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Alternative Biological Treatment Processes for Remediation of Creosote- and PCP-Contaminated Materials

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Preface

The abandoned American Creosote Works at Pensacola, Florida, used creosote as a wood preservative from 1902 until 1950, then a mixture of creosote, pentachlorophenol (PCP) and copper-chromium arsenate (CCA) from 1950 until its closure in 1981. Improper disposal of wastes resulted in extensive contamination of surface soil and the shallow groundwater aquifer at this site. In September 1989, bioremediation was selected to ameliorate surface soils contaminated with creosote and PCP.

To determine the most effective approach to bioremediation of contaminated sediments and surface soil (i.e., slurry phase vs. solid phase), the Microbial Ecology and Biotechnology Branch of the U.S. EPA Environmental Research Laboratory at Gulf Breeze Florida (GBERL) was commissioned in February 1990 to perform bench-scale biotreatability studies. This work was performed as part of a Cooperative Research and Development Agreement between the Gulf Breeze Environmental Research Laboratory and Southern Bio Products, Inc., (Atlanta, GA) as defined under the Federal Technology Transfer Act, 1986 (contract no. FTTA-003). Results and conclusions of these studies have contributed to the selection of an efficient, cost-effective remedial technology.

Abstract

Bench-scale biotreatability studies were performed to determine the most effective of two bioremediation application strategies to ameliorate creosote- and pentachlorophenol (PCP)-contaminated soils present at the American Creosote Works Superfund site, Pensacola, Florida: solid-phase bioremediation or slurry-phase bioremediation. When indigenous microorganisms were employed as biocatalysts, solid-phase bioremediation was slow and ineffective (8-12 weeks required to biodegrade >50% of resident organics). Biodegradation was limited to lower-molecular-weight constituents rather than the more hazardous, higher-molecular-weight (HMW) compounds); PCP and HMW polycyclic aromatic hydrocarbons (PAHs) containing 4 or more fused rings resisted biological attack. Moreover, supplementation with aqueous solution of inorganic nutrients had little effect on the overall effectiveness of the treatment strategy. Alternatively, slurry-phase bioremediation was much more effective: >50% of targeted organics were biodegraded in 14 days. Again, however, more persistent contaminants, such as PCP and HMW PAHs, were not degraded when subjected to the action of indigenous microorganisms.

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This work was performed as part of a Cooperative Research and Development Agreement between the Gulf Breeze Environmental Research Laboratory and Southern Bio Products, Inc., (Atlanta, GA) as defined under the Federal Technology Transfer Act, 1986 (Contract No. FTTA-003).

1. Introduction

1.1 Purpose

The Microbial Ecology and Biotechnology Branch of the U.S. Environmental Protection Agency's Environmental Research Laboratory at Gulf Breeze, Florida (GBERL) performed bench-scale biotreatability studies to help delineate the most applicable approach for remediation of creosote-contaminated surface soils at the American Creosote Works Superfund site, Pensacola, Florida. Two approaches were evaluated: 1) solid-phase bioremediation (land farming), and 2) slurry-phase bioremediation. This document presents performance data generated at the bench-scale level.

1.2 Test Objectives

The primary objective of these studies was to generate bench-scale performance data on two approaches to the bioremediation of PCP- and creosote-contaminated sediment (material beneath the solidified sludge) and surface soil (Operable Unit 1). The two approaches evaluated were: 1) solid-phase bioremediation (land farming), and 2) slurry-phase bioremediation. In addition, preliminary studies were performed to evaluate the potential applicability of biological treatment processes to ameliorate PCP- and creosote-contaminated solidified material and groundwater also present at this site (Operable Unit 2). These data will be used to help delineate the most applicable approach for surface soil bioremediation.

1.3 Site Description

The American Creosote Works site (ACW) at Pensacola, Florida is an 18 acre (7.3 ha) abandoned wood-preserving facility located approximately 600 yards (550 m) north of Pensacola Bay near the entrance of Bayou Chico (Figure 1.1). This plant used creosote as a wood preservative from 1902 until 1950, then a mixture of creosote, pentachlorophenol (PCP) and copper-chromium-arsenic (CCA) from 1950 until its closure in December 1981. Improper disposal of creosote- and PCP-contaminated waste resulted in extensive contamination of surface soil and the shallow groundwater aquifer at this site.

1.4 Site History

In March 1980, considerable quantities of "oily/asphaltic/creosotic material" were found by the City of Pensacola in the groundwater near the intersection of L and Cypress streets. In July 1981, the U.S. Geological Survey installed nine groundwater monitoring wells in the vicinity of the ACW site. Data from these studies led to a decision to close this site in December 1981.

In February 1983, the Site Screening Section of EPA Region IV (Atlanta, GA) conducted a Superfund investigation which included sampling and analysis of on-site soils, wastewater sludges, sediment in drainage ditches, and on-site and off-site groundwater monitoring wells. Because of the threat posed to human and environmental health by frequent overflows from waste ponds located at this site, the U.S. EPA Region IV Emergency Response and Control Section performed an immediate cleanup during September and October, 1983.

A Remedial Investigation/Feasibility Study (RI/FS) under CERCLA was completed by EPA Region IV in 1985. Based on these studies, EPA signed a Record of Decision (ROD) in September 1985, which specified that all on-site and off-site contaminated soils, sludges, and sediments be placed in an on-site RCRA-type landfill. However, the state of Florida was not in agreement with the ROD developed at that time. Consequently, a Post-RI was conducted by EPA Region IV Environmental Services Division (ESD) to identify, develop, and evaluate alternatives for remediation at this site. These studies were completed in August 1989 at which time a proposed plan outlining these alternatives was presented to the public.

In September 1989, a second ROD was adopted which organized the remedial work into two discrete operable units: 1) surface soil remediation, and 2) remediation of contaminated groundwater, solidified material, and underlying sediment. Biological treatment (bioremediation) was selected as the most appropriate technology for operable unit 1 (the second Operable Unit is undergoing additional study to better define the applicability of various remediation alternatives).

To determine the most effective approach to bioremediation of contaminated sediments and surface soils (i.e., slurry phase vs. solid phase), the Microbial Ecology and Biotechnology Branch of the U.S. EPA's Environmental Research Laboratory at Gulf Breeze Florida (GBERL) was commissioned in February 1990 to perform bench-scale biotreatability studies. This document reports the results and conclusions of these studies.

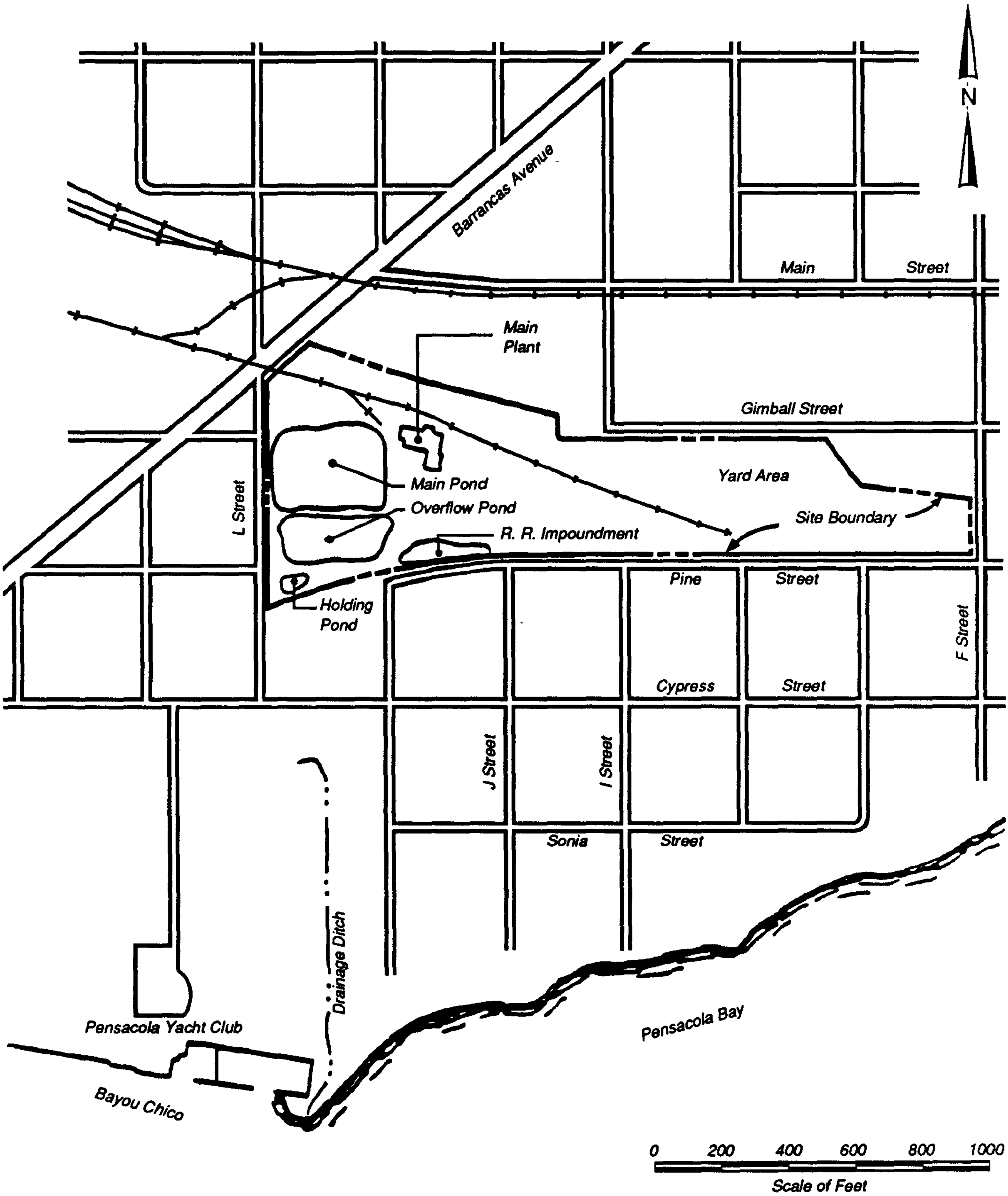

Figure 1.1 *Site layout, American Creosote Works, Superfund site, Pensacola, Florida.*

2. Remedial Technology Description

2.1 Biological Treatment

Bioremediation describes the process whereby organic wastes are biologically degraded under controlled conditions to an innocuous state, or to levels below concentration limits established by law. Biological catalysts used to facilitate this process can include indigenous microbes and/or specially selected microbial inocula. Characteristics of the ACW site (e.g., nature of contaminants, soil type, climate) make it amenable to bioremediation. Hence, bioremediation has been chosen as the treatment technology for Operable Unit 1 (surface soil remediation). However, the exact means through which bioremediation will be employed to restore these materials remains to be defined (this study).

2.1.a Solid-Phase Bioremediation

Solid-phase bioremediation (land farming) is a process that treats contaminated soils in an above-ground system using conventional soil management practices (i.e., tilling, irrigation, fertilization) to enhance the microbial degradation of contaminants. These systems can be designed to reduce abiotic losses of targeted contaminants through processes such as leaching and volatilization. Bench-scale treatability studies described herein have assessed the significance of these processes, and have considered the extent to which they affect the overall performance of solid-phase bioremediation of creosote-and PCP-contaminated sediment and surface soil from the ACW site.

Solid-phase bioremediation has been reportedly used to treat PCP and creosote wastes, oil field and refinery sludges, petroleum products and pesticide wastewaters. While the process is claimed to be effective in treating creosote-contaminated soils, existing data show that the more recalcitrant contaminants (i.e., higher-molecular-weight PAHs and highly chlorinated aromatics) tend to persist. Unfortunately, these same compounds are responsible for a number of the potential adverse effects on environmental and human health.

2.1.b Slurry-Phase Bioremediation

Slurry-phase bioremediation involves the treatment of contaminated solid materials (soil, sediment, sludge) in a bioreactor. Bioreactors can be specially designed in a variety of configurations to accommodate the physical and chemical characteristics of the targeted pollutant(s). Bioreactors can contain indigenous microbes, or they may be inoculated with specially selected microorganisms capable of rapidly and extensively degrading targeted pollutants. In general, the rate and extent of biodegradation is more manageable with bioreactors than with solid-phase biotreatment processes because bioreactors facilitate mixing and intimate contact of microorganisms with targeted pollutants, and they maintain environmental conditions (pH, dissolved oxygen, nutrients, substrate bioavailability, *etc.*) optimum for the biodegradation processes.

While slurry-phase bioremediation systems have been reported to be effective in treating creosote-contaminated soils, the activity of the microorganisms housed in these reactors can be severely limited by the presence of toxic or inhibitory compounds (i.e., heavy metals). As with solid-phase bioremediation, care must be taken to minimize abiotic losses (adsorption, volatilization), and biodegradation of the more recalcitrant pollutants must be demonstrated.

3. Experimental Procedures

3.1 Solid-Phase Bioremediation

Solid-phase bioremediation studies were performed at the bench-scale level with creosote- and PCP-contaminated sediment and surface soil obtained from the ACW site at Pensacola, Florida. The rate and extent of biodegradation by indigenous microorganisms were determined, and the influence of supplementation with inorganic nutrients on the biodegradation process was evaluated. Data generated in these studies have been used to predict the potential effectiveness of solid-phase bioremediation to ameliorate the ACW site.

3.1.a Sample Acquisition and Storage

On March 28, 1990, composite samples of surface soil and sediment were collected from the ACW site by the U.S. EPA Environmental Services Division (ESD), Athens, Georgia. Approximately 56.7 kg of creosote- and PCP-contaminated surface soil (SS) were obtained from Grid no. 47, and an approximate 56.7 kg of highly contaminated sediment material (SD) were removed from a depth of 3-5 m beneath the capped solidified material. A 4.5 kg composite subsample of each of these materials was placed in a 19 L plastic bucket, sealed air-tight and stored at 2°C for solid-phase bioremediation studies. The remainder of each material was divided as follows: approximately 45 kg were stored on site in separate 208 L steel drums (DOT-17C) for subsequent soil washing, a 500 g composite subsample of each material was placed in a clean, sterile, 16 oz I-CHEM jar and stored at 2°C for enumeration of indigenous microorganisms, and a second 500 g composite subsample of each material was placed in a clean, sterile, 16 oz I-CHEM jar and stored at 2°C for Microtox assay, teratogenicity testing and chemical analysis.

3.1.b Experimental Design

Bench-scale biotreatability studies to evaluate the efficiency of land farming (solid-phase bioremediation) to treat creosote-contaminated sediment and surface soil were initiated on April 5, 1990. "Land farming chambers" (Figure 3.1) were specially designed as contained systems by placing large (253 mm ID, 110 mm bowl depth, 50 mm stem), porcelain Buchner funnels (special order, Coors Ceramics, Denver, CO) inside inverted 300 mm OD x 300 mm height, amber-colored, polyetherimide, vacuum chambers (Nalgene Labware, Rochester, New York). Funnels were seated on top of a 250 ml beakers to collect leachate, if any. Oil-free air (oil-free compressor) entering the chambers was saturated with water to prevent drying of the materials within the chambers. Separate lines were used to connect each individual chamber to the air source, and air flow was established through the chambers at 100 ml/min. Air leaving the chambers was passed through an activated carbon trap to retain volatile emissions. An upstream, in-line carbon trap was used as the control for extraneous organics. Since the vacuum chambers were being used under positive pressure, a 4.5 kg weight was placed on top of each chamber to insure an air-tight seal between the chamber and the base-plate.

Approximately 3 kg (± 30 g) of creosote-contaminated surface soil (1.0% creosote [wgt], 6.6% moisture) or sediment (5.5% creosote [wgt], 14% moisture) were placed into each of two Buchner funnels lined with a Whatman no. 1 filter paper (4 chambers). Two treatments were established for each type of material: 1) unamended, and 2) supplementation with aqueous solution of inorganic nutrients (a third treatment, nutritional supplementation plus bioaugmentation using proprietary microbial inocula, is described in an auxiliary report). At the time of loading, 50 ml of sterile, modified Bushnell-Haas (MBH) inorganic nutrient solution (Table 3.1) were added to the chambers designated to receive inorganic nutritional amendments, and materials were mixed well (tilled) by hand using a small trowel. Those materials not supplemented with inorganic nutrients received 50 ml of sterile, distilled water prior to mixing. Solid materials were mixed well (tilled) on a weekly basis. Subsequent additions of water or inorganic nutrient solution were based on maintaining a 10-15% moisture content of the sediment or soil. The resultant schedule for the additions of water or nutrient solution to surface soil and sediment is summarized in Table 3.2.

Table 3.1 Composition of Modified Bushnell-Haas Medium

Compound	*Amount Added (mg/L)*
K_2HPO_4	1000
KH_2PO_4	1000
$(NH_4)_2NO_3$	1000
$MgSO_4\ 7H_2O$	200
$CaCl_2 2H_2O$	20
$FeCl_3$	5
pH	7.1 (adjusted)

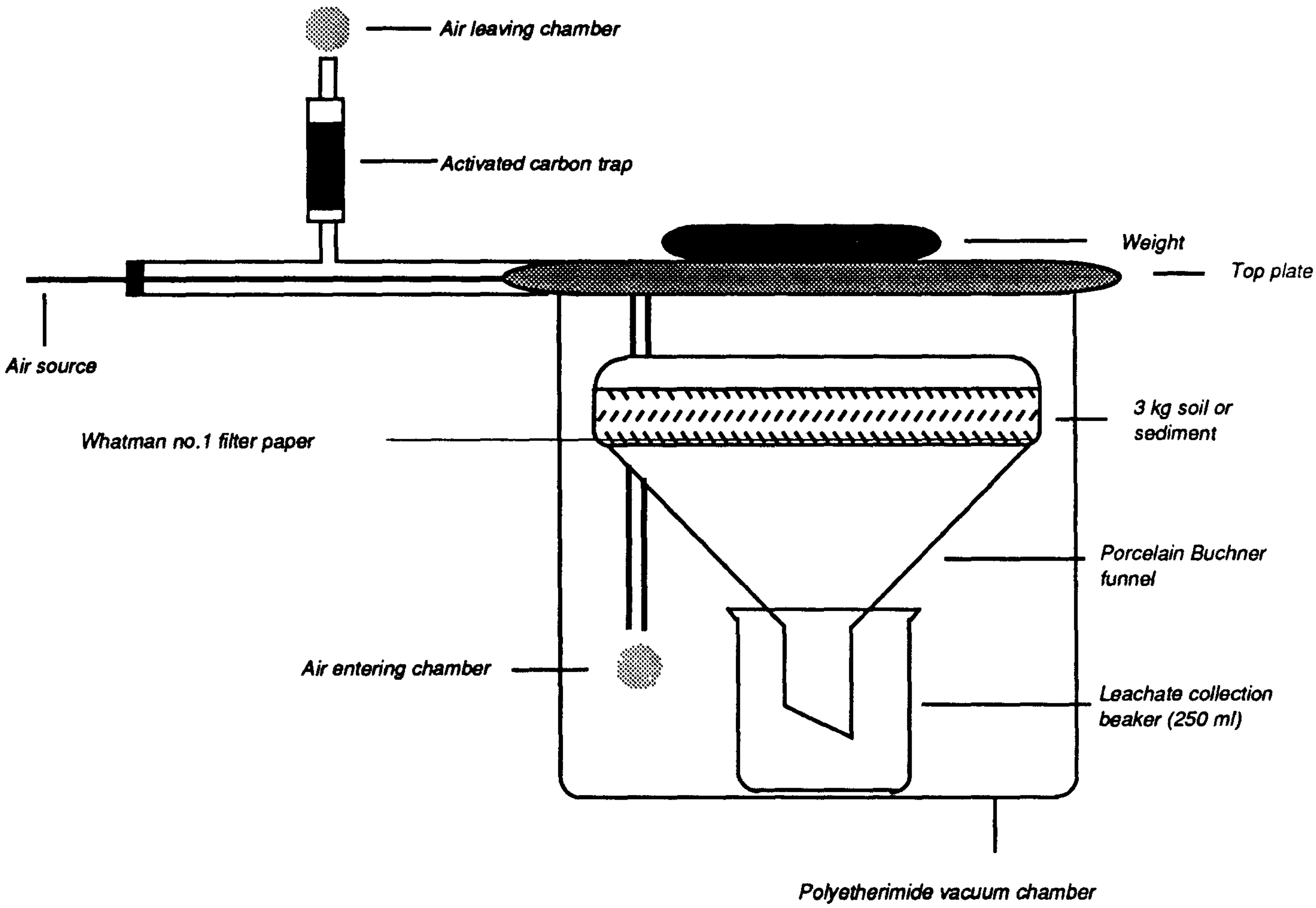

Figure 3.1 Diagram of land farming chambers used for solid-phase biotreatability studies.

Table 3.2 Amounts of Modified Bushnell-Haas Inorganic Nutrient Solution or Distilled Water Added to Each Land Farming Chamber at Weekly Intervals

Date		Surface Soils	Sediments
4/5	(time-zero)	50 ml MBH or 50 ml water	50 ml MBH or 50 ml water
4/12	(week 1)	25 ml MBH or 25 ml water	no additions
4/21	(week 2)	50 ml MBH or 50 ml water	no additions
4/27	(week 3)	25 ml MBH or 25 ml water	25 ml MBH or 25 ml water
5/5	(week 4)	50 ml MBH or 50 ml water	50 ml MBH or 50 ml water
5/11	(week 5)	50 ml MBH or 50 ml water	25 ml MBH or 25 ml water
5/18	(week 6)	50 ml MBH or 50 ml water	25 ml MBH or 25 ml water
5/25	(week 7)	50 ml MBH or 50 ml water	25 ml MBH or 25 ml water
5/31	(week 8)	25 ml MBH or 25 ml water	no additions
6/8	(week 9)	25 ml MBH or 25 ml water	25 ml MBH or 25 ml water
6/15	(week 10)	25 ml MBH or 25 ml water	25 ml MBH or 25 ml water
6/22	(week 11)	25 ml MBH or 25 ml water	25 ml MBH or 25 ml water
6/29	(week 12)	terminate	terminate

Composite subsamples (ca. 45 g) of soil or sediment were removed from each land-farming chamber prior to mixing at time-zero and after 1, 2, 4, 8 and 12 weeks incubation at room temperature (23 ± 3°C). The following parameters were determined on samples: 1) moisture content, 2) microbial population counts, and 3) amounts of PCP and creosote constituents. A 35 g sample was placed in a clean, sterile, 125 ml I-CHEM jar fitted with a Teflon-lined screw-cap, labeled appropriately and stored at 2°C for subsequent moisture and chemical analyses (see ANALYTICAL METHODS). A separate 10 g sample stored at 4°C was used for enumeration of microbial populations (see ANALYTICAL METHODS).

Activated carbon was removed from each trap (including the control trap) and replaced with freshly activated carbon (500°C for 6 hr) at the same time that the soil and sediment samples were collected. An additional sampling was made 2 days after initiation. Activated carbon samples were placed in clean, 125 ml Erlenmeyer flasks fitted with Teflon-lined screw-caps and extracted immediately as described below (see ANALYTICAL METHODS). At the conclusion of these studies (12 weeks incubation), composite subsamples of surface soil and sediment from each chamber were forwarded to ESD (Athens, GA) for independent chemical analysis (see APPENDIX).

Design of the land-farming chambers allowed periodic sampling of soil or sediment, and the quantitation of abiotic losses of PCP and creosote constituents (volatilization, leaching). Hence, losses directly attributable to biodegradation could be quantified accurately. However, materials within the chambers were not exposed to photooxidation or extremes in temperature or moisture content. Therefore, losses observed through volatilization and leaching are probably conservative in comparison to those expected to occur *in situ*. Furthermore, since soil and sediment were incubated in the laboratory within amber-colored chambers, any direct or indirect effects of photocatalysis on the biodegradation of monitored chemicals were eliminated. Thus, creosote and PCP biodegradation data are conservative as well.

3.2 Slurry-Phase Bioremediation

Bench-scale studies evaluated the potential applicability of slurry-phase bioremediation of creosote- and PCP-contaminated soil and sediment from the ACW site. The rate and extent of biodegradation of PCP and selected creosote constituents were monitored, and the removal of pollutants from contaminated materials was determined. Performance data generated has been used to predict the efficacy of this approach employing indigenous microorganisms.

3.2.a Sample Acquisition and Storage

Refer to section 3.1.a.

3.2.b Soil Washing

On April 19, 1990, approximately 34 kg of surface soil and sediment from the ACW site were shipped via overnight express to Chapman, Inc., Freehold, New Jersey (on-site soil washing was performed on April 6 and 7, 1990 but the resultant slurries were not usable). Upon arrival, materials were stored at 4°C for subsequent processing. On April 30, 1990, soil and sediment samples were washed separately with 0.05% Triton X-100 to facilitate dispersion and the transfer of pollutants into the aqueous phase (see APPENDIX A). Nineteen L of resultant slurry of each material were shipped to GBERL on May 10, 1990, and received on May 15, 1990, where, upon arrival, they were stored at 4°C for subsequent studies.

3.2.c Experimental Design

Preliminary analyses established the following properties for sediment and soil slurries, respectively: 1) pH = 10 and 7, 2) percent suspended solids = 2.7 and 2.1%, and 3) organic loading rate = approximately 10 and 1% of the solids (i.e., 10% of the suspended sediment solids was creosote/PCP). On June 5, 1990, slurries were homogenized (mixed for 2 hr) and 1.2 L of each slurry was added to one of two bioreactors. The appropriate amount of dry, inorganic salts was then added to each reactor to provide a base-line level of nutrients as described in Table 3.1. At the same time, 100 ml of each slurry was transferred to a clean, sterile 125 ml I-CHEM jar for time-zero chemical analyses.

Slurry-phase bioremediation studies were performed with two, 1.5 L Biostat M bioreactors (see Figure 3.2), (B. Braun Biotech, Allentown, PA). The bioreactor design was such that all surfaces exposed to hydrophobic creosote constituents were either glass or stainless steel. The pH of each slurry was adjusted to 7.1, and the reactors were operated in a batch culture mode for 30 days. Bioreactors were programmed to automatically maintain pH=7.1 ± 0.1, dissolved oxygen (DO)= 90%, and temperature=28.5°C. The DO concentration was maintained by adjusting both agitation (< 300 rpm) and airflow rates, while the pH was maintained through the automatic addition of acid (1.0 *N* H_2SO_4) or base (1.0 *N* NaOH). Although the operating parameters were controlled electronically, bioreactors were inspected on a daily basis.

Bioreactors were sampled following 1, 3, 5, 7, 14, 21 and 30 days of batch culture operation. Samples were obtained by manually removing 50 ml of medium from each bioreactor with a clean, sterile borosilicate glass pipette. Duplicate 25 ml samples of culture medium from each bioreactor were transferred to a clean, sterile 125 ml I-CHEM jar for immediate extraction and analysis as described below (see ANALYTICAL METHODS). At the same times, separate 1.0 ml samples of culture media were removed from each bioreactor to monitor changes in microbial protein concentrations (see ANALYTICAL METHODS).

Air leaving each bioreactor was passed through an activated carbon trap which was sampled periodically (day 7, 21 and 30) to monitor for losses via volatilization. At the conclusion of these studies, undissolved sludge and oily-creosotic material adhering to the internal surfaces of the bioreactors were removed by washing with methylene chloride which was made up to a standard volume for quantitation of PCP and creosote constituents. By accounting for these different means of abiotic removal of creosote/PCP from aqueous solution (volatilization and adsorption), loss from soil and sediment directly attributable to biodegradation could be quantified accurately.

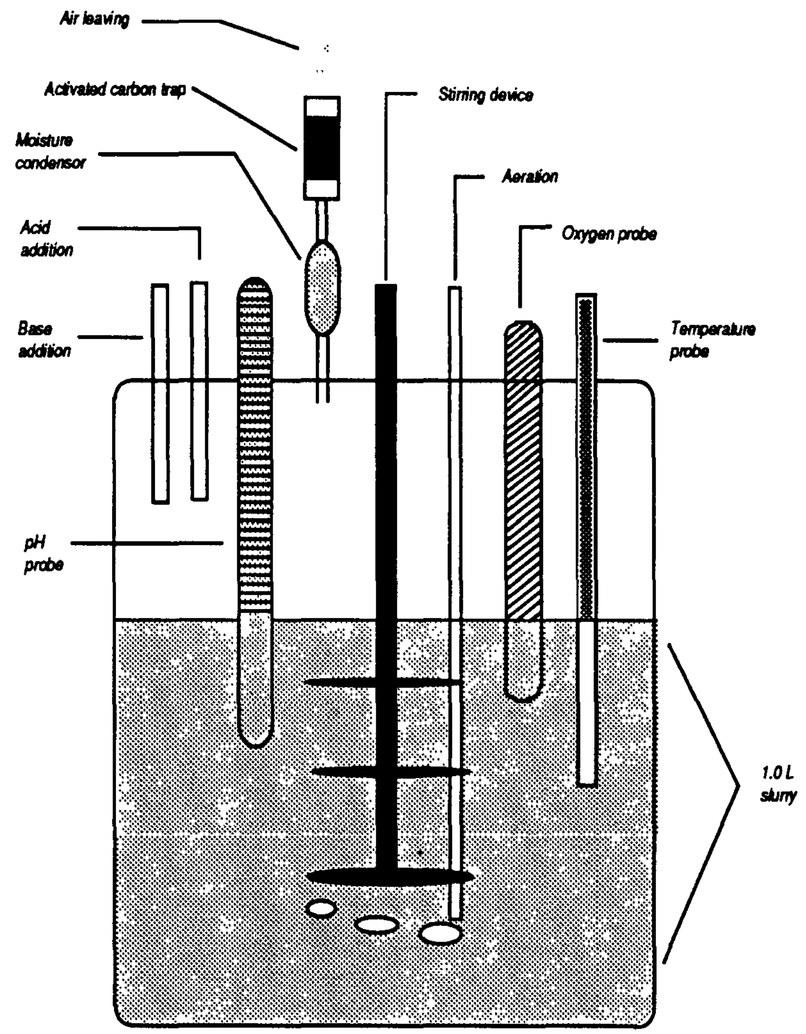

Figure 3.2 *Diagram of Biostat M bioreactor used for slurry-phase biotreatability studies.*

3.3 Shake Flask Studies

While the objective of this biotreatability study was to identify appropriate bioremediation techniques for Operable Unit 1 (surface soil remediation), preliminary studies were also performed to determine the potential effectiveness of biological treatment to degrade creosote and PCP present in groundwater and solidified material at the ACW site. These data will be used to help define appropriate treatment technologies for Operable Unit 2.

3.3.a Groundwater Shake Flask Studies

On March 27, 1990, approximately 400 L of PCP- and creosote-contaminated groundwater (GW) were recovered from Well no. 320 at the ACW site. Groundwater was removed from a depth of 7 m through Teflon-coated Bev-a-line tubing (15 mm ID) by means of an electric pump, transferred directly into two freshly rinsed, 208 L steel drums (DOT-17E) and stored on site for ancillary testing (Supplement to the Final Report). At intermittent times during sampling, five subsamples (1.0 L) were collected in clean, sterile Wheaton bottles fitted with Teflon-lined screw-caps and stored on ice for transport to the laboratory. Upon arrival at the laboratory, subsamples were stored at 2°C for subsequent biodegradation studies, teratogenicity testing and chemical analyses.

Biodegradability of chemicals present in groundwater recovered from the ACW site was evaluated as follows: a total of 15 flasks (125 ml Erlenmeyer flasks fitted with Teflon-lined screw-caps) containing 12.5 ml of filtered groundwater (passed through a plug of silanized glass wool to remove undissolved solids) plus 12.5 ml of modified Bushnell-Haas medium (1:1 ratio/vol:vol) were prepared. Additionally, two clean, sterile 1.0 L Wheaton bottles fitted with Teflon-lined screw-caps received 200 ml of the same groundwater medium (GWM). No difference in terms of organic pollutants present in filtered and unfiltered groundwater could be detected by gas chromatographic analyses or toxicity/teratogenicity studies (data not shown). Hence, the filtered GWM was used to monitor the fate of organic pollutants upon exposure, under optimum conditions for biodegradation, to catabolic activities of indigenous microorganisms.

Microbial inoculum was prepared by mixing 25 g of creosote- and PCP-contaminated surface soil (freshly obtained from grid no. 47) with 100 ml of 2.5 mM phosphate buffer (pH=7). Soils were mixed well and suspensions were centrifuged (2500 rpm, 10 min) to remove larger soil particles. The resultant supernatant was decanted and used as a source of indigenous, "creosote-adapted" microorganisms for the GWM.

Each flask containing 25 ml GWM was inoculated with 1.0 ml (27 μg microbial protein) of the washed soil microbial suspension. The two 1.0 L Wheaton bottles, each containing 200 ml GWM, received 8.0 ml of the same cell suspension. Duplicate 25 ml samples were immediately extracted (see below) for time-zero chemical analysis. Flasks were incubated at 30°C with shaking (200 rpm) in the dark for 14 days. Killed-cell controls were prepared for each sampling time point by adding 2.5 ml of a 37% formaldehyde solution to five of the shake flasks containing 25 ml GWM.

After 1, 3, 5, 8 and 14 days incubation, the entire contents of two active flasks and one killed-cell control flask were separately extracted and analyzed for the presence of PCP and selected creosote constituents (see below). After 14 days incubation, the contents of flasks containing 200 ml GWM were filtered (0.2 micron Teflon filter) and assessed for changes in toxicity (Microtox assay) and teratogenicity as described below (see ANALYTICAL METHODS). These data were compared with those obtained from untreated (non-inoculated) GWM that had been stored at 2°C during the 14 day incubation period.

3.3.b Solidified Material

Creosote- and PCP-contaminated solidified material was recovered from beneath the capped area at the ACW site by ESD (Athens, GA) on March 28,1990. This material was placed in clean, sterile, 64 oz I-CHEM jars and stored at 2°C for subsequent analyses. Shake flask studies were performed to determine the ability of microorganisms indigenous to the ACW site to biodegrade organic contaminants present in this material. This potential was assessed under 3 separate conditions: 1) solidified material as it occurs *in situ* (pH=9.5), 2) solidified material adjusted to pH=7.2, and 3) solidified material adjusted to pH=7.2, plus augmentation with indigenous surface soil microorganisms.

For condition 1, 6.25 g of solidified material were added to a 125 ml Erlenmeyer flask fitted with a Teflon-lined screw-cap containing 18.75 ml of modified Bushnell-Haas medium (Table 3.1) resulting in a slurry containing 25% suspended solids at pH=9.5. Condition 2 was established in the same manner, but the pH of the slurry was adjusted to pH=7.2 with 8.5% phosphoric acid. For the third incubation condition, 5.25 g of solidified material was mixed with 1.0 g of surface soil obtained from the nutrient amended land-farming chamber (after 12 weeks incubation), and the pH was adjusted to pH=7.2. This procedure resulted in the addition of 4.0 x 10^7 bacterial cells as determined by total heterotrophic plate counts.

A sufficient number of flasks was prepared for each treatment such that duplicate flasks could be removed at each sampling point. Additionally, a sufficient number of killed cell control flasks (3.7% formaldehyde) was prepared for each treatment to allow for extraction of duplicate control flasks of each treatment at each time point (4 killed cell control flasks for each treatment). The pH of the flask contents was checked on a daily basis and adjusted as needed since the pH tended to rise with agitation.

After 7 and 14 days incubation at 30°C with shaking (200 rpm), duplicate 1.0 ml samples were recovered from each flask for bacterial plate counts. The remaining slurry was extracted with methylene chloride according to the procedure developed for slurry samples (see EXTRACTION PROCEDURES). Organic extracts were then analyzed by gas chromatography for the presence of PCP and creosote constituents (see ANALYTICAL METHODS).

3.4 Extraction Procedures

3.4.a Aqueous Samples

The procedure for extraction and analysis of aqueous samples from groundwater shake flask studies is outlined in Figure 3.3. The entire volume of GWM from each flask was transferred to a clean (rinsed with methylene chloride), 60 ml separatory funnel. Flasks were then rinsed with 10 ml methylene chloride, and this was added to the aqueous sample. The GWM was adjusted to pH=12.0 with 1*N* NaOH, then extracted 3 times with 10 ml volumes of methylene chloride resulting in the transfer of non-polar (PAHs, *O*, *S*-heterocycles) and weakly basic creosote constituents (*N*-heterocycles) to the organic phase. The combined organic phases were washed once with 10 ml of distilled water (returned to the aqueous phase), dried by passage over a layer of anhydrous sodium sulfate (25 g) and collected in clean, 25 ml Kuderna-Danish concentrating tubes. The volume of methylene chloride was reduced to 1.0 ml by evaporating under a stream of dry nitrogen at 30°C. The organic phase was divided into two, 0.5 ml aliquots, placed in glass vials, spiked with an internal standard (C32-*n*-alkane; dotriacontane), and crimp-sealed for subsequent analysis for PAHs, *O*-, *S*- and *N*-heterocycles by GC-FID (see ANALYTICAL METHODS).

The pH of the extracted aqueous phase was re-adjusted to pH=7.0 through the addition of 8.5% phosphoric acid. Aqueous solutions were then extracted 3 times with 10 ml volumes of methylene chloride to remove weakly acidic phenols, and certain *O*- and *S*-heterocycles, and transfer them to the organic phase. The combined methylene chloride organic phases were dried by passage through a layer of anhydrous sodium sulfate (25 g), and collected into clean, 25 ml Kuderna-Danish concentrating tubes. The organic phase was reduced in volume to 1.0 ml under a stream of dry nitrogen at 30°C and placed in a glass vial. For analysis of phenol constituents by GC-FID (see ANALYTICAL METHODS), *o*-xylene was added as the internal standard.

The pH of the extracted aqueous phase was brought to pH=2.0 by the addition of 8.5% phosphoric acid. Protonated PCP (pKa = 4.7) was then extracted into methylene chloride (3x, 10 ml volumes). The methylene chloride organic phase was washed once with 10 ml distilled water, then dried by passage through a layer of anhydrous sodium sulfate (25 g). The organic phase was reduced in volume to 1.0 ml under a stream of dry nitrogen at 30°C, and transferred to a glass vial. PCP was derivatized (trimethylsilyl derivative) and determined by GC-ECD analysis (see ANALYTICAL METHODS). Quantitation of PCP derivative was based on an external standard curve (0.1-10 ppm), and its identity was confirmed by GC-MS analysis (data not shown).

3.4.b Soil and Sediment Samples

The fractionation and extraction procedures used for analysis of surface soil and sediment are outlined in Figure 3.4. For each analysis (run in duplicate), 10 g samples of soil or sediment were placed into a 25 mm x 80 mm (internal diam x external length) cellulose extraction thimble (Whatman International Ltd., Maidstone, England) and Soxhlet extracted with 100 ml methylene chloride for 4-5 hours. The methylene chloride extracts were then prepared through a series of liquid:liquid extractions to selectively remove PAH, phenolic and heterocyclic components of creosote as described below.

Methylene chloride Soxhlet extracts were first washed 3 times with 15 ml volumes of 1*N* NaOH. This procedure resulted in the transfer of acidic creosote phenolics from the organic phase into the aqueous phase. The organic phase was washed once with 10 ml distilled water to remove residual base, and the wash water was added to the basic aqueous phase which was reserved. Creosote phenolics were removed from the 1*N* NaOH aqueous phase by carefully acidifying to pH=2 with concentrated sulfuric acid, and extracting 3 times with 10 ml volumes of methylene chloride. The combined methylene chloride organic phase was washed with 10 ml distilled water to remove residual acid (wash water and the aqueous phase were discarded). Residual water was removed from the organic phase by passage through a layer of anhydrous sodium sulfate (25 g). The organic phase was then reduced in volume to 1.0 ml under a stream of dry nitrogen at 30°C, transferred to a glass vial, spiked with internal standard (*o*-xylene), and crimp-sealed for GC-FID analysis of extracted phenolic components of creosote (see ANALYTICAL METHODS).

The base-extracted organic phase was subsequently extracted 3 times with 15 ml volumes of 2.5 *N* sulfuric acid. This step was designed to transfer any *N*-heterocycles present in the samples to the acidified aqueous phase. The remaining organic phase was washed once with 10 ml distilled water to remove residual acid (and *N*-heterocycles), and wash water was added to the pooled acidic aqueous phase which was reserved. Residual water was removed from the remaining organic phase by passage through a layer of anhydrous sodium sulfate (25 g). The volume of the organic phase was reduced to 1.0 ml under a stream of dry nitrogen at 30°C, divided into two, 0.5 ml aliquots, and spiked with internal standard (C_{32}) for analysis of PAHs, and neutral *O*- and *S*-heterocyclic components of creosote by GC-FID analysis (see ANALYTICAL METHODS).

To extract weakly basic *N*-heterocycles from the remaining aqueous phase, the pH was adjusted to pH=12 via the slow addition of 10 *N* NaOH. The basified aqueous phase was cooled to room temperature, then extracted 3x with 10 ml volumes of methylene chloride. The resultant organic phase was washed once with 10 ml distilled water to remove residual base (wash water and extracted aqueous phase were discarded), dried over sodium sulfate, reduced in volume to 1.0 ml under a stream of dry nitrogen at 30°C, transferred to a glass vial and mixed with internal standard (C_{32}). The amount of *N*-heterocycles was subsequently determined by GC-FID analysis of organic extracts (see ANALYTICAL METHODS). Quantitation of monitored creosote constituents was calculated from a standard curve for identified chemicals. The ability of this extraction procedure to fractionate creosote constituents into the defined groups (phenolics, PAHs, *N*-, *S*- and *O*-heterocyclics) was verified (see QA/QC).

3.4.c Slurry Samples

Extraction of slurries was accomplished through a combination of the procedures described for the extraction of aqueous and solid samples. The process was initiated by adjusting duplicate, 25 ml samples of soil or sediment slurry to pH=12 with 10 *N* NaOH. A 10 ml volume of methylene chloride was added directly to the slurry while still in the original I-CHEM jar. The contents of the jar were shaken vigorously for 1 min, then centrifuged for 20 min at 3500 rpm (NOTE: I-CHEM jars tend to break at >4000 rpm). The resultant methylene chloride organic layer was subsequently transferred to a clean (solvent rinsed) 250 ml separatory funnel with a solvent-rinsed Pasteur pipette taking care not to remove any emulsion. This procedure was repeated twice for a total of 3 extractions at pH=10. After the third extraction, the slurries were centrifuged a fourth time to recover residual methylene chloride from the emulsion. The pooled methylene chloride extracts were washed once with 10 ml volume of distilled water to remove residual base, and the wash water was added back to the aqueous phase (slurry). Water was removed from the organic extract by passage through a layer of anhydrous sodium sulfate (25 g), and the volume of the organic phase was reduced to 1.0 ml under a stream of dry nitrogen at 30°C. The final volume of basic extract was divided into two, 0.5 ml aliquots and spiked with internal standard (C_{32}) for quantitative analysis of PAH and *O*-, *S*- and *N*-heterocyclic components of creosote (see ANALYTICAL METHODS).

The aqueous slurry was adjusted to pH=7.0 with concentrated phosphoric acid, and extracted 3x with 10 ml volumes of methylene chloride as described above. The centrifugation step was reduced to 10 minutes. The fourth centrifugation following extraction was still necessary since residual methylene chloride was recoverable from the emulsion. Residual water was removed from the combined organic phase by passage through a layer of anhydrous sodium sulfate (25 g), the volume was reduced to 1.0 ml under a stream of dry nitrogen at 30°C and transferred to a glass vial. For analysis of phenolic constituents, *o*-xylene was added as the internal standard (see ANALYTICAL METHODS).

Lastly, PCP was extracted from the slurries by carefully acidifying the aqueous phase to pH=2 with concentrated phosphoric acid and extracting 3 times with 10 ml volumes of methylene chloride. Samples were centrifuged between each extraction. For analysis by GC-ECD, PCP was derivatized to facilitate its chromatographic determination (see ANALYTICAL METHODS). Recovery of derivatized PCP was calculated from an external standard.

3.4.d Extraction of PCP from Soils

The amount of PCP in soil and sediment was determined by placing duplicate 5.0 g samples into clean, 125 ml Erlen-

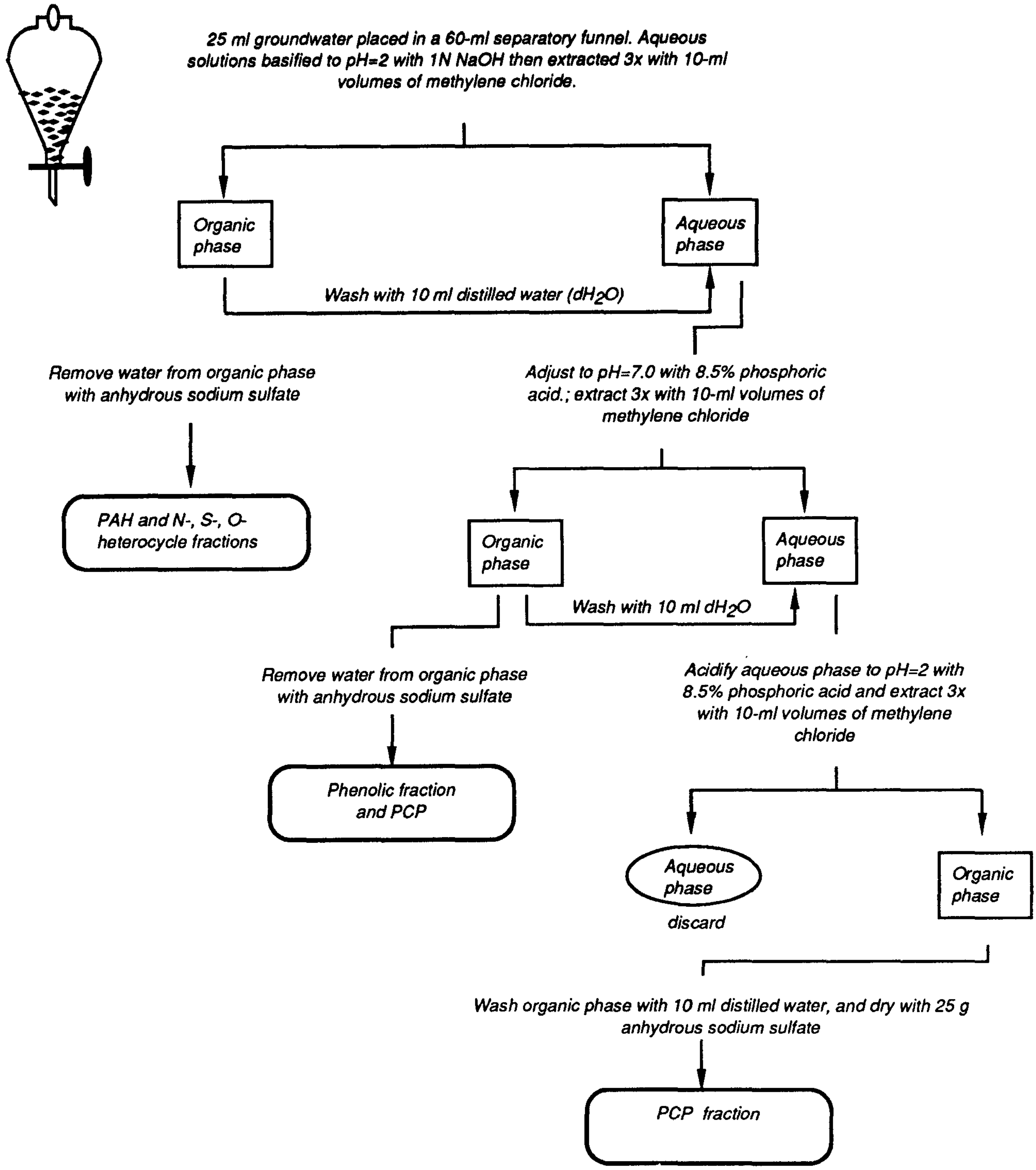

Figure 3.3 *Flow chart for extraction and chemical analysis of aqueous samples.*

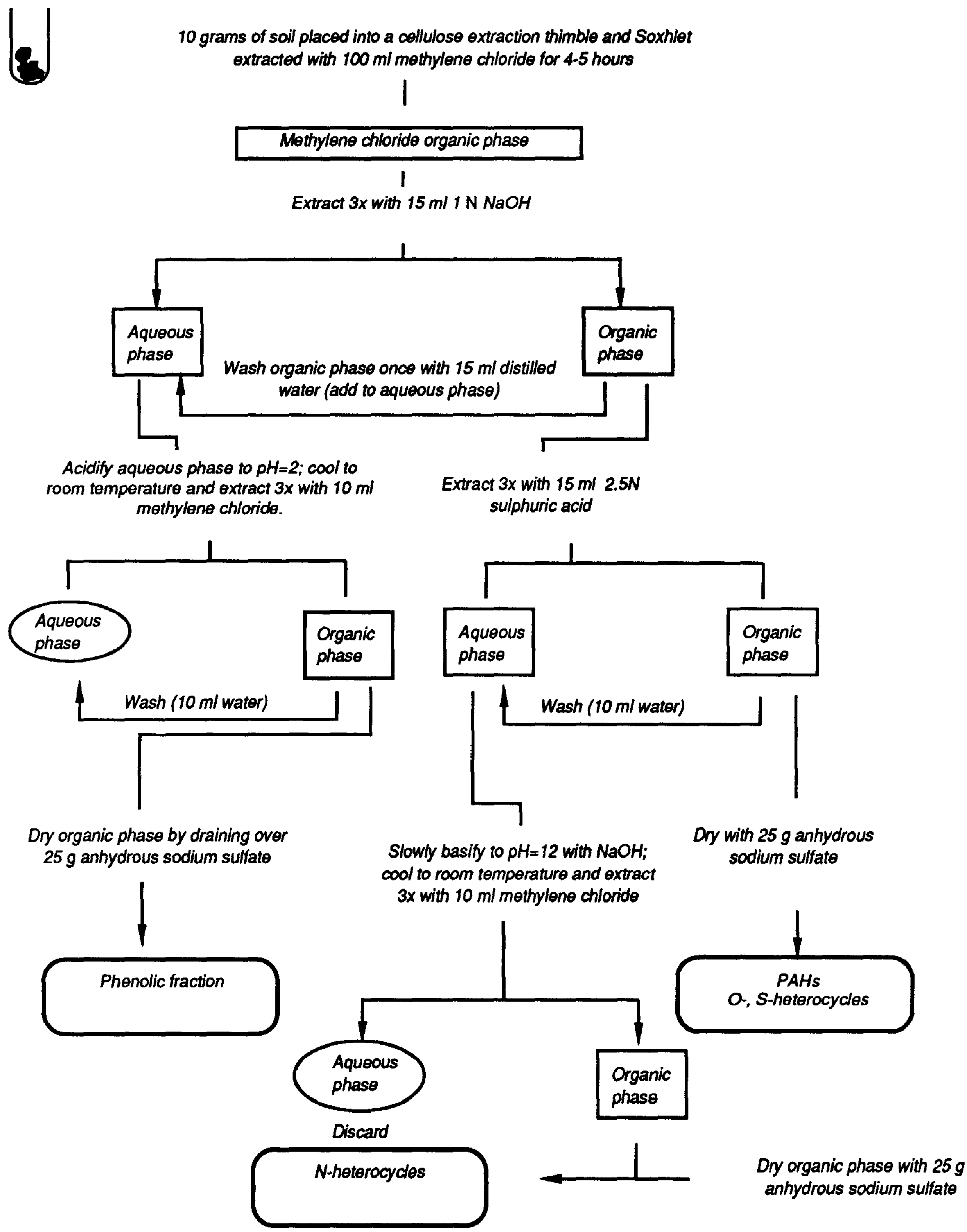

Figure 3.4 Flow chart for extraction and chemical analysis of soils and sediments.

Figure 3.4Flow chart for chemical analysis of soils and sediments meyer flasks fitted with Teflon-lined screw-caps (Figure 3.5). To each flask was added 15 ml methanol, and the methanol slurry was carefully acidified to pH=2 with concentrated sulfuric acid. The transfer of PCP to the organic phase was facilitated by mixing (150 rpm) for at 4-5 hours at room temperature. The soil/methanol slurry was then charged with 10 ml of 0.1 *M* HCl/0.1 *M* KCl, and filtered under vacuum through a Whatman no. 1 filter paper. The filter was washed with ca. 5 ml hexane and 5 ml distilled water. Wash solutions were added to the filtrate. The combined filtrate and washes were then extracted 3x with 5 ml volumes of hexane. The pooled hexane phase was reduced in volume to 1.0 ml under a stream of dry nitrogen at 35°C. As the hexane phase used to extract PCP from soil or sediment was reduced in volume, a precipitate was usually formed. Thus, once the volume was reduced to 1.0 ml, it was necessary to filter hexane extracts through a 0.2 micron Teflon filter (Gelman Sciences, Ann Arbor, MI). Prior to injection and analysis of PCP by GC-ECD, PCP was derivatized to facilitate its chromatographic determination (see ANALYTICAL METHODS). Recovery of PCP was calculated from an external standard curve (see QA/QC), and its identity was confirmed by mass spectral analysis (data not shown).

3.4.e Activated Carbon Traps

The contents of each trap were emptied into separate 125 ml Erlenmeyer flasks fitted with Teflon-lined screw-caps. To each flask was added approximately 25 ml of methylene chloride, and slurries were shaken at 100 rpm for 24 hours at room temperature. The methylene chloride/carbon slurries were then separated by filtration through a Whatman no. 1 filter paper. Residual moisture was removed from the methylene chloride organic phase by passage through a layer of anhydrous sodium sulfate (25 g), then reduced in volume to 2.0 ml under a stream of dry nitrogen at 30°C. The final volume was divided into 4x, 0.5 ml aliquots which were analyzed for PAH, phenolics, heterocyclics, and PCP, respectively. Due to low levels of creosote organics in the activated carbon traps, differential extractions were not performed.

3.5 Analytical Methods

3.5.a PAH Analysis

The amounts of PAH components of creosote in soil, sediment, aqueous samples, slurries, and activated carbon traps were determined by gas chromatographic analysis of organic extracts of these materials. Analyses were performed on a Hewlett-Packard Model 5890 Series II gas chromatograph equipped with cryogenics, two autosamplers, two injection ports, and two flame ionization detectors (FID). Hydrogen was used as the carrier gas (linear velocity 48 cm/sec) while air (250 kPa) and hydrogen (150 kPa) were supplied for the FID. Nitrogen (flow rate 30 ml/min) was used as the make up gas for the detector. Creosote PAHs (present in duplicate 1.0 µl injections) were separated on an SPB-5 (Supelco, Bellafonte, PA) capillary column (15 m x 0.32 mm [inside diam] with a 0.25 µm film thickness). The temperature program was as follows: 30°C for 3 min followed by a linear increase of 5°C/min to 300°C where it was held for 4 min. Injector and detector temperatures were maintained at 300 and 310°C, respectively. The amounts of targeted compounds present were calculated by comparing peak area obtained by duplicate 1.0 µl injections with standards for each chemical and related to the amount of internal standard (C_{32}). The limit of detection for PAHs was set at 400 ppb.

3.5.b N-, S-, O-Heterocycles

The amounts of creosote heterocycles in organic extracts were determined by gas chromatographic analysis as described for PAHs. However, the temperature program was slightly modified to facilitate the separation of creosote heterocycles: initial temperature of 25°C for 1 min followed by a linear increase of 5°C/min to 300°C. The amounts of targeted compounds present were calculated by comparing peak area obtained by duplicate, 1.0 µl injections with those of standards of each chemical and related to the amount of internal standard (C_{32}). The limit of detection for creosote heterocycles was set at 100 ppb.

3.5.c Phenol Analysis

Phenolic compounds, excluding PCP, were identified and quantified by GC-FID analysis on a Hewlett-Packard model 5890 gas chromatograph equipped with dual injection ports, dual columns, an autosampler, a FID detector, and an electron capture detector (ECD). Phenolic compounds were separated with a Nukol (Supelco) fused silica capillary column (30 m x 0.25 mm [inside diam], 0.25 µm film thickness) connected to the FID detector. Hydrogen (linear velocity 48 cm/sec) was used as the carrier gas while air (250 kPa) and hydrogen (150 kPa) were supplied for flame ionization. Nitrogen (flow rate of 30 ml/min) was used as the make up gas for the detector. The oven temperature was programmed as follows: 40°C for 3 min followed by a linear increase of 25°C/min to 150°C where it was held for 10.2 min, then increased at a rate of 5°C/min to 200°C where it was held for 15 min. Injector and detector temperatures were maintained at 180°C and 220°C, respectively. For quantitation of phenolic compounds present in the organic extracts, *o*-xylene was used as the internal standard. The amounts of targeted compounds present were calculated by comparing peak area obtained by duplicate injection (1.0 µl) with standards for each chemical in relation to the amount of internal standard. The limit of detection for creosote phenolics was set at 50 ppb.

3.5.d PCP Analysis

Extracted PCP was quantitatively analyzed as its trimethylsilyl derivative (using BSTFA (N,O-*bis*[trimethylsilyl]trifluoroacetamide)) by gas chromatographic analysis employing a Hewlett-Packard model 5890 gas chromatograph equipped with dual injection ports, dual columns, a FID detector and an ECD detector. Pentachlorophenol derivatives were injected onto a SPB-5 capillary column connected to the ^{63}Ni-electron capture detector. Hydrogen (linear velocity 48 cm/sec) was used as the carrier gas and P-10 (flow rate=30 ml/min) as the ECD make up gas. Column temperature was programmed for 50°C for 0.5 min followed by a linear increase of 10°C/min to 180°C, then 25°C/min to 290°C where it was held for 5 min. Injector and detector temperature was maintained at 150°C and 300°C, respectively. For quantitative analysis of PCP, the amount of targeted compound present in duplicate, 1.0 µl injections was calculated by comparing its peak area with that of derivatized-PCP standards. The limit of detection for PCP was set at 50 ppb.

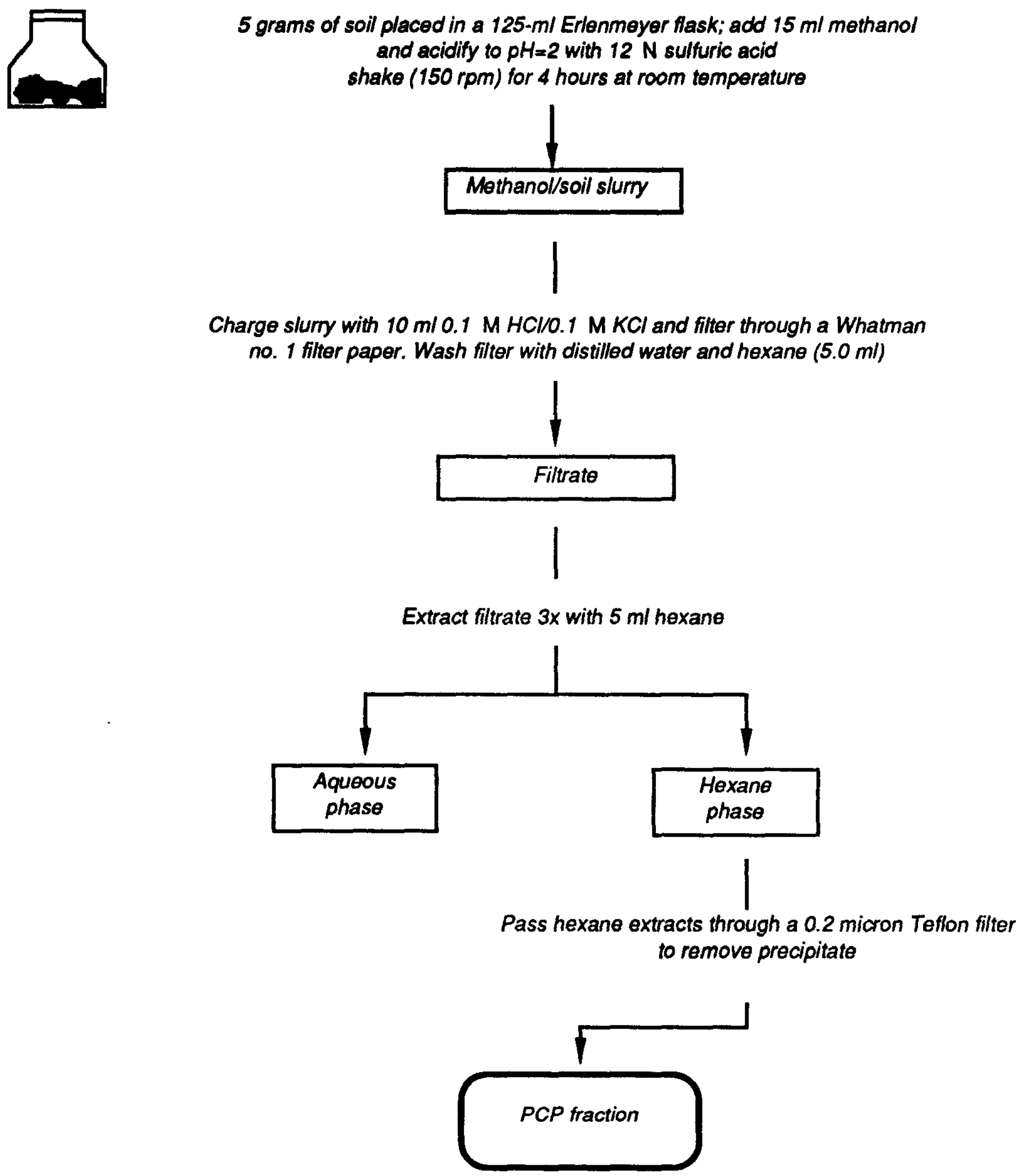

Figure 3.5 *Flow chart for extraction and analysis of PCP in soils.*

3.5.e CLP Analyses

see APPENDIX

3.5.f Microbial Population Counts

Microbial population counts were obtained for both soil and sediment at time-zero and after 1, 2, 4, 8 and 12 weeks incubation in the land-farming chambers. Total heterotrophic bacterial counts were obtained by serially diluting duplicate, 1.0 g samples of soil or sediment (stored at 4°C in clean, sterile I-CHEM jars) to 10^{8} in sterile, 2.5 mM phosphate buffer (pH=7.1). For surface soil, duplicate, 0.1 ml samples from 10^{-5}-10^{-8} dilutions were spread-plated onto complex medium (AB3 agar, Difco Laboratories, Detroit, MI) whereas sediment samples were plated at dilutions from 10^{-2} to 10^{-5} (additional dilutions plated if necessary). Plates were incubated at 30°C for 3 days prior to counting.

In an effort to establish a better correlation between total heterotrophic plate counts and *in situ* creosote-biodegradation potential, phenanthrene was used as a reporter chemical to determine the number of cultured organisms potentially capable of degrading this creosote constituent. The number of phenanthrene-degrading microorganisms was determined by spraying AB3 plates containing between 30 and 300 individual colonies with an ethereal solution of phenanthrene (0.04% phenanthrene). As the ether evaporated, this procedure resulted in the deposition of a thin film of phenanthrene on the surface of the agar medium. Plates were incubated for 3 more days at 30°C after which time the number of phenanthrene-degrading microorganisms was determined by recording the number of colonies which cleared the hydrocarbon substrate.

Microbial populations from the bioreactor and groundwater shake-flask studies were measured after treatment with NaOH using the bicinchoninic acid (BCA) protein assay (Pierce Chemical Co., Rockford, IL).

3.5.g Percent Moisture Content

The moisture content of soil and sediment in the land-farming chambers was measured intermittently as follows: duplicate, 1.0 g samples were weighed into tared trays and dried at room temperature for 3 days. The percent moisture of each material was subsequently calculated:

$$\%\ moisture = \frac{wet\ weight - dry\ weight}{wet\ weight} \times 100$$

3.6 Microtox Assays

Toxicity of various samples was determined with a Microtox model 500 toxicity autoanalyzer (Microbics Corp., Carlsbad, CA). This system was used according to manufacturer specifications to generate data on the toxicity of groundwater and soil slurries before and after treatment. Where appropriate these data were used in conjunction with teratogenicity data to thoroughly evaluate the extent of removal of hazardous components from various media. Since the Microtox system can only analyze aqueous samples, soil and sediment from the land-farming chambers were not analyzed.

3.7 Teratogenicity Assays

Teratological responses in inland silversides (*Menidia beryllina*) embryos exposed to materials from the ACW site before and after treatment were evaluated. Preliminary studies have shown that this test organism offers a sensitive indicator for the presence of creosote and PCP (data not shown). Naturally spawned embryos from an adult population of silversides, maintained in the laboratory at 25°C and 5‰ salinity in the absence of teratogenic substances, were used for all tests.

To initiate experiments, blastula stage embryos were washed 5 times with sterile fresh water of moderate hardness (80-100 mg/L $CaCO_3$), and single embryos were placed in each of 120 randomized Leighton culture tubes. Six ml of clean, sterile media, or waste sample to be evaluated (untreated groundwater, treated groundwater, untreated surface water [creek water], soil slurry, sediment slurry), were added to each of 30 tubes to yield: a) 30 control tubes with a single embyro in each tube, b) 30 tubes containing 100% waste sample with a single embryo in each tube, c) 30 tubes with a 1:10 dilution of waste sample, and d) 30 tubes with 1:100 dilution of waste sample. Tubes were sealed with Teflon-lined screw-caps, placed in stainless steel racks, and incubated in a horizontal position at 25°C with a photoperiod of 14 hr light:10 hr darkness.

On a daily basis, tubes were removed from the incubator and individual embryos were viewed microscopically to determine the presence or absence of terata. A ranking system was used to assign numerical values for the severity of responses in three important organ systems within the developing embryos: a) the craniofacial-central nervous system (CR), b) the cardiovascular-circulatory system (CV), and c) the skeletal system (SK). Teratological responses were documented with photomicrography.

Seven to eight days after exposure, control embryos hatched. The minimum acceptable percentage hatch of control embryos was 80% (if less than 80% experiments were repeated). All hatched larvae were immediately examined microscopically to determine the extent of impact on CR, CV and SK systems. Total test duration did not exceed 10 days, and the dissolved oxygen and pH of the medium of representative tubes was determined at the end of each test. Preliminary studies showed that inland silversides are very susceptible to the complex aqueous phase of creosote/PCP residues, and that this test system offered a very sensitive indicator of teratogenic/toxic components of creosote.

3.8 Quality Assurance/Quality Control

The Biotreatability Study Work Plan describing these studies was submitted to the U.S. EPA Environmental Monitoring Systems Laboratory (Las Vegas, NV) for review. Particular attention was paid to experimental design and statistical soundness. By and large, QA/QC is limited to the procedures for extracting creosote constituents from contaminated materials and their subsequent analysis.

For analysis of PAH, *O*-, *S*-, and *N*-heterocycles, and phenolic components of creosote, various dilutions of standard mixtures of targeted chemicals in each group were used for daily instrument calibration. For PCP analysis, PCP standards were used for instrument calibration. Level 1 concentrations for each standard mixture are reported in Tables 3.3, 3.4 and 3.5. Levels 2, 3, and 4 were prepared by diluting the Level 1 standards 10-, 100-, and 1000-fold, respectively. When necessary, other dilutions were made in order to generate a 3-point calibration curve within the appropriate range. The lowest level of each standard was used to verify the limit of detection (LOD) for individual chemicals. If the LOD was exceeded, then corrective measures were taken (i.e., septum change, insert change).

Instrument performance was verified using standard reference materials (SRM), quality control (QC) samples, and performance evaluation (PE) samples obtained from the U.S. EPA Quality Assurance Branch, Environmental Monitoring Services Laboratory (Cincinnati, OH). Standards were run as unknowns every sixth sample to monitor instrument performance, and methylene chloride blanks were injected daily as contamination checks.

The quantitative analysis of targeted compounds was based on the presence of the internal standards. For PAH and *N*-, *S*-, and *O*-heterocycle analyses, exactly 10 µl of a dotriacontane stock solution (1.0 mg C_{32} in 1.0 ml hexane) were added to each 1.0 ml organic extract sample (or exactly 5 µl to 0.5 ml sample) at the time of extraction (see EXTRACTION PROCEDURES). All measurements were based on the presence of this standard. Likewise, *o*-xylene was used as the internal standard for the analysis of phenolic compounds in organic extracts.

The ability to extract creosote constituents from soil and water substrates was verified by processing samples to which known amounts of authentic chemical standards had been added. Percent recovery for each component was subsequently determined. Likewise, the ability of the various fractionation schemes to differentially extract related groups of contaminants was verified.

Table 3.4 Standard Mixture of 10 Phenolic Constituents of Creosote Used for Instrument Calibration and Determination of Detection Limit

Compound[1]	Chemical[2]	Level 1 Concentration (μg/ml)
1	2,6-xylenol	52.1
2	o-cresol	35.0
3	2,5-xylenol	54.2
4	2,4-xylenol	48.0
5	p-cresol	38.1
6	m-cresol	52.0
7	2,3-xylenol	51.4
8	3,5-xylenol	52.2
9	3,4-xylenol/ 2,3,5-trimethylphenol	77.0

[1] Compounds listed in order of elution.
[2] All compounds used were of the highest purity available (>98%).

Table 3.3 Standard Mixture of 22 PAH Components of Creosote Used for Instrument Calibration and Determination of Detection Limit

Compound[1]	Chemical[2]	Level 1 Concentration (μg/ml)
1	naphthalene	105.4
2	1-methylnaphthalene	102.5
3	2-methylnaphthalene	103.7
4	biphenyl	102.3
5	2,6-dimethylnaphthalene	137.3
6	2,3-dimethylnaphthalene	100.2
7	acenaphthene	102.1
8	acenaphthylene	112.6
9	fluorene	102.3
10	phenanthrene	106.1
11	anthracene	105.8
12	2-methylanthracene	100.7
13	anthraquinone	128.8
14	fluoranthene	128.7
15	pyrene	102.3
16	benzo[b]fluorene	101.5
17	benz[a]anthracene	200
18	chrysene	102.0
19	benzo[b]fluoranthene/ benzo[k]fluoranthene	70.0
20	benzo[a]pyrene	114.7
21	indeno[1,2,3-c,d]pyrene	10.0

[1]Compounds listed in order of elution.
[2]All compounds used were of the highest purity available (>98%).

Table 3.5 Standard Mixture of 13 N-, S-, and O-Heterocyclic Constituents of Creosote Used for Instrument Calibration and Determination of Detection Limit

Compound[1]	Chemical[2]	Level 1 Concentration (μg/ml)
1	2-picoline	50.0
2	3-picoline/ 4-picoline	112.0
3	lutidine	45.0
4	thianaphthene	102.0
5	quinoline	100.0
6	isoquinoline	112.0
7	quinaldine	103.0
8	lepidine	100.0
9	dibenzofuran	100.0
10	dibenzothiophene	92.0
11	acridine	98.0
12	carbazole	100.0

[1]Compounds listed in order of elution.
[2]All compounds used were of the highest purity available (>98%).

4. Results and Discussion

4.1 Compound Identification Numbers

The efficacy of various biotreatability efforts was evaluated primarily by monitoring the fate of PCP and 42 components of creosote. For the sake of simplicity, all data tables make use of compound identification numbers as opposed to continually listing each of these compounds. Table 4.1 identifies the chemical which corresponds to each compound ID number. In the text, brackets, [ ], indicate when a compound ID number is being used in reference to a specific chemical. In the cases where two chemicals co-elute, an individual number refers to the mixture [20, 30, 33].

4.2 Extraction Efficiency

Recovery of PCP and 42 creosote constituents from the spiked soil and water samples are summarized in Table 4.2. In an effort to obtain soils of similar type and texture as those used in actual studies, samples were obtained from just outside the fenced area of the ACW site. However, as is apparent from the background data listed in Table 4.2, these materials contained relatively high concentrations of high-molecular-weight PAHs. Therefore, when the background concentration of individual chemicals was high in relation to the amount added in the matrix spike, percent recoveries were impossibly high (>500%). This was most apparent with compounds [20 and 21] where the background concentration was 4 and 10-times greater than the spike concentration, respectively. Nevertheless, the ability to recover from soil at least 85% of the contaminants present was consistently established, and recovery values were within acceptable limits.

Recovery of spiked materials from aqueous substrates were also within acceptable limits. Excluding lutidine [34], efficiency of extraction for all chemicals was consistently >70%.

4.3 Groundwater Shake Flask Studies

Preliminary studies evaluating the potential for bioremediation of creosote- and PCP-contaminated groundwater at the ACW site demonstrated that many of the contaminants present in this material may be attacked by the indigenous microflora (Table 4.3). While the phenolic components [22-30] were readily biodegraded, a short acclimation period was apparently required before the soil microorganisms degraded resident PAHs [1-21]. With the exception of anthracene [11] and 2-methylanthracene [12], most PAHs with molecular weights less than that of fluoranthene [14] were extensively biodegraded after 5 days incubation. No degradation of PCP was evident.

The catabolic abilities of these organisms appears to have been realized within 8 days of incubation since most of the observed changes had occured by this time. However, some low-level activity or secondary catabolism may have continued since the concentration of the high-molecular-weight PAHs decreased with continued incubation. A shift in the microbial population may also have contributed to this decrease. The concentration of all constituents in the killed cell controls did not decrease with time (data not shown), hence observed losses could be directly attributed to biological activity.

From the analytical chemistry data described above, it was determined that, with the exception of PCP, all monitored contaminants were extensively degraded by the indigenous microflora after 14 days incubation. However, data generated from both the Microtox and teratogenicity assays showed that the bioremediated groundwater was still capable of eliciting a response. Microtox assays showed an EC_{50} of 0.72 (a solution containing 0.72% of the parent material killed 50% of the test organisms) for filtered (silanized glass wool), untreated groundwater freshly recovered from the ACW site (well 320). An EC_{50} of 3.8 was observed for filtered groundwater exposed to biological activity for 14 days.

Teratogenicity assays showed that filtered, untreated groundwater freshly obtained from Well no. 320 at the ACW site was embryo toxic at 100%, and teratogenic at 10 and 1% concentrations (Table 4.4). At the 1% concentration, all hatched larvae had terata, including stunted skeletal axes and deformed hearts. Bioremediation of Well no. 320 groundwater did not reduce the embryo toxicity/teratogenicity at the 100 and 10% groundwater concentrations, but the 1% test solution demonstrated marked improvement: 78% of the embryos that hatched produced normal larvae while only 11% developed observable terata. This sharply contrasts with that observed with untreated groundwater (no normal larvae, 20% terata at the 1% solution).

Preliminary studies have shown that the creosote constituents present in groundwater at the ACW site are susceptible to biodegradation. However, the following points must be considered: 1) studies were performed under well mixed, aerobic conditions, 2) copious amounts of inorganic nutrients were available, 3) relatively high concentrations (27 μg bacterial protein/25 ml medium) of surface soil microorganisms were used to inoculate each flask, and 4) the tests were performed within a closed system. Therefore, the rates and extents of degradation observed in the laboratory probably do not accurately reflect those occurring *in situ*. Nevertheless, the potential for treating creosote-contaminated groundwater through biological processes has been demonstrated.

Table 4.1 Chemicals Corresponding to Compound Identification Numbers

Chemical	*Compound ID Number*
naphthalene	1
2-methylnaphthalene	2
1-methylnaphthalene	3
biphenyl	4
2,6-dimethylnaphthalene	5
2,3-dimethylnaphtahlene	6
acenaphthylene	7
acenaphthene	8
fluorene	9
phenanthrene	10
anthracene	11
2-methylanthracene	12
anthraquinone	13
fluoranthene	14
pyrene	15
benzo[b]fluorene	16
chrysene	17
benzo[a]pyrene	18
benz[a]anthracene	19
benzo[b]fluoranthene/ benzo[k]fluoranthene	20
indeno[1,2,3-c,d]pyrene	21
2,6-xylenol	22
o-cresol	23
2,5-xylenol	24
2,4-xylenol	25
p-cresol	26
m-cresol	27
2,3-xylenol	28
3,5-xylenol	29
3,4-xylenol/ 2,3,5-trimethylphenol	30
pentachlorophenol	31
2-picoline	32
3-picoline/ 4-picoline	33
lutidine	34
thianaphthene	35
quinoline	36
isoquinoline	37
quinaldine	38
lepidine	39
dibenzofuran	40
dibenzothiophene	41
acridine	42
carbazole	43

4.4 Solid-Phase Bioremediation

The biological degradation and subsequent removal of PCP and 42 creosote constituents from contaminated sediment and surface soil obtained from the ACW site was monitored for 12 weeks while samples were incubated in specially designed, closed-system land-farming chambers. Evidence for biodegradation of targeted compounds was based primarily on GC analyses of extracted substrates. In addition, change in microbial populations (total heterotrophic plate counts, and the number of phenanthrene-degrading bacteria) was used as a secondary, or indirect, indication of biological activity towards targeted contaminants.

Table 4.5 presents analytical chemistry data for solid-phase bioremediation of unamended surface soil. By and large, contamination was limited to PAHs and PCP. Table 4.6 summarizes the loss of creosote constituents via volatilization from surface soil during solid-phase bioremediation. Overall, loss via volatilization was less than 0.01% (ca. 28 μg organic creosote constituents recovered from activated carbon traps/ ca. 30,000 mg total creosote per land-farming chamber). Despite this rather low percentage, these data were used in conjunction with analytical chemistry data to quantify accurately the percent biodegradation of individual components of creosote. Percent biodegradation data are presented in Table 4.7, but only the data for week 12 have been corrected for the cumulative loss of individual creosote components by volatilization.

In the absence of inorganic supplements, the first week of solid-phase bioremediation did not result in a significant loss of monitored creosote constituents from contaminated surface soil (Table 4.7). Although biodegradation of most monitored contaminants continued with further incubation, most of the biodegradation of monitored contaminants was realized by the end of the second week of incubation. Exceptions to this generalization include compounds [5], [11] and [12] whose biodegradation did not appear to be initiated until week 8. Hence, the pattern of creosote biodegradation was predictable: lower-molecular-weight contaminants [compounds 1 through 9] were degraded more readily than the higher molecular-weight molecules [compounds 10 through 21 and 31], and creosote constituents containing 4 or more fused rings [compounds 14 through 21] tended to resist biological attack.

Changes in the concentration of monitored creosote constituents during solid-phase bioremediation of surface soils amended with inorganic nutrients are summarized in Table 4.8, and loss of these contaminants via volatilization is shown in Table 4.9. Again, loss from surface soils through volatilization was less than 0.01%, but quantitation of abiotic loss was necessary to determine accurately the rate and extent of creosote degradation attributable to biological activity (Table 4.10).

When compared with data presented in Table 4.7, it is apparent that both the rate and extent of biodegradation was stimulated by the addition of soluble nutrients (Table 4.10). Since nutrient supplementation cannot increase the aqueous solubility of the more recalcitrant molecules, this stimulatory effect was most pronounced with the readily biodegradable components of creosote. With the exception of compounds [10] and [16 -19], the amount of material biodegraded within the first week of incubation was greater when treated with soluble inorganic nutrients. Subsequent additions of inorganic nutrients appeared to further enhance the loss of biodegradable contaminants. By the end of the study, the extent of biodegradation in the presence of soluble inorganic nutrients was greater for all monitored contaminants except for compounds [3], [19] and [31].

Changes in soil microbial numbers during solid-phase bioremediation of creosote-contaminated surface soils with and without nutrient amendments are presented in Table 4.11. While analytical chemistry data suggest that the addition of inorganic nutrients stimulated the rate and extent of creosote biodegradation, total heterotrophic plate counts obtained with unamended soils and with those that received nutritional supplements do not reflect such an effect. However, after 4 and 8 weeks of incubation, the number of phenanthrene-degrading microorganisms was significantly greater in the soils that had received inorganic nutrients. This increase could be correlated with higher values for percent biodegradation of phenanthrene and other higher molecular-weight PAHs observed at these time points with soils amended with soluble nutrients (Tables 4.7 and 4.10).

Changes in the concentration of monitored chemicals during solid-phase bioremediation of unamended sediment are summarized in Table 4.12. On the whole, loss of PCP and creosote constituents from sediments was only 0.7% (Table 4.13). However, volatilization of individual components [compounds 1 and 2] was much higher. When analytical chemistry data were combined with the observed losses via volatilization, percent biodegradation of individual components was calculated accurately (Table 4.14).

As was observed with the unamended surface soils (Table 4.7) the rate of biodegradation was slow and the pattern of biodegradation was predictable. From the data presented, the extent of biodegradation (as determined by percent biodegradation after 12 weeks incubation) appears to have been less with the unamended sediment than with the unamended surface soil. However, since the data are presented on a percent basis, the actual biodegradation must be considered as a function of creosote loading rate. Therefore, the actual amount of carbon turnover in the unamended sediments was greater than that observed in the unamended surface soils. Nevertheless, unamended sediments still contained a very high concentration of creosote after 12 weeks incubation in the land-farming chambers.

Tables 4.15 and 4.16 summarize respectively creosote recovery data from creosote-contaminated sediments following 12 weeks of solid-phase bioremediation with inorganic nutrient amendments, and loss of PCP and 42 monitored creosote constituents via volatilization over this time frame. Loss of creosote constituents from sediments amended with inorganic nutrients was 1.9% over the 12 week incubation time. In combination with the volatilization values reported above for unamended sediment, it appears that volatilization was greater with the sediment materials than with the surface soils. Despite the relative insignificance of these values, abiotic losses such as volatilization were considered when calculating percent biodegradation values (Table 4.17).

In contrast to the results obtained with surface soils, the addition of inorganic nutrients did not exert a stimulatory effect on the rate of biodegradation of monitored constituents in sediments. For the lower molecular weight PAHs, final values for % biodegradation after 12 weeks incubation were roughly equivalent with or without nutrient amendments. However, inorganic nutrient supplementation appeared to have a positive effect on the extent of biodegradation of the higher-molecular-weight components of creosote.

For both sediment treatments, the total heterotrophic populations were equivalent throughout the incubation period (Table 4.18). At the beginning of the experiments, microbial counts were very low presumably due to the high pH (pH=10) and degree of contamination (5% creosote). With continued incubation, however, microbial populations appeared to have adapted to this environment as evidenced by a significant increase in both the total heterotrophic plate counts and phenanthrene-degrading counts after 8 weeks incubation. This increase in microbial numbers correlated well with a decrease in the concentration of monitored contaminants (Tables 4.12 and 4.15). Moreover, the number of phenanthrene-degraders was approximately 100 times greater in the nutrient-amended sediment than in the unamended material which may be related to the greater degradative activity against high-molecular-weight PAHs observed with this treatment.

4.5 Slurry-Phase Bioremediation

On April 6 and 7, 1990, approximately 100 lbs of both creosote-contaminated surface soil from grid 47 and sediment were washed on site by Chapman, Inc. (Freehold, New Jersey). The resultant slurry phases devoid of large (>2 mm diam), uncontaminated solids were to be used for slurry-phase biodegradation studies. However, the surfactant used to facilitate dispersion and the transfer of creosote constituents into the aqueous phase (Nancy B) was shown to be toxic and bacteriocidal. Furthermore, it was later discovered that the washing agent used was considered proprietary. Therefore, this process was repeated (see APPENDIX A) and a second batch of slurries was used in these studies.

Changes in the concentration of monitored chemicals during slurry-phase bioremediation of surface soils are presented in Table 4.19. While loss via volatilization was insignificant (Table 4.20), relatively high concentrations of the higher-molecular-weight PAHs [compounds 7 through 21] and PCP [31] were found in the bioreactor sludge and residues. Although Triton X-100 was present to enhance the solubility of these compounds, abiotic loss through physical adsorption had occured.

Since loss of monitored compounds through abiotic processes was quantified, calculations were made to determine accurately the actual amount of PCP and each monitored creosote constituent biologically degraded in the bioreactor over time (Table 4.21). In general, the % biodegradation of each compound did not increase after 14 days of incubation. Hence, with the exception of napthalene [1], the extent of the biological activity against each compound was fully realized within 14 days of incubation.

As was observed with solid-phase bioremediation of surface soils, indigenous microorganisms readily degraded lower-molecular-weight PAHs and phenolic components of creosote, but the higher-molecular-weight molecules and PCP resisted biological attack. After 14 days of incubation, only 35 to 50% of the high-molecular-weight PAHs containing 4 or more fused rings were biodegraded. With continued incubation (21 and 30 days), only benzo[b]fluorene [16] underwent further degradation. Therefore, slurry-phase bioremediation employing indigenous microorganisms offers an advantage over solid-phase bioremediation of these materials in terms of time (14 days vs. 12 weeks). However, neither approach resulted in extensive degradation of the more recalcitrant contaminants when indigenous microorganisms were employed as biocatalysts.

Table 4.2 Recovery of PCP and 42 Creosote Constituents from Spiked Soil and Water Samples from the ACW Site, Pensacola, Florida

Compound ID[1] Number	Background Concentration[2] µg/ml[4]	Amount Added µg/ml[4]	Recovery[3] Soil %	Water %
1	6.4	52.5	92	90
2	5.6	50.0	93	87
3	1.8	47.0	107	87
4	U	49.5	95	78
5	U	49.5	100	80
6	8.5	58.0	85	80
7	U	48.0	140	80
8	10.3	54.5	100	78
9	4.0	47.5	116	87
10	16.0	55.0	128	94
11	15.7	56.0	109	80
12	6.5	53.5	108	73
13	9.8	51.0	125	138
14	56.1	52.5	202	100
15	56.9	45.5	169	102
16	10.4	49.0	99	100
17	41.3	55.5	207	100
18	50.3	54.5	116	100
19	13.2	5.0	183	107
20	61.7	14	586	97
21	21.5	2.8	665	96
22	U	20.0	36	71
23	U	16.0	43	71
24	U	18.0	50	73
25	U	39.0	37	70
26	U	40.0	28	71
27	U	60.0	39	70
28	U	22.0	44	75
29	U	38.0	48	76
30	U	94.0	47	72
31	1.1	52.0	114	102
32	—	—	—	—
33	—	—	—	—
34	0.3	30.0	18	57
35	0.9	31.0	29	74
36	0.05	28.0	9	88
37	0.3	48.0	76	78
38	7.2	30.0	207	165
39	1.7	46.0	130	152
40	5.6	32.0	73	90
41	3.2	28.0	28	101
42	3.3	16.0	57	163
43	9.1	19.0	128	118

[1] Chemicals identified in Table 4.1.
[2] Average of duplicate analyses on 10 g samples of soil.
[3] Average of triplicate independent analyses.
[4] U=undetected (below LOD).

Table 4.3 **Concentration in μg/ml[1] of PCP and Selected Creosote Constituents in Groundwater Subjected to the Action of Indigenous Microorganisms (Groundwater Shake Flask Study)**

Compound	Incubation Time (Days)					
ID Number	Time-Zero	1	3	5	8	14
1	28.7	17.2	0.1	U	0.1	U
2	4.7	3.0	U	U	0.1	U
3	9.5	5.7	2.1	1.5	U	U
4	3.0	1.7	1.2	U	U	U
5	2.4	1.4	1.2	1.2	1.0	0.3
6	1.3	0.8	0.5	0.8	0.7	0.2
7	0.6	0.3	0.4	0.6	0.6	0.2
8	13.6	9.0	8.3	9.6	9.7	1.8
9	11.6	7.8	8.0	5.2	1.8	0.1
10	32.8	23.5	23.1	15.4	0.3	U
11	4.7	3.2	3.0	2.7	2.2	0.5
12	5.2	3.7	3.7	4.0	4.2	1.5
13	3.3	2.1	1.9	U	U	U
14	16.2	11.5	11.5	13.3	13.5	7.6
15	10.4	7.8	7.3	8.2	8.3	4.7
16	2.5	1.7	1.7	1.8	2.0	1.2
17	2.7	1.8	1.8	2.0	2.1	1.2
18	2.1	0.5	U	U	U	0.9
19	2.9	2.0	2.0	2.0	2.2	1.3
20	2.9	2.8	2.0	2.1	2.1	1.7
21	1.9	1.3	1.4	1.4	1.2	0.9
22	1.1	0.6	0.2	0.1	0.1	U
23	4.2	2.7	0.3	0.2	0.2	U
24	0.1	U	U	U	U	U
25	0.2	U	U	U	U	U
26	2.0	0.1	U	U	U	U
27	2.5	1.9	U	U	U	U
28	0.2	0.1	U	U	U	U
29	1.3	0.5	0.2	0.1	U	U
30	0.4	0.1	0.1	0.1	U	U
31	0.1	0.3	0.1	0.1	0.1	0.1

[1] *Data reported are the averages of duplicate samples.*
U=undetected (below LOD).

Changes in the aqueous concentration of monitored constituents over time during slurry-phase bioremediation of creosote- and PCP-contaminated sediment are summarized in Table 4.22. Given the high degree of contamination of this material, data are reported as milligrams (mg) per bioreactor (all other tables report data in μg). The loss of each monitored compound via volatilization is reported in Table 4.23. Loss via volatilization was greatest in this system compared to all others tested. However, percent loss via volatilization was small in relation to the high concentration of material in the sediment slurry. Large amounts (0.5 to 30 mg) of the higher molecular-weight PAHs were recovered from the sludge and water-insoluble residues of the bioreactor. Hence, losses via physical adsorption were quite significant: 36% of the pyrene [15] originally present in the sediment slurry was recovered from bioreactor residues. Hence, abiotic removal processes contributed greatly to the observed decreases in the concentration of creosote constituents.

Taking into consideration the data quantitating abiotic losses of individual compounds, percent biodegradation values were calculated to quantify the precise amount of material biodegraded over time (Table 4.24). In general, rapid rates of biodegradation were evident. Within 3 days of incubation, a majority of the contaminants was degraded, with little change occurring upon continued incubation. Physical adsorption of the high molecular-weight components and volatilization of the lower molecular-weight contaminants may have contributed to this rapid loss. Nevertheless, data corrected for these losses still reflect extensive degradation.

Of particular interest is the apparent biodegradation of high-molecular-weight PAHs with this system. The extent to which these compounds were degraded in the slurry reactors was much greater than that observed with solid-phase bioremediation. Moreover, the rate of biodegradation of targeted contaminants was much greater with the slurry-phase bioreactors: only three days were required for slurry-phase bioremediation to reduce the concentration to levels achieved after 12 weeks of solid-phase treatment.

Table 4.4 Response of Embryonic *Menidia beryllina* to Untreated and Biotreated Filtered Groundwater from the ACW Site, Pensacola, Florida

Criteria	Dilution Water	Concentration (%) of Well No. 320 Groundwater		
		100	10	1
Untreated Groundwater				
embryos				
% dead (terata)	0	0	100	67
% dead (no terata)	3	100	0	13
totals	3	100	100	80
larvae				
% normal	97	0	0	0
% with terata	0	0	0	20
totals	97	0	0	20
Biotreated Groundwater				
embryos				
% dead (terata)	0	0	97	0
% dead (no terata)	14	100	3	6
totals	14	100	100	6
larvae				
% normal	83	0	0	83
% with terata	3	0	0	11
totals	86	0	0	94

4.6 Sediment Shake Flask Studies

Shake flask studies were performed to evaluate the potential for bioremediation of creosote-contaminated solidified materials present at the ACW site. Since these studies were designed to offer a preliminary assessment of the applicability of biological treatment, only PAHs were monitored (Table 4.25). Following 14 days incubation, changes in the concentration of 21 monitored PAHs was minimal with unamended sediment (SM). Inoculation with indigenous surface soil microorganisms and/or adjustment to pH=7.0 offered only marginal improvement.

Presumably due to a combination of high pH, high creosote concentration and previous environmental conditions (anoxic/anaerobic), solidified material had very low counts of total aerobic heterotrophs ($2x10^2$ cells/g sediment). Despite adjustment to neutrality (pH=7.0), total heterotrophic plate counts did not increase significantly with time (100 cells/ml after 7 and 14 days incubation). When 1.0 g surface soil ($5x10^7$ cells) was added to supply inoculant in conjunction with pH amendment, total heterotrophic counts increased slightly after 14 days ($6x10^3$ cells/ml). Nevertheless, the extremely high creosote concentration in solidified material suggests that it must be diluted prior to implementation of biotreatment strategies.

Table 4.5 **Concentration of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida: Unamended Soil**

Compound ID Number	Weeks of Incubation 0	1	2	4	8	12
	mg/Land-Farming Chamber (3kg) [1]					
1	3.0	3.0	2.4	2.7	2.4	1.8
2	2.1	2.4	1.2	1.2	1.2	U
3	3.6	3.3	1.8	2.4	1.2	U
4	9.9	9.0	4.2	4.5	3.9	3.9
5	7.2	6.6	5.7	6.0	0.9	U
6	4.2	3.6	3.0	U	U	U
7	15.6	12.0	8.9	11.1	10.2	9.6
8	21.3	11.4	5.4	8.7	4.2	3.3
9	9.3	8.7	3.6	7.2	6.9	U
10	33.6	17.4	26.1	25.8	28.8	21.6
11	28.8	32.1	28.8	27.6	23.1	12.0
12	41.7	36.6	37.8	39.3	26.1	8.7
13	48.6	40.8	36.6	48.3	32.4	15.3
14	104.1	103.5	62.4	81.3	78.9	61.2
15	148.2	150.0	86.1	87.3	90.0	69.6
16	23.7	15.6	14.1	13.5	23.4	17.1
17	114.0	84.9	72.9	78.9	88.2	53.4
18	84.3	68.4	58.5	61.2	46.5	63.6
19	35.7	26.7	29.1	30.6	30.0	25.2
20	112.8	115.8	96.6	106.5	105.6	109.8
21	29.7	28.9	29.4	29.1	29.0	29.2
22	0.2	0.1	U	U	U	U
23	U	U	U	U	U	U
24	U	U	U	U	U	U
25	U	U	U	U	U	U
26	U	U	U	U	U	U
27	U	U	U	U	U	U
28	0.9	U	U	U	U	U
29	0.1	0.2	0.2	0.1	0.1	0.1
30	0.1	0.3	0.3	0.2	0.1	0.1
31	123.3	114.9	211.1	80.1	41.1	46.8
32	U	U	U	U	U	U
33	0.2	0.1	0.1	0.1	0.1	U
34	U	U	U	U	U	U
35	0.9	U	U	U	U	U
36	0.1	0.1	0.1	0.1	U	U
37	0.1	0.1	U	U	U	U
38	6.9	5.8	5.7	3.9	2.4	2.4
39	21.6	4.2	4.2	5.7	3.3	4.5
40	20.0	4.8	4.8	3.2	1.8	1.2
41	47.4	32.4	7.3	8.4	2.9	3.3
42	46.8	7.8	14.4	12.3	5.7	8.0
43	70.5	69.3	44.1	37.5	19.5	14.1

[1] Data reported are the averages of duplicate samples; U=undetected (below LOD).

Table 4.6 Loss (Volatilization) from the Land Farming Chamber Containing Unamended Surface Soil

Compound ID Number	Presence in Activated Carbon Traps[1] (µg/10 g Carbon)						Total (µg)
	Day 2	Wk 1	Wk 3	Wk 5	Wk 8	Wk 12	
1	U	0.4	U	U	U	0.5	0.9
2	U	U	1.0	U	U	0.2	1.2
3	U	U	U	U	0.3	0.2	0.5
4	U	U	U	U	U	1.1	1.1
5	U	U	U	U	0.1	0.7	0.8
6	U	U	U	U	0.1	U	0.1
7	U	0.4	0.8	1.0	0.5	1.0	3.7
8	U	U	U	U	0.1	0.5	0.6
9	U	U	U	U	U	1.5	1.5
10	U	U	U	U	U	0.5	0.5
11	U	U	U	U	U	U	U
12	U	U	U	U	U	0.6	0.6
13	U	U	U	12.0	U	0.7	12.7
14	U	U	U	U	0.1	U	0.1
15	U	U	U	U	U	U	U
16	U	U	U	U	0.1	U	0.1
17	U	U	U	U	0.5	0.4	0.9
18	U	U	U	U	0.1	3.1	3.2
19	U	U	U	U	0.1	0.3	0.4
20	U	U	U	U	U	U	U
21	U	U	U	U	U	U	U
22	U	U	U	U	U	U	U
23	U	U	U	U	U	U	U
24	U	U	U	U	U	0.1	O.1
25	U	U	U	U	U	U	U
26	U	U	U	U	U	U	U
27	U	U	U	U	U	U	U
28	U	U	4.8	0.3	U	U	5.1
29	U	U	U	0.1	U	U	0.1
30	U	U	0.5	0.4	U	U	0.9
31	0.1	U	U	U	U	U	U
32	U	U	16.1	U	U	U	16.1
33	0.2	U	U	0.5	U	U	0.7
34	U	U	U	U	U	2.3	2.3
35	U	U	677.5	U	U	0.1	677.6
36	U	0.3	80.4	U	U	U	80.7
37	U	U	U	U	U	U	U
38	U	U	135.3	U	U	0.2	135.5
39	U	U	11.1	0.8	0.4	0.8	13.1
40	U	U	U	0.3	U	1.1	1.4
41	U	U	U	0.3	0.9	0.3	1.5
42	U	U	U	U	U	1.9	1.9
43	U	U	U	U	0.7	U	0.7

[1] Values corrected for presence of individual components in control trap; U=below LOD.

Table 4.7 Percent Biodegradation of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida: Unamended Soil

Compound ID Number	Weeks of Incubation				
	1	2	4	8	12[1]
1	0	20	10	20	40
2	0	43	43	43	99
3	8	50	33	67	99
4	10	57	55	61	61
5	13	21	17	85	99
6	14	29	100	100	99
7	19	43	29	35	39
8	46	75	59	80	85
9	6	61	23	26	99
10	48	22	23	14	36
11	0	0	4	20	58
12	12	9	6	37	79
13	15	25	1	33	69
14	1	40	22	23	41
15	0	42	40	39	53
16	34	41	43	5	28
17	25	36	31	23	53
18	19	30	27	44	25
19	25	19	14	16	29
20	0	14	5	6	3
21	3	1	2	2	2
22	50	100	100	100	100
23	—	—	—	—	—
24	—	—	—	—	—
25	—	—	—	—	—
26	—	—	—	—	—
27	—	—	—	—	—
28	100	100	100	100	99
29	0	0	0	0	0
30	0	0	0	0	0
31	7	0	35	67	62
32	—	—	—	—	—
33	ND	50	ND	ND	99
34	—	—	—	—	—
35	ND	100	ND	ND	22
36	ND	0	ND	ND	20
37	ND	100	ND	ND	100
38	ND	17	ND	ND	64
39	ND	81	ND	ND	79
40	ND	76	ND	ND	94
41	ND	85	ND	ND	93
42	ND	69	ND	ND	83
43	ND	37	ND	ND	80

[1] Week 12 data corrected for volatilization (Table 4.6); ND=not determined.

Table 4.8 **Concentration of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida: Plus Nutritional Amendments**

Compound ID Number	Weeks of Incubation 0	1	2	4	8	12
	mg/Land Farming Chamber (3kg) [1]					
1	3.0	2.7	2.1	2.1	1.2	1.2
2	2.1	1.5	0.9	1.2	0.6	U
3	3.6	0.9	0.9	0.0	1.2	U
4	9.9	9.0	2.7	6.3	3.6	U
5	7.2	6.0	3.3	2.7	0.9	U
6	4.2	2.7	4.5	1.8	0.6	U
7	15.6	12.3	12.3	15.3	9.9	8.4
8	21.3	8.7	7.5	8.7	4.5	3.6
9	9.3	3.3	3.3	2.7	2.1	U
10	33.6	30.9	19.2	25.4	19.3	14.4
11	28.8	32.7	15.0	9.0	5.4	3.3
12	41.7	17.1	15.9	15.3	12.6	9.9
13	48.6	35.7	24.6	33.6	19.2	11.1
14	104.1	97.2	73.5	93.6	61.5	45.6
15	148.2	165.3	102.6	164.4	89.1	55.2
16	23.7	24.0	14.4	22.5	13.8	11.4
17	114.0	95.7	113.4	110.4	51.6	46.2
18	84.3	90.6	78.0	93.6	60.9	47.7
19	35.7	49.8	48.3	51.6	46.5	31.8
20	112.8	111.9	110.1	114.3	96.3	81.3
21	29.7	28.8	28.2	29.1	27.6	24.3
22	0.2	0.1	U	U	U	U
23	U	U	U	U	U	0.1
24	U	U	U	U	U	U
25	U	U	U	U	U	U
26	U	U	U	U	U	U
27	U	U	U	U	U	U
28	0.9	0.1	U	U	U	U
29	0.1	0.2	0.1	0.2	0.2	0.2
30	0.1	0.1	0.1	0.3	U	U
31	123.3	150.9	261.9	102.9	68.4	71.7
32	U	U	U	U	U	U
33	0.2	U	0.1	0.1	0.1	U
34	U	U	U	U	U	U
35	0.9	U	U	U	U	U
36	0.1	0.1	0.1	0.1	0.1	U
37	0.1	0.2	0.1	0.1	0.1	0.1
38	6.9	1.0	2.0	2.1	1.4	U
39	21.6	10.5	9.5	5.1	4.0	3.9
40	20.0	4.2	4.9	3.6	1.7	1.0
41	47.4	21.9	27.9	3.6	5.1	4.2
42	46.8	10.2	29.6	8.7	6.6	6.3
43	70.5	10.0	49.8	39.3	12.6	9.9

[1] Data reported are the averages of duplicate samples; U=undetected (below LOD); ND=not determined.

Table 4.9 Loss (Volatilization) from the Land Farming Chamber Containing Nutrient-Amended Surface Soil

Compound ID Number	Presence in Activated Carbon Traps[1] (g/10 g Carbon)						Total (µg)
	Day 2	Wk 1	Wk 3	Wk 5	Wk 8	Wk 12	
1	U	U	U	U	0.9	1.0	1.9
2	U	U	U	U	U	U	U
3	U	U	U	1	U	U	1.0
4	U	U	U	U	0.1	U	0.1
5	U	U	U	U	U	U	U
6	U	U	U	U	U	U	U
7	U	1.0	U	1.0	U	U	2.0
8	U	U	U	U	U	U	U
9	U	U	U	U	U	0.2	0.2
10	U	U	U	U	U	0.3	0.3
11	U	U	U	U	U	0.8	0.8
12	U	U	U	U	U	U	U
13	U	U	U	6.0	U	U	6.0
14	U	U	U	U	U	U	U
15	U	U	U	U	U	U	U
16	U	U	U	U	U	U	U
17	U	U	U	U	0.4	U	0.4
18	U	U	U	U	0.2	1.5	1.7
19	U	U	1.0	U	1.4	U	[illegible]
20	U	U	U	U	0.1	U	0.1
21	U	U	U	U	U	U	U
22	U	U	U	U	U	U	U
23	U	U	U	U	U	U	U
24	U	U	U	U	U	U	U
25	U	U	U	U	U	U	U
26	U	U	U	U	U	U	U
27	U	U	U	U	U	U	U
28	U	U	U	U	U	U	U
29	U	U	U	U	U	U	U
30	U	U	U	0.3	U	U	0.3
31	0.01	0.02	U	U	U	U	0.03
32	U	U	U	U	U	U	U
33	U	U	U	U	0.1	U	0.1
34	U	U	U	U	U	U	U
35	U	U	0.1	U	U	U	0.1
36	U	0.9	U	U	U	U	0.9
37	U	0.6	0.3	U	U	U	0.9
38	U	1.1	0.4	0.5	U	U	2.0
39	U	0.9	0.2	U	U	U	1.1
40	U	0.4	0.9	1.5	U	U	2.8
41	U	0.8	0.3	0.3	U	0.6	2.0
42	U	U	U	U	U	2.5	2.5
43	U	U	0.4	U	U	U	0.4

[1] Values corrected for presence of individual components in control trap; U=below LOD.

Table 4.10 Percent Biodegradation of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida: Plus Nutritional Amendments

Compound ID Number	Weeks of Incubation 1	2	4	8	12[1]
1	10	30	30	60	60
2	29	57	43	71	99
3	75	75	100	67	99
4	10	73	36	64	99
5	17	54	63	85	100
6	36	50	57	86	100
7	21	21	2	37	46
8	59	65	59	79	83
9	65	65	71	77	99
10	8	43	24	43	57
11	0	48	69	81	89
12	59	62	63	70	76
13	27	49	31	61	77
14	7	29	11	41	56
15	0	30	0	40	63
16	0	39	5	42	52
17	16	1	4	54	59
18	0	7	0	28	43
19	0	0	0	0	11
20	1	1	0	14	28
21	3	5	3	7	18
22	50	100	100	100	100
23	—	—	—	—	—
24	—	—	—	—	—
25	—	—	—	—	—
26	—	—	—	—	—
27	—	—	—	—	—
28	89	100	100	100	100
29	0	0	0	0	0
30	0	0	0	100	100
31	0	0	17	45	42
32	—	—	—	—	—
33	ND	50	ND	ND	100
34	—	—	—	—	—
35	ND	100	ND	ND	100
36	ND	0	ND	ND	100
37	ND	0	ND	ND	0
38	ND	71	ND	ND	100
39	ND	56	ND	ND	82
40	ND	76	ND	ND	95
41	ND	43	ND	ND	91
42	ND	37	ND	ND	87
43	ND	29	ND	ND	86

[1] Week 12 data corrected for volatilization (Table 4.9); ND=not determined.

Table 4.11 Changes in Soil Microbial Numbers during Solid-Phase Bioremediation of Creosote-Contaminated Surface Soils Obtained from the ACW Site, Pensacola, Florida

Time	Unamended		Plus Nutrients	
	Total Heterotrophs	Phenanthrene-degraders	Total Heterotrophs	Phenanthrene-degraders
	log CFU/g Soil			
Initial counts	7.8	0	7.8	0
Week 2	8.1	0	8.1	0
Week 4	8.2	0	8.2	5.7
Week 8	6.2	0	7.3	5.7
Week 12	7.6	5.3	7.9	4.4

Table 4.12 Concentration of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Sediments from the ACW Site, Pensacola, Florida: Unamended Sediment

Compound ID Number	Weeks of Incubation					
	0	1	2	4	8	12
	mg/Land Farming Chamber (3 kg)[1]					
1	11773.5	8325.6	7764.9	7022.7	5137.2	1845.0
2	4356.9	3429.9	3413.4	3294.3	2886.6	2673.0
3	1869.9	1471.2	1433.6	1411.8	1240.5	1191.9
4	995.7	816.6	816.9	810.9	726.0	714.6
5	889.2	730.5	727.8	730.8	654.9	650.1
6	502.5	453.9	436.8	424.5	397.8	390.3
7	148.2	110.1	117.0	117.9	102.0	100.5
8	4103.1	3447.6	3546.3	3497.3	3175.5	3129.3
9	5376.3	4484.4	4792.2	4694.1	4263.9	4286.7
10	13301.4	11055.6	11892.3	11730.9	10677.3	10698.9
11	9111.3	7614.0	9097.2	7683.3	7365.0	7453.2
12	1549.3	1223.7	1290.6	1284.3	1225.2	1206.3
13	1229.7	1274.4	1080.0	1050.3	1168.8	1122.9
14	4886.1	4062.6	4375.8	4373.7	4035.6	3279.0
15	3047.7	2530.2	2615.1	2606.4	2409.0	2326.8
16	864.9	688.8	725.1	724.5	670.8	657.6
17	1443.6	1032.3	1188.6	1185.6	1080.6	1146.6
18	246.6	191.7	205.2	208.5	192.6	183.6
19	513.6	509.4	486.9	426.6	443.7	446.1
20	418.8	489.5	423.9	386.4	384.6	345.6
21	67.8	75.3	67.5	60.3	67.5	54.0
22	6.3	5.1	4.2	3.3	0.5	0.4
23	29.1	30.6	21.9	15.6	0.4	0.4
24	27.0	29.7	17.4	14.7	3.3	2.4
25	60.3	74.4	42.9	29.4	14.1	6.3
26	65.1	42.6	20.1	20.1	U	U
27	63.3	62.7	37.2	32.4	1.4	1.4
28	15.0	12.0	11.1	7.2	4.2	3.9
29	83.1	78.9	57.0	43.2	29.4	27.9
30	37.5	32.1	21.0	18.6	10.2	8.7
31	127.5	68.1	141.6	176.4	154.8	195.6
32	0.6	0.4	U	U	U	U
33	8.3	1.8	U	U	U	U
34	5.4	4.8	U	U	U	U
35	377.4	133.2	265.5	208.5	201.6	161.4
36	170.7	78.3	109.5	140.4	36.4	25.2
37	90.9	84.3	57.3	82.5	72.3	63.0
38	2244.9	1765.2	1752.6	1622.9	1227.6	1318.2
39	1312.8	1260.9	904.2	930.0	978.6	1023.6
40	3793.5	3259.5	3300.6	2853.5	2337.0	2601.6
41	1426.5	1104.6	1196.1	945.7	934.8	1051.2
42	14569.7	14322.3	12655.8	7928.7	8439.3	9949.8
43	5191.8	5357.4	4846.5	2692.2	2841.3	2900.1

[1] Data reported are the averages of duplicate samples; U=undetected (below LOD); ND=not determined.

Table 4.13 **Loss (Volatilization) from the Land Farming Chamber Containing Unamended Sediment**

Compound ID Number	Presence in Activated Carbon Traps[1], µg/10 g Carbon						
	Day 2	Wk 1	Wk 3	Wk 5	Wk 8	Wk 12	Total, µg
1	0.5	7.0	10.0	0.9	34	626	677.4
2	U	U	0.8	38.0	28.0	34.0	100.8
3	U	U	0.6	3.0	16.0	30.0	49.6
4	U	U	U	13.0	8.0	7.0	28.0
5	U	U	U	7.0	2.0	4.0	13.0
6	U	U	U	2.0	2.0	2.0	6.0
7	U	U	U	1.0	6.0	1.0	8.0
8	U	U	U	10.0	3.0	8.0	21.0
9	U	U	U	U	0.5	0.9	1.4
10	U	U	U	U	0.3	0.8	1.1
11	U	U	U	U	0.2	U	0.2
12	U	U	U	U	0.2	U	0.2
13	U	U	U	9.0	U	U	9.0
14	U	U	U	U	0.1	U	0.1
15	U	U	U	U	0.1	U	0.1
16	U	U	U	U	0.1	0.1	0.2
17	U	U	U	U	0.2	U	0.2
18	U	U	U	U	0.3	0.2	0.5
19	U	U	U	U	2.0	U	2.0
20	U	U	U	U	U	U	U
21	U	U	U	U	0.1	U	0.1
22	U	U	U	U	0.7	1.9	2.6
23	U	U	U	U	0.4	0.4	0.8
24	U	U	U	U	U	U	U
25	U	U	U	U	0.2	U	0.2
26	U	U	U	U	0.2	U	0.2
27	U	U	U	U	0.3	U	0.3
28	U	U	U	U	U	0.3	0.3
29	U	U	U	U	0.2	U	0.2
30	U	U	U	U	U	0.3	0.3
31	0.01	U	U	U	U	U	0.01
32	U	U	U	U	U	U	U
33	U	U	U	U	8.7	0.8	9.5
34	U	U	U	U	6.5	U	6.5
35	U	1.4	0.9	1.0	U	6.7	10.0
36	U	1.5	1.2	0.9	U	1.7	5.3
37	U	0.7	2.7	U	U	0.5	3.9
38	U	U	4.5	U	U	2.1	6.6
39	U	U	3.9	2.2	3.0	0.5	9.8
40	U	U	1.5	U	0.9	0.4	2.8
41	U	0.6	0.2	U	1.1	U	1.9
42	U	U	U	U	0.2	U	0.2
43	U	U	0.4	U	1.4	U	1.8

[1] Values corrected for presence of individual components in control trap; U=below LOD.

Table 4.14 **Percent Biodegradation of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Sediment from the ACW Site, Pensacola, Florida: Unamended Sediment**

Compound ID Number	Weeks of Incubation				
	1	2	4	8	12[1]
1	29	34	40	56	84
2	21	22	24	34	39
3	21	23	24	34	36
4	18	18	18	27	28
5	18	18	18	26	27
6	10	13	16	21	22
7	24	20	20	31	32
8	16	14	15	23	24
9	17	11	13	21	20
10	17	11	12	20	20
11	16	1	16	19	18
12	21	17	17	21	22
13	0	12	15	5	7
14	17	10	11	17	33
15	17	14	14	21	24
16	20	16	16	23	24
17	29	18	18	25	21
18	22	17	15	22	24
19	1	5	17	12	12
20	2	0	8	8	18
21	0	0	9	0	13
22	19	33	48	92	52
23	0	25	46	99	96
24	0	36	47	88	91
25	0	17	51	77	89
26	35	70	70	100	99
27	1	41	49	98	98
28	22	26	52	72	72
29	5	31	48	65	66
30	14	44	50	73	77
31	23	0	0	0	0
32	ND	100	ND	ND	100
33	ND	100	ND	ND	100
34	ND	100	ND	ND	100
35	ND	30	ND	ND	57
36	ND	36	ND	ND	85
37	ND	37	ND	ND	31
38	ND	22	ND	ND	41
39	ND	31	ND	ND	22
40	ND	13	ND	ND	31
41	ND	16	ND	ND	26
42	ND	13	ND	ND	32
43	ND	7	ND	ND	44

[1] Week 12 data corrected for volatilization (Table 4.13); ND=not determined

Table 4.15 **Concentration of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Sediments from the ACW Site, Pensacola, Florida: Nutrient-Amended Sediment**

Compound ID Number	Weeks of Incubation					
	0	1	2	4	8	12
	mg/Land Farming Chamber (3kg) [1]					
1	11733.5	8151.9	9843.6	8278.5	6144.6	380.4
2	4356.9	3333.9	3967.5	3525.6	3468.0	1084.8
3	1869.9	1460.7	1660.5	1504.2	1492.5	501.0
4	995.7	792.9	908.4	847.8	869.7	313.5
5	889.2	709.5	808.5	753.9	785.1	290.4
6	502.5	438.3	478.2	441.0	466.2	178.8
7	148.2	107.7	128.4	122.7	128.7	99.8
8	4103.1	3342.0	3951.9	3564.9	3728.1	2887.8
9	5376.3	4392.6	5161.5	4942.2	5003.4	3938.4
10	13301.4	9616.5	12519.6	12362.4	12534.6	10050.6
11	9111.3	4778.7	8970.3	9186.0	8949.0	6706.8
12	1549.2	613.8	1461.6	1332.3	1402.2	1180.8
13	1229.7	1273.2	1135.5	1209.6	1309.5	1202.6
14	4886.9	4286.7	4786.8	4358.7	4575.0	3832.8
15	3047.7	2613.6	2870.4	2633.4	2707.2	2316.0
16	864.9	711.9	815.1	612.3	741.3	622.2
17	1443.6	1032.9	1413.0	1112.7	1281.0	992.4
18	246.6	192.0	219.6	219.0	222.0	178.8
19	513.6	456.9	454.8	504.0	471.3	278.4
20	418.7	426.0	365.7	435.6	418.5	351.6
21	67.8	60.9	68.1	55.2	57.3	47.4
22	6.3	4.7	1.8	1.5	0.8	1.2
23	29.1	27.1	18.5	18.5	0.6	0.4
24	27.0	22.3	15.0	15.0	3.9	2.1
25	60.3	43.2	29.2	30.3	12.0	2.4
26	65.1	36.9	28.0	20.9	0.8	0.3
27	63.3	56.1	38.0	35.7	2.6	0.9
28	15.0	10.2	7.4	7.4	5.3	6.3
29	83.1	68.7	56.1	54.2	39.2	28.8
30	37.5	29.6	21.8	21.8	12.9	18.3
31	127.5	57.3	140.7	141.9	173.1	172.8
32	0.6	0.5	U	U	U	U
33	8.3	0.9	U	U	U	U
34	5.4	3.9	4.8	U	U	0.6
35	377.4	632.1	332.7	341.4	282.2	115.2
36	170.7	153.1	182.7	173.4	61.2	22.8
37	90.9	113.7	81.1	90.1	82.9	53.4
38	2244.9	2151.9	1833.6	1869.9	1420.0	1200.6
39	1312.8	1146.3	1108.5	1188.6	1183.7	903.6
40	3793.5	3638.1	2933.4	2582.1	3263.9	2920.5
41	1426.5	1382.1	1119.9	978.9	1181.0	1044.0
42	14569.5	14991.0	10001.1	10128.3	9936.1	9619.5
43	5191.8	3565.8	4563.0	3988.2	3298.2	2892.9

[1] Data reported are the averages of duplicate samples; U=undetected (below LOD).

Table 4.16 Loss (Volatilization) from the Land Farming Chamber Containing Nutrient-Amended Sediment

Compound ID Number	Presence in Activated Carbon Traps[1] (µg/10 g Carbon)						
	Day 2	Wk 1	Wk 3	Wk 5	Wk 8	Wk 12	Total (µg)
1	3.0	3.0	U	0.1	510.1	720.2	1288.3
2	U	U	3.0	0.1	66.0	845.2	914.3
3	0.4	U	6.0	0.2	42.0	358.0	406.6
4	U	U	U	0.1	7.0	67.0	74.1
5	U	U	U	U	3.0	44.0	47.0
6	U	U	U	0.1	3.0	U	3.1
7	U	U	U	0.1	6.0	U	6.1
8	U	U	0.1	0.2	7.0	59.0	66.3
9	U	U	U	U	0.1	1.4	1.5
10	U	U	U	0.1	0.1	U	0.2
11	U	U	U	U	0.1	0.6	0.7
12	U	U	U	0.2	0.2	0.2	0.6
13	U	U	U	3.0	U	0.1	3.1
14	U	U	U	U	0.1	0.3	0.4
15	U	U	U	U	0.1	U	0.1
16	U	U	U	U	U	U	U
17	U	U	U	U	0.1	0.2	0.3
18	U	U	U	0.3	0.1	U	0.4
19	U	U	U	0.4	0.2	U	0.6
20	U	U	U	U	U	U	U
21	U	U	U	U	U	U	U
22	U	U	U	0.1	2.3	U	2.4
23	U	U	U	U	0.9	0.6	1.5
24	U	U	U	U	U	0.5	0.5
25	U	U	U	U	0.8	1.4	2.2
26	U	U	U	U	U	0.8	0.8
27	U	U	U	U	0.4	0.9	1.3
28	U	U	U	U	U	U	U
29	U	U	U	U	U	0.4	0.4
30	U	U	U	U	U	U	U
31	0.02	U	0.03	U	U	U	0.05
32	U	U	U	U	1.4	0.2	1.6
33	U	U	U	U	49.6	12.1	61.7
34	U	U	U	U	U	U	U
35	U	2.2	750.9	60.0	279.9	657.6	1750.6
36	U	2.2	39.5	5.7	43.5	153.6	244.5
37	U	0.8	16.6	3.3	13.6	U	34.3
38	U	U	34.2	2.1	3.6	4.3	10.3
39	U	U	10.9	0.2	11.3	87.7	110.1
40	U	U	3.4	U	7.4	U	10.7
41	U	U	U	0.4	U	1.0	1.4
42	U	U	0.2	U	U	1.3	1.5
43	U	U	0.4	0.4	1.2	1.8	3.8

[1] Values corrected for presence of individual components in control trap; U=below LOD.

Table 4.17 **Percent Biodegradation of PCP and 42 Creosote Constituents during Solid-Phase Bioremediation of Creosote-Contaminated Sediment from the ACW Site, Pensacola, Florida: Nutrient-Amended Sediment**

Compound ID Number	Weeks of Incubation				
	1	2	4	8	12[1]
1	31	16	30	48	97
2	23	9	19	20	75
3	22	11	20	21	73
4	20	8	15	12	69
5	20	9	15	12	67
6	13	4	12	7	65
7	27	12	18	12	33
8	19	4	13	9	30
9	18	4	8	7	27
10	28	6	7	6	24
11	48	2	0	2	26
12	60	6	14	10	24
13	0	7	2	0	2
14	12	2	11	6	22
15	14	6	14	11	24
16	18	6	29	14	28
17	29	2	23	11	31
18	22	11	11	11	46
19	11	12	2	8	46
20	0	12	0	0	16
21	9	0	15	7	31
22	25	71	76	87	48
23	7	36	36	98	93
24	17	44	44	86	90
25	28	52	50	80	89
26	43	57	68	99	99
27	11	40	44	96	97
28	29	51	51	65	58
29	17	32	35	53	65
30	21	42	42	66	51
31	54	0	0	0	0
32	ND	100	ND	ND	100
33	ND	100	ND	ND	100
34	ND	7	ND	ND	89
35	ND	12	ND	ND	69
36	ND	0	ND	ND	87
37	ND	11	ND	ND	41
38	ND	18	ND	ND	47
39	ND	16	ND	ND	31
40	ND	23	ND	ND	23
41	ND	22	ND	ND	27
42	ND	31	ND	ND	34
43	ND	12	ND	ND	44

[1] Week 12 data corrected for volatilization (Table 4.16); ND=not determined.

Table 4.18 Changes in Soil Microbial Numbers during Solid-Phase Bioremediation of Creosote-Contaminated Sediments Obtained from the ACW Site, Pensacola, Florida

Time	Unamended: Total Heterotrophs	Unamended: Phenanthrene-degraders	Plus Nutrients: Total Heterotrophs	Plus Nutrients: Phenanthrene-degraders
	log CFU/g Soil			
Initial counts	2.9	0	2.9	0
Week 2	2.9	1.5	2.9	1.7
Week 4	3.2	2.3	3.8	2.3
Week 8	8.3	5.4	8.3	7.2
Week 12	7.7	5.7	8.6	7.4

Table 4.19 Concentration of PCP and 42 Monitored Creosote Constituents during Slurry-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida

Compound ID Number	Concentration in µg/Bioreactor (1100 ml)[1] after Incubation for (Days): 0	1	3	5	7	14	21	30
1	55	44	44	22	22	44	55	U
2	55	U	U	U	U	U	U	U
3	110	110	110	77	44	U	U	U
4	155	110	66	55	33	U	U	U
5	U	U	U	U	U	U	U	U
6	880	U	U	U	U	44	U	U
7	770	770	770	660	550	U	U	U
8	110	110	110	77	77	U	U	U
9	155	166	177	99	99	55	55	44
10	1100	990	990	990	990	660	660	660
11	880	880	660	440	440	220	110	110
12	330	330	330	220	220	220	110	110
13	550	550	440	440	440	330	330	220
14	2090	2090	1980	1540	1650	1210	1100	990
15	2530	2420	2310	1980	1980	1650	1210	1320
16	990	880	880	880	550	550	440	220
17	2860	2640	2530	2310	1980	1540	1320	1210
18	6820	5720	5610	5060	4840	3740	3520	3520
19	1067	1045	1089	1089	1034	902	924	902
20	770	671	682	440	693	660	528	506
21	1430	1067	1210	1034	1089	1100	1089	1089
22	22	17	12	4	U	U	U	U
23	34	30	33	U	U	U	U	U
24	U	U	U	U	U	U	U	U
25	U	U	U	U	U	U	U	U
26	U	U	U	U	U	U	U	U
27	33	31	33	U	U	U	U	U
28	110	U	66	U	U	U	U	U
29	66	66	55	45	36	27	22	20
30	110	55	47	22	U	U	U	U
31	99	44	66	44	55	77	55	55
32	U	U	U	U	U	U	U	U
33	U	U	U	U	U	U	U	U
34	U	U	U	U	U	U	U	U
35	40	22	22	22	17	11	11	11
36	3	4	8	U	4	U	U	U
37	66	23	22	26	22	18	18	11
38	55	27	33	26	31	35	22	22
39	55	28	22	40	28	15	2	2
40	121	39	55	50	46	41	22	22
41	90	70	77	75	65	55	59	50
42	242	143	110	143	138	132	89	65
43	473	330	330	286	275	264	264	220

[1] Data reported are the averages of duplicate samples; U=below LOD.

Table 4.20 Abiotic Losses during Slurry-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida

Compound ID Number	Activated Carbon Traps (µg/Trap[1])			Sludge Residue (Day 30)	Total
	7	21	30	µg	µg
1	0.1	0.2	U	0.3	0.3
2	U	U	U	0.2	0.2
3	0.4	U	U	0.2	0.6
4	0.1	U	U	0.2	0.3
5	U	U	U	U	U
6	U	U	U	U	U
7	U	U	U	47.0	47.0
8	U	0.3	0.3	7.0	7.6
9	U	U	U	10.0	10.0
10	U	0.4	U	33.0	30.4
11	U	U	U	13.0	13.0
12	U	U	U	14.0	14.0
13	U	U	U	30.0	30.0
14	U	U	U	145.0	145.0
15	U	U	U	182.0	182.0
16	U	0.1	U	37.0	37.1
17	U	1.5	0.4	167.0	168.9
18	U	0.4	U	483.0	483.4
19	U	U	U	5.0	5.0
20	U	U	U	11.0	11.0
21	U	U	U	8.4	8.4
22	U	U	U	U	U
23	U	12.5	6.2	U	18.7
24	U	U	U	0.1	0.1
25	U	U	U	U	U
26	U	U	U	U	U
27	U	U	U	U	U
28	U	1.6	41.7	U	43.3
29	U	4.7	21.4	1.5	27.6
30	U	11.3	66.7	1.2	79.2
31	0.02	0.02	0.03	3.8	4.5
32	U	U	U	U	U
33	U	0.1	0.1	U	0.2
34	U	0.1	0.1	U	0.2
35	U	U	U	U	U
36	U	U	U	U	U
37	U	U	U	U	U
38	U	U	U	U	U
39	U	U	U	U	U
40	U	0.2	U	U	0.2
41	U	U	U	U	U
42	U	U	U	1.5	1.5
43	U	U	U	1.2	1.2

[1] Volatilization data corrected for background; U=below LOD.

Table 4.21 Percent Biodegradation of PCP and 42 Monitored Creosote Constituents during Slurry-Phase Bioremediation of Creosote-Contaminated Surface Soils from the ACW Site, Pensacola, Florida

Compound ID Number	Days of Incubation 1	3	5	7	14	21	30[1]
1	20	20	40	40	20	40	99
2	100	100	100	100	100	100	100
3	0	0	30	70	100	100	99
4	29	57	65	79	100	100	99
5	—	—	—	—	—	—	—
6	100	100	100	100	95	100	100
7	0	0	14	29	100	100	94
8	0	0	30	30	100	100	93
9	0	0	36	36	65	65	65
10	10	10	10	10	40	40	37
11	0	2	50	50	75	88	86
12	0	0	33	33	33	66	62
13	0	20	20	20	40	40	55
14	0	5	26	21	42	47	46
15	4	9	22	22	35	52	41
16	11	11	11	44	44	56	74
17	8	12	19	31	46	54	52
18	16	18	26	29	45	48	41
19	0	0	0	3	16	13	15
20	13	11	43	10	14	31	15
21	25	15	28	24	23	24	23
22	23	46	82	100	100	100	100
23	12	3	0	100	100	100	45
24	—	—	—	—	—	—	—
25	—	—	—	—	—	—	—
26	—	—	—	—	—	—	—
27	6	0	0	100	100	100	100
28	100	40	100	100	100	100	61
29	0	17	32	45	59	67	28
30	50	57	80	100	100	100	28
31	56	33	56	45	23	45	40
32	—	—	—	—	—	—	—
33	—	—	—	—	—	—	—
34	—	—	—	—	—	—	—
35	50	50	50	58	73	73	73
36	0	0	100	100	100	100	100
37	65	67	61	67	73	73	83
38	51	40	53	44	36	60	60
39	49	60	27	49	73	96	96
40	68	55	59	62	66	83	83
41	22	14	17	28	39	34	44
42	41	55	41	43	46	63	72
43	30	30	40	42	44	44	53

[1] Day 30 values corrected for abiotic losses (Table 4.20).

Table 4.22 **Concentration of PCP and 42 Monitored Creosote Constituents during Slurry-Phase Bioremediation of Creosote-Contaminated Sediment from the ACW Site, Pensacola, Florida**

Compound ID Number	Concentration in mg/Bioreactor (1100 ml)[1] after Incubation for (Days):							
	0	1	3	5	7	14	21	30
1	171	100	1.5	0.9	0.8	0.7	0.1	U
2	79	48	3.6	2.1	1.7	0.9	0.2	0.1
3	39	24	6.4	1.9	U	0.3	U	U
4	22	12	6.1	2.8	U	0.2	U	U
5	19	11	5.6	3.6	1.5	0.4	U	U
6	11	6.5	3.9	1.9	1.5	1.2	0.9	0.7
7	4.3	3.0	1.5	0.9	1.9	U	U	U
8	100	61	36	29	23	10	0.4	0.2
9	125	79	56	41	19	0.4	0.2	0.1
10	341	217	158	116	17	6.7	2.0	1.4
11	167	72	86	63	5.7	3.7	1.7	0.9
12	38	24	17	15	18	17	0.7	0.4
13	30	15	11	11	10	7.8	1.8	1.2
14	138	84	62	58	67	62	1.4	0.9
15	83	50	36	35	40	40	30	19
16	21	13	9.5	9.5	10	11	2.0	1.1
17	34	19	14	14	14	15	2.2	1.8
18	7.5	3.9	2.6	3.1	2.8	3.1	3.4	2.2
19	1.4	1.4	1.1	1.1	1.0	1.2	0.2	0.2
20	5.3	5.2	5.0	4.6	5.2	5.1	5.0	4.0
21	1.0	0.7	0.9	0.6	0.4	0.4	0.6	0.6
22	4.2	0.2	0.2	0.2	0.2	0.1	0.1	U
23	3.3	1.3	1.7	0.3	0.1	0.1	0.1	U
24	1.9	0.8	0.4	0.1	0.1	0.1	0.1	U
25	4.8	1.2	1.2	0.1	0.1	0.1	0.1	U
26	3.2	0.9	0.4	0.1	0.1	0.1	0.1	U
27	6.4	2.9	1.5	0.6	0.2	0.1	0.1	U
28	14.6	1.0	0.9	0.4	1.9	1.5	0.2	0.1
29	6.5	2.9	0.8	2.1	1.0	0.8	0.2	0.1
30	10.8	1.5	0.7	0.4	0.4	0.2	0.3	0.2
31	2.5	1.1	1.2	1.1	0.4	0.9	0.4	1.1
32	U	U	U	U	U	U	U	U
33	U	U	U	U	U	U	U	U
34	U	U	U	U	U	U	U	U
35	7.8	3.0	2.4	2.1	1.0	0.7	0.1	U
36	5.1	4.6	0.9	0.3	0.1	0.1	U	U
37	3.5	2.9	1.2	0.6	0.2	0.1	U	U
38	17.8	17.4	8.0	3.1	0.6	0.2	U	U
39	1.9	1.2	0.9	0.5	0.9	0.6	0.1	U
40	41.6	38.3	29.4	18.4	4.0	1.8	0.3	U
41	15.2	14.5	14.3	13.2	3.9	2.5	1.5	0.3
42	108.2	104.9	97.4	78.4	54.5	39.5	2.5	1.3
43	44.3	46.4	45.3	41.8	21.6	13.0	0.9	0.4

[1]Data reported are the averages of duplicate samples; U=undetected (below LOD).

Table 4.23 ***Abiotic Losses during Slurry-Phase Bioremediation of Creosote-Contaminated Sediments from the ACW Site, Pensacola, Florida***

Compound ID Number	Activated Carbon Traps (µg/Trap[1])			Sludge Residue (Day 30) µg	Total µg
	7	21	30		
1	2474	21	3	420	2.918
2	422	23	24	617	1.086
3	399	U	U	67	0.466
4	133	14	U	203	0.350
5	83	17	U	187	0.287
6	45	25	U	259	0.329
7	5	U	U	541	0.546
8	300	245	44	1039	1.628
9	1	50	34	4219	4.304
10	18	31	15	14265	14.329
11	1	12	24	2043	2.080
12	0.8	4	11	5418	5.434
13	0.7	2	18	5828	5.849
14	U	0.2	3	29903	29.906
15	U	U	2	30214	30.216
16	1.1	U	0.2	5986	5.987
17	1.5	2	0.6	9582	9.586
18	U	0.2	0.7	2569	2.570
19	U	U	U	465	0.465
20	U	U	1.0	506	0.506
21	U	U	U	313	0.313
22	31.0	26.0	8.9	U	0.066
23	78.8	12.9	11.4	0.7	0.104
24	37.6	5.0	2.3	0.5	0.045
25	216.7	4.7	1.2	0.7	0.217
26	9.5	4.2	1.6	0.6	0.016
27	112.7	26.4	5.4	1.1	0.146
28	9.1	129.6	9.0	2.5	0.151
29	49.5	14.3	4.7	3.2	0.072
30	5.7	142.2	73.2	3.9	0.225
31	U	U	U	404	0.404
32	3.3	U	U	U	0.003
33	U	1.3	U	U	0.001
34	6.9	1.5	0.8	U	0.009
35	310.8	16.5	5.8	U	0.333
36	211.1	17.3	9.7	U	0.238
37	201.6	7.9	4.7	U	0.214
38	341.9	2.1	8.5	14.8	0.367
39	73.0	1.1	17.5	6.3	0.098
40	456.2	4.2	35.1	35.0	0.531
41	27.5	0.7	14.2	36.3	0.787
42	2.8	U	12.1	125.3	0.140
43	10.3	U	22.7	438.8	0.472

[1] *Volatilization data corrected for background; U=below LOD.*

Table 4.24 Percent Biodegradation of PCP and 42 Monitored Creosote Constituents during Slurry-Phase Bioremediation of Creosote-Contaminated Sediments from the ACW Site, Pensacola, Florida

Compound ID Number	Days of Incubation						
	1	3	5	7	14	21	30[1]
1	42	99	99	99	99	99	98
2	39	95	97	98	99	99	99
3	39	84	95	100	99	100	99
4	46	72	87	100	99	100	99
5	42	71	81	92	98	100	99
6	41	65	83	86	89	92	91
7	30	65	79	56	100	100	87
8	39	67	71	74	90	99	98
9	37	55	67	85	99	99	96
10	36	54	66	95	98	99	95
11	57	49	62	97	98	99	98
12	37	55	61	53	55	98	85
13	50	63	67	67	74	94	77
14	39	55	58	51	55	99	78
15	40	57	58	52	52	64	41
16	38	55	55	52	48	91	67
17	44	59	59	59	56	94	66
18	48	65	59	63	59	55	36
19	0	21	21	29	14	86	57
20	2	6	13	2	4	6	15
21	30	10	40	60	60	40	10
22	95	95	95	95	98	98	99
23	61	49	91	97	97	97	97
24	58	79	95	95	95	95	89
25	75	75	98	98	\	98	99
26	66	88	97	97	97	97	94
27	55	77	91	97	98	98	97
28	93	94	97	87	90	97	99
29	55	88	67	85	88	97	97
30	86	94	96	96	98	97	96
31	56	52	56	84	64	84	40
32	—	—	—	—	—	—	—
33	—	—	—	—	—	—	—
34	—	—	—	—	—	—	—
35	61	69	73	87	91	99	96
36	10	82	94	98	98	100	94
37	17	66	83	94	97	100	94
38	2	55	83	97	99	100	98
39	37	53	74	53	68	95	95
40	8	29	56	90	96	99	99
41	5	6	13	74	84	90	93
42	3	10	28	50	63	98	98
43	0	0	6	51	71	98	98

[1] Day 30 values corrected for abiotic losses (Table 4.23).

Table 4.25 **Biodegradation in µg/ml of 21 PAHs during Slurry-Phase Bioremediation of Solidified Material from the ACW Site, Pensacola, Florida**

Compound ID Number	Time-zero	Day 7 SM	Day 7 SM7	Day 7 SM7+	Day 14 SM	Day 14 SM7	Day 14 SM7+	Day 14 Killed
1	951.5	918.5	554.9	542.5	805.6	835.7	621.1	879.3
2	459.7	424.3	330.7	289.4	424.4	418.6	350.4	452.1
3	187.2	175.9	133.6	126.0	174.5	175.8	150.5	189.3
4	96.3	87.5	70.9	67.7	91.8	90.4	79.8	95.0
5	103.7	92.4	79.1	69.5	96.9	95.7	84.5	100.8
6	53.7	47.8	42.4	38.4	51.5	51.6	45.1	53.3
7	18.8	17.3	15.8	15.0	18.3	18.0	15.9	18.4
8	476.8	448.8	383.2	342.1	450.4	462.8	409.9	481.9
9	550.4	513.0	455.0	400.0	532.0	525.7	461.9	537.6
10	1704.9	1636	1521	1339	1704	1701	1507	1717
11	380.8	368.1	325.1	282.5	377.7	364.9	329.8	367.4
12	174.8	163.3	142.1	125.0	174.2	158.0	156.9	177.3
13	139.7	131.5	124.6	113.3	142.3	140.7	120.6	139.6
14	722.9	688.3	668.3	563.2	713.6	703.3	630.9	716.7
15	411.5	393.5	361.0	320.2	415.0	397.4	363.7	406.9
16	86.6	81.1	80.6	67.9	81.5	83.8	73.6	87.4
17	49.6	47.8	44.3	34.8	46.1	40.3	42.7	47.3
18	39.5	37.8	37.1	32.7	38.7	38.4	35.7	39.2
19	22.4	21.1	23.0	17.3	21.0	21.3	20.1	22.3
20	62.0	50.1	60.3	48.4	47.9	58.9	51.0	59.6
21	5.8	5.8	5.0	5.0	5.7	5.1	5.0	5.8

SM=unamended solidified material (SM), pH=10-11.
SM7=SM adjusted to pH=7.0.
SM7+=SM adjusted to pH=7.0 plus surface soil inoculum.
Killed=killed cell control (3.7% formaldehyde).
Data reported represent the average of duplicate analyses.

5. Conclusions

5.1 Solid-Phase Bioremediation: Surface Soils

i. Solid-phase bioremediation of creosote-contaminated surface soil from the ACW site resulted in predictable patterns of biodegradation: lower-molecular-weight contaminants were biodegraded more readily than higher-molecular-weight compounds, and PAHs containing 4 or more fused rings resisted biological attack by indigenous microorganisms. However, land-farming chambers excluded the effects of photodegradation which may have resulted in more extensive degradation of these compounds.

ii. The addition of soluble inorganic nutrients accelerated the rate, and enhanced the extent, of biodegradation. However, the process was still slow and inefficient (8 weeks required to degrade ca. 50% of the pollutants present).

iii. Volatilization of creosote constituents was low and relatively insignificant in terms of abiotic losses under the conditions of these experiments. However, soils were not exposed to extremes in temperature or other climatic variables, such as high winds, as would occur in the field.

5.2 Solid-Phase Bioremediation: Sediment

i. Solid-phase bioremediation of sediment was basically non- effective. The biodegradation process was slow and inefficient (12 weeks required to biodegrade ca. 50% of the pollutants present), and the pattern of biodegradation was predictable. However, materials were used as they occur *in situ* (pH=10) hence pH adjustment to neutrality may enhance the activity of indigenous microorganisms.

ii. The addition of soluble inorganic nutrients to sediment did not accelerate rates of biodegradation, but the extent of biodegradation of the higher-molecular-weight PAHs was enhanced.

iii. Volatilization of creosote constituents was more significant, and even greater losses would be expected to occur *in situ* as a result of temperature changes and prevailing air movements determined by climate.

5.3 Slurry-Phase Bioremediation: Surface Soil

i. Slurry-phase bioremediation employing indigenous microorganisms offered an advantage over solid-phase bioremediation of these materials in terms of time (14 days vs. 12 weeks). However, neither approach resulted in extensive degradation of the more recalcitrant contaminants when indigenous microoganisms were employed as biocatalysts.

ii. Volatilization during slurry-phase bioremediation was insignificant, but physical adsorption accounted for 1 to 17% of the observed losses.

5.4 Slurry-Phase Bioremediation: Sediment

i. Slurry-phase bioremediation of sediment offered significant advantages over solid-phase bioremediation i[illegible] of time and effectiveness (3 to 5 days slurry-phase [illegible] weeks solid-phase to degrade >50% of the targeted poi[illegible]

ii. Slurry-phase bioremediation of sediments a[illegible] to pH=7.1 resulted in relatively rapid and extensive [illegible] dation of higher-molecular-weight PAHs which typic[illegible] sist biological attack (14 days required to biodegrade c[illegible] of the higher-molecular-weight PAHs).

iii. Abiotic losses of monitored constituents of creoso[illegible] were significant: volatilization of naphthalene accounted f[illegible] 1.5% of the observed loss, and physical adsorption acc[illegible] for 36% of the observed loss of pyrene.

5.5 Site Specific Factors

i. Regardless of the biotreatment strategy selec[illegible] pH of the sediment must be adjusted to neutrality prio[illegible] implementation.

ii. Microorganisms indigenous to the ACW [illegible] effectively degrade the lower-molecular-weight [illegible] components. However, efficient removal of the more [illegible] trant, high-molecular-weight PAHs will require ad[illegible] incubation time (>12 weeks using land farming or <30 [illegible] slurry treatment), or the use of microbial inocula with [illegible] strated abilities to degrade these pollutants.

iii. If solid-phase bioremediation is selected [illegible] remediation, efforts to contain volatile emiss.ons sh[illegible] undertaken.

5.6 Preliminary Studies

i. Bioremediation represents a potentially eff[illegible] means for removing creosote constituents from groun[illegible] present at the ACW site.

ii. Bioremediation represents a potentially effec[illegible] means of treating creosote-contaminated solidified ma[illegible] However, the pH of the substrate must be adjusted to neu[illegible] ity, and the addition of indigenous microorganisms app[illegible] accelerate the rate of biodegradation.

Appendix A

PILOT SOIL WASHING AT
AMERICAN CREOSOTE WORKS
PENSACOLA FLORIDA

OVERVIEW

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Purchase Order # 9003A075
To Technical Resources, Inc.
EPA Contract No. 68 - 03 - 3479

May 30,1990

U. S. ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL RESEARCH LABORATORY
SABINE ISLAND
GULF BREEZE, FLORIDA 32561

OVERVIEW

BACKGROUND

Soil at the old American Creosote Works Site in Pensacola Florida is contaminated as a result of past wood treating operations. Bioremediation is a treatment option being investigated by the US EPA, and in one of the approaches under evaluation, EPA researchers biotreat dispersed creosote and creosote residuals in an aqueous slurry. Reverse osmosis is used to polish the wash water prior to discharge. In order to obtain slurries for lab and pilot scale tests, Chapman, Inc. was engaged to wash surface soil and sandy sediment from beneath an unlined waste lagoon. Soil washing was performed both at the site and at a Chapman, Inc. facility.

BENCH TESTS

Approximately six pounds of surface soil, taken from site grid #47, was sent to Chapman for preliminary bench washing tests. These tests were conducted to determine an effective dispersing wash solution. Using the theory that 90 to 99% of the contamination is in the fine fraction of this otherwise sandy soil, no effort was made to determine solubilization of creosote from sand surfaces. Effectiveness was based on settling rates and cumulative volumes of the coarse fraction in Imhoff cones. At first three solutions were used: water alone, Citrikleen[R], and Moncosolve[R] 100. Both products were used at 1-pound/ton soil (500-mg/kg.) Water washing produced an unstable dispersion containing the finer soil fraction that represented 23% of the soil. Citrikleen[R] dispersed some fine grain sand and produced a stable dispersion containing 50% of the finer soil fraction. A 27% moderately stable dispersion was produced using Moncosolve[R]. Subsequently a third product was evaluated. Because of successful washing tests on another project using a laundry product (brand name Nancy B[R]), this powdered detergent was included. It produced a very stable dispersion containing 27% fine material. No sediment material was available for bench testing.

PILOT SOIL WASHER

The pilot soil washer used to produce wash slurries for biotreatment and reverse osmosis studies consists of three unit operations. They are:

A single deck screen to remove material considered oversize for this study

A single shaft paddle mixer to blend the washing solution and screened soil

An up-flow separator designed to elutriate the suspended material from the coarser settled soil fractions.

Both the screen and mixer are designed for continuous operation. The separator is a batch unit and designed for this particular job. All three units are mounted on a 12-foot long trailer. Figure 1 is a picture of the unit at the American Creosote Works Site. In the configuration shown the unit can handle sand and loam soils that have weak aggregates.

FIELD WORK AT AMERICAN CREOSOTE WORKS SITE

Both contaminated surface soil and the sandy sediment matrices were washed at the American Creosote Works Site. The surface matrix had very similar characteristics to the sample studied during the bench tests. (This was not the case with the surface soil used in a second round of pilot tests.) It was a moist sandy loam with approximately 12% debris - mostly broken stone and brick. The sediment matrix was heavily contaminated sand with no debris other than aggregates of sand and fines held together by creosote. Free creosote that drained out of the sediment as it was removed. In total 200-pounds of soil were washed resulting in 165 gallons of wash slurry or 0.83-gallons/pound of soil.

WASHING THE SURFACE SOIL

When washing the surface matrix soil all three process units were used. Nancy B[R] detergent, a powder, was added to the feed hopper of the single deck screen at a rate of 1-pound/ton of soil. A total of 125 pounds of soil was weighed out incrementally on a platform scale. Because the 1-pound/ton dosage rate was based on the total soil the actual rate, after the oversized material was removed, was 1.15-pound/ton.

After passing through the screen the soil entered the paddle mixer through a neoprene interconnect tube. Inside the mixer water was added to the soil at .25-gallon/minute. Since there was only a small quantity of soil being tested, the mixer operated only five minutes. In that time 85-pounds mixed soil/water was discharged to provide slurry for biotreatment and RO studies.

The roughly 74-pounds of soil (mix less the water) was then separated in the up-flow separator shown in Figure 2. This produced a total of 60-gallons of slurry. Thirty-five gallons were placed in a 55-gallon drum, 5-gallon in each of two 5-gallon pails, and the balance discharged back to the site. The water usage rate was 0.8-gallon/pound of soil. Slurry and washed soil samples were taken for analysis by the EPA laboratory, Gulf Breeze.

WASHING THE SEDIMENT

Of the three units in the pilot system only the up-flow separator was used when washing the sediment matrix. No screening was necessary. And, since there was a limited amount of material, hand mixing was judged to make more efficient use of what was available. Two sediment wash tests were done: a preliminary test, and the one reported below.

Twenty-five pounds of sediment, six grams of Nancy B[R] and 400-milliliters of water were blended in a 5-gallon pail to a uniform consistency. After mixing sediment was incrementally added to the up-flow separator. The wash slurry volume was approximately 38-gallons which represents a rate of 1.5 gallons/pound of soil. Wash slurry and washed sediment samples were taken for analyses by the EPA Lab at Gulf Breeze. The majority of the wash slurry was placed in a 55-gallon drum (along with wash slurry from the preliminary sediment wash test.) Five gallons of slurry were taken for biotreatment tests.

TOXICITY TESTS

Toxicity tests performed at the Gulf Breeze Lab showed that the detergent Nancy B[R] is toxic to the bacteria intended for use in biotreatment at the site. Chapman, Inc. was notified and requested to supply an alternate product(s) and submit it (them) for toxicity testing. Two products were formulated and tested. One of the two was found acceptable.

Because of an EPA requirement that all formulations must be fully disclosed and that it would become public information, Chapman chose not to disclose the new acceptable formulation. A second round of soil washing was requested by EPA using a nonproprietary dispersing agent such as Triton X-100.

SECOND PILOT SOIL WASHING TESTS

Two separate washing tests were repeated. For each of two 34-pound samples Triton X-100 (@ 1-pound/ton) was added and mixed by hand. No additional water was added to the sediment matrix since there was free water present. The surface soil matrix required more liquid so the Triton X-100 was dissolved in 1-liter of water before being added to the soil. An additional 0.6-liter of water was required during mixing. Thirty-five to thirty seven-gallons of wash slurry was produced from each of the samples using the up-flow separator. Because of the small size of the samples, the only unit process used from the pilot system was the up-flow separator.

The sediment matrix did not require screening and a Gilson vibratory screen was used to screen the surface soil. One observation of the surface soil sample used in the repeat work was that it had a low bulk density of 62-pound/ft^3. Excavated soil is most often in the 75 to 95-pound/ft^3 range. Another unusual characteristic of the surface soil was the consistency of the mix. It was like a granular butter cake icing.

SUMMARY

The work reported above was totally restricted to the physical/mechanical aspects of soil washing and specifically to the production of a wash slurry/sludge that could be used for biotreatment and reverse osmosis treatment studies. No chemical analyses were performed as part of this work and for this reason are not reported.

General observations of the behavior of the contaminated matrices in terms of partitioning and wettability during washing are:

1. The sediment soil, although evidently containing high quantities of creosote, is easily dispersed.

2. Hand mixing did not shear the frequently encountered aggregates held together by nondispersed viscous creosote residuals. These aggregates would deform when mixed but were not dispersed. They were visible in the mix, and when individually sliced with the edge of the trowel, they dispersed easily. This characteristic, encountered in the sediment matrix only, could be overcome by a kneader mixer which would apply greater shear force to the aggregates than the single paddle mixer .

3. The surface soil is easily dispersed and the fine fractions can be easily separated from the sand and coarse fractions.

4. The up-flow separator was not adequate in removing fine material from coarse. Fine material that was loosely associated with coarser material was "piggy-backed" to the clean soil collector.

General operational characteristics of the pilot work are presented in Table 1. These values are presented in a per ton basis in Table 1(A). In 1(B) these conditions have been converted to a per minute basis for a 20-ton/hr washing system.

TABLE I PILOT STUDY OF SOIL WASHING FOR AWC SITE

	Sediment	Soil
(A) GENERAL OPERATIONAL CHARACTERISTICS		
Dispersing Agent	1.0#/ton	1.0#/ton-1/2#/ton
Mixing Water	0-9 gal/ton	25 gal/ton
Total Process Water	1600-3000 gal/ton	1600-2000 gal/ton
(B) BASED ON A 20-TON PER HOUR SYSTEM		
Agent	20#/hr	20-24#/hr
Mixing Water	0-3 gpm	8.5 gpm
Total Process Water	530-1000 gpm	530-670 gpm
Sludge @ 15% Solids	110 gpm	135 gpm

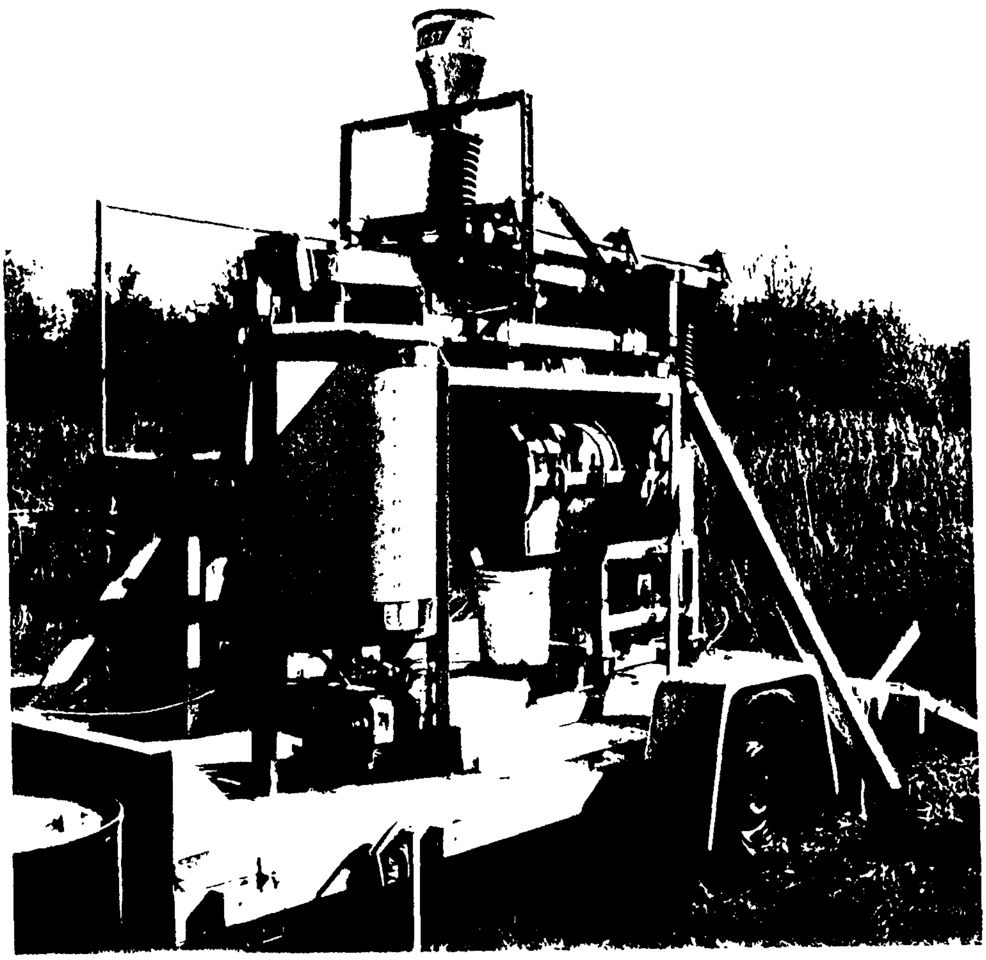

FIGURE 1. Chapman Mobile Soil Washer pilot unit at the American Creosote Site, Pensacola, Florida

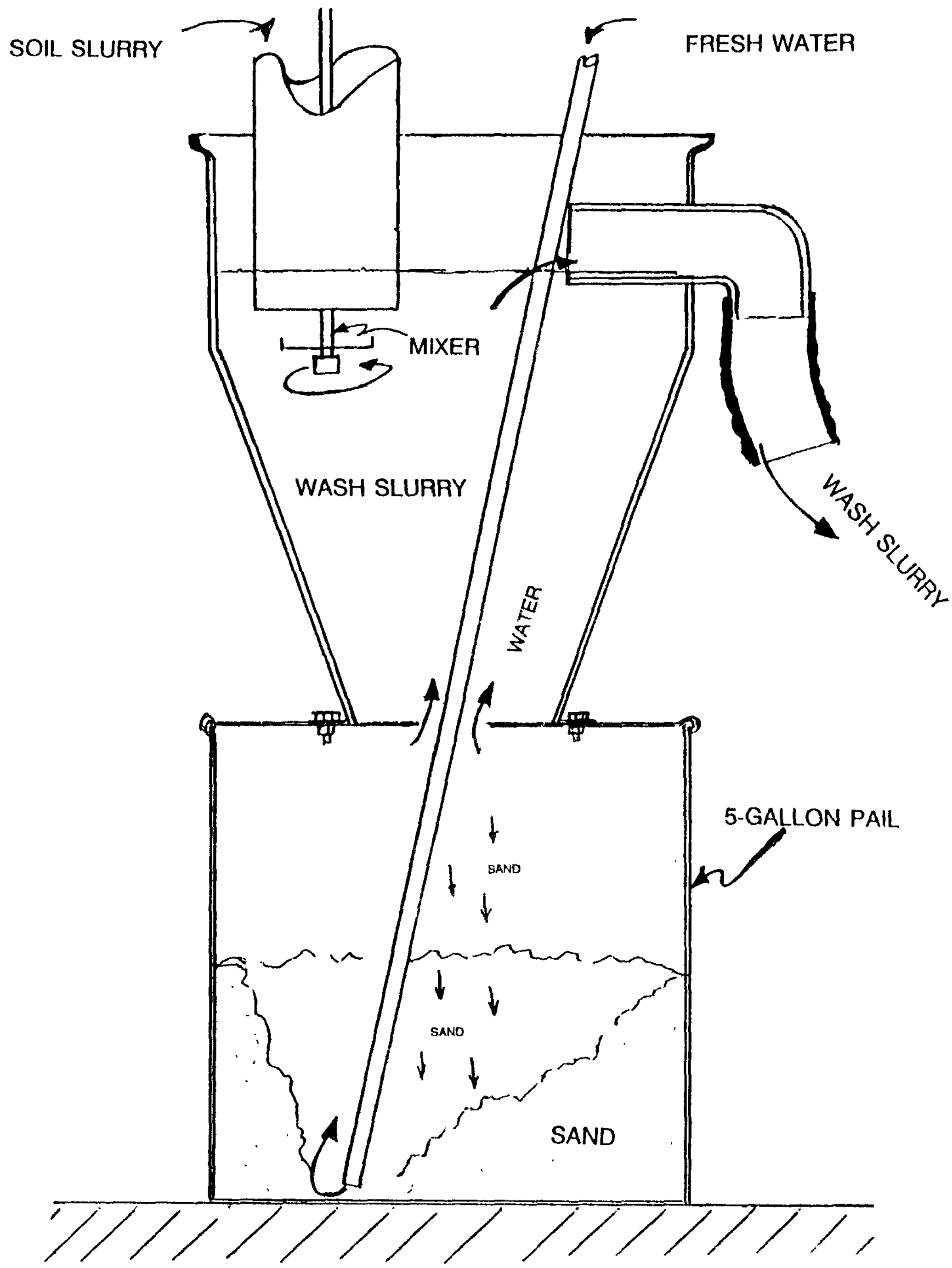

FIGURE 2. An up-flow separator used for pilot treatment studies at the American Creosote Site, Pensacola, Florida

Appendix B

U. S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV, ATHENS, GEORGIA

MEMORANDUM

DATE: SEP 12 1990

SUBJECT: American Creosote Works, Pensacola, Florida, Treatability Study Analytical Results

FROM: Dan Thoman, Regional Expert
Hazardous Waste Section
Environmental Compliance Branch
Environmental Services Division

YELLOW COPY

TO: Natalie Ellington
South Site Management Section
Superfund Branch
Waste Management Division

THRU: William R. Bokey, Chief
Hazardous Waste Section
Environmental Compliance Branch
Environmental Services Division

	Initials	Date
Originator	DT	9-11-90
Unit Chief	H	9-11/90
W.R. Bokey, Chief	WRB	9-12-90

Attached are the analytical results for the treatability study samples submitted by the Gulf Breeze Environmental Research Laboratory.

If you have any questions, please call me at FTS 250-3172.

Attachment

cc: Finger/Wright
Bokey/Hall
Knight

YELLOW COPY THOMAN:dpt:September 11, 1990:ECB/HWS:3351

AMERICAN CREOSOTE WORKS
PENSACOLA FLORIDA
DATA SUMMARY TABLE
TREATABILITY STUDY

	1-BR 06/14/90	2-BR 06/14/90	6-BR 07/09/90	7-BR 07/09/90	8-BR 07/09/90	9-BR 07/09/90	10-BR 07/09/90	11-BR 07/09/90
EXTRACTABLE ORGANIC COMPOUNDS	UG/L	UG/L	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
Quinolinol	--	2000JN	--	--	--	--	--	--
Methylphenanthrene (3-isomers)	--	800JN	--	--	--	--	--	--
Benzofluorene (2-isomers)	--	300JN	--	--	--	--	--	--
Methylfluoranthene (5 isomers)	--	--	20000JN	--	--	--	--	--
Benzanthracenone (2 isomers)	--	--	7000JN	--	--	--	--	--
Benzofluoranthene (not B or K)(3 isom	--	--	30000JN	--	--	--	--	--
Methylbenzoanthracene	--	--	4000JN	--	--	--	--	--
Anthracenecarbonitrile	8JN	--	3000JN	3000JN	--	--	--	--
Methylfluoranthene (2 isomers)	--	--	--	5000JN	--	--	--	--
Benzanthraceneone (2 isomers)	--	--	--	7000JN	--	--	--	--
Benzofluoranthene (not B or K)(4 isom	--	--	--	30000JN	--	--	--	--
Methylbenzanthracene	--	--	--	4000JN	--	--	--	--
Naphthacenedione	--	--	--	2000JN	--	--	--	--
Petroleum Product	--	--	N	N	--	--	--	--
Dimethylnaphthalene (3 isomers)	--	--	--	--	500000JN	--	--	--
(Propenyl)naphthalene (2 isomers)	--	--	--	--	200000JN	--	--	--
Methylbiphenyl (2 isomers)	--	--	--	--	--	200000JN	--	--
Methylfluorene	--	--	--	--	--	90000JN	--	--
Benzofluoranthene (not B or K)	--	--	--	--	--	--	10000JN	--
1-Methylnaphthalene	--	900JN	--	--	300000JN	300000JN	--	300000JN
Ethenylnaphthalene	--	700JN	--	--	200000JN	200000JN	--	200000JN
Ethylnaphthalene	--	200JN	--	--	60000JN	50000JN	--	70000JN
Dimethylnaphthalene (4 isomers)	--	--	--	--	--	300000JN	--	600000JN
Trimethylnaphthalene	--	--	--	--	--	--	--	60000JN
(Propenyl)naphthalene (3 isomers)	--	--	--	--	--	--	--	200000JN
Methyldibenzofuran (2 isomers)	--	--	--	--	200000JN	200000JN	--	300000JN
Methylfluorene (2 isomers)	--	--	--	--	100000JN	--	--	200000JN
Dibenzothiophene	--	--	--	--	300000JN	300000JN	--	300000JN
Benzoquinoline	--	200JN	--	--	70000JN	70000JN	--	80000JN
Carbazole	--	700JN	--	--	600000JN	600000JN	--	700000JN
Methylphenanthrene (4 isomers)	--	--	--	--	500000JN	500000JN	--	500000JN
Cyclopentaphenanthrene	--	300JN	--	--	300000JN	300000JN	--	300000JN
Phenylnaphthalene	--	--	--	--	100000JN	90000JN	--	100000JN
Benzofluorene (2 isomers)	--	--	--	--	200000JN	200000JN	--	200000JN

AMERICAN CREOSOTE WORKS
PENSACOLA FLORIDA
DATA SUMMARY TABLE
TREATABILITY STUDY

	1-BR 06/14/90	2-BR 06/14/90	6-BR 07/09/90	7-BR 07/09/90	8-BR 07/09/90	9-BR 07/09/90	10-BR 07/09/90	11-BR 07/09/90
EXTRACTABLE ORGANIC COMPOUNDS	UG/L	UG/L	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
2-METHYLNAPHTHALENE	--	2000	--	--	700000	630000	--	750000
NAPHTHALENE	--	6300	--	--	390000	190000J	--	250000J
ACENAPHTHENE	--	1700	--	--	880000	870000	--	940000
DIBENZOFURAN	--	1400	--	--	820000	810000	--	880000
FLUORENE	--	1600	--	--	1.1E6	1.1E6	--	1.2E6
N-NITROSODIPHENYLAMINE/DIPHENYLAMINE	--	--	--	--	--	37000J	--	--
PHENANTHRENE	--	4000	2500J	1900J	2.3E6	2.3E6	11000J	2.6E6
ANTHRACENE	9.5J	500J	1900J	1900J	1.9E6	1.8E6	--	2.1E6
FLUORANTHENE	--	1400	19000	16000	1.2E6	950000	31000J	1.2E6
PYRENE	5.2J	940J	24000	22000	730000	640000	37000J	780000
BENZO(A)ANTHRACENE	5.1J	260J	13000J	11000J	170000J	170000J	14000J	180000J
CHRYSENE	9.8J	260J	21000	21000	280000J	290000J	25000J	310000J
BENZO(B AND/OR K)FLUORANTHENE	35J	--	49000	48000	110000J	100000J	49000J	120000J
BENZO-A-PYRENE	13J	--	17000	16000	--	--	15000J	--
INDENO (1,2,3-CD) PYRENE	13J	--	11000J	9900J	--	--	--	--
DIBENZO(A,H)ANTHRACENE	--	--	--	2900J	--	--	--	--
BENZO(GHI)PERYLENE	14J	--	11000J	9700J	--	--	--	--
2-METHYLPHENOL	--	840J	--	--	--	--	--	--
(3-AND/OR 4-)METHYLPHENOL	--	2800	--	--	--	--	--	--
PHENOL	--	720J	--	--	--	--	--	--
2,4-DIMETHYLPHENOL	--	1500	--	--	--	--	--	--
PENTACHLOROPHENOL	--	4700	120000	110000	--	--	190000	--
Diphenylcyclopropenone	6JN	--	--	--	--	--	--	--
Benzofluoranthene (not b or k) (2-is	30JN	--	--	--	--	--	--	--
Carboxybenzeneacetic Acid	--	100JN	--	--	--	--	--	--
Ethenylmethylbenzene	--	200JN	--	--	--	--	--	--
Dimethylphenol (not 2,4)	--	2000JN	--	--	--	--	--	--
Benzothiophene	--	1000JN	--	--	--	--	--	--
Isoquinoline (2-isomers)	--	4000JN	--	--	--	--	--	--
Propylphenol	--	1000JN	--	--	--	--	--	--
Benzeneacetonitrile	--	600JN	--	--	--	--	--	--
Methylisoquinoline (4-isomers)	--	2000JN	--	--	--	--	--	--
Dimethylnaphthalene (3-isomers)	--	1000JN	--	--	--	--	--	--
Naphthalenecaronitrile	--	200JN	--	--	--	--	--	--
Propenylnaphthalene	--	100JN	--	--	--	--	--	--
Methyldibenzofuran (2-isomers)	--	500JN	--	--	--	--	--	--

AMERICAN CREOSOTE WORKS
PENSACOLA FLORIDA
DATA SUMMARY TABLE
TREATABILITY STUDY

PURGEABLE ORGANIC COMPOUNDS	1-BR 06/14/90 UG/L	2-BR 06/14/90 UG/L	6-BR 07/09/90 UG/KG	7-BR 07/09/90 UG/KG	8-BR 07/09/90 UG/KG	9-BR 07/09/90 UG/KG	10-BR 07/09/90 UG/KG	11-BR 07/09/90 UG/KG
TRICHLOROFLUOROMETHANE	--	--	5.7J	--	--	--	--	34J
CHLOROMETHANE	1.1J	--	--	--	--	--	--	--
ACETONE	--	430	--	--	--	--	--	--
METHYL ETHYL KETONE	--	84J	--	--	--	--	--	--
CHLOROFORM	3.0J	--	--	--	--	--	--	--
BENZENE	--	12J	--	--	--	--	--	--
TOLUENE	--	34	--	--	--	--	--	--
ETHYL BENZENE	--	18J	--	--	--	--	--	--
(M- AND/OR P-)XYLENE	--	66	--	--	--	--	--	--
O-XYLENE	--	34	--	--	--	--	--	--
STYRENE	--	21J	--	--	--	--	--	--
TETRAHYDROFURAN	20JN	--	--	--	--	--	--	--
PINENE	--	80JN	--	--	--	--	--	--
ETHYLMETHYLBENZENE	--	40JN	--	--	--	--	--	--
TRIMETHYLBENZENE (2 ISOMERS)	--	100JN	--	--	--	--	--	--
Pinene	--	--	--	--	--	--	--	5000JN
Ethylmethylbenzene (2 isomers)	--	--	--	--	--	--	--	700JN
Trimethylbenzene	--	--	--	--	--	100JN	--	1000JN
Propynylbenzene	--	--	--	--	--	--	--	20000JN
Petroleum product	N	--	--	--	N	N	N	N

****

FOOTNOTES
J - ESTIMATED VALUE
N - PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
-- - MATERIAL WAS ANALYZED FOR BUT NOT DETECTED
BR - SURFACE SOIL SLURRY

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/09/90

PURGEABLE ORGANICS DATA REPORT

PROJECT NO. 90-654 SAMPLE NO. 47346 SAMPLE TYPE: WATER
SOURCE: AMERICAN CREOSOTE
STATION ID: 1-BR SURFACE SOIL SLURRY

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 06/14/90 STOP: 00/00/00

UG/L	ANALYTICAL RESULTS
1.1J	CHLOROMETHANE
5.0U	VINYL CHLORIDE
5.0U	BROMOMETHANE
5.0U	CHLOROETHANE
5.0U	TRICHLOROFLUOROMETHANE
5.0U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
50U	ACETONE
50U	CARBON DISULFIDE
5.0U	METHYLENE CHLORIDE
5.0U	TRANS-1,2-DICHLOROETHENE
5.0U	1,1-DICHLOROETHANE
50U	VINYL ACETATE
5.0U	CIS-1,2-DICHLOROETHENE
5.0U	2,2-DICHLOROPROPANE
50U	METHYL ETHYL KETONE
5.0U	BROMOCHLOROMETHANE
3.0J	CHLOROFORM
5.0U	1,1,1-TRICHLOROETHANE
5.0U	1,1-DICHLOROPROPENE
5.0U	CARBON TETRACHLORIDE
5.0U	1,2-DICHLOROETHANE
5.0U	BENZENE
5.0U	TRICHLOROETHENE(TRICHLOROETHYLENE)
5.0U	1,2-DICHLOROPROPANE
5.0U	DIBROMOMETHANE
5.0U	BROMODICHLOROMETHANE

UG/L	ANALYTICAL RESULTS
5.0U	CIS-1,3-DICHLOROPROPENE
50U	METHYL ISOBUTYL KETONE
5.0U	TOLUENE
5.0U	TRANS-1,3-DICHLOROPROPENE
5.0U	1,1,2-TRICHLOROETHANE
5.0U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
5.0U	1,3-DICHLOROPROPANE
50U	METHYL BUTYL KETONE
5.0U	DIBROMOCHLOROMETHANE
5.0U	CHLOROBENZENE
5.0U	1,1,1,2-TETRACHLOROETHANE
5.0U	ETHYL BENZENE
5.0U	(M- AND/OR P-)XYLENE
5.0U	O-XYLENE
5.0U	STYRENE
5.0U	BROMOFORM
5.0U	BROMOBENZENE
5.0U	1,1,2,2-TETRACHLOROETHANE
5.0U	1,2,3-TRICHLOROPROPANE
5.0U	O-CHLOROTOLUENE
5.0U	P-CHLOROTOLUENE
5.0U	1,3-DICHLOROBENZENE
5.0U	1,4-DICHLOROBENZENE
5.0U	1,2-DICHLOROBENZENE

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REMARKS
RECOMMENDED HOLDING TIME EXCEEDED PURGEABLE ORGANICS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/09/90

MISCELLANEOUS PURGEABLE ORGANICS - DATA REPORT

*** ***

** PROJECT NO. 90-654 SAMPLE NO. 47346 SAMPLE TYPE: WATER PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 1-BR SURFACE SOIL SLURRY COLLECTION START: 06/14/90 STOP: 00/00/00 **

*** ***

ANALYTICAL RESULTS UG/L

20JN TETRAHYDROFURAN

REMARKS
RECOMMENDED HOLDING TIME EXCEEDED-PURGEABLE ORGANICS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.
*R-QC INDICATES THAT DATA UNUSABLE. COMPOUND MAY OR MAY NOT BE PRESENT. RESAMPLING AND REANALYSIS IS NECESSARY FOR VERIFICATION.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA. 07/12/90

EXTRACTABLE ORGANICS DATA REPORT

PROJECT NO. 90-654 SAMPLE NO. 47346 SAMPLE TYPE: WATER PROG ELEM: SSF COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 1-BR SURFACE SOIL SLURRY COLLECTION START: 06/14/90 STOP: 00/00/00

UG/L	ANALYTICAL RESULTS
50U	BIS(2-CHLOROETHYL) ETHER
50U	BIS(2-CHLOROISOPROPYL) ETHER
50U	N-NITROSODI-N-PROPYLAMINE
50U	HEXACHLOROETHANE
50U	NITROBENZENE
50U	ISOPHORONE
50U	BIS(2-CHLOROETHOXY) METHANE
50U	1,2,4-TRICHLOROBENZENE
50U	NAPHTHALENE
50U	4-CHLOROANILINE
50U	HEXACHLOROBUTADIENE
50U	2-METHYLNAPHTHALENE
50U	HEXACHLOROCYCLOPENTADIENE (HCCP)
50U	2-CHLORONAPHTHALENE
50U	2-NITROANILINE
50U	DIMETHYL PHTHALATE
50U	ACENAPHTHYLENE
50U	2,6-DINITROTOLUENE
50U	3-NITROANILINE
50U	ACENAPHTHENE
50U	DIBENZOFURAN
50U	2,4-DINITROTOLUENE
50U	DIETHYL PHTHALATE
50U	FLUORENE
50U	4-CHLOROPHENYL PHENYL ETHER
50U	4-NITROANILINE
50U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
50U	4-BROMOPHENYL PHENYL ETHER
50U	HEXACHLOROBENZENE (HCB)
50U	PHENANTHRENE
9.5J	ANTHRACENE
50U	DI-N-BUTYLPHTHALATE

UG/L	ANALYTICAL RESULTS
50U	FLUORANTHENE
5.2J	PYRENE
50U	BENZYL BUTYL PHTHALATE
50U	3,3'-DICHLOROBENZIDINE
5.1J	BENZO(A)ANTHRACENE
9.8J	CHRYSENE
50U	BIS(2-ETHYLHEXYL) PHTHALATE
50U	DI-N-OCTYLPHTHALATE
35J	BENZO(B AND/OR K)FLUORANTHENE
13J	BENZO-A-PYRENE
13J	INDENO (1,2,3-CD) PYRENE
50U	DIBENZO(A,H)ANTHRACENE
14J	BENZO(GHI)PERYLENE
50U	PHENOL
50U	2-CHLOROPHENOL
100U	BENZYL ALCOHOL
50U	2-METHYLPHENOL
50U	(3-AND/OR 4-)METHYLPHENOL
50U	2-NITROPHENOL
50U	2,4-DIMETHYLPHENOL
100U	BENZOIC ACID
50U	2,4-DICHLOROPHENOL
50U	4-CHLORO-3-METHYLPHENOL
50U	2,4,6-TRICHLOROPHENOL
50U	2,4,5-TRICHLOROPHENOL
100U	2,4-DINITROPHENOL
100U	4-NITROPHENOL
50U	2,3,4,6-TETRACHLOROPHENOL
100U	2-METHYL-4,6-DINITROPHENOL
100U	PENTACHLOROPHENOL

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA. 07/12/90

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

*** ***
** PROJECT NO. 90-654 SAMPLE NO. 47346 SAMPLE TYPE: WATER PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 1-BR SURFACE SOIL SLURRY COLLECTION START: 06/14/90 STOP: 00/00/00 **
** **
*** ***

ANALYTICAL RESULTS UG/L

8JN	Anthracenecarbonitrile
6JN	Diphenylcyclopropenone
30JN	Benzofluoranthene (not b or k) (2-isomers)
N	Petroleum product

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FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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*R-QC INDICATES THAT DATA UNUSABLE. COMPOUND MAY OR MAY NOT BE PRESENT. RESAMPLING AND REANALYSIS IS NECESSARY FOR VERIFICATION.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/09/90

PURGEABLE ORGANICS DATA REPORT

PROJECT NO. 90-654 SAMPLE NO. 47347 SAMPLE TYPE: WATER
SOURCE: AMERICAN CREOSOTE
STATION ID: 2-BR SEDIMENT SLURRY

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 06/14/90 STOP: 00/00/00

UG/L	ANALYTICAL RESULTS
25U	CHLOROMETHANE
25U	VINYL CHLORIDE
25U	BROMOMETHANE
25U	CHLOROETHANE
25U	TRICHLOROFLUOROMETHANE
25U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
430	ACETONE
250U	CARBON DISULFIDE
25U	METHYLENE CHLORIDE
25U	TRANS-1,2-DICHLOROETHENE
25U	1,1-DICHLOROETHANE
250U	VINYL ACETATE
25U	CIS-1,2-DICHLOROETHENE
25U	2,2-DICHLOROPROPANE
84J	METHYL ETHYL KETONE
25U	BROMOCHLOROMETHANE
25U	CHLOROFORM
25U	1,1,1-TRICHLOROETHANE
25U	1,1-DICHLOROPROPENE
25U	CARBON TETRACHLORIDE
25U	1,2-DICHLOROETHANE
12J	BENZENE
25U	TRICHLOROETHENE(TRICHLOROETHYLENE)
25U	1,2-DICHLOROPROPANE
25U	DIBROMOMETHANE
25U	BROMODICHLOROMETHANE

UG/L	ANALYTICAL RESULTS
25U	CIS-1,3-DICHLOROPROPENE
250U	METHYL ISOBUTYL KETONE
34	TOLUENE
25U	TRANS-1,3-DICHLOROPROPENE
25U	1,1,2-TRICHLOROETHANE
25U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
25U	1,3-DICHLOROPROPANE
250U	METHYL BUTYL KETONE
25U	DIBROMOCHLOROMETHANE
25U	CHLOROBENZENE
25U	1,1,1,2-TETRACHLOROETHANE
18J	ETHYL BENZENE
66	(M- AND/OR P-)XYLENE
34	O-XYLENE
21J	STYRENE
25U	BROMOFORM
25U	BROMOBENZENE
25U	1,1,2,2-TETRACHLOROETHANE
25U	1,2,3-TRICHLOROPROPANE
25U	O-CHLOROTOLUENE
25U	P-CHLOROTOLUENE
25U	1,3-DICHLOROBENZENE
25U	1,4-DICHLOROBENZENE
25U	1,2-DICHLOROBENZENE

REMARKS
RECOMMENDED HOLDING TIME EXCEEDED PURGEABLE ORGANICS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/09/90

MISCELLANEOUS PURGEABLE ORGANICS - DATA REPORT

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**   PROJECT NO. 90-654   SAMPLE NO. 47347  SAMPLE TYPE: WATER      PROG ELEM: SSF   COLLECTED BY: D THOMAN                    **
**   SOURCE: AMERICAN CREOSOTE                                       CITY: PENSACOLA             ST: FL                         **
**   STATION ID: 2-BR SEDIMENT SLURRY                                COLLECTION START: 06/14/90        STOP. 00/00/00           **
**                                                                                                                              **
*** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * ***
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ANALYTICAL RESULTS UG/L

80JN	PINENE
40JN	ETHYLMETHYLBENZENE
100JN	TRIMETHYLBENZENE (2 ISOMERS)

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REMARKS
RECOMMENDED HOLDING TIME EXCEEDED-PURGEABLE ORGANICS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE   *NA-NOT ANALYZED   *NAI-INTERFERENCES   *J-ESTIMATED VALUE   *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

EXTRACTABLE ORGANICS DATA REPORT 07/12/90

PROJECT NO. 90-654 SAMPLE NO. 47347 SAMPLE TYPE: WATER PROG ELEM: SSF COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 2-BR SEDIMENT SLURRY COLLECTION START: 06/14/90 STOP: 00/00/00

UG/L	ANALYTICAL RESULTS
1000U	BIS(2-CHLOROETHYL) ETHER
1000U	BIS(2-CHLOROISOPROPYL) ETHER
1000U	N-NITROSODI-N-PROPYLAMINE
1000U	HEXACHLOROETHANE
1000U	NITROBENZENE
1000U	ISOPHORONE
1000U	BIS(2-CHLOROETHOXY) METHANE
1000U	1,2,4-TRICHLOROBENZENE
6300	NAPHTHALENE
1000U	4-CHLOROANILINE
1000U	HEXACHLOROBUTADIENE
2000	2-METHYLNAPHTHALENE
1000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
1000U	2-CHLORONAPHTHALENE
1000U	2-NITROANILINE
1000U	DIMETHYL PHTHALATE
1000U	ACENAPHTHYLENE
1000U	2,6-DINITROTOLUENE
1000U	3-NITROANILINE
1700	ACENAPHTHENE
1400	DIBENZOFURAN
1000U	2,4-DINITROTOLUENE
1000U	DIETHYL PHTHALATE
1600	FLUORENE
1000U	4-CHLOROPHENYL PHENYL ETHER
1000U	4-NITROANILINE
1000U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
1000U	4-BROMOPHENYL PHENYL ETHER
1000U	HEXACHLOROBENZENE (HCB)
4000	PHENANTHRENE
500J	ANTHRACENE
1000U	DI-N-BUTYLPHTHALATE

UG/L	ANALYTICAL RESULTS
1400	FLUORANTHENE
940J	PYRENE
1000U	BENZYL BUTYL PHTHALATE
1000U	3,3'-DICHLOROBENZIDINE
260J	BENZO(A)ANTHRACENE
260J	CHRYSENE
1000U	BIS(2-ETHYLHEXYL) PHTHALATE
1000U	DI-N-OCTYLPHTHALATE
1000U	BENZO(B AND/OR K)FLUORANTHENE
1000U	BENZO-A-PYRENE
1000U	INDENO (1,2,3-CD) PYRENE
1000U	DIBENZO(A,H)ANTHRACENE
1000U	BENZO(GHI)PERYLENE
720J	PHENOL
1000U	2-CHLOROPHENOL
2000U	BENZYL ALCOHOL
840J	2-METHYLPHENOL
2800	(3-AND/OR 4-)METHYLPHENOL
1000U	2-NITROPHENOL
1500	2,4-DIMETHYLPHENOL
2000U	BENZOIC ACID
1000U	2,4-DICHLOROPHENOL
1000U	4-CHLORO-3-METHYLPHENOL
1000U	2,4,6-TRICHLOROPHENOL
1000U	2,4,5-TRICHLOROPHENOL
2000U	2,4-DINITROPHENOL
2000U	4-NITROPHENOL
1000U	2,3,4,6-TETRACHLOROPHENOL
2000U	2-METHYL-4,6-DINITROPHENOL
4700	PENTACHLOROPHENOL

REMARKS ***REMARKS***

FOOTNOTES
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/12/90

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

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**   PROJECT NO. 90-654   SAMPLE NO. 47347  SAMPLE TYPE: WATER       PROG ELEM: SSF   COLLECTED BY: D THOMAN             **
**   SOURCE: AMERICAN CREOSOTE                                       CITY: PENSACOLA             ST: FL                   **
**   STATION ID: 2-BR SEDIMENT SLURRY                                COLLECTION START: 06/14/90       STOP: 00/00/00      **
**                                                                                                                        **
*** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * ***
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	ANALYTICAL RESULTS UG/L
100JN	Carboxybenzeneacetic Acid
200JN	Ethenylmethylbenzene
2000JN	Dimethylphenol (not 2,4)
1000JN	Benzothiophene
4000JN	Isoquinoline (2-isomers)
1000JN	Propylphenol
600JN	Benzeneacetonitrile
2000JN	Methylisoquinoline (4-isomers)
900JN	1-Methylnaphthalene
700JN	Ethenylnaphthalene
200JN	Ethylnaphthalene
1000JN	Dimethylnaphthalene (3-isomers)
200JN	Naphthalenecaronitrile
100JN	Propenylnaphthalene
500JN	Methyldibenzofuran (2-isomers)
2000JN	Quinolinol
200JN	Benzoquinoline
700JN	Carbazole
800JN	Methylphenanthrene (3-isomers)
300JN	Cyclopentaphenanthrene
300JN	Benzofluorene (2-isomers)

FOOTNOTES
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/26/90

PURGEABLE ORGANICS DATA REPORT

PROJECT NO. 90-715   SAMPLE NO. 48154   SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 6-BR

PROG ELEM: SSF   COLLECTED BY: D THOMAN
CITY: PENSACOLA   ST: FL
COLLECTION START: 07/09/90 1500   STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
46U	CHLOROMETHANE
46U	VINYL CHLORIDE
46U	BROMOMETHANE
46U	CHLOROETHANE
5.7J	TRICHLOROFLUOROMETHANE
46U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
460U	ACETONE
460U	CARBON DISULFIDE
92U	METHYLENE CHLORIDE
46U	TRANS-1,2-DICHLOROETHENE
46U	1,1-DICHLOROETHANE
460U	VINYL ACETATE
46U	CIS-1,2-DICHLOROETHENE
46U	2,2-DICHLOROPROPANE
460U	METHYL ETHYL KETONE
46U	BROMOCHLOROMETHANE
46U	CHLOROFORM
46U	1,1,1-TRICHLOROETHANE
46U	1,1-DICHLOROPROPENE
46U	CARBON TETRACHLORIDE
46U	1,2-DICHLOROETHANE
46U	BENZENE
46U	TRICHLOROETHENE(TRICHLOROETHYLENE)
46U	1,2-DICHLOROPROPANE
46U	DIBROMOMETHANE
46U	BROMODICHLOROMETHANE
46U	CIS-1,3-DICHLOROPROPENE
460U	METHYL ISOBUTYL KETONE
46U	TOLUENE
46U	TRANS-1,3-DICHLOROPROPENE
46U	1,1,2-TRICHLOROETHANE
46U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
46U	1,3-DICHLOROPROPANE
460U	METHYL BUTYL KETONE
46U	DIBROMOCHLOROMETHANE
46U	CHLOROBENZENE
46U	1,1,1,2-TETRACHLOROETHANE
46U	ETHYL BENZENE
46U	(M- AND/OR P-)XYLENE
46U	O-XYLENE
46U	STYRENE
46U	BROMOFORM
46U	BROMOBENZENE
46U	1,1,2,2-TETRACHLOROETHANE
46U	1,2,3-TRICHLOROPROPANE
46U	O-CHLOROTOLUENE
46U	P-CHLOROTOLUENE
46U	1,3-DICHLOROBENZENE
46U	1,4-DICHLOROBENZENE
46U	1,2-DICHLOROBENZENE
10.2	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE   *NA-NOT ANALYZED   *NAI-INTERFERENCES   *J-ESTIMATED VALUE   *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN   *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.   07/25/90

EXTRACTABLE ORGANICS DATA REPORT

*** ***
** PROJECT NO. 90-715   SAMPLE NO. 48154   SAMPLE TYPE: SOIL   PROG ELEM: SSF   COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE   CITY: PENSACOLA   ST: FL **
** STATION ID: 6-BR   COLLECTION START: 07/09/90 1500   STOP: 00/00/00 **
** **
*** ***

UG/KG	ANALYTICAL RESULTS
15000U	BIS(2-CHLOROETHYL) ETHER
15000U	BIS(2-CHLOROISOPROPYL) ETHER
15000U	N-NITROSODI-N-PROPYLAMINE
15000U	HEXACHLOROETHANE
15000U	NITROBENZENE
15000U	ISOPHORONE
15000U	BIS(2-CHLOROETHOXY) METHANE
15000U	1,2,4-TRICHLOROBENZENE
15000U	NAPHTHALENE
15000U	4-CHLOROANILINE
15000U	HEXACHLOROBUTADIENE
15000U	2-METHYLNAPHTHALENE
15000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
15000U	2-CHLORONAPHTHALENE
15000U	2-NITROANILINE
15000U	DIMETHYL PHTHALATE
15000U	ACENAPHTHYLENE
15000U	2,6-DINITROTOLUENE
15000U	3-NITROANILINE
15000U	ACENAPHTHENE
15000U	DIBENZOFURAN
15000U	2,4-DINITROTOLUENE
15000U	DIETHYL PHTHALATE
15000U	FLUORENE
15000U	4-CHLOROPHENYL PHENYL ETHER
15000U	4-NITROANILINE
15000U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
15000U	4-BROMOPHENYL PHENYL ETHER
15000U	HEXACHLOROBENZENE (HCB)
2500J	PHENANTHRENE
1900J	ANTHRACENE
15000U	DI-N-BUTYLPHTHALATE

UG/KG	ANALYTICAL RESULTS
19000	FLUORANTHENE
24000	PYRENE
15000U	BENZYL BUTYL PHTHALATE
15000U	3,3'-DICHLOROBENZIDINE
13000J	BENZO(A)ANTHRACENE
21000	CHRYSENE
15000U	BIS(2-ETHYLHEXYL) PHTHALATE
15000U	DI-N-OCTYLPHTHALATE
49000	BENZO(B AND/OR K)FLUORANTHENE
17000	BENZO-A-PYRENE
11000J	INDENO (1,2,3-CD) PYRENE
15000U	DIBENZO(A,H)ANTHRACENE
11000J	BENZO(GHI)PERYLENE
15000U	PHENOL
15000U	2-CHLOROPHENOL
29000U	BENZYL ALCOHOL
15000U	2-METHYLPHENOL
15000U	(3-AND/OR 4-)METHYLPHENOL
15000U	2-NITROPHENOL
15000U	2,4-DIMETHYLPHENOL
29000U	BENZOIC ACID
15000U	2,4-DICHLOROPHENOL
15000U	4-CHLORO-3-METHYLPHENOL
15000U	2,4,6-TRICHLOROPHENOL
15000U	2,4,5-TRICHLOROPHENOL
29000U	2,4-DINITROPHENOL
29000U	4-NITROPHENOL
15000U	2,3,4,6-TETRACHLOROPHENOL
29000U	2-METHYL-4,6-DINITROPHENOL
120000	PENTACHLOROPHENOL
10.2	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE   *NA-NOT ANALYZED   *NAI-INTERFERENCES   *J-ESTIMATED VALUE   *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN   *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

PROJECT NO. 90-715 SAMPLE NO. 48154 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 6-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00

ANALYTICAL RESULTS UG/KG

3000JN	Anthracenecarbonitrile
20000JN	Methylfluoranthene (5 isomers)
7000JN	Benzanthracenone (2 isomers)
30000JN	Benzofluoranthene (not B or K)(3 isomers)
4000JN	Methylbenzoanthracene
N	Petroleum Product

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FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.
*R-QC INDICATES THAT DATA UNUSABLE. COMPOUND MAY OR MAY NOT BE PRESENT. RESAMPLING AND REANALYSIS IS NECESSARY FOR VERIFICATION.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA. 07/26/90

PURGEABLE ORGANICS DATA REPORT

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** PROJECT NO. 90-715 SAMPLE NO. 48155 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 7-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **

*** ***

UG/KG	ANALYTICAL RESULTS
44U	CHLOROMETHANE
44U	VINYL CHLORIDE
44U	BROMOMETHANE
44U	CHLOROETHANE
44U	TRICHLOROFLUOROMETHANE
44U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
440U	ACETONE
440U	CARBON DISULFIDE
88U	METHYLENE CHLORIDE
44U	TRANS-1,2-DICHLOROETHENE
44U	1,1-DICHLOROETHANE
440U	VINYL ACETATE
44U	CIS-1,2-DICHLOROETHENE
44U	2,2-DICHLOROPROPANE
440U	METHYL ETHYL KETONE
44U	BROMOCHLOROMETHANE
44U	CHLOROFORM
44U	1,1,1-TRICHLOROETHANE
44U	1,1-DICHLOROPROPENE
44U	CARBON TETRACHLORIDE
44U	1,2-DICHLOROETHANE
44U	BENZENE
44U	TRICHLOROETHENE(TRICHLOROETHYLENE)
44U	1,2-DICHLOROPROPANE
44U	DIBROMOMETHANE
44U	BROMODICHLOROMETHANE

UG/KG	ANALYTICAL RESULTS
44U	CIS-1,3-DICHLOROPROPENE
440U	METHYL ISOBUTYL KETONE
44U	TOLUENE
44U	TRANS-1,3-DICHLOROPROPENE
44U	1,1,2-TRICHLOROETHANE
44U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
44U	1,3-DICHLOROPROPANE
440U	METHYL BUTYL KETONE
44U	DIBROMOCHLOROMETHANE
44U	CHLOROBENZENE
44U	1,1,1,2-TETRACHLOROETHANE
44U	ETHYL BENZENE
44U	(M- AND/OR P-)XYLENE
44U	O-XYLENE
44U	STYRENE
44U	BROMOFORM
44U	BROMOBENZENE
44U	1,1,2,2-TETRACHLOROETHANE
44U	1,2,3-TRICHLOROPROPANE
44U	O-CHLOROTOLUENE
44U	P-CHLOROTOLUENE
44U	1,3-DICHLOROBENZENE
44U	1,4-DICHLOROBENZENE
44U	1,2-DICHLOROBENZENE
12.6	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/25/90

EXTRACTABLE ORGANICS DATA REPORT

PROJECT NO. 90-715 SAMPLE NO. 48155 SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 7-BR

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
15000U	BIS(2-CHLOROETHYL) ETHER
15000U	BIS(2-CHLOROISOPROPYL) ETHER
15000U	N-NITROSODI-N-PROPYLAMINE
15000U	HEXACHLOROETHANE
15000U	NITROBENZENE
15000U	ISOPHORONE
15000U	BIS(2-CHLOROETHOXY) METHANE
15000U	1,2,4-TRICHLOROBENZENE
15000U	NAPHTHALENE
15000U	4-CHLOROANILINE
15000U	HEXACHLOROBUTADIENE
15000U	2-METHYLNAPHTHALENE
15000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
15000U	2-CHLORONAPHTHALENE
15000U	2-NITROANILINE
15000U	DIMETHYL PHTHALATE
15000U	ACENAPHTHYLENE
15000U	2,6-DINITROTOLUENE
15000U	3-NITROANILINE
15000U	ACENAPHTHENE
15000U	DIBENZOFURAN
15000U	2,4-DINITROTOLUENE
15000U	DIETHYL PHTHALATE
15000U	FLUORENE
15000U	4-CHLOROPHENYL PHENYL ETHER
15000U	4-NITROANILINE
15000U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
15000U	4-BROMOPHENYL PHENYL ETHER
15000U	HEXACHLOROBENZENE (HCB)
1900J	PHENANTHRENE
1900J	ANTHRACENE
15000U	DI-N-BUTYLPHTHALATE

UG/KG	ANALYTICAL RESULTS
16000	FLUORANTHENE
22000	PYRENE
15000U	BENZYL BUTYL PHTHALATE
15000U	3,3'-DICHLOROBENZIDINE
11000J	BENZO(A)ANTHRACENE
21000	CHRYSENE
15000U	BIS(2-ETHYLHEXYL) PHTHALATE
15000U	DI-N-OCTYLPHTHALATE
48000	BENZO(B AND/OR K)FLUORANTHENE
16000	BENZO-A-PYRENE
9900J	INDENO (1,2,3-CD) PYRENE
2900J	DIBENZO(A,H)ANTHRACENE
9700J	BENZO(GHI)PERYLENE
15000U	PHENOL
15000U	2-CHLOROPHENOL
31000U	BENZYL ALCOHOL
15000U	2-METHYLPHENOL
15000U	(3-AND/OR 4-)METHYLPHENOL
15000U	2-NITROPHENOL
15000U	2,4-DIMETHYLPHENOL
31000U	BENZOIC ACID
15000U	2,4-DICHLOROPHENOL
15000U	4-CHLORO-3-METHYLPHENOL
15000U	2,4,6-TRICHLOROPHENOL
15000U	2,4,5-TRICHLOROPHENOL
31000U	2,4-DINITROPHENOL
31000U	4-NITROPHENOL
15000U	2,3,4,6-TETRACHLOROPHENOL
31000U	2-METHYL-4,6-DINITROPHENOL
110000	PENTACHLOROPHENOL
12.6	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

PROJECT NO. 90-715 SAMPLE NO. 48155 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 7-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00

ANALYTICAL RESULTS UG/KG

3000JN	Anthracenecarbonitrile
5000JN	Methylfluoranthene (2 isomers)
7000JN	Benzanthraceneone (2 isomers)
30000JN	Benzofluoranthene (not B or K)(4 isomers)
4000JN	Methylbenzanthracene
2000JN	Naphthacenedione
N	Petroleum Product

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.
*R-QC INDICATES THAT DATA UNUSABLE. COMPOUND MAY OR MAY NOT BE PRESENT. RESAMPLING AND REANALYSIS IS NECESSARY FOR VERIFICATION.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/26/90

PURGEABLE ORGANICS DATA REPORT

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** PROJECT NO. 90-715 SAMPLE NO. 48156 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 8-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **

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UG/KG	ANALYTICAL RESULTS
270U	CHLOROMETHANE
270U	VINYL CHLORIDE
270U	BROMOMETHANE
270U	CHLOROETHANE
270U	TRICHLOROFLUOROMETHANE
270U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
2700U	ACETONE
2700U	CARBON DISULFIDE
270U	METHYLENE CHLORIDE
270U	TRANS-1,2-DICHLOROETHENE
270U	1,1-DICHLOROETHANE
2700U	VINYL ACETATE
270U	CIS-1,2-DICHLOROETHENE
270U	2,2-DICHLOROPROPANE
2700U	METHYL ETHYL KETONE
270U	BROMOCHLOROMETHANE
270U	CHLOROFORM
270U	1,1,1-TRICHLOROETHANE
270U	1,1-DICHLOROPROPENE
270U	CARBON TETRACHLORIDE
270U	1,2-DICHLOROETHANE
270U	BENZENE
270U	TRICHLOROETHENE(TRICHLOROETHYLENE)
270U	1,2-DICHLOROPROPANE
270U	DIBROMOMETHANE
270U	BROMODICHLOROMETHANE

UG/KG	ANALYTICAL RESULTS
270U	CIS-1,3-DICHLOROPROPENE
2700U	METHYL ISOBUTYL KETONE
270U	TOLUENE
270U	TRANS-1,3-DICHLOROPROPENE
270U	1,1,2-TRICHLOROETHANE
270U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
270U	1,3-DICHLOROPROPANE
2700U	METHYL BUTYL KETONE
270U	DIBROMOCHLOROMETHANE
270U	CHLOROBENZENE
270U	1,1,1,2-TETRACHLOROETHANE
270U	ETHYL BENZENE
270U	(M- AND/OR P-)XYLENE
270U	O-XYLENE
270U	STYRENE
270U	BROMOFORM
270U	BROMOBENZENE
270U	1,1,2,2-TETRACHLOROETHANE
270U	1,2,3-TRICHLOROPROPANE
270U	O-CHLOROTOLUENE
270U	P-CHLOROTOLUENE
270U	1,3-DICHLOROBENZENE
270U	1,4-DICHLOROBENZENE
270U	1,2-DICHLOROBENZENE
7.5	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/26/90

MISCELLANEOUS PURGEABLE ORGANICS - DATA REPORT

*** ***
** PROJECT NO. 90-715 SAMPLE NO. 48156 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 8-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **
** **
*** ***

ANALYTICAL RESULTS UG/KG

N Petroleum product

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/25/90

EXTRACTABLE ORGANICS DATA REPORT

PROJECT NO. 90-715 SAMPLE NO. 48156 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 8-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
350000U	BIS(2-CHLOROETHYL) ETHER
350000U	BIS(2-CHLOROISOPROPYL) ETHER
350000U	N-NITROSODI-N-PROPYLAMINE
350000U	HEXACHLOROETHANE
350000U	NITROBENZENE
350000U	ISOPHORONE
350000U	BIS(2-CHLOROETHOXY) METHANE
350000U	1,2,4-TRICHLOROBENZENE
390000	NAPHTHALENE
350000U	4-CHLOROANILINE
350000U	HEXACHLOROBUTADIENE
700000	2-METHYLNAPHTHALENE
350000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
350000U	2-CHLORONAPHTHALENE
350000U	2-NITROANILINE
350000U	DIMETHYL PHTHALATE
350000U	ACENAPHTHYLENE
350000U	2,6-DINITROTOLUENE
350000U	3-NITROANILINE
880000	ACENAPHTHENE
820000	DIBENZOFURAN
350000U	2,4-DINITROTOLUENE
350000U	DIETHYL PHTHALATE
1.1E6	FLUORENE
350000U	4-CHLOROPHENYL PHENYL ETHER
350000U	4-NITROANILINE
350000U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
350000U	4-BROMOPHENYL PHENYL ETHER
350000U	HEXACHLOROBENZENE (HCB)
2.3E6	PHENANTHRENE
1.9E6	ANTHRACENE
350000U	DI-N-BUTYLPHTHALATE

UG/KG	ANALYTICAL RESULTS
1.2E6	FLUORANTHENE
730000	PYRENE
350000U	BENZYL BUTYL PHTHALATE
350000U	3,3'-DICHLOROBENZIDINE
170000J	BENZO(A)ANTHRACENE
280000J	CHRYSENE
350000U	BIS(2-ETHYLHEXYL) PHTHALATE
350000U	DI-N-OCTYLPHTHALATE
110000J	BENZO(B AND/OR K)FLUORANTHENE
350000U	BENZO-A-PYRENE
350000U	INDENO (1,2,3-CD) PYRENE
350000U	DIBENZO(A,H)ANTHRACENE
350000U	BENZO(GHI)PERYLENE
350000U	PHENOL
350000U	2-CHLOROPHENOL
710000U	BENZYL ALCOHOL
350000U	2-METHYLPHENOL
350000U	(3-AND/OR 4-)METHYLPHENOL
350000U	2-NITROPHENOL
350000U	2,4-DIMETHYLPHENOL
710000U	BENZOIC ACID
350000U	2,4-DICHLOROPHENOL
350000U	4-CHLORO-3-METHYLPHENOL
350000U	2,4,6-TRICHLOROPHENOL
350000U	2,4,5-TRICHLOROPHENOL
710000U	2,4-DINITROPHENOL
710000U	4-NITROPHENOL
350000U	2,3,4,6-TETRACHLOROPHENOL
710000U	2-METHYL-4,6-DINITROPHENOL
710000U	PENTACHLOROPHENOL
7.5	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
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MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

PROJECT NO. 90-715 SAMPLE NO. 48156 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTEDBY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 8-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00

ANALYTICAL RESULTS UG/KG

300000JN	1-Methylnaphthalene
200000JN	Ethenylnaphthalene
60000JN	Ethylnaphthalene
500000JN	Dimethylnaphthalene (3 isomers)
200000JN	(Propenyl)naphthalene (2 isomers)
200000JN	Methyldibenzofuran (2 isomers)
100000JN	Methylfluorene (2 isomers)
300000JN	Dibenzothiophene
70000JN	Benzoquinoline
500000JN	Methylphenanthrene (4 isomers)
300000JN	Cyclopentaphenanthrene
100000JN	Phenylnaphthalene
200000JN	Benzofluorene (2 isomers)
600000JN	Carbazole

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FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

PURGEABLE ORGANICS DATA REPORT 07/31/90

PROJECT NO. 90-715 SAMPLE NO. 48157 SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 9-BR

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
280U	CHLOROMETHANE
280U	VINYL CHLORIDE
280U	BROMOMETHANE
280U	CHLOROETHANE
280U	TRICHLOROFLUOROMETHANE
280U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
2800U	ACETONE
2800U	CARBON DISULFIDE
280U	METHYLENE CHLORIDE
280U	TRANS-1,2-DICHLOROETHENE
280U	1,1-DICHLOROETHANE
2800U	VINYL ACETATE
280U	CIS-1,2-DICHLOROETHENE
280U	2,2-DICHLOROPROPANE
2800U	METHYL ETHYL KETONE
280U	BROMOCHLOROMETHANE
280U	CHLOROFORM
280U	1,1,1-TRICHLOROETHANE
280U	1,1-DICHLOROPROPENE
280U	CARBON TETRACHLORIDE
280U	1,2-DICHLOROETHANE
280U	BENZENE
280U	TRICHLOROETHENE(TRICHLOROETHYLENE)
280U	1,2-DICHLOROPROPANE
280U	DIBROMOMETHANE
280U	BROMODICHLOROMETHANE

UG/KG	ANALYTICAL RESULTS
280U	CIS-1,3-DICHLOROPROPENE
2800U	METHYL ISOBUTYL KETONE
280U	TOLUENE
280U	TRANS-1,3-DICHLOROPROPENE
280U	1,1,2-TRICHLOROETHANE
280U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
280U	1,3-DICHLOROPROPANE
2800U	METHYL BUTYL KETONE
280U	DIBROMOCHLOROMETHANE
280U	CHLOROBENZENE
280U	1,1,1,2-TETRACHLOROETHANE
280U	ETHYL BENZENE
280U	(M- AND/OR P-)XYLENE
280U	O-XYLENE
280U	STYRENE
280U	BROMOFORM
280U	BROMOBENZENE
280U	1,1,2,2-TETRACHLOROETHANE
280U	1,2,3-TRICHLOROPROPANE
280U	O-CHLOROTOLUENE
280U	P-CHLOROTOLUENE
280U	1,3-DICHLOROBENZENE
280U	1,4-DICHLOROBENZENE
280U	1,2-DICHLOROBENZENE
10.8	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/31/90

MISCELLANEOUS PURGEABLE ORGANICS - DATA REPORT

*** ***
** PROJECT NO. 90-715 SAMPLE NO. 48157 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 9-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **
** **
*** ***

ANALYTICAL RESULTS UG/KG

100JN	Trimethylbenzene
N	Petroleum product

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

EXTRACTABLE ORGANICS DATA REPORT 07/25/90

** PROJECT NO. 90-715 SAMPLE NO. 48157 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 9-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **

UG/KG	ANALYTICAL RESULTS
360000U	BIS(2-CHLOROETHYL) ETHER
360000U	BIS(2-CHLOROISOPROPYL) ETHER
360000U	N-NITROSODI-N-PROPYLAMINE
360000U	HEXACHLOROETHANE
360000U	NITROBENZENE
360000U	ISOPHORONE
360000U	BIS(2-CHLOROETHOXY) METHANE
360000U	1,2,4-TRICHLOROBENZENE
190000J	NAPHTHALENE
360000U	4-CHLOROANILINE
360000U	HEXACHLOROBUTADIENE
630000	2-METHYLNAPHTHALENE
360000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
360000U	2-CHLORONAPHTHALENE
360000U	2-NITROANILINE
360000U	DIMETHYL PHTHALATE
360000U	ACENAPHTHYLENE
360000U	2,6-DINITROTOLUENE
360000U	3-NITROANILINE
870000	ACENAPHTHENE
810000	DIBENZOFURAN
360000U	2,4-DINITROTOLUENE
360000U	DIETHYL PHTHALATE
1.1E6	FLUORENE
360000U	4-CHLOROPHENYL PHENYL ETHER
360000U	4-NITROANILINE
37000J	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
360000U	4-BROMOPHENYL PHENYL ETHER
360000U	HEXACHLOROBENZENE (HCB)
2.3E6	PHENANTHRENE
1.8E6	ANTHRACENE
360000U	DI-N-BUTYLPHTHALATE

UG/KG	ANALYTICAL RESULTS
950000	FLUORANTHENE
640000	PYRENE
360000U	BENZYL BUTYL PHTHALATE
360000U	3,3'-DICHLOROBENZIDINE
170000J	BENZO(A)ANTHRACENE
290000J	CHRYSENE
360000U	BIS(2-ETHYLHEXYL) PHTHALATE
360000U	DI-N-OCTYLPHTHALATE
100000J	BENZO(B AND/OR K)FLUORANTHENE
360000U	BENZO-A-PYRENE
360000U	INDENO (1,2,3-CD) PYRENE
360000U	DIBENZO(A,H)ANTHRACENE
360000U	BENZO(GHI)PERYLENE
360000U	PHENOL
360000U	2-CHLOROPHENOL
720000U	BENZYL ALCOHOL
360000U	2-METHYLPHENOL
360000U	(3-AND/OR 4-)METHYLPHENOL
360000U	2-NITROPHENOL
360000U	2,4-DIMETHYLPHENOL
720000U	BENZOIC ACID
360000U	2,4-DICHLOROPHENOL
360000U	4-CHLORO-3-METHYLPHENOL
360000U	2,4,6-TRICHLOROPHENOL
360000U	2,4,5-TRICHLOROPHENOL
720000U	2,4-DINITROPHENOL
720000U	4-NITROPHENOL
360000U	2,3,4,6-TETRACHLOROPHENOL
720000U	2-METHYL-4,6-DINITROPHENOL
720000U	PENTACHLOROPHENOL
10.8	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
*U-MATERIAL WAS ANALYZED FOR BUT NOT DETECTED. THE NUMBER IS THE MINIMUM QUANTITATION LIMIT.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.   07/25/90

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

PROJECT NO. 90-715   SAMPLE NO. 48157   SAMPLE TYPE: SOIL   PROG ELEM: SSF   COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE   CITY: PENSACOLA   ST: FL
STATION ID: 9-BR   COLLECTION START: 07/09/90 1500   STOP: 00/00/00

ANALYTICAL RESULTS UG/KG

300000JN	1-Methylnaphthalene
200000JN	Ethenylnaphthalene
50000JN	Ethylnaphthalene
300000JN	Dimethylnaphthalene (4 isomers)
200000JN	Methylbiphenyl (2 isomers)
200000JN	Methyldibenzofuran (2 isomers)
90000JN	Methylfluorene
300000JN	Dibenzothiophene
70000JN	Benzoquinoline
600000JN	Carbazole
500000JN	Methylphenanthrene (4 isomers)
300000JN	Cyclopentaphenanthrene
90000JN	Phenylnaphthalene
200000JN	Benzofluorene (2 isomers)

FOOTNOTES
*A-AVERAGE VALUE   *NA-NOT ANALYZED   *NAI-INTERFERENCES   *J-ESTIMATED VALUE   *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN   *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
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*R-QC INDICATES THAT DATA UNUSABLE. COMPOUND MAY OR MAY NOT BE PRESENT. RESAMPLING AND REANALYSIS IS NECESSARY FOR VERIFICATION.

SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

PURGEABLE ORGANICS DATA REPORT 07/31/90

PROJECT NO. 90-715 SAMPLE NO. 48158 SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 10-BR

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
58U	CHLOROMETHANE
58U	VINYL CHLORIDE
58U	BROMOMETHANE
58U	CHLOROETHANE
58U	TRICHLOROFLUOROMETHANE
58U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
580U	ACETONE
580U	CARBON DISULFIDE
120U	METHYLENE CHLORIDE
58U	TRANS-1,2-DICHLOROETHENE
58U	1,1-DICHLOROETHANE
580U	VINYL ACETATE
58U	CIS-1,2-DICHLOROETHENE
58U	2,2-DICHLOROPROPANE
580U	METHYL ETHYL KETONE
58U	BROMOCHLOROMETHANE
58U	CHLOROFORM
58U	1,1,1-TRICHLOROETHANE
58U	1,1-DICHLOROPROPENE
58U	CARBON TETRACHLORIDE
58U	1,2-DICHLOROETHANE
58U	BENZENE
58U	TRICHLOROETHENE(TRICHLOROETHYLENE)
58U	1,2-DICHLOROPROPANE
58U	DIBROMOMETHANE
58U	BROMODICHLOROMETHANE

UG/KG	ANALYTICAL RESULTS
58U	CIS-1,3-DICHLOROPROPENE
580U	METHYL ISOBUTYL KETONE
58U	TOLUENE
58U	TRANS-1,3-DICHLOROPROPENE
58U	1,1,2-TRICHLOROETHANE
58U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
58U	1,3-DICHLOROPROPANE
580U	METHYL BUTYL KETONE
58U	DIBROMOCHLOROMETHANE
58U	CHLOROBENZENE
58U	1,1,1,2-TETRACHLOROETHANE
58U	ETHYL BENZENE
58U	(M- AND/OR P-)XYLENE
58U	O-XYLENE
58U	STYRENE
58U	BROMOFORM
58U	BROMOBENZENE
58U	1,1,2,2-TETRACHLOROETHANE
58U	1,2,3-TRICHLOROPROPANE
58U	O-CHLOROTOLUENE
58U	P-CHLOROTOLUENE
58U	1,3-DICHLOROBENZENE
58U	1,4-DICHLOROBENZENE
58U	1,2-DICHLOROBENZENE
13.4	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/31/90

MISCELLANEOUS PURGEABLE ORGANICS - DATA REPORT

*** ***
** PROJECT NO. 90-715 SAMPLE NO. 48158 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 10-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **
** **
*** ***

ANALYTICAL RESULTS UG/KG

N Petroleum product

82

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

EXTRACTABLE ORGANICS DATA REPORT 07/25/90

PROJECT NO. 90-715 SAMPLE NO. 48158 SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 10-BR

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
72000U	BIS(2-CHLOROETHYL) ETHER
72000U	BIS(2-CHLOROISOPROPYL) ETHER
72000U	N-NITROSODI-N-PROPYLAMINE
72000U	HEXACHLOROETHANE
72000U	NITROBENZENE
72000U	ISOPHORONE
72000U	BIS(2-CHLOROETHOXY) METHANE
72000U	1,2,4-TRICHLOROBENZENE
72000U	NAPHTHALENE
72000U	4-CHLOROANILINE
72000U	HEXACHLOROBUTADIENE
72000U	2-METHYLNAPHTHALENE
72000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
72000U	2-CHLORONAPHTHALENE
72000U	2-NITROANILINE
72000U	DIMETHYL PHTHALATE
72000U	ACENAPHTHYLENE
72000U	2,6-DINITROTOLUENE
72000U	3-NITROANILINE
72000U	ACENAPHTHENE
72000U	DIBENZOFURAN
72000U	2,4-DINITROTOLUENE
72000U	DIETHYL PHTHALATE
72000U	FLUORENE
72000U	4-CHLOROPHENYL PHENYL ETHER
72000U	4-NITROANILINE
72000U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
72000U	4-BROMOPHENYL PHENYL ETHER
72000U	HEXACHLOROBENZENE (HCB)
11000J	PHENANTHRENE
72000U	ANTHRACENE
72000U	DI-N-BUTYLPHTHALATE

UG/KG	ANALYTICAL RESULTS
31000J	FLUORANTHENE
37000J	PYRENE
72000U	BENZYL BUTYL PHTHALATE
72000U	3,3'-DICHLOROBENZIDINE
14000J	BENZO(A)ANTHRACENE
25000J	CHRYSENE
72000U	BIS(2-ETHYLHEXYL) PHTHALATE
72000U	DI-N-OCTYLPHTHALATE
49000J	BENZO(B AND/OR K)FLUORANTHENE
15000J	BENZO-A-PYRENE
72000U	INDENO (1,2,3-CD) PYRENE
72000U	DIBENZO(A,H)ANTHRACENE
72000U	BENZO(GHI)PERYLENE
72000U	PHENOL
72000U	2-CHLOROPHENOL
140000U	BENZYL ALCOHOL
72000U	2-METHYLPHENOL
72000U	(3-AND/OR 4-)METHYLPHENOL
72000U	2-NITROPHENOL
72000U	2,4-DIMETHYLPHENOL
140000U	BENZOIC ACID
72000U	2,4-DICHLOROPHENOL
72000U	4-CHLORO-3-METHYLPHENOL
72000U	2,4,6-TRICHLOROPHENOL
72000U	2,4,5-TRICHLOROPHENOL
140000U	2,4-DINITROPHENOL
140000U	4-NITROPHENOL
72000U	2,3,4,6-TETRACHLOROPHENOL
140000U	2-METHYL-4,6-DINITROPHENOL
190000	PENTACHLOROPHENOL
13.4	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/25/90

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

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**   PROJECT NO. 90-715   SAMPLE NO. 48158  SAMPLE TYPE: SOIL        PROG ELEM: SSF   COLLECTED BY: D THOMAN                        **
**   SOURCE: AMERICAN CREOSOTE                                       CITY: PENSACOLA                 ST: FL                          **
**   STATION ID: 10-BR                                               COLLECTION START: 07/09/90  1500   STOP: 00/00/00               **
**                                                                                                                                   **
*** * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * ***
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ANALYTICAL RESULTS UG/KG

10000JN   Benzofluoranthene (not B or K)

FOOTNOTES
*A-AVERAGE VALUE   *NA-NOT ANALYZED   *NAI-INTERFERENCES   *J-ESTIMATED VALUE   *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

PURGEABLE ORGANICS DATA REPORT 07/26/90

PROJECT NO. 90-715 SAMPLE NO. 48159 SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 11-BR

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
280U	CHLOROMETHANE
280U	VINYL CHLORIDE
280U	BROMOMETHANE
280U	CHLOROETHANE
34J	TRICHLOROFLUOROMETHANE
280U	1,1-DICHLOROETHENE(1,1-DICHLOROETHYLENE)
2800U	ACETONE
2800U	CARBON DISULFIDE
280U	METHYLENE CHLORIDE
280U	TRANS-1,2-DICHLOROETHENE
280U	1,1-DICHLOROETHANE
2800U	VINYL ACETATE
280U	CIS-1,2-DICHLOROETHENE
280U	2,2-DICHLOROPROPANE
2800U	METHYL ETHYL KETONE
280U	BROMOCHLOROMETHANE
280U	CHLOROFORM
280U	1,1,1-TRICHLOROETHANE
280U	1,1-DICHLOROPROPENE
280U	CARBON TETRACHLORIDE
280U	1,2-DICHLOROETHANE
280U	BENZENE
280U	TRICHLOROETHENE(TRICHLOROETHYLENE)
280U	1,2-DICHLOROPROPANE
280U	DIBROMOMETHANE
280U	BROMODICHLOROMETHANE

UG/KG	ANALYTICAL RESULTS
280U	CIS-1,3-DICHLOROPROPENE
2800U	METHYL ISOBUTYL KETONE
280U	TOLUENE
280U	TRANS-1,3-DICHLOROPROPENE
280U	1,1,2-TRICHLOROETHANE
280U	TETRACHLOROETHENE(TETRACHLOROETHYLENE)
280U	1,3-DICHLOROPROPANE
2800U	METHYL BUTYL KETONE
280U	DIBROMOCHLOROMETHANE
280U	CHLOROBENZENE
280U	1,1,1,2-TETRACHLOROETHANE
280U	ETHYL BENZENE
280U	(M- AND/OR P-)XYLENE
280U	O-XYLENE
280U	STYRENE
280U	BROMOFORM
280U	BROMOBENZENE
280U	1,1,2,2-TETRACHLOROETHANE
280U	1,2,3-TRICHLOROPROPANE
280U	O-CHLOROTOLUENE
280U	P-CHLOROTOLUENE
280U	1,3-DICHLOROBENZENE
280U	1,4-DICHLOROBENZENE
280U	1,2-DICHLOROBENZENE
11.3	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/26/90

MISCELLANEOUS PURGEABLE ORGANICS - DATA REPORT

*** ***
** PROJECT NO. 90-715 SAMPLE NO. 48159 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN **
** SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL **
** STATION ID: 11-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00 **
** **
*** ***

ANALYTICAL RESULTS UG/KG

5000JN	Pinene
700JN	Ethylmethylbenzene (2 isomers)
1000JN	Trimethylbenzene
20000JN	Propynylbenzene
N	Petroleum product

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

EXTRACTABLE ORGANICS DATA REPORT 07/25/90

PROJECT NO. 90-715 SAMPLE NO. 48159 SAMPLE TYPE: SOIL PROG ELEM: SSF COLLECTED BY: D THOMAN
SOURCE: AMERICAN CREOSOTE CITY: PENSACOLA ST: FL
STATION ID: 11-BR COLLECTION START: 07/09/90 1500 STOP: 00/00/00

UG/KG	ANALYTICAL RESULTS
370000U	BIS(2-CHLOROETHYL) ETHER
370000U	BIS(2-CHLOROISOPROPYL) ETHER
370000U	N-NITROSODI-N-PROPYLAMINE
370000U	HEXACHLOROETHANE
370000U	NITROBENZENE
370000U	ISOPHORONE
370000U	BIS(2-CHLOROETHOXY) METHANE
370000U	1,2,4-TRICHLOROBENZENE
250000J	NAPHTHALENE
370000U	4-CHLOROANILINE
370000U	HEXACHLOROBUTADIENE
750000	2-METHYLNAPHTHALENE
370000U	HEXACHLOROCYCLOPENTADIENE (HCCP)
370000U	2-CHLORONAPHTHALENE
370000U	2-NITROANILINE
370000U	DIMETHYL PHTHALATE
370000U	ACENAPHTHYLENE
370000U	2,6-DINITROTOLUENE
370000U	3-NITROANILINE
940000	ACENAPHTHENE
880000	DIBENZOFURAN
370000U	2,4-DINITROTOLUENE
370000U	DIETHYL PHTHALATE
1.2E6	FLUORENE
370000U	4-CHLOROPHENYL PHENYL ETHER
370000U	4-NITROANILINE
370000U	N-NITROSODIPHENYLAMINE/DIPHENYLAMINE
370000U	4-BROMOPHENYL PHENYL ETHER
370000U	HEXACHLOROBENZENE (HCB)
2.6E6	PHENANTHRENE
2.1E6	ANTHRACENE
370000U	DI-N-BUTYLPHTHALATE

UG/KG	ANALYTICAL RESULTS
1.2E6	FLUORANTHENE
780000	PYRENE
370000U	BENZYL BUTYL PHTHALATE
370000U	3,3'-DICHLOROBENZIDINE
180000J	BENZO(A)ANTHRACENE
310000J	CHRYSENE
370000U	BIS(2-ETHYLHEXYL) PHTHALATE
370000U	DI-N-OCTYLPHTHALATE
120000J	BENZO(B AND/OR K)FLUORANTHENE
370000U	BENZO-A-PYRENE
370000U	INDENO (1,2,3-CD) PYRENE
370000U	DIBENZO(A,H)ANTHRACENE
370000U	BENZO(GHI)PERYLENE
370000U	PHENOL
370000U	2-CHLOROPHENOL
750000U	BENZYL ALCOHOL
370000U	2-METHYLPHENOL
370000U	(3-AND/OR 4-)METHYLPHENOL
370000U	2-NITROPHENOL
370000U	2,4-DIMETHYLPHENOL
750000U	BENZOIC ACID
370000U	2,4-DICHLOROPHENOL
370000U	4-CHLORO-3-METHYLPHENOL
370000U	2,4,6-TRICHLOROPHENOL
370000U	2,4,5-TRICHLOROPHENOL
750000U	2,4-DINITROPHENOL
750000U	4-NITROPHENOL
370000U	2,3,4,6-TETRACHLOROPHENOL
750000U	2-METHYL-4,6-DINITROPHENOL
750000U	PENTACHLOROPHENOL
11.3	PERCENT MOISTURE

REMARKS

REMARKS

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
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SAMPLE AND ANALYSIS MANAGEMENT SYSTEM
EPA-REGION IV ESD, ATHENS, GA.

07/25/90

MISCELLANEOUS EXTRACTABLE COMPOUNDS - DATA REPORT

PROJECT NO. 90-715 SAMPLE NO. 48159 SAMPLE TYPE: SOIL
SOURCE: AMERICAN CREOSOTE
STATION ID: 11-BR

PROG ELEM: SSF COLLECTED BY: D THOMAN
CITY: PENSACOLA ST: FL
COLLECTION START: 07/09/90 1500 STOP: 00/00/00

ANALYTICAL RESULTS UG/KG

300000JN	1-Methylnaphthalene
200000JN	Ethenylnaphthalene
70000JN	Ethylnaphthalene
600000JN	Dimethylnaphthalene (4 isomers)
60000JN	Trimethylnaphthalene
200000JN	(Propenyl)naphthalene (3 isomers)
300000JN	Methyldibenzofuran (2 isomers)
200000JN	Methylfluorene (2 isomers)
300000JN	Dibenzothiophene
80000JN	Benzoquinoline
700000JN	Carbazole
500000JN	Methylphenanthrene (4 isomers)
300000JN	Cyclopentaphenanthrene
100000JN	Phenylnaphthalene
200000JN	Benzofluorene (2 isomers)

FOOTNOTES
*A-AVERAGE VALUE *NA-NOT ANALYZED *NAI-INTERFERENCES *J-ESTIMATED VALUE *N-PRESUMPTIVE EVIDENCE OF PRESENCE OF MATERIAL
*K-ACTUAL VALUE IS KNOWN TO BE LESS THAN VALUE GIVEN *L-ACTUAL VALUE IS KNOWN TO BE GREATER THAN VALUE GIVEN
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