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,100
chlorobenzene	400
1,2-dichloroethane	<30. (28)
ethyl benzene	570
styrene	ND
tetrachloroethene	520
xylenes (total)	1,300

Remarks: 30. = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 17.89

Approved by Alyce K. Tinder
Laboratory Manager
Title

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Sample Description: P/HMLO/R1/10-60 (Soil) received August 5, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,300
chlorobenzene	160
1,2-dichloroethane	<30. (18)
ethyl benzene	1,200
styrene	ND
tetrachloroethene	92
xylenes (total)	2,600

Remarks: 30. = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 16.48

Approved by Alyce K. Mason
Laboratory Manager
Title

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Sample Description: P/LMLO/R1D/60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	800,000
bis(2-ethylhexyl)phthalate	460,000
pentachlorophenol	<13,000 (9,400)

Remarks: 13,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 33.95

Approved by: Laboratory Manager

Title

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Sample Description: P/LMLO/R1/60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	730,000
bis(2-ethylhexyl)phthalate	450,000
pentachlorophenol	15,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 24.61

Approved by Alyce K. Mack
Laboratory Manager
Title

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Sample Description: P/LMHO/R1D/60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	680,000
bis(2-ethylhexyl)phthalate	1,100,000
pentachlorophenol	<150,000 (49,000)

Remarks: 150,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 40.42

Approved by Laboratory Manager

Title

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Sample Description: P/LMHO/R1/60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	760,000
bis(2-ethylhexyl)phthalate	1,400,000
pentachlorophenol	77,000

Remarks: 15,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 35.07

Approved by Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 29 OF 41

Sample Description: P/HMLO/R1D/60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,000,000
bis(2-ethylhexyl)phthalate	770,000
pentachlorophenol	<84,000 (46,000)

Remarks: 84,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 53.77

Approved by Laboratory Manager

Title

93-9-85

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: P/HMLO/R1/60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
anthracene	1,500,000
bis(2-ethylhexyl)phthalate	1,000,000
pentachlorophenol	<74,000 (44,000)

Remarks: 74,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 53.02

Approved by Laboratory Manager

Title

5.0 QA/QC PROCEDURES

The QA/QC procedures that are applicable to the full-scale operation include procedures that relate to the following activities:

- Sample preparation
- Laboratory analysis
- Data reduction, validation, and reporting

The procedures that will be followed to ensure that high quality data is generated and maintained throughout the performance of this subtask with regard to these activities is detailed in the QA/QC Plan for the overall work assignment and, therefore, will not be reiterated here.

Other Equipment Failure

If any other equipment on site fails to operate properly, the Project Team Leader and Site Safety Officer will be notified and the effect of this failure on continuing operations on site will be determined. If the failure affects the safety of personnel or prevents completion of the field activities, all personnel will leave the exclusion zone until the situation is evaluated and appropriate actions taken.

Equipment needed to facilitate decontamination include: plastic drop cloths containers (tubes), decon solution (soap), rinse water and scrub brushes. These materials will be located outside the exclusion zone.

4.12 EMERGENCY PROCEDURES

The following standard emergency procedures will be used by onsite personnel. The PEI industrial hygienists will be notified of any onsite emergencies.

Personnel Injury in the Exclusion Zone

Upon notification of an injury in the exclusion zone, the support personnel will enter (using the proper level of protection) if needed. The injured person should be moved to the decontamination line. The nature of the injury will be evaluated and the affected person will be decontaminated to the extent possible prior to movement to the support zone. The appropriate first aid will be administered and arrangements will be made with the designated medical facility (if required). No person shall reenter the exclusion zone until the cause of the injury or symptoms is determined.

Fire/Explosion

In the event of a fire or explosion, the fire department will be notified and personnel will move to a safe distance from the affected area.

Personal Protective Equipment Failure

If any site worker experiences a failure or alternation of protective equipment that affects the protection factor, that person and his/her buddy will immediately leave the exclusion zone. Reentry will not be permitted until the equipment has been repaired or replaced.

TABLE 4-2. LIST OF ENVIRONMENTAL MONITORING EQUIPMENT

Monitoring equipment	Hazard	Ambient level	Action
Combustible gas indicator	Explosive atompshere	<10% LEL	Continue investigation with caution
		10%-25%	Continue on-site monitoring with extreme caution as high levels are encountered
		>25% LEL	Explosion hazard; withdraw from area immediately
Oxygen concentration meter	Oxygen	<19.5%	Monitor wearing SCBA NOTE: Combustible gas readings are not valid in atmospheres with <19.5% oxygen
		19.5%-25%	Continue investigation with caution; SCBA not needed, based on oxygen content only
		>25.0%	Discontinue inspection; fire hazard potential; consult specialist

(National Mines Model MX241 or equivalent). The CGI alarm will be set at 25 percent of the lower explosive limit (LEL). The necessary action levels are listed in Table 4-2.

4.9 PROTECTIVE EQUIPMENT

The following protective equipment will be worn at all times by field personnel working inside the building during actual blending activities.

Level B protection

1) Supplied air respirator

   - pressure-demand, self-contained breathing apparatus
   - pressure-demand, airline respirator with escape bottle

2) Chemical resistant inner and outer gloves

   - Viton - for volatiles and semivolatiles except acetone
   - Butyl rubber - for acetone

3) Chemical resistant steel toe and shank outer boots

4) Chemical resistant splash suit

5) Hard hat and splash shield (optional)

4.10 FIELD OPERATING PROCEDURES

During the SARMS blending operation, the mixing equipment, soil containers, and chemical containers will be properly banded and grounded according to 29 CFR §1910.106. The soil-chemical blending procedures will be carried out as determined by the bench-scale operation (see Section 3.1).

Drums of soil will be handled using a "drum hydra-lift" or equivalent drum handling equipment.

4.11 DECONTAMINATION PROCEDURES

Personnel and equipment leaving the exclusion zone will be thoroughly decontaminated using the standard Level B decontamination protocol.

TABLE 4-1 (continued)

Substance	Exposure symptom	First-aid
Lead sulfate	Strong eye and skin irritation, mucous membrane irritation	
Zinc oxide	Skin and eye irritation, metallic taste, throat irritation	Artificial respiration
Cadmium sulfate	Dryness of throat, cough, headache, feeling of constriction of chest, nausea, shortness of breath	
Arsenic trioxide		
Copper sulfate	Mucous membrane and pharynx irritation, eye irritation, metal taste, dermatitis	Irrigate eyes immediately, promptly wash skin with soap
Chromic oxide		
Nickel nitrate	Allergic skin rash, respiratory irritation	Water wash skin, artificial respiration

TABLE 4-1. EMERGENCY MEDICAL INFORMATION

Substance	Exposure symptom	First-aid
Anthracene	Skin irritation	
Pentachlorophenol	Weakness, resp. changes, dermatitis, convulsions	Irrigate eyes, wash skin with soap, artificial respiration
Bis(2-ethylhexyl) phthalate	Skin, eye irritation	
Ethylbenzene	Eye irritation, mucous membrane irritation	Irrigate eyes, water wash skin
Xylene	Dizziness, excitement, drowsiness, incoherence, staggering gait	Irrigate eyes immediately, promptly wash skin with soap
1,2-Dichloroethane		
1,1,2,2-Tetrachloroethylene	ENT irritation, nausea, vertigo, incoherence	Irrigate eyes immediately, promptly wash skin with soap
Acetone	ENT irritation, dizziness, dermatitis	Irrigate eyes immediately, promptly wash skin with soap, artificial respiration
Chlorobenzene	Eye and nose irritation, drowsiness, incoherence, skin irritation	Irrigate eyes immediately, promptly wash with soap, artificial respiration
Styrene	Eye and nose irritation, drowsiness, weak, unsteady gait, nausea	Irrigate eyes immediately, water flush skin, artificial respiration

(continued)

4.6 EMERGENCY MEDICAL INFORMATION

The availability of information regarding the exposure symptoms of each individual chemical being used during the full-scale activities is critical to maintain the health and safety of field personnel. In addition, all field personnel will be familiar with the first-aid requirements of each chemical. Table 4-1 presents a summary of critical emergency medical information associated with each of the 17 contaminants.

4.7 EMERGENCY CONTACTS

In addition to being familiar with chemical-specific first aid measures, all field personnel will be aware of the various local agencies and facilities that are potentially available during an emergency situation. These local agencies/facilities and their phone numbers are as follows:

Agency/Facility	Phone number
Cincinnati Police	765-1212
Cincinnati Fire Department	241-2525
St. Francis - St. George Hospital	389-5000
University of Cincinnati Hospital	872-3100
Ambulance (Cincinnati Fire Department)	241-2525
Poison Control Center	872-5111
PEI Associates	782-4700

4.8 ENVIRONMENTAL MONITORING

During the SARMS blending operation, continuous air monitoring will be carried out adjacent to the mixer with a combustible gas indicator (CGI). Monitoring will be conducted with a continuous-operating CGI with an alarm

4.3 PERSONNEL HEALTH AND SAFETY TRAINING

All personnel involved in the SARMS blending operation will be trained and experienced in the proper use of personnel protective equipment as required in 29 CFR §1910.120. This includes instruction in levels of protection, self-contained breathing apparatus (SCBA), air-purifying respirators and respirator decision logic. All individuals required to wear an air-purifying respirator or air supply apparatus will be fit-tested and a record of the fit-test will be on file at PEI.

4.4 MEDICAL SURVEILLANCE

The PEI medical monitoring program requires that employees involved in hazardous waste site activities receive a baseline medical examination and annual medical examination. Personnel involved in the SARMS blending operation have been trained in Red Cross first-aid. In addition, one of the field personnel who will be working at the site is experienced as an Advanced Life Support paramedic.

4.5 EMERGENCY EQUIPMENT LOCATIONS

The following types of medical equipment will be present onsite, within eacy access by all field personnel:

First-aid kit - outside blending building

Emergency eye wash - outside blending building

Emergency shower - outside blending building

Fire extinguishers - inside blending building
outside blending building

4.0 HEALTH AND SAFETY PROCEDURES AND REQUIREMENTS

The following section discusses the health and safety procedures and requirements that will be followed and met, respectively, during the full-scale SARMS blending operation at EPA's Center Hill facility.

4.1 ONSITE CONTROL

Access to the SARMS blending building will be through a locked door, coordinated by the PEI staff at the site and will be limited to individuals wearing the proper level of protection. Two individuals will work inside the building to prepare the SARM samples and a minimum of one person outside the building to assist and support the people inside. For the purpose of the project and the health and safety plan, the building will be considered the "exclusion zone" during actual SARM preparation and entry into this exclusion zone will require Level B protection.

The full-scale SARMS blending operation will be conducted using a 15-ft^3 mortar mixer located inside a 16' x 19' building. The building will be ventilated and the vented air will be carbon-filtered.

4.2 SITE PLAN

Figure 4-1 shows the plan of the U.S. Environmental Protection Agency Center Hill Research Facility indicating the building to be used for the SARMS blending, all structures in the vicinity of the building, and the locations of telephones and first aid stations.

spill response report will be submitted to the Center Hill contact and the EPA Project Officer describing, in detail, the nature and extent of the spill and the cleanup response measures. Any incident of significance will also be reported to PEI's staff industrial hygienist and project manager for further discussion and review.

Additional emergency response measures and procedures are described in Section 4.0, Health and Safety Procedures.

as the procedures to be followed during actual blending of the SARM samples. The minimization of release potential will be accomplished by a number of mechanisms; 1) only trained, experienced individuals will participate in the actual blending operations, 2) appropriate personal protective gear will be worn to provide field personnel the security and comfort to work confidently with the contaminant chemicals and resulting SARM samples, 3) equipment has been selected and modified to minimize the potential for leaks, chemical incompatibility, ignition source, and breakage, and 4) individual chemicals will be combined, to the greatest extent possible, before the actual blending begins, reducing the total number of times that a spill could occur.

It is impossible to eliminate all risk of spills or releases, therefore, a contingency plan for containment and cleanup has been developed for the full-scale blending operations. Fugitive volatile organics will unavoidably be released when SARM material is transferred from the mixer to the shipping containers and possibly during the blending. Emissions from the mixer (closed and opened) will be collected by a field-fabricated fume hood designed to provide an airflow past the mixer sufficient to capture fugitive volatile organics and pass them through an activated carbon filter.

In the event of a chemical or contaminanted-soil spill the key personnel (in Level B protective gear) will implement measures necessary to: 1) halt the release, 2) contain the spread of contaminants, and 3) promptly begin cleanup of spilled and contaminated materials. Cleanup materials will be stored inside the shed and will include sorbent materials, an empty salvage drum, shovels, dustpans, etc. Contaminated materials will be placed in the salvage drum for later disposal. An accurate estimate of the amount of material spilled and an evaluation of the adequacy of the cleanup will be made. The spill incident and response measures taken will be documented. A

The pour-spout on the mixer may also be used to fill the 5-gallon pails, however, a shovel will probably be necessary to efficiently fill these containers. The four 5-gallon pails for each of the four SARM types will be filled from one of four single batch-mixes.

The 400 0.5-lb SARM samples to be archived will be placed in pre-labeled sample containers using a stainless steel trowel, and will be immediately sealed. One-hundred (100) 0.5-gallon jars will be filled with each SARM type. Each archive SARM type will be prepared for a single batch-mix. Transportation, consignee, and amounts of SARM samples to be shipped to testing locations are presented in Table 3-4.

3.3 WASTE HANDLING PRACTICES

Contaminated waste materials generated during the full-scale blending activities will be containerized in DOT 17E open head drums over the course of the operation. Upon completion of the full-scale field activities, all containerized waste materials, e.g., spill cleanup materials, absorbents, protective clothing, decontamination materials, spilled chemicals, etc., will be treated as hazardous waste. Building materials that cannot be decontaminated at the end of field activities (wood, disposable plastic, etc.) will be disposed of as hazardous waste. A single TCDD waste analysis will be conducted on the waste materials prior to disposal.

Contaminated materials being disposed of as hazardous waste will be appropriately manifested using the U.S. EPA's Center Hill Research Facility's address.

3.4 CHEMICAL RELEASE PREVENTION AND RESPONSE PROCEDURES

The potential for an accidental release of contaminants to the environment will be minimized by the design and construction of the building as well

TABLE 3-4. LOCATIONS, QUANTITIES, AND TRANSPORTATION OF SARM SAMPLES

SARM destination	Container		Transport mode	SARM quantity (lb)
	Number	Size (capacity)		
John Zinc Co. Jake Cambell Tulsa, OK	48	55-gal (500-lb)	Contract trucking	24,000
Stabilization	8	5-gal (50-lb)	Common carrier	400
Thermal desorption Robert Fox IT 312 Directors Rd. Knoxville, TN	4	5-gal (50-lb)	Common carrier	200
Chemical Treatment Dr. Thomas O. Tiernan Brehm Laboratory Wright State University Dayton, OH	4	5-gal (50-lb)	Common carrier	200
Physical treatment	4	5-gal (50-lb)	Common carrier	200
Archive	400	0.5-gal (5-lb)	Contract trucking	2000

grain probe (thief or trier), with the sample being collected on line through the center of the holder (mixer) lengthwise, with aliquots being taken from the front, middle, and back of the holder. The operation will be repeated on each of two lines parallel with and halfway between the original line and each side of the holder. All collected portions will be analyzed separately to determine the extent of homogeneity. All sampling equipment will be cleaned between the collection of each sample.

3.2 SARMS PACKAGING AND SHIPPING

A total of 27,000 lbs of SARM samples will be prepared and packaged for shipment to the BDAT testing locations and the archive location. Batches of 1,000 lbs of each SARM will be prepared at a time. Immediately following the blending of contaminants with the soil fraction, the SARM will be placed directly into the appropriate packages for shipment to the BDAT locations and to the archive storage facility. Table 3-4 identifies the type and number of containers that will be used to package the SARM samples for the various BDAT's and archiving. Twenty-four thousand (24,000) pounds of SARMS will be packaged in 48 epoxy-lined, 55-gallon steel drums. One-thousand (1,000) lbs of SARMS will be packaged in 20 5-gallon steel pails. Two-thousand (2,000) lbs of SARMS will be packaged in 400 0.5-gallon glass jars for archiving.

The modified mortar mixer has a pour-spout that will facilitate dumping the SARM samples directly into 55-gallon drums. Filled drums will be immediately closed, sealed, and labeled. As drums are filled with SARM material, they will be moved to the staging area outside the shed. Drums of clean soil matrix will then be moved into the shed in preparation for blending the next batch.

TABLE 3-3 (continued)

[a] The Hazardous Substance List, which is currently used for EPA's Contract Lab Programs (CLP), is included herein as Attachment A.

[b]

Volatiles	Semi-Volatiles
Ethylbenzene	Anthracene
Xylene	Pentachlorophenol
1,2-Dichloroethane	Bis(2-ethylhexyl)phthalate
1,1,2,2-Tetrachloroethylene	
Acetone	
Chlorobenzene	
Styrene	

Metals

Lead
Zinc
Cadmium
Arsenic
Copper
Chromium
Nickel

TABLE 3-3. SUMMARY OF PROPOSED ANALYTICAL WORK

Sample ID	No. of samples	Proposed analytes	Intended use of data
1. Clean soil matrix- following full-scale mixing of first 15,000-lb batch	5	Cation exchange capacity	Confirm homogeneity of mix
2. Clean soil matrix- following full-scale mixing of second 15,000-lb batch	5	Cation exchange capacity	Confirm homogeneity of mix
3. Clean soil matrix- following full-scale mixing of first 15,000-lb batch	3	Grain size distribution, pH, TOC, moisture content, mineralogy	Confirm physical characteristics are within predetermined range
4. Clean soil matrix- following full-scale mixing of second 15,000-lb batch	3	Grain size distribution, pH, TOC, moisture content, mineralogy	Confirm physical characteristics are within predetermined range
5. Clean soil matrix- following full-scale mixing of 30,000 lbs	1	Hazardous Substance List[a]	Verify "clean" soil is uncontaminated
6. SARMS Batch No. 1 after mixing 6 min., and after 12 min.	12 (6 at each 6-min. interval)	Pb, and Zn	Determine mixing time for SARMS blending
7. SARMS Batch No. 1 after mixing 6 min., and after 12 min.	4 (2 at each 6-min. interval)	Volatiles, semi-volatiles, metals[b]	Confirm that target levels are met during blending

(continued)

1,000 lbs will be packaged and shipped to U.S. EPA in Edison, New Jersey for potential future research.

3.1.3 Sample Collection and Analysis

The following five types of soil samples will be collected and analyzed over the course of the full-scale operations:

1. Clean soil homogeneity samples
2. Clean soil verification sample
3. Clean soil physical parameter samples
4. SARMS homogeneity samples
5. SARMS contaminant target level-confirmation samples.

Table 3-3 presents a summary of the proposed full-scale analytical work.

As briefly discussed in Section 2.1, Phase 1 - Mixing of Clean Soil Matrix, the clean soil components will be mixed together in a cement mixer in two separate 15,000-lb batches. Samples from the two batches will be collected using a grain probe during the soil packaging process. Five samples from each batch will be collected and analyzed for cation exchange capacity (CEC) to confirm the homogeneity within and between the two batches.

The second and third types of samples will be collected and analyzed to verify the "clean" nature of the soil matrix, and to confirm that the physical characteristics of the soil are within predetermined ranges, respectively.

The fourth and fifth types of samples that will be collected will be used to determine the SARMS mixing time, and to confirm that contaminant target levels have been met. Contaminated soil from the first 1,000-lb batch will be sampled from the mixer during various phases of the mixing to determine homogeneity within the batch. These samples will be collected using a

TABLE 3-2. FULL-SCALE ADDITIVE QUANTITIES FOR SARMS PREPARATION

SARMS	Additive quantity[a]			
	No. 1 (lbs) (Solid metal mix)	No. 2 (lbs) (Liquid metal mix)	No. 3 (lbs)[b] (Anthracene)	No. 4 (lbs) (Liquid organic mix)
SARMS 1 High organics Low metals	1.544	6.5	1.45	33.48
SARMS 2 Low organics Low metals	1.544	0.65	1.45	3.348
SARMS 3 Low organics High metals	55.938	6.50	72.812	33.48
SARMS 4 High organics High metals	55.938	6.50	72.818	3.348

[a] Quantities presented are based on a 1,000-lb batch size, e.g., to prepare 1,000 lbs of SARMS 1, the respective quantities shown will be added to (1,000 lbs minus the mass of contaminants) of soil.

[b] Liquid metal mix weights do not include water.

Additive No. 4, the liquid organic mixture, will be prepared by first combining the appropriate amounts of acetone, bis(2-ethylhexyl)phthalate, and styrene, composed of ethylbenzene, chlorobenzene, xylene, dichloroethane, perchloroethane, and pentachlorophenol will be prepared and then added to the first properties. Again, the quantities of each ingredient that will be used to prepare each mixture are shown in Table 2-4.

Table 3-2 presents the quantity of each additive that will be blended with the soil to prepare the four different SARM samples in 1,000-lb batch quantities.

3.1.2 Preparation of SARM Samples

A total of 28,000 lbs (28 batches) of SARM samples will be prepared over th course of the full-scale blending operation. For every SARM batch that is prepared, the appropriate quantities of each of the four additives (see Table 3-2) will be measured out from their respective bulk batches. The designated quantities of the liquid additives will be transferred into the appropriate contaminant application units which will be attached to the inside of the mortar mixer located in the building. The designated quantities of the two solid additives will be manually added to the mixer. The following order will be followed for the SARMS preparation:

1. SARMS 4 (Hi/Hi) - prepare one 1,000-lb batch
3. SARMS 2 (Lo/Lo) - prepare 13 1,000-lb batches
4. SARMS 1 (Hi/Lo) - prepare 13 1,000-lb batches
2. SARMS 3 (Lo/Hi) - prepare one 1,000-lb batch

The total quantity of SARM samples to be blended is different than the total quantity to be shipped to the BDAT's and archive location. Twenty-eight thousand pounds (28,000 lbs) will be blended, however, only 27,000 lbs will be packaged and shipped out for BDAT testing and archiving. The remaining

TABLE 3-1. PREMIX FORMULAS

Additive components	SARM 1 13,000 lbs soil[a]	SARM 2 13,000 lbs soil[a]	SARM 3 1,000 lbs soil[b]	SARM 4 1,000 lbs soil[b]
Additive No. 1				
Arsenic trioxide (As_2O_3)				
Lead sulfate ($PbSO_4$)				
Zinc oxide (ZnO)				
Additive No. 2				
Cadmium sulfate ($3Cd\ SO_4 \cdot 8H_2O$)				
Nickel nitrate [$Ni(NO_3)_2 \cdot 6H_2O$]				
Copper sulfate ($CuSO_4$)				
Chrome nitrate [$Cr(NO_3)_3 \cdot 9H_2O$]				
Water				
Additive No. 3				
Anthracene				
Additive No. 4				
Ethylbenzene				
Xylene				
1,2-Dichloroethane				
1,1,2,2-Tetrachloroethylene				
Acetone				
Chlorobenzene				
Styrene				
Pentachlorophenol				
Bis(2-ethyhexyl)phthalate				

[a] Amount of pre-mix shown is sufficient to prepare 13 1000-lb batches of SARM.

[b] Amount of pre-mix shown is sufficient to prepare one 1000-lb batch of SARM.

chemical additive. These four additives, as they will be referred to, are as follows:

Additive No. 1 - A dry mixture of insoluble metal powders consisting of arsenic trioxide (As_2O_3), lead sulfate ($PbSO_4$), and zinc oxide (ZnO).

Additive No. 2 - Anthracene in solid form.

Additive No. 3 - An aqueous solution of nickel nitrate [$Ni(NO_3)_2 \cdot 6H_2O$)], copper sulfate ($CuSO_4 \cdot 5H_2O$), cadmium sulfate ($3CdSO_4 \cdot 8H_2O$), and chromium nitrate [$Cr(NO_3)_3 \cdot 9H_2O$].

Additive No. 4 - A mixture of organic liquids consisting of ethylbenzene, xylene, 1,2-dichloroethane, 1,1,2,2-tetrachloroethylene, acetone, chlorobenzene, styrene, pentachlorophenol, and bis(2-ethyhexyl)phthalate.

Using the quantities presented in Table 2-4 in Section 2.2.4, the Additive Mixtures 1, 2, and 4, above, will be prepared prior to beginning each SARM. Additive No. 3 will require no blending.

The dry metal mixture (Additive No. 1) will be prepared by weighing out the appropriate mass of each salt (see Table 2-4) into an appropriately-sized container. The container will then be mounted to a custom-made drum-rolling mechanism on site and rolled with its contents until a thorough mix is achieved. Rolling/mixing time will be approximately 60 minutes.

Anthracene (Additive No. 2) will be added to the soil as a single contaminant and, therefore, requires no preparation.

The aqueous mixture (Additive No. 3) will be prepared by weighing and adding the appropriate mass of each water-soluble ingredient (see Table 2-4) to a minimal amount of water in an appropriately-sized container. The contents will be stirred and water added as necessary until the salts are completely dissolved. Dissolution may be facilitated by crushing the hydrated crystals or warming the mixture water.

3.0 IMPLEMENTATION OF FULL-SCALE SARMS BLENDING OPERATIONS

The following section discusses the implementation of the SARMS blending operation.

3.1 SARMS BLENDING PROCEDURES

The chemicals that will be used during the full-scale SARMS blending operations are presently being stored in a flammable materials storage vault located at the Center Hill facility (see Figure 2-1). When handling the chemicals, appropriate personal protective gear will be used and precautions will be taken to limit the potential for spills of chemicals during their transfer from one area of the facility to another (see Sections 3.4 and 4.0).

The full-scale SARMS blending operation will proceed in a sequence of well-defined steps. These steps are as follows:

1. For each SARM, prepare pre-mix solution or mixtures of contaminants to be added to each batch.
2. Determine quantities of pre-mix solution/mixture that will be added to make a 1,000-lb batch of SARM.
3. Blend a total of 28 1,000-lb batches of SARM samples.
4. Blend first batch of soil and chemicals, collecting samples from the first batch to confirm that target contaminant levels were met, and determine the mixing time for all subsequent batches.

The following subsections discuss, in detail, each of the steps listed above.

3.1.1 Pre-mixing of Chemicals

As determined during the bench-scale SARMS blending activities, chemicals will be pre-mixed to form three contaminant mixtures and one, single

This determination will be based on the results of a series of sample analyses to be conducted on samples collected from Batch No. 1 at designated time intervals. Samples will be collected (during mixing of the first batch only) after 6 minutes and 12 minutes of mixing following addition of organic contaminants to determine the mixing time needed to obtain a homogenous mixture. Six samples will be collected after 6 minutes of mixing and analyzed for lead (Pb) and copper (Cu). Another six samples will be collected after 12 minutes of mixing and analyzed for Pb and Cu. The criteria for acceptance or rejection for each sample set will be based on the following F test:

$$F = \frac{S_b}{S_w}^2$$

If the F values exceed 4.96 (σ = .05) the batch will be mixed for another 6 minutes and the F test repeated using the 12-minute and 18-minute analytical results. This technique will ensure that the mixing of SARMS will be of sufficient length to obtain a homogenous mixture. The mixing time determined during preparation of Batch No. 1 will then be used for the blending of all subsequent batches. Sampling and analysis will not be conducted to determine homogeneity between different batches due to logistical and budget restraints.

TABLE 2-4. FULL-SCALE CHEMICAL QUANTITIES

Chemical	Quantity[a] SARMS 1 high organics low metals 13,000 lbs	SARMS 2 low organics low metals 13,000 lbs	SARMS 3 low organics high metals 1,000 lbs	SARMS 4 high organics high metals 1,000 lbs	Total quantity
Volatiles					
Ethylbenzene	49.92	4.99	0.38	3.84	59.13
Xylene	127.92	12.79	0.98	9.84	151.53
1,2-Dichloroethane	13.03	1.30	0.10	1.00	15.43
1,1,2,2-Tetrachloroethylene	10.92	1.09	0.08	0.84	12.93
Acetone	154.70	15.47	1.19	11.90	183.26
Chlorobenzene	7.28	0.73	0.05	0.55	8.61
Styrene	13.00	1.30	0.10	0.99	15.39
Semi-Volatiles					
Anthracene	84.50	8.45	0.65	6.50	100.1
Pentachlorophenol	13.00	1.30	0.10	0.99	15.39
Bis(2-ethylhexyl)phthalate	45.50	4.55	0.35	3.50	53.9
Metals					
Lead ($PbSO_4 \cdot PbO$)	5.54	5.54	21.32	21.32	53.72
Zinc (ZnO)	8.74	8.74	33.62	33.62	135.82
Cadmium ($3CdSO_4 \cdot 8H_2O$)[b]	0.77	0.77	2.96	2.96	7.46
Arsenic (As_2O_3)	0.26	0.26	0.99	0.99	2.50
Copper ($CuSO_4 \cdot 5H_2O$)[b]	13.61	13.61	52.36	52.36	131.94
Chromium [$Cr(NO_3)_3 \cdot 9H_2O$][b]	3.00	3.00	11.55	11.55	29.10
Nickel [$Ni(NO_3)_2 \cdot 6H_2O$][b]	1.54	1.54	5.94	5.94	14.96

[a] All quantities are in pounds.

[b] Water-soluble metal salts.

TABLE 2-3. TARGET HIGH AND LOW CONTAMINANT CONCENTRATIONS FOR SARM SAMPLES

Contaminant	Proportions (%)	High (ppm)	Low (ppm)
Volatiles			
Ethylbenzene	15	3,200	320
Xylene	39	8,200	820
1,2-Dichloroethane	3	600	60
1,1,2,2-Tetrachloroethylene	3	600	60
Acetone	33	6,800	680
Chlorobenzene	2	400	40
Styrene	5	1,000	100
	100	20,800	2,080
Semivolatiles			
Anthracene	65	6,500	650
PCP	10	1,000	100
Bis (2-ethylhexyl)Phthalate	25	2,500	250
	100	10,000	1,000
Metals			
Lead (Pb)	28	14,000	280
Zinc (Zn)	45	22,500	450
Cadmium (Cd)	2	1,000	20
Arsenic (As)	1	500	10
Copper (Cu)	19	9,500	190
Chromium (Cr)	3	1,500	30
Nickel (Ni)	2	1,000	30
	100	50,000	1,000

2.2.3 SARMS Blending Equipment Design

The various SARMS will be mixed using a 16-ft^3 capacity STONE mortar mixer. This mixer has been modified by replacing the grate cover with a custom-fabricated solid cover and replacing the standard motor with a 5-horsepower explosion-proof electric motor. The cover will be hinged to allow for the transfer of soils into and from the mixer, from and into 55- and 5-gallon drums and pails. A liquid contaminant application unit consisting of a stainless steel tube-manifold will be fabricated and attached to the inside of the custom cover to allow the addition of liquid contaminants directly to the soil in the mixer without opening the cover. This manifold will be attached to a liquid reservoir by a non-reactive tube with an in-line flow control valve. The mixer will be located inside the building and a fume hood will be constructed around the mixer that will collect fugitive vapors being released from the mixture during mixing and emptying operations.

2.2.4 Determination of Full-Scale Chemical Quantities

Table 2-3 indicates the target high and low contaminant concentrations for the SARM samples. Table 2-4 presents the quantities of each chemical that will be added to make each 1,000-lb batch of the four SARM samples. These quantities have been determined utilizing analytical results of SARM samples prepared during bench-scale research. Section 3.1 discusses the various mixtures of chemicals that will be prepared and then added to the soil, and the specific blending procedures that will be followed over the course of the full-scale operation.

2.2.5 Determination of SARMS Mixing Time

The mixing time required to achieve a homogenous blend of soil and chemicals will be determined during the preparation of the first SARM batch.

TABLE 2-2. EQUIPMENT LIST FOR FULL-SCALE SARMS BLENDING

16-ft^3 STONE mortar mixer with explosion-proof motor
Activated carbon filter (air purification)
1200-cfs blower and field-fabricated fume hood (vented to carbon filter)
CASE 1835 front-end loader (outside drum handling)
125-gm capacity electronic scale
Assorted graduated cylinders, syringes and burrettes
An assortment of tools, shovels and trowels
Paper towels and laboratory wipes
Bulk chemical absorbent
HydroLift (inside drum handling)
Cascade air-line supplied air system (two-man)[a]
PPV full-face, air-line respirators with back-up (hip air)[a]
Tyvec coveralls[a]
Viton and butyl rubber gloves and glove liners[a]
Disposable boot covers[a]
Empty 55-gallon open-head steel drums and lids (SARMS packaging)
Empty 5-gallon steel pails and lids (SARMS packaging)
Empty 0.5-gallon glass containers with teflon-lined lids (SARMS packaging)
Sample jars with teflon-lined lids
33-mm camera and video recording camera
Site intercom and telephone communications equipment
Fire extinguishers (2)

[a] Health and safety procedures and equipment are discussed, in detail, in Section 4.0.

2.2.1 SARMS Blending Site Layout

A plan-view drawing of the full-scale SARMS blending site is shown in Figure 2-1. Locations noted on this drawing include; access road and driveway, blending building, clean and contaminated soil staging area (drums), chemical storage vault, emergency eye-wash and shower, remote power center, and general facility laboratories. Figure 2-2 shows the anticipated floor plan and activity area within the blending building, subject to modification during the mixing activity.

2.2.2 SARMS Blending Equipment Requirements

The equipment necessary to complete the full-scale SARM blending operation is presented in Table 2-2. This list may expand as necessary to address actual conditions encountered during blending.

In addition to the listed equipment, a temporary building will be erected to be used during blending activities for both containment of fugitive emissions of chemical contaminants, as well as protection from the elements. Electric power to this building will be provided by explosion-proof wiring inspected and approved by Cincinnati Gas & Electric Co. Work tables and storage areas for equipment and supplies. The wooden floor will be covered by smooth-vinyl flooring; all seams will be sealed to prevent contaminant migration to flooring beneath and protective sheathing will be placed over the vinyl to protect it from physical damage by drums and drum-handling A large (8-ft wide) sliding door which will be fitted to the building to allow easy passage of drums and equipment into and out from the blending area, will also provide auxiliary replacement air (for ventilation system) and easy egress under emergency situations.

The clean soil mixing operation will take place at the Oeder Sand and Gravel Company in Morrow, Ohio and will involve the mixing of two 15,000-lb batches of clean soil. For each 15,000-lb batch, half of the quantity of each soil component shown in Table 2-1, will be weighed using an industrial-size scale and placed in a large 6-yd^3 cement mixer. The soil components will then be mixed for approximately one hour. Once the clean soil matrix is thoroughly mixed, it will be weighed out into 500-lb batches and placed in 60 epoxy-lined, 55-gallon steel drums. Forty-eight of these containers will be used later during Phase II to transport SARM samples to the J. Zink incineration facility.

During the clean soil packaging process, representative samples will be collected for analysis to confirm homogeneity, and the physical and chemical characteristics of the soil mix. Ten (10) samples will be collected for cation exchange capacity (CEC) analysis to confirm the CEC of the overall soil mixture, and the homogeneity of the mix. Six (6) samples will be collected to confirm the physical characteristics of the soil. Analyses will include grain size distribution, TOC, pH, and mineralogy. Lastly, a single sample will be collected for a hazardous substance list (HSL) analysis to identify any contaminants that may be present in the soil prior to the SARMS blending operation. A more complete discussion of proposed full-scale sampling and analysis is provided in Section 3.1.3.

2.2 PHASE 2 - BLENDING OF SARM SAMPLES

Phase 2 of the full-scale operation involves the blending of various levels of chemicals with the soil matrix to formulate the four different SARM blends. Phase 2 will be conducted at the U.S. EPA's Center Hill Research Facility in Cincinnati, Ohio.

2.0 FULL-SCALE OPERATIONS DESIGN

The following section discusses the design of the two phases of the full-scale operation.

2.1 PHASE 1 - MIXING OF CLEAN SOIL MATRIX

A total of 30,000 lbs of soil matrix components will be mixed together to form the soil that will be used for the preparation of the SARM samples. Table 2-1 indicates the source and quantity of each soil component that will be used in the full-scale soil mixing.

TABLE 2-1. SOIL COMPONENT QUANTITIES FOR FULL-SCALE

Soil component	Quantity[a] (lbs)	Source/location
Gravel (No. 9)	1,710	Oeder Sand & Gravel Co./Morrow, OH
Sand	9,450	Oeder Sand & Gravel Co./Morrow, OH
Silt	8,490	Oeder Sand & Gravel Co./Morrow, OH
Clay		
- Bentonite	1,620	American Colloid Co./Skoky, IL[b]
- Kaolinite	2,820	Charles B. Chrystal & Co./Brooklyn, NY[c]
Topsoil	5,940	Oeder Sand & Gravel Co./Morrow, OH
	30,030	

[a] Quantities based on the following recipe using volume percentages: gravel - 5%; sand - 20%; silt - 25%; topsoil - 20%; bentonite clay - 7.5%; kaolinite clay - 22.5%. Equivalent weight percentages are: gravel - 5.7%; sand - 31.47%; silt - 28.29%; bentonite clay - 5.37%; kaolinite clay - 9.35%; topsoil - 19.81%. Recipe finalized by peer review committee on 6/16/87.

[b] Actual source of bentonite is Mississippi.

[c] Actual source of kaolinite is Georgia.

TABLE 1-1. QUANTITIES OF SARM SAMPLES TO BE BLENDED FOR BDAT'S AND ARCHIVE STORAGE

BDAT	(SARMS 1) High organics, low metals (lbs)	(SARMS 2) Low organics, low metals (lbs)	(SARMS 3) Low organics high metals (lbs)	(SARMS 4) High organics high metals (lbs)
Incineration	12,000	12,000	0	0
Stabilization	100	100	100	100
Thermal desorption	50	50	50	50
Chemical treatment	50	50	50	50
Physical treatment	50	50	50	50
Archive	500	500	500	500
Other reserve	250	250	250	250
Totals	13,000	13,000	1000	1000

1.2 SUMMARY OF APPROACH

The full-scale operations will be conducted in two phases:

- Phase I - Mixing of Clean Soil Matrix
- Phase II - Blending of SARM Samples

Phase I, which will include mixing a total of 30,000 lbs of soil components into a homogeneous soil mix, will be completed at the Oeder Sand and Gravel Company, located in Morrow, Ohio. The clean soil mix will then be packaged and shipped to EPA's Center Hill Research Facility located in Cincinnati, Ohio where Phase II will be conducted. Phase II will entail the actual blending of the four SARM samples and will be completed over a one-week period. The following sections describe, in detail, the procedures and equipment that will be followed and used, respectively, over the course of the full-scale operation.

1.0 INTRODUCTION

This procedures plan is prepared as part of Work Assignment 7, Task 1 under U.S. EPA, Land Pollution Control Division Contract No. 68-03-3413. Task 1 involves the formulation of standard analytical reference matrix (SARM) samples to be used in the development of best demonstrated available technology (BDAT) treatment levels for soil and debris wastes from CERCLA site response actions. This procedures plan presents a detailed description of PEI's approach for conducting the full-scale SARMS blending operation.

1.1 OBJECTIVE

The objective of the full-scale SARMS blending operation is to prepare pre-designated quantities of each of the following four SARM samples for five EPA-selected BDAT's:

1. High levels of organics (20,000 ppm volatiles plus 10,000 ppm semi-volatiles) and low levels of metals (1,000 ppm total metals).
2. Low levels of organics (2,000 ppm volatiles plus 1,000 ppm semi-volatiles) and low levels of metals (1,000 ppm total metals).
3. Low levels of organics (2,000 ppm volatiles plus 1,000 ppm semi-volatiles) and high levels of metals (a number of different metals would be represented with a total concentration of 50,000 ppm).
4. High levels of organics (20,000 ppm volatiles plus 10,000 ppm semi-volatiles) and high levels of metals (a number of different metals would be represented with a total concentration of 50,000 ppm).

In addition to samples being prepared for the technologies, SARMS will also be prepared and packaged for storage in a selected archive location. Table 1-1 presents the quantity of each SARM sample blend that will be prepared and delivered to each technology and to the archive storage location.

FIGURES

TABLES

CONTENTS

APPENDIX E

PROCEDURES PLAN FOR FULL-SCALE SARM PREPARATION

by

PEI Associates, Inc.
11499 Chester Road
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Contract No. 68-03-3413
Work Assignment No. 0-7
PN 3741-7-1
Task 1, Subtask 1.10

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Hazardous Waste Engineering Research Laboratory
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Cincinnati, Ohio 45268

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E. Harris, Project Officer

June 1987

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Digestion Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q2792301-PB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	—	% Surrogate Recovery
Terphenyl-d14	—	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.01	U
Chromium	0.01	U
Copper	0.04	U
Lead	0.15	U
Nickel	0.04	U
Zinc	0.01	U

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Digestion Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q2792401-PB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.01	U
Chromium	0.01	U
Copper	0.04	U
Lead	0.15	U
Nickel	0.04	U
Zinc	0.01	U

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Spiked Blank Duplicate Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1792403-SBD

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.04	46% Rec - RPD = 27%
Anthracene	0.108	100% Rec - RPD = 10%
Bis(2-ethyl hexyl)phthalate	0.14	105% Rec - RPD = 1%
2,4,6-Tribromophenol		96% Surrogate Recovery
Terphenyl-d14		114% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Spiked Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1792402-SB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	35	35% Rec
Anthracene	121	110% Rec
Bis(2-ethyl hexyl)phthalate	138	104% Rec
2,4,6-Tribromophenol	86%	Surrogate Recovery
Terphenyl-d14	110%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Extraction Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1792401-ExB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.05	U,J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	80%	Surrogate Recovery
Terphenyl-d14	69%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Extraction Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1792201-ExB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.04	U,J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	56%	Surrogate Recovery
Terphenyl-d14	61%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Extraction Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1791501-ExB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.06	U,J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	63%	Surrogate Recovery
Terphenyl-d14	94%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Extraction Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1791403-ExB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.06	U,J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	54%	Surrogate Recovery
Terphenyl-d14	103%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: Extraction Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1791101-ExB

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.05	U,J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U,J-Calibration Problem
2,4,6-Tribromophenol	63%	Surrogate Recovery
Terphenyl-d14	59%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP SV/M Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1790201-LF1B

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.04	U
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	69%	Surrogate Recovery
Terphenyl-d14	81%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP SV/M Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1783101-LF1B

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.06	U,J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	48	% Surrogate Recovery
Terphenyl-d14	66	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

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TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP - SV/M Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1783001-LF1B

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.05	U
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	68%	Surrogate Recovery
Terphenyl-d14	75%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.01	U
Chromium	0.01	U
Copper	0.04	U
Lead	0.15	U
Nickel	0.04	U
Zinc	0.01	U

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP SV/M Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-Q1782601-LF1B

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.03	U,J-Calibration Problem
Anthracene	0.03	U
Bis(2-ethyl hexyl)phthalate	0.01	U,J-Calibration Problem
2,4,6-Tribromophenol	72%	Surrogate Recovery
Terphenyl-d14	52%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP-Volatiles Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-TCLPBLK3-1

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.02	
1,2-Dichloroethane	0.01	U
Tetrachloroethene	0.05	U
Chlorobenzene	0.05	U
Ethyl Benzene	0.14	
Styrene	0.01	L
Xylenes (Total)	0.34	
Toluene-d8	100%	Surrogate Recovery
Bromofluorobenzene	100%	Surrogate Recovery
1,2-Dichloroethane-d4	113%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP-Volatiles Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-TCLPBLK2-1

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.16	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.01	U
Chlorobenzene	0.01	U
Ethyl Benzene	0.06	
Styrene	0.01	U
Xylenes (Total)	0.04	
Toluene-d8	95%	Surrogate Recovery
Bromofluorobenzene	104%	Surrogate Recovery
1,2-Dichloroethane-d4	88%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP-Volatiles Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-TCLPBLK1-1

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.37	H
1,2-Dichloroethane	0.01	L,H
Tetrachloroethene	0.02	L,H
Chlorobenzene	0.04	L,H
Ethyl Benzene	0.34	H
Styrene	0.06	H
Xylenes (Total)	0.80	H
Toluene-d8	108%	Surrogate Recovery
Bromofluorobenzene	104%	Surrogate Recovery
1,2-Dichloroethane-d4	96%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: TCLP-Volatiles Blank Date Received: 8/13/87

Lab Ref. I.D. #: 7080-TCLPBLK C-4

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	-	NF
1,2-Dichloroethane	0.01	U
Tetrachloroethene	0.01	U
Chlorobenzene	0.01	U
Ethyl Benzene	0.01	U
Styrene	0.01	U
Xylene, ortho	0.01	U
Toluene-d8	91%	Surrogate Recovery
Bromofluorobenzene	102%	Surrogate Recovery
1,2-Dichloroethane-d4	110%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name:_ T/HMHO/R2/60 (extraction duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708039 D

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	4.54	J RPD = 61%
Anthracene	0.71	U diff.= 0 mg/L
Bis(2-ethyl hexyl)phthalate	0.63	U diff.= 0 mg/L
2,4,6-Tribromophenol	D	% Surrogate Recovery
Terphenyl-d14	D	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R2/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708039

Extraction duplicate performed for semi-volatiles; see next page for results

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	1.40	
1,2-Dichloroethane	0.21	
Tetrachloroethene	1.90	
Chlorobenzene	1.50	
Ethyl Benzene	15.0	
Styrene	4.20	
Xylenes (Total)	36.0	
Toluene-d8	98,97%	Surrogate Recovery
Bromofluorobenzene	103,97%	Surrogate Recovery
1,2-Dichloroethane-d4	98%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	8.50	E,J-Calibration Problem
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.21	U
2,4,6-Tribromophenol	24%	Surrogate Recovery
Terphenyl-d14	37%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	5.81	
Cadmium	10.6	
Chromium	0.65	
Copper	118.4	
Lead	151.3	
Nickel	12.2	
Zinc	165.6	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R2/10-60 (extraction duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708038 D

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.66	J diff.= 0.14 mg/L
Anthracene	0.01	J diff.= 0 mg/L
Bis(2-ethyl hexyl)phthalate	0.18	U diff.= 0 mg/L
2,4,6-Tribromophenol	4%	Surrogate Recovery
Terphenyl-d14	32%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R2/60 (TCLP duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708038 LD

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.33	diff.= 0.34 mg/L
1,2-Dichloroethane	0.02	L diff.= 0.01 mg/L
Tetrachloroethene	0.11	diff.= 0.02 mg/L
Chlorobenzene	0.11	diff.= 0.02 mg/L
Ethyl Benzene	1.06	RPD = 14%
Styrene	0.24	diff.= 0.01 mg/L
Xylenes (Total)	2.80	RPD = 24%
Toluene-d8	105%	Surrogate Recovery
Bromofluorobenzene	97%	Surrogate Recovery
1,2-Dichloroethane-d4	102%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R2/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708038

TCLP duplicate performed for volatiles and extraction duplicate performed for semi-volatiles; see next two pages for results

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.67	
1,2-Dichloroethane	0.01	L
Tetrachloroethene	0.09	
Chlorobenzene	0.09	
Ethyl Benzene	0.92	
Styrene	0.23	
Xylenes (Total)	2.20	
Toluene-d8	95%	Surrogate Recovery
Bromofluorobenzene	100%	Surrogate Recovery
1,2-Dichloroethane-d4	94%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.52	J-Calibration Problem
Anthracene	0.25	U
Bis(2-ethyl hexyl)phthalate	0.22	U
2,4,6-Tribromophenol	11%	Surrogate Recovery
Terphenyl-d14	34%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	1.91	
Cadmium	5.54	
Chromium	0.01	U
Copper	9.88	
Lead	4.59	
Nickel	2.52	
Zinc	136.9	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R2/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708037

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.78	
1,2-Dichloroethane	0.04	L
Tetrachloroethene	0.03	L
Chlorobenzene	0.07	
Ethyl Benzene	0.50	
Styrene	0.14	
Xylenes (Total)	1.20	
Toluene-d8	95%	Surrogate Recovery
Bromofluorobenzene	103%	Surrogate Recovery
1,2-Dichloroethane-d4	97%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.37	E,J-Calibration Problem
Anthracene	0.01	J-Identification Uncertain
Bis(2-ethyl hexyl)phthalate	0.10	U
2,4,6-Tribromophenol	26%	Surrogate Recovery
Terphenyl-d14	47%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.75	
Cadmium	1.62	
Chromium	0.01	U
Copper	1.61	
Lead	0.40	
Nickel	0.99	
Zinc	41.0	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R3/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708036

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.10	U
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.05	U
Chlorobenzene	0.05	U
Ethyl Benzene	0.10	
Styrene	0.02	L
Xylenes (Total)	0.23	
Toluene-d8	98%	Surrogate Recovery
Bromofluorobenzene	101%	Surrogate Recovery
1,2-Dichloroethane-d4	93%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.61	J-Calibration Problem
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.02	J-Identification Uncertain
2,4,6-Tribromophenol	47%	Surrogate Recovery
Terphenyl-d14	86%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.60	
Cadmium	1.17	
Chromium	0.80	
Copper	7.15	
Lead	4.53	
Nickel	0.92	
Zinc	38.4	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R3/10-60 (TCLP duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708035 LD

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.24	RPD = 16%
Anthracene	0.01	L diff.= 0 mg/L
Bis(2-ethyl hexyl)phthalate	0.02	J diff.= 0 mg/L
2,4,6-Tribromophenol	50%	Surrogate Recovery
Terphenyl-d14	79%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R3/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708035

TCLP performed in duplicate for semi-volatiles; see next page for results

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.10	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.02	L
Chlorobenzene	0.05	U
Ethyl Benzene	0.25	
Styrene	0.07	
Xylenes (Total)	0.64	
Toluene-d8	102%	Surrogate Recovery
Bromofluorobenzene	103%	Surrogate Recovery
1,2-Dichloroethane-d4	99%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.21	J-Calibration Problem
Anthracene	0.02	L
Bis(2-ethyl hexyl)phthalate	0.02	J-Identification Uncertain
2,4,6-Tribromophenol	48%	Surrogate Recovery
Terphenyl-d14	90%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.23	
Chromium	0.01	U
Copper	0.10	
Lead	0.15	
Nickel	0.09	
Zinc	3.77	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R3/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708034

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.10	U
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.01	L
Chlorobenzene	0.02	L
Ethyl Benzene	0.17	
Styrene	0.05	L
Xylenes (Total)	0.40	
Toluene-d8	98%	Surrogate Recovery
Bromofluorobenzene	99%	Surrogate Recovery
1,2-Dichloroethane-d4	98%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.04	
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.01	J-Identification Uncertain
2,4,6-Tribromophenol	61%	Surrogate Recovery
Terphenyl-d14	81%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.03	
Chromium	0.01	U
Copper	0.05	U
Lead	0.15	U
Nickel	0.12	
Zinc	0.11	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R2/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708033

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.10	U
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.02	L
Chlorobenzene	0.02	L
Ethyl Benzene	0.24	
Styrene	0.06	
Xylenes (Total)	0.55	
Toluene-d8	99%	Surrogate Recovery
Bromofluorobenzene	99%	Surrogate Recovery
1,2-Dichloroethane-d4	97%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.24	
Anthracene	0.02	L
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	61%	Surrogate Recovery
Terphenyl-d14	88%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.17	
Chromium	0.53	
Copper	4.12	
Lead	2.32	
Nickel	0.73	
Zinc	11.7	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R2/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708032

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.10	U
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.05	U
Chlorobenzene	0.05	U
Ethyl Benzene	0.06	
Styrene	0.05	U
Xylenes (Total)	0.15	
Toluene-d8	100%	Surrogate Recovery
Bromofluorobenzene	103%	Surrogate Recovery
1,2-Dichloroethane-d4	95%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.16	
Anthracene	0.02	L
Bis(2-ethyl hexyl)phthalate	0.03	J-identification uncertain
2,4,6-Tribromophenol	61%	Surrogate Recovery
Terphenyl-d14	74%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.07	
Chromium	0.01	U
Copper	0.12	
Lead	0.15	U
Nickel	0.11	
Zinc	0.75	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Untreated (PEI Associates)
Final Report - October 16, 1987

Sample Name: HMHO - SARM IV Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708029

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	130	
1,2-Dichloroethane	13	
Tetrachloroethene	4.5	
Chlorobenzene	6.7	
Ethyl Benzene	47	
Styrene	11	
Xylenes (Total)	100	
Toluene-d8	100,100%	Surrogate Recovery
Bromofluorobenzene	101, 97%	Surrogate Recovery
1,2-Dichloroethane-d4	109%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	3.8	J-Calibration Problem
Anthracene	3.4	U
Bis(2-ethyl hexyl)phthalate	3.0	U
2,4,6-Tribromophenol	D	% Surrogate Recovery
Terphenyl-d14	D	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	9.58	
Cadmium	35.3	
Chromium	0.06	
Copper	159.9	
Lead	70.4	
Nickel	26.8	
Zinc	395.9	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: HMLO - SARM III Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708028

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	7.10	
1,2-Dichloroethane	0.50	U
Tetrachloroethene	0.33	L
Chlorobenzene	0.38	L
Ethyl Benzene	4.60	
Styrene	0.50	U
Xylenes (Total)	11.00	
Toluene-d8	99%	Surrogate Recovery
Bromofluorobenzene	99%	Surrogate Recovery
1,2-Dichloroethane-d4	109%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.34	J-Low Surrogate Recovery
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.09	U
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	21%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	6.39	
Cadmium	33.1	
Chromium	0.01	U
Copper	80.7	
Lead	19.9	
Nickel	17.5	
Zinc	358.5	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Untreated (PEI Associates)
Final Report - October 16, 1987

Sample Name: LMLO - SARM II Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708027

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.92	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.05	U
Chlorobenzene	0.05	U
Ethyl Benzene	0.12	
Styrene	0.03	L
Xylenes (Total)	0.30	
Toluene-d8	102%	Surrogate Recovery
Bromofluorobenzene	99%	Surrogate Recovery
1,2-Dichloroethane-d4	111%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.90	
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.22	U
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	46%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.73	
Chromium	0.01	U
Copper	0.89	
Lead	0.70	
Nickel	0.40	
Zinc	14.6	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Untreated (PEI Associates)
Final Report - October 16, 1987

Sample Name: LMHO - SARM I (TCLP duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708026 LD

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	7.8	RPD = 3%
Anthracene	2.6	U diff.= 0 mg/L
Bis(2-ethyl hexyl)phthalate	2.3	U diff.= 0 mg/L
2,4,6-Tribromophenol	D	% Surrogate Recovery
Terphenyl-d14	D	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U diff.= 0 mg/L
Cadmium	0.55	RPD = 4%
Chromium	0.01	U diff.= 0 mg/L
Copper	0.64	RPD = 5%
Lead	0.49	diff.= 0 mg/L
Nickel	0.28	diff.= 0.01 mg/L
Zinc	9.2	RPD = 0%

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: LMHO - SARM I Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708026

TCLP performed in duplicate for semi-violatiles/metals; see nest page for results

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	110	
1,2-Dichloroethane	76	
Tetrachloroethene	3.3	
Chlorobenzene	5.2	
Ethyl Benzene	27	
Styrene	9.0	
Xylenes (Total)	62	
Toluene-d8	100, 97%	Surrogate Recovery
Bromofluorobenzene	100,101%	Surrogate Recovery
1,2-Dichloroethane-d4	108%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	7.6	J-Calibration Problem
Anthracene	0.07	L
Bis(2-ethyl hexyl)phthalate	0.10	L
2,4,6-Tribromophenol	18%	Surrogate Recovery
Terphenyl-d14	42%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.53	
Chromium	0.01	U
Copper	0.61	
Lead	0.49	
Nickel	0.27	
Zinc	9.2	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R3/60 **Date Received:** 8/13/87

Lab Ref. I.D. #: 7080-8708025

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	1.00	
1,2-Dichloroethane	0.06	
Tetrachloroethene	0.64	
Chlorobenzene	0.54	
Ethyl Benzene	5.40	
Styrene	1.40	
Xylenes (Total)	12.00	
Toluene-d8	100, 99%	Surrogate Recovery
Bromofluorobenzene	103,101%	Surrogate Recovery
1,2-Dichloroethane-d4	93%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	2.07	E
Anthracene	0.30	
Bis(2-ethyl hexyl)phthalate	5.5	
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	52%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.36	
Cadmium	0.70	
Chromium	0.74	
Copper	3.60	
Lead	1.06	
Nickel	0.73	
Zinc	15.4	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R3/100-60 (TCLP duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708024 LD

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.20	diff.= 0.45 mg/L
1,2-Dichloroethane	0.05	U diff.= 0 mg/L
Tetrachloroethene	0.07	diff.= 0.03 mg/L
Chlorobenzene	0.10	diff.= 0.02 mg/L
Ethyl Benzene	0.88	diff.= 0.09 mg/L
Styrene	0.22	diff.= 0.03 mg/L
Xylenes (Total)	2.40	RPD = 9%
Toluene-d8	100%	Surrogate Recovery
Bromofluorobenzene	96%	Surrogate Recovery
1,2-Dichloroethane-d4	101%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	NA	
Cadmium	NA	
Chromium	NA	
Copper	NA	
Lead	NA	
Nickel	NA	
Zinc	NA	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R3/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708024

TCLP performed in duplicate for volatiles; see next page for results
Digestion spike performed for metals

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.65	
1,2-Dichloroethane	0.03	L
Tetrachloroethene	0.10	
Chlorobenzene	0.12	
Ethyl Benzene	0.97	
Styrene	0.25	
Xylenes (Total)	2.20	
Toluene-d8		100% Surrogate Recovery
Bromofluorobenzene		100% Surrogate Recovery
1,2-Dichloroethane-d4		91% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.41	
Anthracene	0.02	L
Bis(2-ethyl hexyl)phthalate	0.10	U
2,4,6-Tribromophenol		D % Surrogate Recovery
Terphenyl-d14		52% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U % Rec.= 94
Cadmium	0.26	% Rec.= 82
Chromium	0.01	U % Rec.= 88
Copper	0.18	% Rec.= 87
Lead	0.15	U % Rec.= 84
Nickel	0.06	% Rec.= 85
Zinc	1.90	% Rec.= 72

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R3/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708023

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	1.80	
1,2-Dichloroethane	0.03	L
Tetrachloroethene	0.03	L
Chlorobenzene	0.06	
Ethyl Benzene	0.44	
Styrene	0.13	
Xylenes (Total)	1.00	
Toluene-d8	102%	Surrogate Recovery
Bromofluorobenzene	100%	Surrogate Recovery
1,2-Dichloroethane-d4	99%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.04	L
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.10	U
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	40%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.05	U
Cadmium	0.12	
Chromium	0.01	U
Copper	0.06	
Lead	0.15	U
Nickel	0.04	
Zinc	0.85	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R3/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708022

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	1.50	
1,2-Dichloroethane	0.05	L
Tetrachloroethene	0.18	
Chlorobenzene	0.17	
Ethyl Benzene	2.00	
Styrene	0.46	
Xylenes (Total)	5.00	
Toluene-d8	104,101%	Surrogate Recovery
Bromofluorobenzene	100,100%	Surrogate Recovery
1,2-Dichloroethane-d4	95%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.24	
Anthracene	0.11	
Bis(2-ethyl hexyl)phthalate	0.10	U
2,4,6-Tribromophenol	13%	Surrogate Recovery
Terphenyl-d14	81%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	12.8	
Cadmium	25.2	
Chromium	2.19	
Copper	192.0	
Lead	13.4	
Nickel	21.95	
Zinc	412.8	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R3/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708021

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.81	
1,2-Dichloroethane	0.04	L
Tetrachloroethene	0.08	
Chlorobenzene	0.10	
Ethyl Benzene	0.78	
Styrene	0.22	
Xylenes (Total)	1.80	
Toluene-d8	99%	Surrogate Recovery
Bromofluorobenzene	101%	Surrogate Recovery
1,2-Dichloroethane-d4	101%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.28	J-Calibration Problem
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.10	U,J-Calibration Problem
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	33%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	2.91	
Cadmium	9.60	
Chromium	0.25	
Copper	15.06	
Lead	28.79	
Nickel	2.73	
Zinc	150.0	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R3/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708020

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	1.80	
1,2-Dichloroethane	0.02	L
Tetrachloroethene	0.05	U
Chlorobenzene	0.02	L
Ethyl Benzene	0.12	
Styrene	0.03	L
Xylenes (Total)	0.23	
Toluene-d8	101%	Surrogate Recovery
Bromofluorobenzene	97%	Surrogate Recovery
1,2-Dichloroethane-d4	95%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.05	J-Calibration problem
Anthracene	0.11	U,J-Low Surrogate Recovery
Bis(2-ethyl hexyl)phthalate	0.11	U,J-Low Surrogate Recovery
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	28%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.97	
Cadmium	4.87	
Chromium	0.01	U
Copper	1.94	
Lead	0.50	
Nickel	1.06	
Zinc	42.5	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMLO/R2/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708019

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.25	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.03	
Chlorobenzene	0.02	
Ethyl Benzene	0.19	
Styrene	0.06	
Xylenes (Total)	0.55	
Toluene-d8	95,103%	Surrogate Recovery
Bromofluorobenzene	104,96%	Surrogate Recovery
1,2-Dichloroethane-d4	102%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.27	
Anthracene	0.01	U
Bis(2-ethyl hexyl)phthalate	0.02	U,J-Internal Standard Area High
2,4,6-Tribromophenol	25%	Surrogate Recovery
Terphenyl-d14	34%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	8.12	
Cadmium	5.1	
Chromium	1.16	
Copper	52.6	
Lead	64.8	
Nickel	8.6	
Zinc	216.4	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMLO/R2/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708018

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.25	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.02	L
Chlorobenzene	0.02	L
Ethyl Benzene	0.25	
Styrene	0.06	
Xylenes (Total)	0.73	
Toluene-d8	99%	Surrogate Recovery
Bromofluorobenzene	95%	Surrogate Recovery
1,2-Dichloroethane-d4	104%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.40	E,J-Poor Surrogate Recovery
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.05	U
2,4,6-Tribromophenol	3%	Surrogate Recovery
Terphenyl-d14	54%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.55	
Cadmium	2.15	
Chromium	0.01	
Copper	1.39	
Lead	1.56	
Nickel	0.94	
Zinc	26.8	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMLO/R1/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708017

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.40	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.02	L
Chlorobenzene	0.03	L
Ethyl Benzene	0.32	
Styrene	0.09	
Xylenes (Total)	0.90	
Toluene-d8	104%	Surrogate Recovery
Bromofluorobenzene	98%	Surrogate Recovery
1,2-Dichloroethane-d4	102%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	2.20	E,J-Poor Surrogate Recoveries
Anthracene	0.04	J-Poor Surrogate Recoveries
Bis(2-ethyl hexyl)phthalate	0.02	U,J-Poor Surrogate Recoveries
2,4,6-Tribromophenol	-	% Surrogate Recovery
Terphenyl-d14	29%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	8.00	
Cadmium	19.16	
Chromium	0.03	
Copper	144.0	
Lead	19.85	
Nickel	18.5	
Zinc	320.1	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMLO/R1/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708016

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	6.10	
1,2-Dichloroethane	0.31	
Tetrachloroethene	0.89	
Chlorobenzene	1.10	
Ethyl Benzene	9.50	
Styrene	2.80	
Xylenes (Total)	30.00	
Toluene-d8	103,100%	Surrogate Recovery
Bromofluorobenzene	101,100%	Surrogate Recovery
1,2-Dichloroethane-d4	109, 93%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.93	J-Calibration Problem
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	19%	Surrogate Recovery
Terphenyl-d14	53%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	1.75	
Cadmium	7.79	
Chromium	0.04	
Copper	6.39	
Lead	11.67	
Nickel	1.56	
Zinc	52.9	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMLO/R1/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708015

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.45	H
1,2-Dichloroethane	0.05	U,H
Tetrachloroethene	0.05	U,H
Chlorobenzene	0.05	U,H
Ethyl Benzene	0.04	L,H
Styrene	0.05	U,H
Xylenes (Total)	0.10	H
Toluene-d8	105%	Surrogate Recovery
Bromofluorobenzene	107%	Surrogate Recovery
1,2-Dichloroethane-d4	104%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.17	
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	57%	Surrogate Recovery
Terphenyl-d14	105%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.86	
Cadmium	4.95	
Chromium	0.01	U
Copper	1.32	
Lead	6.46	
Nickel	1.26	
Zinc	50.0	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R1/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708014

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.62	H
1,2-Dichloroethane	0.05	U,H
Tetrachloroethene	0.05	U,H
Chlorobenzene	0.02	L,H
Ethyl Benzene	0.16	H
Styrene	0.04	L,H
Xylenes (Total)	0.45	H
Toluene-d8	104%	Surrogate Recovery
Bromofluorobenzene	103%	Surrogate Recovery
1,2-Dichloroethane-d4	101%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.5	J-Calibration Problem
Anthracene	2.1	U
Bis(2-ethyl hexyl)phthalate	0.2	L
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	D%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.93	
Chromium	0.01	U
Copper	1.87	
Lead	1.05	
Nickel	0.39	
Zinc	10.7	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R1/10-60 (TCLP duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708013 LD

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.17	diff. = 0.57 mg/L
1,2-Dichloroethane	0.05	U diff. = 0 mg/L
Tetrachloroethene	0.06	diff. = 0.04 mg/L
Chlorobenzene	0.07	diff. = 0.03 mg/L
Ethyl Benzene	0.70	diff. = 0.37 mg/L
Styrene	0.16	diff. = 0.06 mg/L
Xylenes (Total)	1.80	diff. = 0.89 mg/L
Toluene-d8		104% Surrogate Recovery
Bromofluorobenzene		97% Surrogate Recovery
1,2-Dichloroethane-d4		98% Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.12	RPD = 6%
Anthracene	0.42	diff. = 0.32 mg/L
Bis(2-ethyl hexyl)phthalate	0.06	L diff. = 0.03 mg/L
2,4,6-Tribromophenol		D% Surrogate Recovery
Terphenyl-d14		53% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U diff. = 0 mg/L
Cadmium	0.39	RPD = 3%
Chromium	0.01	U diff. = 0 mg/L
Copper	0.21	diff. = 0.07 mg/L
Lead	0.10	diff. = 0.12 mg/L
Nickel	0.10	diff. = 0.01 mg/L
Zinc	2.78	RPD = 16%

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R1/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708013

TCLP performed in duplicate for volatiles and semi-volatiles/metals; see next page for results.

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.74	H
1,2-Dichloroethane	0.05	U,H
Tetrachloroethene	0.02	L,H
Chlorobenzene	0.04	L,H
Ethyl Benzene	0.33	H
Styrene	0.10	H
Xylenes (Total)	0.91	H
Toluene-d8	107%	Surrogate Recovery
Bromofluorobenzene	109%	Surrogate Recovery
1,2-Dichloroethane-d4	100%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.10	
Anthracene	0.10	L
Bis(2-ethyl hexyl)phthalate	0.04	L
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	82%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.40	
Chromium	0.01	U
Copper	0.28	
Lead	0.22	
Nickel	0.09	
Zinc	3.25	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMHO/R1/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708012

Compound	Result (mg/L)	:Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	1.30	H
1,2-Dichloroethane	0.05	U,H
Tetrachloroethene	0.02	L,H
Chlorobenzene	0.04	L,H
Ethyl Benzene	0.40	H
Styrene	0.12	H
Xylenes (Total)	1.20	H
Toluene-d8	105%	Surrogate Recovery
Bromofluorobenzene	99%	Surrogate Recovery
1,2-Dichloroethane-d4	101%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.06	L
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.04	U
2,4,6-Tribromophenol	D%	Surrogate Recovery
Terphenyl-d14	80%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.15	
Chromium	0.01	U
Copper	0.04	
Lead	0.15	U
Nickel	0.04	
Zinc	0.88	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R1/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708011

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.16	H
1,2-Dichloroethane	0.05	U,H
Tetrachloroethene	0.05	U,H
Chlorobenzene	0.05	U,H
Ethyl Benzene	0.08	H
Styrene	0.02	L,H
Xylenes (Total)	0.17	H
Toluene-d8	100%	Surrogate Recovery
Bromofluorobenzene	104%	Surrogate Recovery
1,2-Dichloroethane-d4	96%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.46	J-Low Surrogate Recovery
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.03	U
2,4,6-Tribromophenol	7%	Surrogate Recovery
Terphenyl-d14	67%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.18	
Cadmium	1.68	
Chromium	0.01	U
Copper	4.49	
Lead	3.44	
Nickel	0.89	
Zinc	28.2	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R1/10-60 (digestion duplicate) Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708010 D

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	NA	
1,2-Dichloroethane	NA	
Tetrachloroethene	NA	
Chlorobenzene	NA	
Ethyl Benzene	NA	
Styrene	NA	
Xylenes (Total)	NA	
Toluene-d8	NA	% Surrogate Recovery
Bromofluorobenzene	NA	% Surrogate Recovery
1,2-Dichloroethane-d4	NA	% Surrogate Recovery
Semivplatile Organics (SW-846, Method 8270)		
Pentachlorophenol	NA	
Anthracene	NA	
Bis(2-ethyl hexyl)phthalate	NA	
2,4,6-Tribromophenol	NA	% Surrogate Recovery
Terphenyl-d14	NA	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15 U	diff. = 0 mg/L
Cadmium	0.33	RPD = 3%
Chromium	0.01 U	diff. = 0 mg/L
Copper	0.32	diff. = 0 mg/L
Lead	0.74	diff. = 0.06 mg/L
Nickel	0.11	diff. = 0.01 mg/L
Zinc	6.40	RPD = 4%

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R1/10-60 Date Received: 8/13/87

Lab Ref. I.D. # 7080-8708010

Digestion duplicate performed for metals; see next page for results

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.05	U
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.02	J-High Surrogate Recovery
Chlorobenzene	0.05	U,J-High Surrogate Recovery
Ethyl Benzene	0.05	U,J-High Surrogate Recovery
Styrene	0.22	J-High Surrogate Recovery
Xylenes (Total)	3.90	E,J-High Surrogate Recovery
Toluene-d8	99%	Surrogate Recovery
Bromofluorobenzene	152%	Surrogate Recovery
1,2-Dichloroethane-d4	112%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.05	L
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	26%	Surrogate Recovery
Terphenyl-d14	44%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.32	
Chromium	0.01	U
Copper	0.32	
Lead	0.68	
Nickel	0.12	
Zinc	6.17	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R1/10-60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708007

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	-	NF
1,2-Dichloroethane	0.03	
Tetrachloroethene	0.07	
Chlorobenzene	0.09	
Ethyl Benzene	0.94	J-Poor Surrogate Recovery
Styrene	0.17	
Xylenes (Total)	1.57	J-Poor Surrogate Recovery
Toluene-d8	104,97%	Surrogate Recovery
Bromofluorobenzene	106%	Surrogate Recovery
1,2-Dichloroethane-d4	81%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.60	J-Calibration Problem
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.04	U
2,4,6-Tribromophenol	51%	Surrogate Recovery
Terphenyl-d14	66%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	2.09	
Cadmium	9.05	
Chromium	0.08	
Copper	14.52	
Lead	25.20	
Nickel	2.95	
Zinc	175.4	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R1/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708006

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	-	NF - Metlylene Chloride Interference
1,2-Dichloroethane	0.02	
Tetrachloroethene	0.03	
Chlorobenzene	0.04	
Ethyl Benzene	0.24	E
Styrene	0.07	
Xylenes (Total)	0.44	E
Toluene-d8	107%	Surrogate Recovery
Bromofluorobenzene	98%	Surrogate Recovery
1,2-Dichloroethane-d4	85%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.58	J-Calibration Problem
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	100%	Surrogate Recovery
Terphenyl-d14	48%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.94	
Cadmium	2.98	
Chromium	0.01	U
Copper	3.01	
Lead	0.35	
Nickel	1.23	
Zinc	79.1	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R1/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708009

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	3.40	E
1,2-Dichloroethane	0.25	
Tetrachloroethene	0.97	J-High Surrogate Recoveries
Chlorobenzene	0.91	J-High Surrogate Recoveries
Ethyl Benzene	9.11	E,J-High Surrogate Recoveries
Styrene	2.32	E,J-High Surrogate Recoveries
Xylenes (Total)	17.82	E,J-High Surrogate Recoveries
Toluene-d8	97%	Surrogate Recovery
Bromofluorobenzene	123%	Surrogate Recovery
1,2-Dichloroethane-d4	120%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.01	L
Anthracene	0.02	U
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	11%	Surrogate Recovery
Terphenyl-d14	46%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.07	
Chromium	0.01	U
Copper	0.04	
Lead	0.06	
Nickel	0.15	U
Zinc	0.47	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMHO/R1/60 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708008

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.47	J-High Surrogate Recovery
1,2-Dichloroethane	0.36	J-High Surrogate Recovery
Tetrachloroethene	0.84	
Chlorobenzene	0.69	
Ethyl Benzene	7.33	E
Styrene	1.52	
Xylenes (Total)	13.23	
Toluene-d8	90%	Surrogate Recovery
Bromofluorobenzene	114%	Surrogate Recovery
1,2-Dichloroethane-d4	230%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	1.9	J-Calibration Problem
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	1.0	U
2,4,6-Tribromophenol	D	% Surrogate Recovery
Terphenyl-d14	D	% Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	10.94	
Cadmium	14.7	
Chromium	0.03	
Copper	210.8	
Lead	55.43	
Nickel	19.2	
Zinc	326.4	

*Description of flags provided on a separate page

EXPLANATION OF FLAGS USED

U - Less than quantitation limit

NF - Not Found due to interference from methylene chloride

E - Estimated value: value greater than highest standard

L - estimated value: compound found in sample at level less than quantitation limit

H - analysis performed after 14 days holding expired

J - estimated value

D - Surrogates deleted out

diff - difference between duplicate values

RPD - Relative percent difference between duplicate values

NA - Not Applicable

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10 & F/HMHO/R3T/10 (Soil) received August 18, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.
pentachlorophenol	62,000	69,000	62,000	0	77,000	13
anthracene	250,000	<10,000 (3,100)	200,000	79	200,000	79
bis(2-ethylhexyl) phthalate	120,000	<10,000 (1,200)	94,000	77	120,000	99

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.94

Approved by Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R3/60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	48,000
chlorobenzene	30,000
1,2-dichloroethane	<8,100 (5,500)
ethyl benzene	710,000
styrene	110,000
tetrachloroethene	47,000
xylenes (total)	970,000

Remarks: 8,100 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 38.07

Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24820
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3D/60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	56,000
chlorobenzene	21,000
1,2-dichloroethane	4,400
ethyl benzene	270,000
styrene	51,000
tetrachloroethene	39,000
xylenes (total)	460,000

Remarks: 2,000 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 37.33

Approved by: Alyce K. Mack
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 14 OF 51

Sample Description: F/LML0/R3/60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,100
chlorobenzene	ND
1,2-dichloroethane	ND
ethyl benzene	<470 (450)
styrene	<470 (350)
tetrachloroethene	ND
xylenes (total)	1,000

Note: This sample could not be run undiluted due to foaming in the purge cell.

Remarks: 470 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 46.79

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R3D/60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	53,000
chlorobenzene	32,000
1,2-dichloroethane	6,500
ethyl benzene	650,000
styrene	82,000
tetrachloroethene	51,000
xylenes (total)	660,000

Remarks: 2,300 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 46.51

Approved by Alyce L. Mason
Laboratory Manager
Title

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	11,000
chlorobenzene	130
1,2-dichloroethane	160
ethyl benzene	930
styrene	280
tetrachloroethene	88
xylenes (total)	1,500

Remarks:
5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.94

Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LML0/R3D/60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,400
chlorobenzene	ND
1,2-dichloroethane	ND
ethyl benzene	780
styrene	<250 (210)
tetrachloroethene	130
xylenes (total)	1,600

Note: This sample could not be run undiluted due to foaming in the purge cell.

Remarks: 250 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 46.41

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10-60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	15,000
chlorobenzene	890
1,2-dichloroethane	ND
ethyl benzene	7,200
styrene	ND
tetrachloroethene	880
xylenes (total)	36,000

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.27

Approved by Laboratory Manager
Title

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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24820
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3D/10 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	18,000
chlorobenzene	23
1,2-dichloroethane	39
ethyl benzene	110
styrene	60.
tetrachloroethene	7
xylenes (total)	230

Remarks:
5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.99

Approved by: Alyce L. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R3/10 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
acetone[1]	31,000
chlorobenzene	560
1,2-dichloroethane	260
ethyl benzene	4,500
styrene	ND
tetrachloroethene	390
xylenes (total)	7,700

Remarks: 260 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 2.97

Approved by Laboratory Manager

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Sample Description: F/HMHO/R3D/10-60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	15,000
chlorobenzene	1,000
1,2-dichloroethane	<310 (300)
ethyl benzene	7,700
styrene	ND
tetrachloroethene	1,400
xylenes (total)	15,000

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 18.98

Approved by Alyce L. Moore
Laboratory Manager
Title

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Sample Description: F/LMHO/R3/10-60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	12,000
chlorobenzene	1,100
1,2-dichloroethane	460
ethyl benzene	8,800
styrene	ND
tetrachloroethene	690
xylenes (total)	15,000

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 18.98

Approved by
Laboratory Manager
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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 22 OF 51

Sample Description: F/LMHO/R3D/10 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	14,000
chlorobenzene	34
1,2-dichloroethane	33
ethyl benzene	130
styrene	83
tetrachloroethene	6
xylenes (total)	260

Remarks:
5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.37

Approved by Laboratory Manager
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Sample Description: F/LML0/R3/10 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	590
chlorobenzene	<5 (2)
1,2-dichloroethane	ND
ethyl benzene	9
styrene	12
tetrachloroethene	ND
xylenes (total)	29

Remarks:
5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.38

Approved by: Laboratory Manager
Title

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Sample Description: F/LMHO/R3D/10-60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,000
chlorobenzene	900
1,2-dichloroethane	<310 (180)
ethyl benzene	8,200
styrene	ND
tetrachloroethene	930
xylenes (total)	14,000

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 18.45

Approved by Alyce K. Mann
Laboratory Manager
Title

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Sample Description: F/LML0/R3/10-60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	740
chlorobenzene	<6 (3)
1,2-dichloroethane	<6 (4)
ethyl benzene	18
styrene	20.
tetrachloroethene	ND
xylenes (total)	48

Remarks:
6 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 16.59

Approved by
Laboratory Manager
Title

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Sample Description: F/LML0/R3D/10 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	330
chlorobenzene	<5 (2)
1,2-dichloroethane	ND
ethyl benzene	9
styrene	9
tetrachloroethene	ND
xylenes (total)	28

Remarks:
5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
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% Moisture = 3.15

Approved by
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER: 805018 (PEI-3741-7-2)
PAGE 28 OF 51

Sample Description: F/HMHO/R3/60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	4,300,000
bis(2-ethylhexyl)phthalate	1,700,000
pentachlorophenol	<730,000 (86,000)

Remarks: 730,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 31.50

Approved by Laboratory Manager
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Sample Description: F/LML0/R3D/10-60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	760
chlorobenzene	<6 (2)
1,2-dichloroethane	<6 (3)
ethyl benzene	12
styrene	ND
tetrachloroethene	ND
xylenes (total)	32

Remarks:
6 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 15.11

Approved by Laboratory Manager
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Sample Description: F/LMHO/R3/60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,800,000
bis(2-ethylhexyl)phthalate	1,900,000
pentachlorophenol	ND

Remarks: 400,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 38.07

Approved by
Laboratory Manager
Title

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ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3D/60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	7,300,000
bis(2-ethylhexyl)phthalate	1,300,000
pentachlorophenol	<370,000 (120,000)

Remarks: 370,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 37.33

Approved by: Elgin K. Moore
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	720,000
bis(2-ethylhexyl)phthalate	160,000
pentachlorophenol	ND

Remarks: 18,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 46.79

Approved by Laboratory Manager
Title

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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 31 OF 51

Sample Description: F/LMHO/R3D/60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	3,600,000
bis(2-ethylhexyl)phthalate	1,300,000
pentachlorophenol	ND

Remarks: 450,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 46.51

Approved by Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<10,000 (3,100)
bis(2-ethylhexyl)phthalate	<10,000 (1,200)
pentachlorophenol	69,000

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.94

Approved by
Laboratory Manager
Title

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Sample Description: F/LML0/R3D/60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	690,000
bis(2-ethylhexyl)phthalate	150,000
pentachlorophenol	ND

Remarks: 19,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 46.41

Approved by Alyce K. Moore
Laboratory Manager
Title

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Sample Description: F/HMHO/R3/10-60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,400,000
bis(2-ethylhexyl)phthalate	25,000
pentachlorophenol	71,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 19.27

Approved by
Laboratory Manager
Title

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Sample Description: F/HMHO/R3D/10 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<10,000 (1,800)
bis(2-ethylhexyl)phthalate	ND
pentachlorophenol	<10,000 (7,900)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.99

Approved by: Laboratory Manager
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Sample Description: F/LMHO/R3/10 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
anthracene	<10,000 (4,100)
bis(2-ethylhexyl)phthalate	ND
pentachlorophenol	<10,000 (9,500)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 2.97

Approved by
Laboratory Manager
Title

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Sample Description: F/HMHO/R3D/10-60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,300,000
bis(2-ethylhexyl)phthalate	27,000
pentachlorophenol	12,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 18.98

Approved by

Laboratory Manager
Title

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Sample Description: F/LMHO/R3/10-60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,500,000
bis(2-ethylhexyl)phthalate	100,000
pentachlorophenol	<12,000 (5,800)

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 18.98

Approved by
Laboratory Manager

The

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R3D/10 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,900 (2,500)
bis(2-ethylhexyl)phthalate	<9,900 (2,200)
pentachlorophenol	<9,900 (7,300)

Remarks: 9,900 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.37

Approved by Laboratory Manager
Title

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Sample Description: F/LML0/R3/10 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<10,000 (1,200)
bis(2-ethylhexyl)phthalate	24,000
pentachlorophenol	<10,000 (1,100)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.38

Approved by
Laboratory Manager
Title

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Sample Description: F/LMHO/R3D/10-60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,500,000
bis(2-ethylhexyl)phthalate	110,000
pentachlorophenol	<12,000 (3,400)

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 18.45

Approved by Laboratory Manager
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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LML0/R3/10-60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	150,000
bis(2-ethylhexyl)phthalate	19,000
pentachlorophenol	<11,000 (6,200)

Remarks: 11,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 16.59

Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 44 OF 51

Sample Description: F/LMLO/R3D/10 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<10,000 (2,100)
bis(2-ethylhexyl)phthalate	32,000
pentachlorophenol	<10,000 (3,800)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.15

Approved by
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/60 & F/HMHO/R3D/60 (Soil) received August 18, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
acetone	73,000	31,000	70,000	53	67,000	49	7.8
chlorobenzene	73,000	34,000	100,000	90.	110,000	104	-14
1,2-dichloroethane	73,000	5,400	96,000	124	79,000	101	20.
ethyl benzene	190,000	540,000	720,000	95	830,000	153	-47
styrene	73,000	88,000	130,000	58	170,000	112	-64
tetrachloroethane	73,000	60,000	120,000	82	120,000	82	0
xylenes	150,000	800,000	950,000	100	1,000,000	133	-28

Remarks: 7,300 = Quantitation Limit

Moisture = 31.50

Note: OS values are from a rerun of the sample, not the same run used for data reports.

Approved by

Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LML0/R3D/10-60 (Soil) received August 18, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	100,000
bis(2-ethylhexyl)phthalate	44,000
pentachlorophenol	<12,000 (9,300)

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 15.11

Approved by Laboratory Manager
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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10-60 & F/HMHO/R3T/10-60 (Soil) received August 18, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
acetone	15,000	6,600	12,000	36	13,000	43	-18
1,2-dichloroethane	3,100	<310 (140)	3,300	102	3,200	99	3.0
tetrachloroethane	3,100	1,900	5,200	106	6,300	142	-5.6
chlorobenzene	3,100	1,800	4,900	100	5,700	126	-23
ethyl benzene	7,400	17,000	28,000	149	36,000	257	-53
styrene	3,100	5,100	8,900	123	11,000	190	-43
total xylenes	3,100	32,000	38,000	194	51,000	613	-104

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

Moisture = 19.27

Note: OS values are from a rerun of the sample, not the same run used for data reports.

Approved by
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 47 OF 51

Sample Description: F/HMHO/R3/10 & F/HMHO/R3T/60 (Soil) received August 18, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
acetone	13,000	14,000	29,000	115	31,000	131	-1[illegible]
chlorobenzene	2,600	340	3,500	122	4,300	152	-22
1,2-dichloroethane	2,600	ND	2,500	96	2,400	92	4.
ethyl benzene	2,600	2,700	10,000	281	17,000	550	-65
styrene	2,600	820	4,800	150	6,300	211	-34
tetrachloroethane	2,600	310	3,600	127	4,600	165	-26
xylenes	2,600	4,600	15,000	400	27,000	862	-73

Remarks: 250 = Quantitation Limit
ND = Not detected

Moisture = 3.94

Note: OS values are from a rerun of the sample, not the same run used for data reports.

Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10-60 & F/HMHO/R3T/10-60 (Soil) received August 18, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
pentachlorophenol	145,000	71,000	67,000	0	70,000	0	0
anthracene	579,000	1,400,000	680,000	0	410,000	0	0
bis(2-ethylhexyl) phthalate	289,000	25,000	180,000	54	190,000	57	-5.4

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 19.27

Approved by Laboratory Manager

Title

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11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24820
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/60 & F/HMHO/R3T/60 (Soil) received August 18, 1987

Concentration units are µg/kg (ppb) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.
pentachlorophenol	350,000	<730,000 (86,000)	190,000	24	270,000	52
anthracene	1,400,000	4,300,000	3,500,000	0	5,500,000	86
bis(2-ethylhexyl) phthalate	700,000	1,700,000	2,200,000	57	2,300,000	86

Remarks: 730,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 31.50

Approved by: Laboratory Manager
Title

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/LMLO/R2/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708031

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.10	U
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.01	L
Chlorobenzene	0.01	L
Ethyl Benzene	0.07	
Styrene	0.02	
Xylenes (Total)	0.13	
Toluene-d8	106%	Surrogate Recovery
Bromofluorobenzene	111%	Surrogate Recovery
1,2-Dichloroethane-d4	97%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.01	L
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.04	
2,4,6-Tribromophenol	68%	Surrogate Recovery
Terphenyl-d14	72%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.15	U
Cadmium	0.05	
Chromium	0.01	U
Copper	0.10	
Lead	0.15	U
Nickel	0.04	U
Zinc	0.42	

*Description of flags provided on a separate page

LEE WAN & ASSOCIATES - LABORATORY DIVISION
TCLP - Volatile Organics, Semivolatile Organics, Metals
EPA Contract # 68-03-3393 LWA Project 86523

Treatment Technology: Washing (PEI Associates)
Final Report - October 16, 1987

Sample Name: T/HMLO/R2/10 Date Received: 8/13/87

Lab Ref. I.D. #: 7080-8708030

Compound	Result (mg/L)	Flag*/Remark
Volatile Organics (SW-846, Method 8240)		
Acetone	0.38	
1,2-Dichloroethane	0.05	U
Tetrachloroethene	0.03	
Chlorobenzene	0.04	
Ethyl Benzene	0.34	
Styrene	0.08	
Xylenes (Total)	0.82	
Toluene-d8	93,102%	Surrogate Recovery
Bromofluorobenzene	94,101%	Surrogate Recovery
1,2-Dichloroethane-d4	107%	Surrogate Recovery
Semivolatile Organics (SW-846, Method 8270)		
Pentachlorophenol	0.03	L,J-Low Surrogate Recovery
Anthracene	0.01	L
Bis(2-ethyl hexyl)phthalate	0.02	U
2,4,6-Tribromophenol	3%	Surrogate Recovery
Terphenyl-d14	44%	Surrogate Recovery
Metals (SW-846, Method 6010)		
Arsenic	0.64	
Cadmium	3.67	
Chromium	0.01	
Copper	1.15	
Lead	5.27	
Nickel	1.32	
Zinc	46.2	

*Description of flags provided on a separate page

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/10-60 & F/HMHO/R3T/10-60

Concentration units are mg/kg (ppm) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added MS	Conc. Spike Added MSD	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
arsenic	516	563	105	600.	96	707	107	-11
cadmium	2,060	2,250	311	2,230	93	2,390	92	1.1
chromium	516	563	30.3	489	89	536	90.	-1.1
copper	2,060	2,250	390.	2,610	108	2,640	100	7.7
lead	2,060	2,250	657	2,430	86	3,130	102	17
nickel	516	563	52.1	523	91	595	96	-5.3
zinc	10,300	11,300	1,980	12,600	103	14,300	109	-5.7

RPD = Relative Percent Difference

Approved by Alyce K. Moore
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/60 (Soil) received August 18, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
acetone[1]	50,000
chlorobenzene	23,000
1,2-dichloroethane	4,500
ethyl benzene	330,000
styrene	56,000
tetrachloroethene	51,000
xylenes (total)	460,000

Remarks: 1,800 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 31.50

Approved by Alyce L. Moore
Laboratory Manager
Title

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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R3/60 & F/HMHO/R3T/60

Concentration units are mg/kg (ppm) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added MS	Conc. Spike Added MSD	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
arsenic	2,470	2,610	523	2,780	91	2,800	87	4.5
cadmium	3,710	3,910	724	4,180	93	4,130	87	6.7
chromium	7,420	7,820	1,480	8,330	92	8,330	88	4.4
copper	55,700	58,600	11,100	68,600	103	69,400	85	19
lead	74,200	78,200	14,600	78,900	87	78,600	82	5.9
nickel	3,090	3,260	641	3,480	92	3,500	88	4.4
zinc	124,000	130,000	24,800	141,000	94	144,000	92	2.2

RPD = Relative Percent Difference

Approved by Alyce K Mason
Laboratory Manager
Title

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PROJECT CODE: ITEC 24820
ORDER NUMBER: 805018 (PEI-3741-7-2)
PAGE 8 OF 51

Sample Description: F/HMHO/R3/10 & F/HMHO/R3T/10

Concentration units are mg/kg (ppm) on a dry weight basis

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added MS	Conc. Spike Added MSD	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
arsenic	38.2	39.7	38.8	81.4	112	84.3	115	-2.6
cadmium	38.2	39.7	286	322	94	645	905*	162
chromium	38.2	39.7	6.2	33.0	70.	40.5	86	-21
copper	38.2	39.7	76.9	94.5	46	127	126	-93
lead	38.2	39.7	16.2	42.2	68	50.6	87	-25
nickel	38.2	39.7	81.5	121	103	161	200	-64
zinc	38.2	39.7	456	473	45	777	808*	-179

RPD = Relative Percent Difference

* = Spike concentration < 4 times the native analyte concentration, therefore QC criteria do not apply.

Approved by: Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 18, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LMHO/R3/10	F/LMHO/R3/10-60	F/LMHO/R3D/10	F/LMHO/R3D/10-6
Arsenic	2.5	6.7	6.5	4.9
Cadmium	6.6	10.6	7.2	11.3
Chromium	2.8	3.2	3.2	2.8
Copper	10.4	37.2	13.3	32.0
Lead	9.8	31.5	10.4	48.7
Nickel	3.1	6.8	7.1	6.7
Zinc	39.6	101	56.2	101
% Moisture	2.97	18.98	3.37	18.45

Approved by Laboratory Manager

Title

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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24820
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 18, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LML0/R3/10	F/LML0/R3/10-60	F/LML0/R3D/10	F/LML0/R3D/10-60
Arsenic	3.6	3.2	2.3	3.9
Cadmium	4.2	9.8	5.3	9.1
Chromium	2.2	2.9	3.2	4.1
Copper	9.4	20.1	8.6	37.0
Lead	8.5	24.2	8.5	39.3
Nickel	3.0	5.2	3.3	8.4
Zinc	23.8	72.3	27.8	152
% Moisture	3.38	16.59	3.15	15.11

Alice F Moore
Approved by

Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Two (2) soil samples received August 18, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMHO/R3/10 & F/HMHO/R3T/10	F/HMHO/R3/10-60 & F/HMHO/R3T/10-60
Arsenic	32.7	105
Cadmium	253	311
Chromium	5.6	30.3
Copper	72.8	390.
Lead	80.8	657
Nickel	14.9	52.1
Zinc	412	1,980
% Moisture	3.94	19.27

Approved by Laboratory Manager

Title

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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Two (2) soil samples received August 18, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMH0/R3D/10	F/HMH0/R3D/10-60
Arsenic	27.2	114
Cadmium	363	362
Chromium	6.2	34.7
Copper	53.4	501
Lead	56.0	979
Nickel	13.1	73.7
Zinc	513	4,090
% Moisture	3.99	18.98

Approved by Laboratory Manager

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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Two (2) soil samples received August 18, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMH0/R3/60 & F/HMH0/R3T/60	F/HMH0/R3D/60
Arsenic	523	552
Cadmium	724	754
Chromium	1,480	1,510
Copper	11,100	11,100
Lead	14,600	15,300
Nickel	641	596
Zinc	24,800	26,000
% Moisture	31.5	37.33

Approved by Alyce L. Moore
Laboratory Manager
Title

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PROJECT CODE ITEC 24820
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 18, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LMH0/R3/60	F/LMH0/R3D/60	F/LML0/R3/60	F/LML0/R3D/60
Arsenic	16.3	21.9	20.1	35.6
Cadmium	22.8	29.7	39.6	35.8
Chromium	41.3	52.3	62.6	50.6
Copper	349	420.	505	450.
Lead	372	468	528	494
Nickel	28.7	34.4	45.1	38.6
Zinc	596	698	917	894
% Moisture	38.07	46.51	46.79	46.41

Approved by Laboratory Manager

Title

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TO IT Corporation
ATTN: Barbara Locke
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Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 39 OF 41

Sample Description: F/LMHO/R1/10-60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	27,000
chlorobenzene	450
1,2-dichloroethane	<310 (290)
ethyl benzene	1,900
styrene	ND
tetrachloroethene	<310 (170)
xylenes (total)	4,600

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.21

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

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Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24756
ORDER NUMBER: 805018 (PEI-3741-7-2)
PAGE 41 OF 41

Sample Description: F/LMH0/R1D/10-60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	12,000
chlorobenzene	110
1,2-dichloroethane	74
ethyl benzene	800
styrene	ND
tetrachloroethene	74
xylenes (total)	1,800

Remarks: 31 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.02

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R1/10 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	16,000
chlorobenzene	27
1,2-dichloroethane	<26 (20.)
ethyl benzene	110
styrene	ND
tetrachloroethene	<26 (8)
xylenes (total)	260

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.49

Approved by Laboratory Manager

Title

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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24756
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R1D/10 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,200
chlorobenzene	28
1,2-dichloroethane	ND
ethyl benzene	150
styrene	ND
tetrachloroethene	<26 (10.)
xylenes (total)	500

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.07

Approved by: Alyce F. Frazier
Laboratory Manager
Title

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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24756
ORDER NUMBER: 805018 (PEI-3741-7-2)
PAGE 35 OF 41

Sample Description: F/HMLO/R1/10-60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,100
chlorobenzene	190
1,2-dichloroethane	<31 (27)
ethyl benzene	1,700
styrene	570
tetrachloroethene	200
xylenes (total)	3,200

Remarks: 31 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 20.19

Approved by

Laboratory Manager
Title

93-9-8

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HML0/R1D/10-60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,300
chlorobenzene	140
1,2-dichloroethane	<31 (21)
ethyl benzene	940
styrene	ND
tetrachloroethene	120
xylenes (total)	1,900

Remarks: 31 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 20.15

Approved by Laboratory Manager

Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 34 OF 41

Sample Description: F/HMLO/R1/10 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	670
chlorobenzene	10.
1,2-dichloroethane	<5 (2)
ethyl benzene	55
styrene	34
tetrachloroethene	<5 (3)
xylenes (total)	120

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.42

Approved by Laboratory Manager

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMLO/R1D/10 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	810
chlorobenzene	6
1,2-dichloroethane	ND
ethyl benzene	24
styrene	18
tetrachloroethene	<5 (1)
xylenes (total)	89

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.70

Approved by Laboratory Manager

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 31 OF 41

Sample Description: P/HMHO/R1/10-60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,700
chlorobenzene	<310 (260)
1,2-dichloroethane	<310 (160)
ethyl benzene	1,400
styrene	ND
tetrachloroethene	<310 (210)
xylenes (total)	3,300

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 18.11

Approved by Alyce L. Moore
Laboratory Manager

Title

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PROJECT CODE ITEC 24756
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PAGE 33 OF 41

Sample Description: P/HMHO/R1D/10-60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	5,400
chlorobenzene	340
1,2-dichloroethane	<62 (20.)
ethyl benzene	2,800
styrene	ND
tetrachloroethene	230
xylenes (total)	5,600

Remarks: 62 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.83

Approved by Laboratory Manager

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 30 OF 41

Sample Description: P/HMHO/R1/10 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,400
chlorobenzene	ND
1,2-dichloroethane	<26 (7)
ethyl benzene	<26 (25)
styrene	29
tetrachloroethene	ND
xylenes (total)	98

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.72

Approved by Laboratory Manager

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 32 OF 41

Sample Description: P/HMHO/R1D/10 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	5,700
chlorobenzene	<26 (7)
1,2-dichloroethane	ND
ethyl benzene	35
styrene	ND
tetrachloroethene	ND
xylenes (total)	76

Remarks: 26 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 5.07

Approved by Laboratory Manager

Title

93-9-85

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R1/60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	150,000
chlorobenzene	130,000
1,2-dichloroethane	19,000
ethyl benzene	1,900,000
styrene	340,000
tetrachloroethene	200,000
xylenes (total)	3,000,000

Remarks: 2,200 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 42.34

Approved by Allyce L. Mace
Laboratory Manager

Title

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Sample Description: F/LMHO/R1D/60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	140,000
chlorobenzene	190,000
1,2-dichloroethane	30,000
ethyl benzene	2,700,000
styrene	470,000
tetrachloroethene	300,000
xylenes (total)	530,000

Remarks: 2,000 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 36.64

Approved by Allyce L. Mason
Laboratory Manager
Title

93-6-65

INTERNATIONAL TECHNOLOGY CORPORATION

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HML0/R1/60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	8,700
chlorobenzene	2,100
1,2-dichloroethane	<550 (120)
ethyl benzene	41,000
styrene	8,400
tetrachloroethene	3,700
xylenes (total)	76,000

Remarks: 550 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 54.49

Approved by Laboratory Manager

Title

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Sample Description: F/HMLO/R1D/60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	24,000
chlorobenzene	1,100
1,2-dichloroethane	<240 (49)
ethyl benzene	27,000
styrene	4,500
tetrachloroethene	2,200
xylenes (total)	41,000

Remarks: 240 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 57.59

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 24 OF 41

Sample Description: P/HMHO/R1/60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	150,000
chlorobenzene	340,000
1,2-dichloroethane	50,000
ethyl benzene	3,300,000 E
styrene	780,000 E
tetrachloroethene	590,000 E
xylenes (total)	240,000

Remarks: 2,900 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
E = Exceeds calibration range; however, values compared well with P/HMHO/R1D/60.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 56.35

Approved by Laboratory Manager

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ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 25 OF 41

Sample Description: P/HMHO/R1D/60 (Soil) received August 6, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	450,000
chlorobenzene	270,000
1,2-dichloroethane	46,000
ethyl benzene	4,600,000
styrene	720,000
tetrachloroethene	450,000
xylenes (total)	6,500,000

Remarks: 57,000 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 55.95

Alyce K. Moore
Approved by Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMHO/R1/10-60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,900,000
bis(2-ethylhexyl)phthalate	110,000
pentachlorophenol	<55,000 (18,000)

Remarks: 55,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 19.21

Approved by Laboratory Manager

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Sample Description: F/LMHO/R1D/10-60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	3,400,000
bis(2-ethylhexyl)phthalate	75,000
pentachlorophenol	<50,000 (34,000)

Remarks: 50,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 19.02

Approved by Laboratory Manager

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 20 OF 41

Sample Description: F/LMHO/R1/10 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<53,000 (9,000)
bis(2-ethylhexyl)phthalate	<53,000 (5,600)
pentachlorophenol	<53,000 (11,000)

Remarks: 53,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.49

Approved by Laboratory Manager

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Sample Description: F/LMHO/R1D/10 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<20,000 (4,000)
bis(2-ethylhexyl)phthalate	<20,000 (2,400)
pentachlorophenol	120,000

Remarks: 20,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.07

Approved by Laboratory Manager

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Sample Description: F/HMLO/R1/10-60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	520,000
bis(2-ethylhexyl)phthalate	<11,000 (9,000)
pentachlorophenol	37,000

Remarks: 11,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 20.19

Approved by Laboratory Manager

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Sample Description: F/HMLO/R1D/10-60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	430,000
bis(2-ethylhexyl)phthalate	<12,000 (5,900)
pentachlorophenol	43,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 20.15

Approved by Laboratory Manager
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Sample Description: F/HMLO/R1/10 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<8,900 (1,300)
bis(2-ethylhexyl)phthalate	<8,900 (2,200)
pentachlorophenol	11,000

Remarks: 8,900 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.42

Approved by
Laboratory Manager
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Sample Description: F/HMLO/R1D/10 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	ND
bis(2-ethylhexyl)phthalate	<10,000 (2,300)
pentachlorophenol	<10,000 (7,400)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.70

Approved by Laboratory Manager

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Sample Description: P/HMHO/R1/10-60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,800,000
bis(2-ethylhexyl)phthalate	63,000
pentachlorophenol	130,000

Remarks: 11,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 18.11

Approved by Laboratory Manager

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/HMHO/R1D/10-60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	3,000,000
bis(2-ethylhexyl)phthalate	54,000
pentachlorophenol	160,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 19.83

Approved by Laboratory Manager

Title

INTERNATIONAL TECHNOLOGY CORPORATION

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5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 12 OF 41

Sample Description: P/HMHO/R1/10 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,600 (5,600)
bis(2-ethylhexyl)phthalate	<9,600 (1,800)
pentachlorophenol	24,000

Remarks: 9,600 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.72

Approved by Laboratory Manager

Title

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PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/HMHO/R1D/10 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,500 (7,200)
bis(2-ethylhexyl)phthalate	<9,500 (3,400)
pentachlorophenol	12,000

Remarks: 9,500 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 5.07

Alyce L. Moore
Approved by
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 10 OF 41

Sample Description: F/LMHO/R1/60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,100,000
bis(2-ethylhexyl)phthalate	2,200,000
pentachlorophenol	<80,000 (52,000)

Remarks: 80,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 42.34

Approved by Alyce K. Moore
Laboratory Manager

Title

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ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 11 OF 41

Sample Description: F/LMHO/R1D/60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	800,000
bis(2-ethylhexyl)phthalate	1,100,000
pentachlorophenol	<70,000 (54,000)

Remarks: 70,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 36.64

Approved by Laboratory Manager

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PAGE 8 OF 41

Sample Description: F/HMLO/R1/60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (ug/kg dry weight)
anthracene	1,700,000
bis(2-ethylhexyl)phthalate	980,000
pentachlorophenol	44,000

Remarks: 38,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 54.49

Approved by Laboratory Manager

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PAGE 9 OF 41

Sample Description: F/HMLO/R1D/60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,900,000
bis(2-ethylhexyl)phthalate	1,200,000
pentachlorophenol	<120,000 (74,000)

Remarks: 120,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 57.59

Approved by Laboratory Manager

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ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 6 OF 41

Sample Description: P/HMHO/R1/60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	9,000,000
bis(2-ethylhexyl)phthalate	6,200,000
pentachlorophenol	520,000

Remarks: 220,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 56.35

Approved by Laboratory Manager

Title

93-9-85

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/HMHO/R1D/60 (Soil) received August 6, 1987

SEMIVOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	7,600,000
bis(2-ethylhexyl)phthalate	5,200,000
pentachlorophenol	<390,000 (350,000)

Remarks: 390,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 55.95

Approved by Laboratory Manager

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 6, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMLO/R1D/10	F/HMLO/R1D/10-60	F/LMHO/R1/10	F/LMHO/R1/10-60
Arsenic	51.8	89.3	2.7	7.0
Cadmium	342	283	6.3	11.9
Chromium	4.3	15.3	0.94	3.1
Copper	82.9	254	9.0	31.3
Lead	128	424	11.7	27.7
Nickel	23.5	43.8	2.5	8.9
Zinc	564	1,120	42.0	94.6
% Moisture	4.70	20.15	4.49	19.21

Approved by
Laboratory Manager
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Sample Description: Two (2) soil samples received August 6, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LMHO/R1D/10	F/LMHO/R1D/10-60
Arsenic	3.3	3.3
Cadmium	8.3	10.7
Chromium	2.1	2.1
Copper	12.3	29.7
Lead	10.5	29.9
Nickel	3.8	6.7
Zinc	47.5	117
% Moisture	4.07	19.02

Approved by Laboratory Manager

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 6, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LMH0/R1/60	F/LMH0/R1D/60	P/HMH0/R1/10	P/HMH0/R1/10-60
Arsenic	21.2	16.1	100.	112
Cadmium	32.8	24.9	303	309
Chromium	52.5	34.4	3.7	63.4
Copper	462	312	122	813
Lead	470.	333	146	1,520
Nickel	41.8	28.4	26.0	129
Zinc	853	599	706	8,430
% Moisture	42.34	36.64	4.72	18.11

Approved by
Laboratory Manager
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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 6, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/HMHO/R1D/10	P/HMHO/R1D/10-60	F/HMLO/R1/10	F/HMLO/R1/10-60
Arsenic	36.9	108	57.5	114
Cadmium	337	273	402	270.
Chromium	3.7	45.5	3.4	14.3
Copper	71.7	673	54.0	273
Lead	85.1	1,040	115	558
Nickel	16.1	96.5	13.6	40.7
Zinc	465	6,420	553	906
% Moisture	5.07	19.83	4.42	20.19

Approved by Laboratory Manager

Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24776
ORDER NUMBER 805018 (PEI-3741-7-2)
PAGE 41 OF 41

Sample Description: F/HMHO/R2D/10-60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,000,000
bis(2-ethylhexyl)phthalate	<110,000 (89,000)
pentachlorophenol	<110,000 (20,000)

Remarks: 110,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 19.28

Approved by Alyce K. Moore
Laboratory Manager

Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24756
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 6, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	P/HMHO/R1/60	P/HMHO/R1D/60	F/HMLO/R1/60	F/HMLO/R1D/60
Arsenic	957	901	984	1,330
Cadmium	659	644	643	850.
Chromium	2,260	2,100	2,200	2,980
Copper	23,300	20,700	17,900	23,600
Lead	25,100	22,600	26,000	35,100
Nickel	1,370	1,270	1,340	1,800
Zinc	37,600	34,300	42,200	54,200
% Moisture	56.35	55.95	54.49	57.59

Approved by: Alyce K. Tinnea
Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R2D/10 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	27,000
bis(2-ethylhexyl)phthalate	<19,000 (5,300)
pentachlorophenol	<19,000 (9,800)

Remarks: 19,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 1.90

Alyce K. Moore
Approved by
Laboratory Manager
Title

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Sample Description: F/HMHO/R2/10-60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,400,000
bis(2-ethylhexyl)phthalate	<100,000 (52,000)
pentachlorophenol	<100,000 (25,000)

Remarks: 100,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 11.35

Approved by Alice K. Tracy
Laboratory Manager
Title

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Sample Description: F/HMLO/R2D/10-60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	350,000
bis(2-ethylhexyl)phthalate	<25,000 (5,700)
pentachlorophenol	<25,000 (8,700)

Remarks: 25,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 21.30

Approved by Alyce K. Moore
Laboratory Manager
Title

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SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	54,000
bis(2-ethylhexyl)phthalate	<18,000 (14,000)
pentachlorophenol	<18,000 (6,900)

Remarks: 18,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 5.50

Alyce K. Moore
Approved by
Laboratory Manager
Title

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SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,900 (1,400)
bis(2-ethylhexyl)phthalate	<9,900 (2,500)
pentachlorophenol	<9,900 (3,700)

Remarks: 9,900 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.20

Approved by Laboratory Manager

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Sample Description: F/HML0/R2/10-60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	720,000
bis(2-ethylhexyl)phthalate	<22,000 (13,000)
pentachlorophenol	<22,000 (18,000)

Remarks: 22,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 21.93

Approved by Laboratory Manager

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Sample Description: F/LML0/R2D/10-60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	320,000
bis(2-ethylhexyl)phthalate	37,000
pentachlorophenol	<12,000 (3,400)

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 18.65

Approved by Alyce K. Moore
Laboratory Manager
Title

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Sample Description: F/HML0/R2/10 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,600 (2,000)
bis(2-ethylhexyl)phthalate	<9,600 (4,400)
pentachlorophenol	ND

Remarks: 9,600 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.98

Approved by Alyce K Thrasher
Laboratory Manager
Title

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Sample Description: F/LML0/R2D/10 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<9,300 (3,500)
bis(2-ethylhexyl)phthalate	44,000
pentachlorophenol	ND

Remarks: 9,300 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.68

Approved by Alyce L. Moore
Laboratory Manager
Title

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Sample Description: F/LML0/R2/10-60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	97,000
bis(2-ethylhexyl)phthalate	52,000
pentachlorophenol	<14,000 (6,800)

Remarks: 14,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 35.09

Approved by: Laboratory Manager

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Sample Description: F/HMHO/R2D/60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	3,300,000
bis(2-ethylhexyl)phthalate	2,400,000
pentachlorophenol	ND

Remarks: 350,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 44.39

Approved by Alyce F. Rose
Laboratory Manager
Title

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Sample Description: F/LMLO/R2/10 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<21,000 (14,000)
bis(2-ethylhexyl)phthalate	37,000
pentachlorophenol	ND

Remarks: 21,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.00

Approved by Laboratory Manager
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Sample Description: F/HML0/R2D/60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,500,000
bis(2-ethylhexyl)phthalate	800,000
pentachlorophenol	ND

Remarks: 190,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 55.94

Approved by Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24776
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: F/HMHO/R2/60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	3,300,000
bis(2-ethylhexyl)phthalate	3,300,000
pentachlorophenol	<41,000 (4,300)

Remarks: 41,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 53.26

Approved by
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24776
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LML0/R2D/60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	1,100,000
bis(2-ethylhexyl)phthalate	370,000
pentachlorophenol	ND

Remarks: 210,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 55.46

Alyce K. Moore
Approved by
Laboratory Manager
Title

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Sample Description: F/HMLO/R2/60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,200,000
bis(2-ethylhexyl)phthalate	780,000
pentachlorophenol	<20,000 (2,400)

Remarks: 20,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 50.75

Approved by Laboratory Manager
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ORDER NUMBER: 805018 (PEI-3741-7-2)
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Sample Description: F/HMHO/R2D/10-60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	9,500
chlorobenzene	1,400
1,2-dichloroethane	ND
ethyl benzene	13,000
styrene	ND
tetrachloroethene	1,500
xylenes (total)	23,000

Remarks: 310 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 19.28

Approved by Alyce K. Meade
Laboratory Manager
Title

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PROJECT CODE ITEC 24776
ORDER NUMBER 805018 (PEI-3741-7-2)
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Sample Description: F/LML0/R2/60 (Soil) received August 10, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	230,000
bis(2-ethylhexyl)phthalate	140,000
pentachlorophenol	ND

Remarks: 16,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 45.89

Approved by
Laboratory Manager
Title

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Sample Description: F/HMHO/R2D/10 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	25,000
chlorobenzene	20.
1,2-dichloroethane	ND
ethyl benzene	84
styrene	47
tetrachloroethene	10.
xylenes (total)	190

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 1.90

Approved by Allyce K. Moore
Laboratory Manager
Title

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Sample Description: F/HMHO/R2/10-60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	32,000
chlorobenzene	1,400
1,2-dichloroethane	780
ethyl benzene	12,000
styrene	ND
tetrachloroethene	1,400
xylenes (total)	23,000

Remarks: 280 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 11.35

Approved by: Alyce L. Moore
Laboratory Manager
Title

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Sample Description: F/HMLO/R2D/10-60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,500
chlorobenzene	180
1,2-dichloroethane	25
ethyl benzene	1,500
styrene	390
tetrachloroethene	200
xylenes (total)	2,600

Remarks: 13 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 21.30

Approved by Alyce K. Moore
Laboratory Manager
Title

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Sample Description: F/HMHO/R2/10 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	6,100
chlorobenzene	<5 (4)
1,2-dichloroethane	<5 (2)
ethyl benzene	18
styrene	ND
tetrachloroethene	<5 (2)
xylenes (total)	35

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 5.50

Approved by Alyce K. Thomas
Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMLO/R2D/10 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	410
chlorobenzene	8
1,2-dichloroethane	<5 (3)
ethyl benzene	30.
styrene	ND
tetrachloroethene	<5 (4)
xylenes (total)	72

Remarks:
5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.20

Approved by Alyce L. Moore
Laboratory Manager
Title

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Sample Description: F/HMLO/R2/10-60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,800
chlorobenzene	280
1,2-dichloroethane	43
ethyl benzene	2,600
styrene	710
tetrachloroethene	260
xylenes (total)	4,600

Remarks: 6 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 21.93

Approved by Laboratory Manager

Title

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PROJECT CODE ITEC 24776
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PAGE 15 OF 41

Sample Description: F/LML0/R2D/10-60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,300
chlorobenzene	<6 (5)
1,2-dichloroethane	<6 (3)
ethyl benzene	26
styrene	33
tetrachloroethene	<6 (2)
xylenes (total)	110

Remarks: 6 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 18.65

Approved by Alyce L. Moore
Laboratory Manager
Title

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Sample Description: F/HMLO/R2/10 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	1,500
chlorobenzene	14
1,2-dichloroethane	<5 (1)
ethyl benzene	77
styrene	ND
tetrachloroethene	8
xylenes (total)	110

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.98

Approved by Laboratory Manager
Title

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Sample Description: F/LML0/R2D/10 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	650
chlorobenzene	<5 (2)
1,2-dichloroethane	ND
ethyl benzene	6
styrene	8
tetrachloroethene	ND
xylenes (total)	26

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 3.68

Approved by Alyce R. Moore
Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LML0/R2/10-60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µ g/kg dry weight)
acetone[1]	1,000
chlorobenzene	8
1,2-dichloroethane	<8 (3)
ethyl benzene	91
styrene	100
tetrachloroethene	<8 (5)
xylenes (total)	300

Remarks: 8 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 35.09

Approved by Alyce K. Tiedt
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/HMH0/R2D/60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	200,000
chlorobenzene	48,000
1,2-dichloroethane	49,000
ethyl benzene	600,000
styrene	120,000
tetrachloroethene	94,000
xylenes (total)	1,000,000

Remarks: 2,200 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 44.39

Approved by: Laboratory Manager
Title

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Sample Description: F/LML0/R2/10 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	520
chlorobenzene	ND
1,2-dichloroethane	ND
ethyl benzene	<5 (4)
styrene	ND
tetrachloroethene	ND
xylenes (total)	16

Remarks: 5 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 4.00

Alyce K. Moore
Approved by
Laboratory Manager
Title

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Sample Description: F/HMLO/R2D/60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,300
chlorobenzene	740
1,2-dichloroethane	<110 (48)
ethyl benzene	17,000
styrene	2,500
tetrachloroethene	1,600
xylenes (total)	25,000

Remarks: 110 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 55.94

Approved by Allyce L. Moore
Laboratory Manager
Title

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Sample Description: F/HMHO/R2/60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	170,000
chlorobenzene	150,000
1,2-dichloroethane	32,000
ethyl benzene	1,500,000
styrene	270,000
tetrachloroethene	240,000
xylenes (total)	2,400,000

Remarks: 2,700 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 53.26

Approved by: Laboratory Manager
Title

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/kg
98. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
99. Dibenz(a,h)anthracene	53-70-3	10	330
100. Benzo(g,h,i)perylene	191-24-2	10	330

[c]Medium Water Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[d]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 60 times the individual Low Soil/Sediment CRDL.

Pesticides	CAS Number	Detection Limits* Low Water[e] ug/L	Low Soil/Sediment[f] ug/Kg
101. alpha-BHC	319-84-6	0.05	8.0
102. beta-BHC	319-85-7	0.05	8.0
103. delta-BHC	319-86-8	0.05	8.0
104. gamma-BHC (Lindane)	58-89-9	0.05	8.0
105. Heptachlor	76-44-8	0.05	8.0
106. Aldrin	309-00-2	0.05	8.0
107. Heptachlor Epoxide	1024-57-3	0.05	8.0
108. Endosulfan I	959-98-8	0.05	8.0
109. Dieldrin	60-57-1	0.10	16.0
110. 4,4'-DDE	72-55-9	0.10	16.0
111. Endrin	72-20-8	0.10	16.0
112. Endosulfan II	33213-65-9	0.10	16.0
113. 4,4'-DDD	72-54-8	0.10	16.0
114. Endosulfan Sulfate	1031-07-8	0.10	16.0
115. 4,4'-DDT	50-29-3	0.10	16.0
116. Endrin Ketone	53494-70-5	0.10	16.0
117. Methoxychlor	72-43-5	0.5	80.0
118. Chlordane	57-74-9	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. AROCLOR-1016	12674-11-2	0.5	80.0
121. AROCLOR-1221	11104-28-2	0.5	80.0
122. AROCLOR-1232	11141-16-5	0.5	80.0
123. AROCLOR-1242	53469-21-9	0.5	80.0
124. AROCLOR-1248	12672-29-6	0.5	80.0
125. AROCLOR-1254	11097-69-1	1.0	160.0
126. AROCLOR-1260	11096-82-5	1.0	160.0

[e]Medium Water Contract Required Detection Limits (CRDL) for Pesticide HSL Compounds are 100 times the individual Low Water CRDL.

[f]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Pesticide HSL compounds are 15 times the individual Low Soil/Sediment CRDL.

*Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, as required by the contract, will be higher.

** Specific detection limits are highly matrix dependent. The detection limits listed herein are provided for guidance and may not always be achievable.

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/kg
36. Phenol	108-95-2	10	330
37. bis(2-Chloroethyl) ether	111-44-4	10	330
38. 2-Chlorophenol	95-57-8	10	330
39. 1,3-Dichlorobenzene	541-73-1	10	330
40. 1,4-Dichlorobenzene	106-46-7	10	330
41. Benzyl Alcohol	100-51-6	10	330
42. 1,2-Dichlorobenzene	95-50-1	10	330
43. 2-Methylphenol	95-48-7	10	330
44. bis(2-Chloroisopropyl) ether	39638-32-9	10	330
45. 4-Methylphenol	106-44-5	10	330
46. N-Nitroso-Dipropylamine	621-64-7	10	330
47. Hexachloroethane	67-72-1	10	330
48. Nitrobenzene	98-95-3	10	330
49. Isophorone	78-59-1	10	330
50. 2-Nitrophenol	88-75-5	10	330
51. 2,4-Dimethylphenol	105-67-9	10	330
52. Benzoic Acid	65-85-0	50	1600
53. bis(2-Chloroethoxy) methane	111-91-1	10	330
54 2,4-Dichlorophenol	120-83-2	10	330
55. 1,2,4-Trichlorobenzene	120-82-1	10	330
56. Naphthalene	91-20-3	10	330
57. 4-Chloroaniline	106-47-8	10	330
58. Hexachlorobutadiene	87-68-3	10	330
59. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
60. 2-Methylnaphthalene	91-57-6	10	330
61. Hexachlorocyclopentadiene	77-47-4	10	330
62. 2,4,6-Trichlorophenol	88-06-2	10	330
63. 2,4,5-Trichlorophenol	95-95-4	50	1600

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[c] ug/kg
64. 2-Chloronaphthalene	91-58-7	10	330
65. 2-Nitroaniline	88-74-4	50	1600
66. Dimethyl Phthalate	131-11-3	10	330
67. Acenaphthylene	208-96-8	10	330
68. 3-Nitroaniline	99-09-2	50	1600
69. Acenaphthene	83-32-9	10	330
70. 2,4-Dinitrophenol	51-28-5	50	1600
71. 4-Nitrophenol	100-02-7	50	1600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-Dinitrotoluene	121-14-2	10	330
74. 2,6-Dinitrotoluene	606-20-2	10	330
75. Diethylphthalate	84-66-2	10	330
76. 4-Chlorophenyl Phenyl ether	7005-72-3	10	330
77. Fluorene	86-73-7	10	330
78. 4-Nitroaniline	100-01-6	50	1600
79. 4,6-Dinitro-2-methylphenol	534-52-1	50	1600
80. N-nitrosodiphenylamine	86-30-6	10	330
81. 4-Bromophenyl Phenyl ether	101-55-3	10	330
82. Hexachlorobenzene	118-74-1	10	330
83. Pentachlorophenol	87-86-5	50	1600
84. Phenanthrene	85-01-8	10	330
85. Anthracene	120-12-7	10	330
86. Di-n-butylphthalate	84-74-2	10	330
87. Fluoranthene	206-44-0	10	330
88. Pyrene	129-00-0	10	330
89. Butyl Benzyl Phthalate	85-68-7	10	330
90. 3,3'-Dichlorobenzidine	91-94-1	20	660
91. Benzo(a)anthracene	56-55-3	10	330
92. bis(2-ethylhexyl)phthalate	117-81-7	10	330
93. Chrysene	218-01-9	10	330
94. Di-n-octyl Phthalate	117-84-0	10	330
95. Benzo(b)fluoranthene	205-99-2	10	330
96. Benzo(k)fluoranthene	207-08-9	10	330
97. Benzo(a)pyrene	50-32-8	10	330

ATTACHMENT A

Hazardous Substance List (HSL) and
Contract Required Detection Limits (CRDL)**

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-35-3	5	5
10. trans-1,2-Dichloroethene	156-60-5	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,1,2,2-Tetrachloroethane	79-34-5	5	5
19. 1,2-Dichloropropane	78-87-5	5	5
20. trans-1,3-Dichloropropene	10061-02-6	5	5
21. Trichloroethene	79-01-6	5	5
22. Dibromochloromethane	124-48-1	5	5
23. 1,1,2-Trichloroethane	79-00-5	5	5
24. Benzene	71-43-2	5	5
25. cis-1,3-Dichloropropene	10061-01-5	5	5

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
26. 2-Chloroethyl Vinyl Ether	110-75-8	10	10
27. Bromoform	75-25-2	5	5
28. 2-Hexanone	591-78-6	10	10
29. 4-Methyl-2-pentanone	108-10-1	10	10
30. Tetrachloroethene	127-18-4	5	5
31. Toluene	108-88-3	5	5
32. Chlorobenzene	108-90-7	5	5
33. Ethyl Benzene	100-41-4	5	5
34. Styrene	100-42-5	5	5
35. Total Xylenes		5	5

[a]Medium Water Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[b]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Soil/Sediment CRDL.

ATTACHMENT A

HAZARDOUS SUBSTANCE LIST
AND
EPA ANALYTICAL METHODS

The organics would be determined using methods 8240, 8270, and 8080 from the third edition of SW-846. This target list and methodology is essentially the same as that currently used for EPA's Contract Laboratory Program (CLP). Data summaries, but not a full CLP data package, would be supplied.

HSL metals would be determined using method 7060 for arsenic, 7471, for mercury, 7740 for selenium, and 6010 for the other 23 HSL metals. These methods are not the current CLP protocol, but will produce data of equivalent quality.

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO IT Corporation
ATTN: Barbara Locke
11499 Chester Road
Cincinnati, OH 45246

DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24776
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: F/LMLO/R2D/60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	4,500
chlorobenzene	25
1,2-dichloroethane	<11 (4)
ethyl benzene	150
styrene	150
tetrachloroethene	11
xylenes (total)	520

Remarks: 11 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 55.46

Approved by Laboratory Manager
Title

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Sample Description: F/HMLO/R2/60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	2,300
chlorobenzene	1,600
1,2-dichloroethane	ND
ethyl benzene	22,000
styrene	3,600
tetrachloroethene	2,700
xylenes (total)	37,000

Remarks: 51 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 50.75

Approved by Alyce K. Tiedge
Laboratory Manager
Title

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PROJECT CODE. ITEC 24776
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Two (2) soil samples received August 10, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMHO/R2D/10	F/HMHO/R2D/10-60
Arsenic	74.4	89.8
Cadmium	387	212
Chromium	6.4	29.6
Copper	91.8	310
Lead	117	314
Nickel	20.5	51.5
Zinc	628	2,690
% Moisture	1.90	19.28

Approved by Alyce L. Moore Laboratory Manager

Title

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Sample Description: F/LML0/R2/60 (Soil) received August 10, 1987

VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
acetone[1]	880
chlorobenzene	14
1,2-dichloroethane	<9 (2)
ethyl benzene	110
styrene	100
tetrachloroethene	<9 (7)
xylenes (total)	360

Remarks: 9 = Quantitation Limit
ND = Not detected
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.
[1] = This component has a quantitation limit two (2) times that listed.

% Moisture = 45.89

Approved by Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 10, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LML0/R2D/10	F/LML0/R2D/10-60	F/HML0/R2/10	F/HML0/R2/10-60
Arsenic	2.9	4.0	22.1	54.6
Cadmium	2.2	2.7	411	114
Chromium	1.9	3.0	2.4	10.1
Copper	9.9	13.0	32.2	112
Lead	7.0	10.6	63.2	130.
Nickel	4.7	5.9	17.3	29.3
Zinc	33.8	52.7	554	577
% Moisture	3.68	18.65	3.98	21.93

Approved by Alyce K. Moore
Laboratory Manager
Title

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Sample Description: Four (4) soil samples received August 10, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMLO/R2D/10	F/HMLO/R2D/10-60	F/HMHO/R2/10	F/HMHO/R2/10-60
Arsenic	51.1	47.5	52.3	93.6
Cadmium	168	119	171	208
Chromium	3.9	8.4	6.3	29.9
Copper	45.1	96.4	69.3	354
Lead	133	212	88.1	231
Nickel	17.7	27.1	18.2	89.9
Zinc	445	461	488	6,770
% Moisture	4.20	21.30	5.50	11.35

Approved by Alice K. Moore
Laboratory Manager
Title

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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 10, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/LML0/R2/60	F/LML0/R2D/60	F/HML0/R2/60	F/HML0/R2D/60
Arsenic	13.9	11.4	197	289
Cadmium	5.4	9.6	106	115
Chromium	33.4	106	1,450	2,420
Copper	135	342	1,920	2,580
Lead	66.3	154	1,400	1,540
Nickel	23.5	62.6	374	570
Zinc	324	769	5,450	8,080
% Moisture	45.89	55.46	50.75	55.94

Approved by Alyce R. Moore
Laboratory Manager
Title

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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: Four (4) soil samples received August 10, 1987

Concentration units are mg/kg (ppm) on a dry weight basis

	F/HMHO/R2/60	F/HMHO/R2D/60	F/LMLO/R2/10	F/LMLO/R2/10-60
Arsenic	166	193	4.9	4.8
Cadmium	114	99.4	1.9	5.4
Chromium	1,260	1,700	1.2	3.7
Copper	2,050	1,930	6.6	18.1
Lead	1,430	1,280	5.5	14.5
Nickel	262	305	3.8	8.2
Zinc	5,260	5,060	22.8	74.4
% Moisture	53.26	44.39	4.00	35.09

Approved by Laboratory Manager

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DATE REPORTED September 30, 1987
PROJECT CODE ITEC 24749
ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/HMLO/R1/10-60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	420,000
bis(2-ethylhexyl)phthalate	17,000
pentachlorophenol	48,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 16.48

Approved by Laboratory Manager

Title

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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: P/HMLO/R1D/10-60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	590,000
bis(2-ethylhexyl)phthalate	<12,000 (9,200)
pentachlorophenol	41,000

Remarks: 12,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 17.89

Approved by: Laboratory Manager
Title

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Sample Description: P/HMLO/R1/10 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	15,000
bis(2-ethylhexyl)phthalate	<9,700 (4,900)
pentachlorophenol	<9,700 (4,600)

Remarks: 9,700 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 5.24

Approved by Alyce K. Mikac
Laboratory Manager
Title

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Sample Description: P/HMLO/R1D/10 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	<10,000 (8,500)
bis(2-ethylhexyl)phthalate	<10,000 (3,000)
pentachlorophenol	<10,000 (3,300)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 5.18

Approved by
Laboratory Manager
Title

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DATE REPORTED: September 30, 1987
PROJECT CODE: ITEC 24749
ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1/10-60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	2,600,000
bis(2-ethylhexyl)phthalate	1,100,000
pentachlorophenol	160,000

Remarks: 11,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 16.50

Approved by: Alyce L. Moore
Laboratory Manager
Title

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Sample Description: P/LMHO/R1D/10-60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	4,900,000
bis(2-ethylhexyl)phthalate	1,700,000
pentachlorophenol	<100,000 (57,000)

Remarks: 100,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 17.16

Approved by Laboratory Manager

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DATE REPORTED: September 30, 1987
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ORDER NUMBER: 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1/10 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	27,000
bis(2-ethylhexyl)phthalate	<10,000 (4,300)
pentachlorophenol	<10,000 (9,900)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 4.57

Approved by
Laboratory Manager
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DATE REPORTED September 30, 1987
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ORDER NUMBER 805018 (PEI-3741-7-2)

Sample Description: P/LMHO/R1D/10 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	50,000
bis(2-ethylhexyl)phthalate	12,000
pentachlorophenol	40,000

Remarks: 9,200 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 2.91

Approved by

Laboratory Manager
Title

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Sample Description: P/LML0/R1/10-60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	44,000
bis(2-ethylhexyl)phthalate	42,000
pentachlorophenol	<11,000 (6,700)

Remarks: 11,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 14.37

Approved by Laboratory Manager

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Sample Description: P/LMLO/R1D/10-60 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	77,000
bis(2-ethylhexyl)phthalate	58,000
pentachlorophenol	<11,000 (7,800)

Remarks: 11,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 14.48

Approved by
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Sample Description: P/LMLO/R1/10 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	ND
bis(2-ethylhexyl)phthalate	44,000
pentachlorophenol	ND

Remarks: 9,700 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.

% Moisture = 5.19

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Sample Description: P/LMLO/R1D/10 (Soil) received August 5, 1987

SEMI-VOLATILE ORGANIC ANALYSIS

Compound	Concentration (µg/kg dry weight)
anthracene	ND
bis(2-ethylhexyl)phthalate	23,000
pentachlorophenol	<10,000 (2,200)

Remarks: 10,000 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit. Values in parenthesis are estimated.

% Moisture = 3.78

Approved by Laboratory Manager

Title