U. S. Fish and Wildlife Service
Region 2

CONTAMINANTS INVESTIGATION OF FORMER PRODUCTION AREA WITHIN CADDO LAKE NATIONAL WILDLIFE REFUGE, TEXAS 2005
Project ID No. 1902-2007-21420

Prepared by
Craig M. Giggleman and Jacob M. Lewis
Arlington Ecological Services Field Office
711 Stadium Drive, Suite #252
Arlington, Texas 76011

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ABSTRACT

In June, 2005, the United States Fish and Wildlife Service conducted a contaminants investigation at Caddo Lake National Wildlife Refuge in Harrison County, Texas. This Refuge was an overlay refuge established on the site of a former munitions production facility, Longhorn Army Ammunition Plant. The purpose of the investigation was to determine surficial soil contaminant levels of metals, organochlorine pesticides, polychlorinated biphenyls, and perchlorate in approximately 728 acres (294 hectares) within the former production area located in the north-central portion of the Refuge. Surficial soil grab samples were collected from 32 sites, which were selected through a computer generated stratified random matrix grid. Six metals (lead, manganese, mercury, selenium, vanadium, and zinc), one organochlorine pesticide (eldrin), and two polychlorinated biphenyl congeners (Arochlor-1254 and 1260) were detected at slightly elevated levels throughout the area sampled. Perchlorate was not detected in any of the samples collected. In comparison to available ecological screening criteria, none of the detected surficial soil contaminant concentrations were at levels likely to adversely affect ecological resources.

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INTRODUCTION

In June, 2005, a contaminants investigation was conducted at Caddo Lake National Wildlife Refuge (CLNWR) by the United States Fish and Wildlife Service (USFWS). The purpose of this investigation was to determine contaminant (metals, organochlorine pesticides, polychlorinated biphenyls, and perchlorate) levels in soils in approximately 728 acres (294 hectares) within the former production area located in the north-central portion of the Refuge. Data resulting from this investigation would be used by the USFWS to determine the suitability of transfer of administrative control of this portion of the Refuge from the United States Army to the USFWS.

STUDY AREA & BACKGROUND

Caddo Lake National Wildlife Refuge is an overlay refuge located on the site of a former military munitions production facility in Harrison County, Texas, southwest of Caddo Lake (Figure 1). The entire site consists of 8,493 acres (3,437 hectares) of mixed upland pine and bottomland hardwood forests interlaced with remnant structures from the munitions plant. The area is drained by four principal lotic systems, Goose Prairie Bayou, Central Creek, Harrison Bayou, and Saunders Branch, all flowing into Caddo Lake. The former production facility was known as Longhorn Army Ammunition Plant (LHAAP). This plant was established by the United States Department of Defense (USDOD) under the jurisdiction of the U.S. Army Armament, Munitions, and Chemical Command (AMCCOM) in 1941 to produce trinitrotoluene (TNT) flake through the contract operator Monsanto Chemical Company (TSHA 2002). The plant produced over four hundred million pounds (greater than 180 million kilograms) of TNT between 1942 and 1945 (TSHA 2002). In late 1945, TNT production ceased and Monsanto suspended all operations at the site, while the facility was placed on standby status by the USDOD (TSHA 2002). The plant remained inactive until 1952, when operations were re-initiated under the contract operator, Universal Match Corporation to produce pyrotechnic and illuminating ammunition such as photoflash bombs, simulators, hand signals, and 40 millimeter tracers (GS 2002, TSHA 2002). By 1956, Morton-Thiokol Incorporated (formerly known as the Thiokol Corporation) had assumed contract operation responsibilities at the facility (GS 2002, TSHA 2002). From 1956 through 1965, the primary mission of the plant was the production of solid propellant rocket motors and fuels for the Nike-Hercules, Falcon, Lacrosse, Honest John, and Sergeant Missile programs (GS 2002). In 1965, the production of pyrotechnic and illuminating ammunition was re-initiated at the plant by Thiokol. The plant continued to produce munitions all during the 1960s and 1970s. At its peak, the facility employed over 2,200 people (D. Tolbert, USACE, personal communication, 2002).

In 1987, LHAAP was selected as one of the sites for the static firing and elimination of Pershing IA and II rocket motors in order to comply with the terms of the Intermediate Nuclear Force Treaty between the U.S. and the Soviet Union (GS 2002). This project was completed by 1991

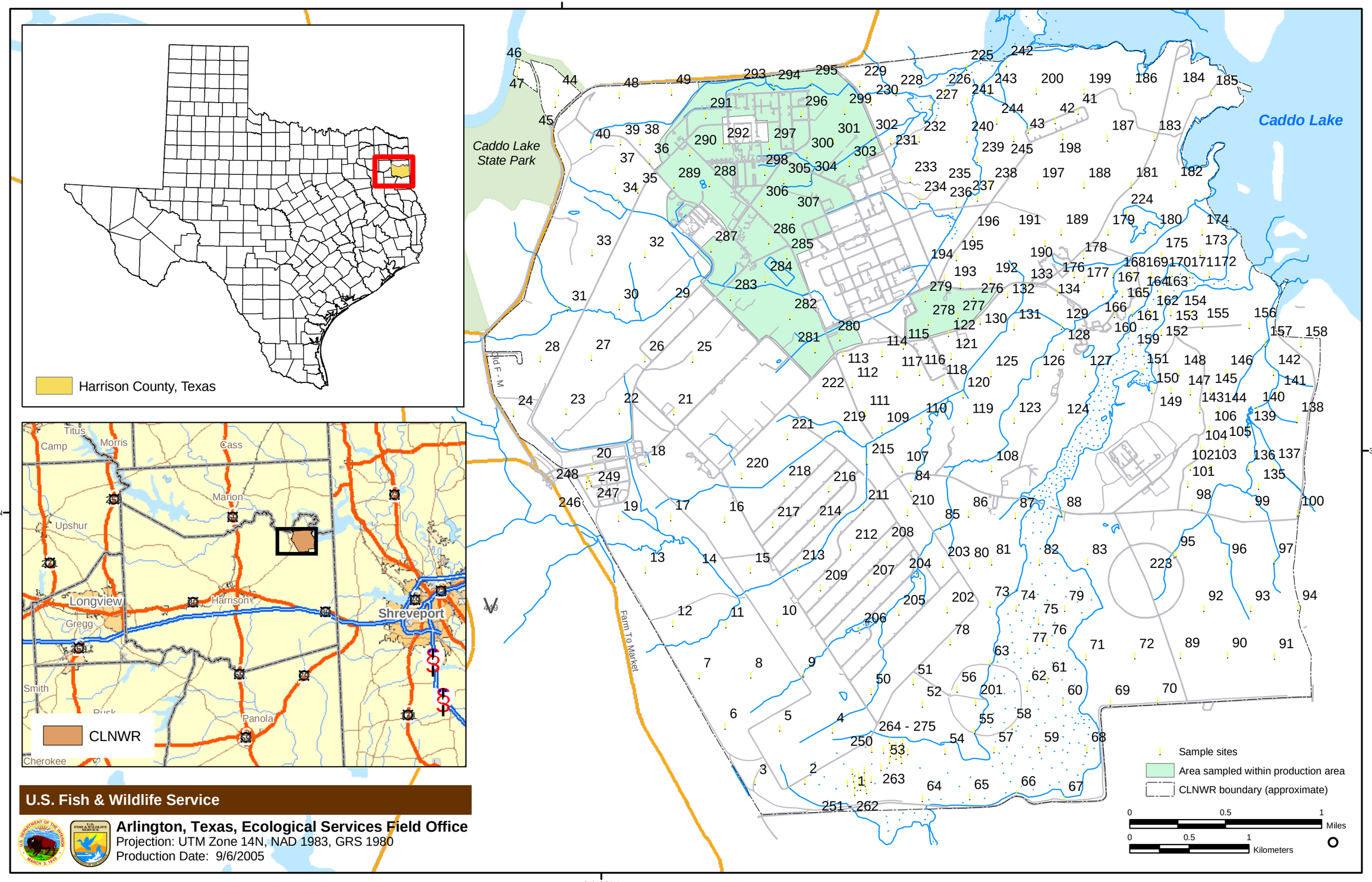

Figure 1: Caddo Lake NWR location and USFWS sample sites at Caddo Lake NWR, 2002-2005

(TSHA 2002). In 1990, the facility was placed by the U.S. Environmental Protection Agency (USEPA) on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priority List (NPL). This listing as a Superfund site was due to groundwater, surface water, sediments, and soil contamination (ATSDR 2002). Contaminants associated with the listing included metals, explosives, semi-volatile organic compounds, and volatile organic compounds (ATSDR 2002). Activities to remediate this contamination were initiated in 1990 and are expected to be completed no earlier than 2030. Thiokol continued operations at the plant, primarily the production of the plastic explosive CL-20, until 1997 (ATSDR 2002). By 1998, Thiokol had ceased operations at the site and AMCCOM had classified the plant as excess property. In 1999, negotiations were initiated between AMCCOM and USFWS over the possible absorption of the site into the National Wildlife Refuge System. In October, 2000, LHAAP became Caddo Lake National Wildlife Refuge, an overlay refuge, with the U.S. Army maintaining administrative control of the property until primary jurisdiction for the site is deemed suitable for transfer to the USFWS.

Since 2002, the USFWS has conducted three other contaminants investigations at CLNWR. These investigations included the western portion (Figure 1, Sites 1 through 43) (Giggleman and Lewis 2002); the far northwestern portion (Figure 1, Sites 44 through 49) (Giggleman and Lewis 2003a); and the northern, central, and eastern portions of CLNWR (Figure 1, Sites 50 through 249) (Giggleman and Lewis 2003b). The results of these investigations indicated that elevated metals, organochlorine pesticides, and total-PCB contamination were scattered throughout these portions of the Refuge, while perchlorate contamination was limited to two small areas in the southwestern and far northwestern portions of the Refuge (Giggleman and Lewis 2002, Giggleman and Lewis 2003a, Giggleman and Lewis 2003b).

In February, 2004, US Army Corps of Engineers (USACE), Tulsa District personnel and a USFWS representative performed confirmation sampling to define the extent of perchlorate contamination in the southwestern portion of CLNWR (Figure 1, Sites 250 through 275). No perchlorate contamination was detected in any of these USACE sample sites (C. Murray, USACE, personal communication, 2005).

MATERIALS & METHODS

Surficial grab soil sediment samples were collected from 32 sites (Sites 276 through 307) within the former production area located in the north-central portion of CLNWR (Figure 1) by USFWS personnel in June, 2005. The overall area sampled covered approximately 728 acres (294 hectares). The individual sampling sites were selected through a computer generated stratified random matrix grid. The distance between sampling points ranged from approximately 174 to 432 meters (570 to 1418 feet). Each soil sample was collected at a depth of 0 to 6 inches [0 to 15 centimeters (cm)] using a disposable plastic scoop, placed in a pre-cleaned glass container, and placed on ice in a cooler. These samples were then shipped over-night to General Engineering Laboratories, LLC (GEL) for chemical analyses. Samples from each site were analyzed for percent moisture content; metals (aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium, and zinc) in milligrams/kilogram (mg/kg) dry weight;

organochlorine pesticides [4,4'-dichloro-diphenyl-dichloroethane (4,4'-DDD), 4,4'-dichloro-diphenyl-dichloroethylene (4,4'-DDE), 4,4'-dichloro-diphenyl-trichloroethane (4,4'-DDT), aldrin, alpha hexachlorocyclohexane (alpha-BHC), beta hexachlorocyclohexane (beta-BHC), chlordane (tech.), delta hexachlorocyclohexane (delta-BHC), dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, gamma hexachlorocyclohexane (gamma-BHC), heptachlor, heptachlor epoxide, methoxychlor, and toxaphene] in micrograms/kilogram (µg/kg) dry weight; polychlorobiphenyls (PCBs - Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254, and Aroclor-1260) in µg/kg dry weight; and perchlorate content in µg/kg dry weight (for analytical methods see Appendix A).

Following the methodology recommended by the USEPA (1995), field duplicate soil samples were collected from Sites 281, 288, and 296 and handled in the same manner as the other samples collected at these sites. These duplicate samples were also submitted through GEL to be analyzed for metals, organochlorine pesticides, PCBs, and perchlorate. The purpose of these duplicates was to assess the laboratory analytical procedures as well as to assess the quality of field sampling techniques.

RESULTS & DISCUSSION

Soil moisture content and the results of the analyses are presented in Appendix B, Table 1. Where applicable, all analytical results were compared with soil benchmarks proposed by Efroymson et al. (1997), the USEPA, and the Texas Commission on Environmental Quality [TCEQ formerly known as the Texas Natural Resource Conservation Commission (TNRCC)] (2001), as well as with data from comparative studies and other screening criteria such as remedial target values to determine the possible effects of contamination in soils collected from CLNWR. Benchmarks and/or screening criteria are values derived from toxicity data resulting from multiple studies. Soil benchmarks are typically based on the degree of toxicity of a given contaminant to plants, earthworms, heterotrophic microbes, and other invertebrates (Efroymson et al. 1997). Remedial target values are soil cleanup levels employed to address human health concerns.

Metals

Results of the metals analyses for the 32 soil samples are presented in Appendix B, Table 1. All of the 20 metallic analytes were detected in one or more of the samples.

[Aluminum (Al)] Approximately 8.1% of the Earth's crust is composed of aluminum (Miller and Gardiner 1998). Background surface soil concentrations in the western U.S. range up to 74,000 mg Al/kg (Shacklette and Boerngen 1984). According to the TCEQ (2001), a soil-aluminum concentration of 30,000 mg Al/kg is considered background in the State of Texas. Efroymson et al. (1997), proposed 600 mg Al/kg dry weight as a screening benchmark value for aluminum toxicity to soil microorganisms. In birds, elevated levels of aluminum in the diet can result in adverse effects in calcium and phosphorus metabolism (Sparling and Lowe 1996).

Aluminum levels were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Soil-aluminum concentrations ranged from 3,250 mg Al/kg dry weight at Site 303 to 20,600 mg Al/kg dry weight at Site 281 (Appendix B, Table 1). All of these concentrations exceeded the soil benchmark value proposed by Efroymson et al. (1997), but none of the measured aluminum levels exceeded the soil background values suggested by Shacklette and Boerngen (1984) and the TCEQ (2001).

[Arsenic (As)] According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background elemental arsenic concentrations in surface soils in the western U.S. is 7 mg As/kg, while the TCEQ (2001), considers a soil-arsenic concentration of 5.9 mg As/kg as background in the State of Texas. Pennington (1991) reported soil-arsenic concentrations ranging up to 13.36 mg As/kg in the Texas Panhandle. Efroymson et al. (1997), proposed an earthworm soils toxicity screening benchmark value of 60 mg As/kg dry weight, while the USEPA (2000) considers a soil-arsenic concentration of 37 mg As/kg dry weight as a benchmark value for terrestrial plants. Birds and freshwater biota usually contain arsenic concentrations less than 1 mg As/kg wet weight (USDOI 1998).

Arsenic concentrations were detected above the analytical detection limits in all of the samples collected (Appendix B, Table 1). The detected soil-arsenic concentrations ranged from 0.96 mg As/kg dry weight (estimated) at Site 289 to 7.81 mg As/kg dry weight at Site 293 (Appendix B, Table 1). The detected concentration at Site 289 (7.81 mg As/kg dry weight) exceeded all of the cited background values, but was well below the cited ecological benchmarks (Shacklette and Boerngen 1984, Efroymson et al. 1997, USEPA 2000, TCEQ 2001).

[Barium (Ba)] Barium compounds are used in a variety of industrial applications. In nature, barium chiefly occurs as the relatively insoluble salts, barite and witherite (USEPA 1986). Shacklette and Boerngen (1984) reported an estimated arithmetic mean of 670 mg Ba/kg as background for soils in the western U.S. while a soils concentration of 300 mg Ba/kg dry weight is considered background in the State of Texas (TCEQ 2001). According to Efroymson et al. (1997), a proposed screening benchmark value for barium toxicity to soil microorganisms is 3000 mg Ba/kg dry weight, while the TCEQ (2001) considers a soil-barium concentration of 500 mg Ba/kg dry weight as a benchmark value for terrestrial plants.

Barium levels were detected above the analytical detection limits in all samples collected (Appendix B, Table 1). The soil-barium concentrations ranged from 38.9 mg Ba/kg dry weight at Site 289 to 388 mg Ba/kg dry weight at Site 284 (Appendix B, Table 1). Site 284 was the only site that exceeded the soil-barium background concentration reported by the TCEQ (2001); however, all soil-barium concentrations were below the background concentration estimated by Shacklette and Boerngen (1984) and the cited ecological screening criteria (Efroymson et al. 1997, TCEQ 2001).

[Beryllium (Be)] Although not truly a heavy metal, beryllium is a rare element that is considered potentially toxic (Irwin and Dodson, 1991; Manahan, 1991). The distribution of beryllium in the environment largely results from the combustion of coal and oil (Goyer 1991, Manahan 1991). Coal mined from the mid-west U.S. contains an average of about 2.5 mg Be/kg while crude oil can contain approximately 0.08 mg Be/kg (Goyer 1991). Beryllium

concentrations in soils in the U.S. can range up to 15 mg Be/kg (Shacklette and Boerngen 1984), however according to Shacklette and Boerngen (1984), the estimated arithmetic mean for background beryllium concentrations in soils in the western U.S. is 0.97 mg Be/kg. In the State of Texas, a soil-beryllium concentration of 1.5 mg Be/kg dry weight is considered background (TCEQ 2001). The TCEQ (2001) considers a soil-beryllium concentration of 10 mg Be/kg dry weight as a benchmark value for terrestrial plants.

Beryllium concentrations were detected above the analytical detection limits in all of the soil samples collected (Appendix B, Table 1). The detected soil-beryllium concentrations ranged from 0.18 mg Be/kg dry weight at Site 289 to 2.79 mg Be/kg dry weight at Site 277 (Appendix B, Table 1). While 12.5% of these samples (4/32) contained soil-beryllium concentrations that equaled or exceeded the estimated arithmetic mean for background beryllium levels reported by Shacklette and Boerngen (1984), only 6.25% (2/32) exceeded the background concentration reported by the TCEQ (2001). None of the soil samples contained beryllium levels that approached the ecological benchmark recommended by the TCEQ (2001).

[Boron (B)] Boron compounds are used in the production of fertilizers and other agricultural chemicals such as herbicides and insecticides (Moore et al. 1990; USDOI 1998). In the U.S., boron concentrations in soils typically range from 10-300 mg B/kg (USDOI 1998). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background boron concentrations in western soils is 29 mg B/kg while a soils concentration of 30 mg B/kg is considered background in the State of Texas (TCEQ 2001). Efroymson et al. (1997), recommend a screening benchmark value of 20 mg B/kg dry weight for boron toxicity to soil microorganisms and microbial processes, while the TCEQ (2001) considers a soil-boron concentration of 0.5 mg B/kg dry weight as a benchmark value for terrestrial plants. Usually, arid, saline soils will contain higher boron concentrations in comparison to watered, loamy soils (USDOI 1998). Furthermore, soils formed from marine sediments typically contain higher concentrations of boron than those formed from igneous rocks (Moore et al. 1990).

Boron concentrations were detected above the analytical detection limits in 25 soil samples (Appendix B, Table 1). The measured boron-soil levels ranged from 0.952 mg B/kg dry weight at Site 283 to 7.18 mg B/kg dry weight at Site 284 (Appendix B, Table 1). All of the detected soil-boron concentrations exceeded the lower benchmark value recommended by the TCEQ (2001); however, none of these concentrations exceeded the background values reported by Shacklette and Boerngen (1984), USDOI (1998), or the TCEQ (2001), nor approached the higher toxicity threshold value recommended by Efroymson et al. (1997).

[Cadmium (Cd)] Ryan et al. (1980) reported that the normal range for elemental cadmium in surface soils in the U.S. is 0.06 to 0.5 mg Cd/kg. According to Efroymson et al. (1997), a proposed screening benchmark value for cadmium toxicity to soil microorganisms is 20 mg Cd/kg dry weight, while the TCEQ (2001) reports concentrations of 110 mg Cd/kg dry weight and 29 mg Cd/kg dry weight as ecological benchmarks for earthworms and terrestrial plants, respectively.

Cadmium concentrations were detected above the analytical detection limits in all soil samples collected (Appendix B, Table 1). The detected soil-cadmium levels ranged from 0.06 mg Cd/kg

dry weight at Site 289 to 0.50 mg Cd/kg dry weight at Site 284 (Appendix B, Table 1), all well below cited ecological benchmarks for terrestrial systems (Efroymson et al. 1997, TCEQ 2001).

[Chromium (Cr)] Excessive chromium can be mutagenic, carcinogenic, and teratogenic to a wide variety of organisms (Eisler 1986). Shacklette and Boerngen (1984) reported an estimated arithmetic mean of 56 mg Cr/kg as background for soils in the western U.S. According to the TCEQ (2001), a soil-chromium concentration of 30 mg Cr/kg dry weight can be considered background in the State of Texas. Efroymson et al. (1997), proposed soil toxicity screening benchmark values ranging from 0.4 mg Cr/kg dry weight for earthworms to 10 mg Cr/kg dry weight for soil microorganisms. The USEPA (2000) considers a soil-chromium concentration of 5 mg Cr/kg dry weight as a benchmark value for terrestrial plants.

Chromium concentrations were detected above the analytical detection limits in all samples collected (Appendix B, Table 1). Soil-chromium concentrations ranged from 5.8 mg Cr/kg dry weight at Site 289 to 34.0 mg Cr/kg dry weight at Site 292 (Appendix B, Table 1). All of the soil samples contained chromium levels that exceeded the lower toxicity threshold value proposed by Efroymson et al. (1997) and the benchmark for plants recommended by the USEPA (2000), while 65.6% (21/32) contained chromium levels that exceeded the benchmark for soil microorganisms (Efroymson et al. 1997). In contrast, only the sample collected from Site 292 contained a soil-chromium concentration that exceeded the TCEQ (2001) background value, whereas none of the samples contained chromium concentrations above the background value suggested by Shacklette and Boerngen (1984).

[Copper (Cu)] Copper is primarily used in the manufacturing of electrical equipment, pipe, and machinery (Eisler 1998). It is also an essential micronutrient that interacts in animals with other essential trace elements such as iron, zinc, molybdenum, manganese, nickel, and selenium and also with nonessential elements including silver, cadmium, mercury, and lead (Goyer 1991, Eisler 1998). In soils, Shacklette and Boerngen (1984), consider 27 mg Cu/kg as the arithmetic mean background copper concentration in the western U.S., while a soil-copper concentration of 15 mg/kg dry weight is considered background in the State of Texas (TCEQ 2001). Efroymson et al. (1997) proposed a soils toxicity screening benchmark value of 100 mg Cu/kg dry weight. The TCEQ (2001) reports 61 mg Cu/kg dry weight as the soils benchmark value for earthworms.

Copper concentrations were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Measured soil-copper concentrations ranged from 1.58 mg Cu/kg dry weight at Site 289 to 8.31 mg Cu/kg dry weight at Site 281 (Appendix B, Table 1). None of the 32 sites sampled contained soil-copper concentrations that were elevated in comparison to any of the cited soils screening criteria.

[Iron (Fe)] Iron is a necessary nutrient that is a constituent of many enzymatic and other cellular processes (Horne and Goldman, 1994). It is absolutely essential both for the transport of oxygen to the tissues and for maintenance of oxidative systems within the tissue cells (Guyton 1981). Iron composes approximately 5% of the Earth's crust (Miller and Gardiner 1998). Background iron concentrations in surface soils in the western U.S. range up to 26,000 mg Fe/kg (Shacklette and Boerngen 1984). In Texas, median background soil-iron concentrations are reported as 15,000 mg Fe/kg (TCEQ 2001).

Iron levels were detected above the analytical detection limits in all samples collected (Appendix B, Table 1). Soil-iron concentrations ranged from 3,440 mg Fe/kg dry weight at Site 286 to 31,900 mg Fe/kg dry weight at Site 292 (Appendix B, Table 1). Three sites (Sites 292, 293, and 303) contained soil-iron levels that exceeded the reported median background concentration for Texas (TCEQ 2001). Of these 3 sites, only one (Site 292) contained soil-iron concentrations that exceeded the background value reported by Shacklette and Boerngen (1984). Although elevated at this site, the detected iron levels would not be expected to cause significant detrimental affects to ecological resources.

[Lead (Pb)] Listed by the USEPA as a priority pollutant, lead is used in pigment and chemical production, metallurgy and steel manufacturing, storage batteries, ceramics, petroleum products, cable sheathing, pipe and sheeting fabrication, and ammunition production (Eisler 1988). Lead is neither essential nor beneficial to living organisms, and unlike mercury, lead does not exhibit bio-magnification through progressive trophic levels (Eisler 1988, Pain 1995). Lead is naturally occurring in soils. According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background lead concentrations in surface soils in the western U.S. is 20 mg Pb/kg. The TCEQ (2001) considers a soil-lead concentration of 15 mg Pb/kg dry weight as background in the State of Texas. Soil ecological screening criteria range from 50 mg Pb/kg dry weight for terrestrial plants to 500 mg Pb/kg dry weight for earthworms (TCEQ 2001).

Lead was detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Soil-lead concentrations ranged from 9.01 mg Pb/kg dry weight at Site 296 to 54.7 mg Pb/kg dry weight at Site 279 (Appendix B, Table 1). Detected soil-lead levels exceeded the background concentration reported by the TCEQ (2001) in 43.8% (14/32) of the samples and were greater than the background value estimated by Shacklette and Boerngen (1984) in 18.8 % (6/32) of the samples (Appendix B, Table 1). Of these soil samples, only the concentration detected at Site 279 (54.7 mg Pb/kg dry weight) exceeded any of the ecological benchmark recommended by the TCEQ (2001). The lead concentrations measured at this site exceeded the lower threshold value (TCEQ 2001) and warrants further investigation.

[Magnesium (Mg)] Magnesium is an essential nutrient that is required for energy transfer in all living cells because it catalyzes the change from adenosine triphosphate (ATP) to adenosine diphosphate (ADP) (Horne and Goldman 1994). The Earth's crust is composed of approximately 2.1% magnesium (Miller and Gardiner 1998). Shacklette and Boerngen (1984) estimated the arithmetic mean for background magnesium concentrations in surface soils in the western U.S. as 10,000 mg Mg/kg.

Magnesium concentrations were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Soil-magnesium levels ranged from 250 mg Mg/kg dry weight at Site 289 to 2,120 mg Mg/kg dry weight at Site 292. None of the sites sampled contained magnesium levels above the background soil value reported by Shacklette and Boerngen (1984).

[Manganese (Mn)] Manganese is a widely distributed, abundant element that constitutes approximately 0.085% of the earth's crust (Irwin and Dodson 1991). It is a necessary nutrient for plants and animals and is relatively nontoxic to aquatic biota (Wiener and Giesy 1979, Cole

1983). In freshwater systems, it stimulates planktonic growth by activating enzymatic mechanisms (Cole 1983). For surface soils, 480 mg Mn/kg is considered an estimated arithmetic mean for background manganese concentrations in the western U.S. (Shacklette and Boerngen 1984). The TCEQ (2001) considers a soil-manganese concentration of 300 mg Mn/kg dry weight as background in the State of Texas. According to Efroymson et al. (1997), a proposed screening benchmark value for manganese toxicity to soil microorganisms is 100 mg Mn/kg dry weight, while the TCEQ (2001) reports a soil-manganese concentration of 500 mg Mn/kg dry weight as a benchmark value for terrestrial plants. The ecological screening benchmark recommended by the USEPA for manganese in soils is 100 mg Mn/kg (RAIS 2002).

Manganese concentrations were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Soil-manganese concentrations ranged from 64.1 mg Mn/kg dry weight at Site 292 to 3,190 mg Mn/kg dry weight at Site 277 (Appendix B, Table 1). Approximately 78.1% (25/32) of these soil samples contained manganese levels that exceeded the Texas background concentration (TCEQ, 2001), while 62.5% (20/32) contained manganese concentrations that exceeded the background value estimated by Shacklette and Boerngen (1984) (Appendix B, Table 1). In addition, 93.8% (30/32) of the soil samples contained manganese levels that exceeded the lower ecological threshold value suggested by Efroymson et al. (1997) and the USEPA (RAIS 2002), while 56.3% (18/32) had manganese levels that exceeded the upper ecological benchmark recommended by the TCEQ (2001) (Appendix B, Table 1). The widespread distribution of elevated soil-manganese levels may be indicative of naturally high background concentrations; however, further investigation is warranted to determine if a site-related gradient exists for soil-manganese contamination at the Refuge.

[Mercury (Hg)] Mercury has been used in metallurgy, the preparation of dental amalgams, in switches, thermometers, barometers, pharmaceuticals, munitions, and in the electrolytic preparation of chlorine (Eisler 1987). Major anthropogenic sources of mercury include pulp and paper mills, mining and processing of metallic ores, and the incomplete combustion of fossil fuels (Eisler 1987). In terrestrial systems, background surface-soil mercury concentrations in the western U.S. are typically less than or equal to 0.065 mg Hg/kg (Shacklette and Boerngen 1984). In the State of Texas, a soil-mercury concentration of 0.04 is considered background (TCEQ 2001). The TCEQ (2001) recommends soil-mercury concentrations of 0.1 mg Hg/kg dry weight as a benchmark for earthworms and 0.3 mg Hg/kg dry weight as a benchmark for terrestrial plants.

Mercury levels were detected above the analytical detection limits in every site sampled (Appendix B, Table 1). Detected soil-mercury concentrations ranged from 0.019 mg Hg/kg dry weight at Site 293 to 0.117 mg Hg/kg dry weight at Site 281 (Appendix B, Table 1). Six (18.8%) of the 32 soil samples that contained detectable amounts of mercury equaled or exceeded the background concentration recommended by Shacklette and Boerngen, (1984), while 78.1% of the soil samples (25/32) contained mercury levels that equaled or exceeded the background concentration recommended by the TCEQ (2001) (Appendix B, Table 1). Furthermore, Sites 281 and 292 contained soil-mercury concentrations that exceeded the earthworm-benchmark suggested by the TCEQ (2001) (Appendix B, Table 1). However, none of the soil samples analyzed contained mercury levels that equaled or exceeded the TCEQ's (2001) benchmark for terrestrial plants (Appendix B, Table 1).

[Molybdenum (Mo)] Molybdenum is a comparatively rare element that does not occur free in nature and is usually found in conjunction with sulfur, oxygen, tungsten, lead, uranium, iron, magnesium, cobalt, vanadium, bismuth, or calcium (Eisler 1989). It is an essential micronutrient for most life forms. It is even necessary for fixing atmospheric nitrogen by bacteria in plants; however, excessive exposure can result in toxicity to both animals and humans (Goyer 1991, USDOI 1998). In terrestrial environments, the highest soil-molybdenum concentrations are usually found within the top 30 cm of surface soils (USDOI 1998). Ionic forms of molybdenum such as molybdate, tend to be sorbed most readily in alkaline soils which are high in calcium and chlorides, whereas retention is limited in low pH and low sulfate soils (Eisler 1989). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background molybdenum concentrations in surface soils in the western U.S. is 1.1 mg Mo/kg. Efroymson et al. (1997), proposed a soils toxicity screening benchmark value of 200 mg Mo/kg dry weight for soil microorganisms, while the TCEQ (2001) considers a soils concentration of 2 mg Mo/kg as the benchmark value for terrestrial plants. Pastures containing between 20-100 mg Mo/kg may produce a disease in grazing animals known as teart (molybdenosis) which can prove fatal (Goyer 1991).

Molybdenum levels were detected above the analytical detection limits in every site sampled (Appendix B, Table 1). Detected soil-molybdenum concentrations ranged from 0.136 mg Mo/kg dry weight at Site 303 to 0.811 mg Mo/kg dry weight at Site 279 (Appendix B, Table 1). None of the 32 soil samples that contained detectable amounts of molybdenum equaled or exceeded the background concentration recommended by Shacklette and Boerngen (1984) and all sites were below the benchmark values reported by the TCEQ (2001) and Efroymson et al. (1997).

[Nickel (Ni)] Background surface soil-nickel concentrations range up to 19 mg Ni/kg in the western U.S. and up to 10 mg Ni/kg in the State of Texas (Shacklette and Boerngen 1984, TCEQ 2001). According to Efroymson et al. (1997), a proposed screening benchmark value for nickel toxicity to soil microorganisms is 90 mg Ni/kg dry weight, while the TCEQ (2001) reports a soil-nickel concentration of 30 mg Ni/kg dry weight as a benchmark value for terrestrial plants.

Nickel concentrations were detected above the analytical detection limits in all samples collected (Appendix B, Table 1). Soil-nickel concentrations ranged from 2.38 mg Ni/kg dry weight at Site 306 to 16.2 mg Ni/kg dry weight at Site 277 (Appendix B, Table 1). Approximately 21.9% (7/32) of the soil samples contained nickel levels that exceeded the TCEQ (2001) background concentration while none exceeded the background value reported by Shacklette and Boerngen (1984) (Appendix B, Table 1). None of the soil samples contained nickel concentrations that exceeded any of the cited ecological benchmarks (Efroymson et al. 1997, TCEQ 2001).

[Selenium (Se)] Selenium is an essential micronutrient but like other necessary dietary minerals, elevated levels can have detrimental effects on exposed organisms. It typically exists in nature and biotic systems as either selenate, selenite, elemental selenium, and/or selenide (Eisler 1985, Goyer 1991). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background selenium concentrations in surface soils in the western U.S. is 0.34 mg Se/kg. The TCEQ (2001) considers a soil-selenium concentration of 0.3 mg Se/kg dry weight as background in the State of Texas. Selenium volatilizes from soils and sediments at rates that are modified by

temperature, moisture, time, season of year, concentration of water soluble selenium, and microbial activity (Eisler 1985). The TCEQ (2001) reports soil-selenium concentrations of 1 mg Se/kg dry weight as a benchmark value for terrestrial plants and 70 mg Se/kg as a benchmark value for earthworms.

Selenium levels were measured above the analytical detection limits in soil samples collected from 11 sites (Sites 276, 277, 279, 292, 293, 295, 296, 298, 300, 302, and 304) (Appendix B, Table 1). The detected soil-selenium concentrations ranged from 0.59 mg Se/kg dry weight at Site 300 to 1.11 mg Se/kg dry weight at Site 277 (Appendix B, Table 1). All of the measured soil-selenium concentrations (Appendix B, Table 1) exceeded background values reported by Shacklette and Boerngen (1984) and the TCEQ (2001). Approximately 45.5% (5/11) of the detected soil-selenium concentrations (Appendix B, Table 1) exceeded the benchmark value for terrestrial plants recommended by the TCEQ (2001); however, none exceeded the soil benchmark value recommended for earthworms by the TCEQ (2001).

[Silver (Ag)] Silver and its compounds have a wide variety of industrial uses. They were used at the former Longhorn Army Ammunition Plant in x-rays and photographic materials (D. Tolbert, USACE, personal communication, 2002). In soils, Efroymson et al. (1997), proposed a toxicity screening benchmark value of 50 mg Ag/kg dry weight for soil microorganisms, while the TCEQ (2001) considers a soil-silver concentration of 2 mg Ag/kg dry weight as a benchmark value for terrestrial plants.

Silver was measured above the analytical detection limit at CLNWR in 26 soil samples (Appendix B, Table 1). The measured silver concentrations in soils collected from these sites ranged from 0.042 mg Ag/kg dry weight at Site 297 to 0.127 mg Ag/kg dry weight at Site 279 (Appendix B, Table 1). All detected soil-silver concentrations were below all applicable screening criteria and benchmark values (Efroymson et al. 1997, TCEQ 2001).

[Strontium (Sr)] Strontium compounds are used in the manufacturing of pyrotechnics including signal flares and tracer bullets, the production of glass and ceramics, and sugar refining (Merck 1989). Strontium is a fairly common alkaline earth metal (Irwin and Dodson 1991). According to Shacklette and Boerngen (1984), the estimated arithmetic mean for background strontium concentrations in western soils in the U.S. is 270 mg Sr/kg, while a soils concentration of 100 mg Sr/kg is considered background in the State of Texas (TCEQ 2001).

Strontium concentrations were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Soil-strontium concentrations ranged from 6.62 mg Sr/kg dry weight at Site 289 to 87.8 mg Sr/kg dry weight at Site 284 (Appendix B, Table 1), all below the suggested background values (Shacklette and Boerngen 1984, TCEQ 2001).

[Vanadium (V)] Approximately 0.01% of the Earth's crust is composed of vanadium (Merck 1989). Vanadium compounds are used in the production of rust-resistant metals, the manufacturing of ammunition, in x-rays, as catalysts in the distillation of alcohols and the production of synthetic rubber, and to reduce mercuric and ferric salts to mercurous and ferrous salts in industrial processes (Sax and Lewis 1987, Merck 1989). Vanadium is also a trace component of fossil fuels (Merck 1989, ETC 2000). Crude oil from West Texas contains

approximately 3.2 mg V/L (ETC 2000). In soils, vanadium concentrations can range up to 500 mg V/kg in the U.S. (Shacklette and Boerngen 1984). The estimated arithmetic mean for background vanadium concentrations in soils in the western U.S. is 88 mg V/kg (Shacklette and Boerngen 1984), while a soils concentration of 50 mg V/kg dry weight is considered background in the State of Texas (TCEQ 2001). The soils ecological screening benchmark recommended by the USEPA for vanadium is 2 mg V/kg (RAIS 2002). However, Efroymson et al. (1997), proposed a screening criterion of 20 mg V/kg for soil microorganisms, while the TCEQ (2001) considers a soil-vanadium concentration of 2 mg V/kg dry weight as a benchmark value for terrestrial plants.

Vanadium concentrations were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Soil-vanadium concentrations ranged from 9.32 mg V/kg dry weight at Site 301 to 63.4 mg V/kg dry weight at Site 292 (Appendix B, Table2). All 32 sites contained soil-vanadium levels that exceeded the lower ecological benchmarks recommended by the USEPA (RAIS 2002) and TCEQ (2001). In addition, 37.5% (12/32) of these sites contained soil-vanadium concentrations that equaled or exceeded the upper ecological benchmark proposed by Efroymson et al. (1997). However, all sites sampled contained soil-vanadium concentrations below the western U.S. mean background value estimated by Shacklette and Boerngen (1984). In addition, with the exception of Site 292, all sites contained vanadium concentrations below the Texas background value (TCEQ 2001).

[Zinc (Zn)] Zinc is a naturally occurring metallic element found in soil but is also listed by the USEPA as a priority pollutant (Giggleman et al. 1998). It is used in the production of non-corrosive alloys and brass and in galvanizing steel and iron products (Eisler 1993). Shacklette and Boerngen (1984) estimated the arithmetic mean for background zinc concentrations in surface soils in the western U.S. at 65 mg Zn/kg. The TCEQ (2001) considers a soil-zinc concentration of 30 mg Zn/kg as background in the State of Texas. Efroymson et al. (1997), proposed a soils toxicity screening benchmark value of 100 mg Zn/kg dry weight for soil microorganisms and invertebrates, whereas the ecological screening benchmark recommended by the USEPA for zinc in soils is 50 mg Zn/kg (RAIS 2002).

Zinc concentrations were detected above the analytical detection limits in every sample collected (Appendix B, Table 1). Measured soil-zinc levels ranged from 9.94 mg Zn/kg dry weight at Site 289 to 85.6 mg Zn/kg dry weight at Site 302 (Appendix B, Table 1). Approximately 31.3% (10/32) of the soil samples exceeded the TCEQ (2001) background concentration, while 6.3% (2/32) had zinc levels that were elevated in comparison to the background value reported by Shacklette and Boerngen (1984). Three (9.4%) of the sites (Sites 291, 302, and 304) contained soil-zinc concentrations that exceeded the lower ecological benchmark suggested by the USEPA (RAIS 2002), while none exceeded the upper ecological benchmark proposed by Efroymson et al. (1997).

Organochlorine Pesticides

Results of the organochlorine pesticides analyses for the 32 soil samples are presented in Appendix B, Table 1. Each sample was analyzed for 19 organochlorine pesticides compounds.

Of these compounds, only endrin was detected above the analytical detection limits in any of the samples collected (Appendix B, Table 4).

[Endrin] Endrin is a stereoisomer of dieldrin (ATSDR 1996). It was first used as an insecticide, rodenticide, and avicide in 1951 (ATSDR 1996). In 1991, the manufacturing of this compound discontinued in the United States primarily because of its toxicity to non-target populations of raptors and migratory birds (ATSDR 1996). The ecological screening benchmark recommended by the USEPA for endrin in soils is 0.001 mg/kg (RAIS 2002). The State of Louisiana recommends a soil-endrin concentration of 1.6 mg/kg as the target value for remedial actions in non-industrial areas (AEHS 2002).

Endrin was detected above the analytical detection limits at Sites 294, 299, and 300 (Appendix B, Table 1). The detected soil concentrations ranged from 0.00466 mg/kg dry weight at Site 294 to 0.0125 mg/kg dry weight at Site 299 (Appendix B, Table 1). The concentrations measured at these three sites exceeded the ecological benchmark suggested by the USEPA (RAIS 2002); however, all detected soil-endrin levels were well below the Louisiana remedial target value (AEHS 2002).

Polychlorinated Biphenyls

[Polychlorinated Biphenyls (PCBs)] Polychlorinated biphenyls were used extensively in electrical transformers, capacitors, heat transfer fluids, and electrical utilities as lubricants, insulators, and coolants until production was banned in 1979 (USEPA 1994, Moring 1997). Total PCBs represents a quantification of approximately 209 individual congeners (Moring 1997). These congeners are relatively stable compounds that exhibit low water solubilities, high heat capacities, low flammabilities, low electric conductivities, and low vapor pressures (USEPA 1994, Moring 1997). In wildlife, PCBs can be teratogenic and tumorigenic and demonstrate a trend to bio-accumulate and bio-magnify in succeeding trophic levels. For soils, the ecological screening benchmark recommended by the USEPA is 0.02 mg/kg, while the Oak Ridge National Laboratory considers a soil-total PCBs concentration of 40 mg/kg as a benchmark value protective of plants (RAIS 2002). The Canadian Council of Ministers of the Environment recommends a soil-total PCBs concentration of 0.3 mg/kg as the screening criterion for agricultural, residential, and parkland soils (EPT 1999). Buchman (1999) considers a soil-total PCBs concentration of 0.5 mg/kg dry weight as the target value for remedial efforts in agricultural areas and a concentration of 5 mg/kg dry weight as the target value for remedial activities in urban park/residential soils. The State of Louisiana recommends a soil-total- PCB concentration of 0.19 mg/kg as the target value for remedial actions in non-industrial areas to address potential carcinogenic health concerns (AEHS 2002), while the State of Texas considers a soil-total-PCB concentration of 10 mg/kg as protective of human health in residential areas (TAC 1993).

Of the seven PCB congeners evaluated, only two (Arochlor-1254 and/or 1260) were detected above the analytical detection limits at 16 sample sites (Appendix B, Table 1). Measured soil-total PCB concentrations ranged from 0.0024 mg/kg dry weight at Sites 295 and 296 to 0.221 mg/kg dry weight at Site 304 (Appendix B, Table 1). The levels detected at Sites 287, 288, 289, 302, 304, and 305 exceeded the lower ecological threshold recommended by the USEPA (RAIS

2002). One sample site, Site 304, contained a total-PCB concentration that exceeded the target value recommended by the State of Louisiana (AEHS 2002), but was well below the benchmark value protective of plants recommended by the Oak Ridge National Laboratory (RAIS 2002).

Perchlorate

[Perchlorate (ClO_4)] Perchlorate compounds are strong oxidizers that have been widely used as additives in solid rocket propellants and ignitable sources in munitions and fireworks (Smith *et al.*, 2001; York *et al.*, 2001). In the environment, perchlorate is highly soluble in water, readily moves through both groundwater and surface water, and can persist for decades (Nzengung and Wang, 2000; Smith *et al.*, 2001). In humans, perchlorate can interfere with iodine uptake in the thyroid gland and at elevated concentrations interferes with the thyroid's ability to produce hormones and regulate metabolism (Nzengung and Wang, 2000). Nationally, the toxicological and risk characteristics of perchlorate are currently being reviewed by the USEPA. In the interim, the current action level for perchlorate in groundwater in Texas is 4 µg/L (J. Sher, TCEQ, personal communication, 2002). In this investigation, perchlorate was not detected above the minimum reporting limit in any of the 32 sites sampled (Appendix B, Table 1).

CONCLUSIONS & RECOMMENDATIONS

Metals, residual organochlorine pesticides, and PCBs concentrations were detected at acceptable levels in comparison to ecological screening criteria and/or accepted background concentrations in soil throughout the 728 acres (294 hectares) sampled in the production area of CLNWR. Perchlorate was not detected above the minimum reporting limit at any site.

Of the metals analyzed, the elevated lead soil-concentration detected at Site 279 exceeded ecological screening criteria for terrestrial plants; however, it was well below the criteria for earthworms. Manganese was detected at elevated concentrations in 56.3% of the soil samples collected. Based on results of previous studies (Giggleman and Lewis 2002; Giggleman and Lewis 2003a; Giggleman and Lewis 2003b), the widespread distribution of elevated manganese at CLNWR may be attributed to naturally high background concentrations. Mercury was detected above analytical detection limits in all of the samples collected and two sites (Sites 281 and 292) exceeded the lower ecological benchmark for earthworms; however, all sites were well below the ecological benchmark for terrestrial plants. The widespread distribution of low levels of mercury through out the Refuge may be indicative of aerial deposition associated with the incomplete combustion of fossil fuels from upwind of the site. Selenium was detected at levels that exceeded the ecological benchmark value for terrestrial plants at five sites, but all soil-selenium concentrations were well below the ecological benchmark for earthworms. Vanadium was detected at elevated levels in all soil samples collected; however, all sites were below the mean background value estimated for the western U.S. Zinc detected in soils from Sites 291, 302, and 304 exceeded the lower soils ecological benchmark but were well below the upper benchmark.

The only organochlorine pesticide found in surficial soils collected from the production area, endrin, was detected at three sites (Sites 294, 299, and 300). These three sites contained soil-

endrin levels that exceeded the lower ecological screening benchmark but were well below the remedial target value. Two PCB congeners (Arochlor-1254 and/or 1260) were detected above the analytical detection limits in 50% of the sites but at concentrations well below the benchmark value protective of terrestrial plants.

In conclusion, perchlorate was not detected, and the soil-concentrations of metals, organochlorine pesticides, and PCBs detected during this investigation were not at levels likely to adversely affect ecological resources within or adjacent to CLNWR. Therefore, further surficial evaluation is not necessary prior to the USFWS assuming administrative control over the 728 acres (294 hectares) sampled within the former production area. It should be noted that this investigation did not address potential ground water contamination that may be present within this area of the facility. Consequently, ground water contamination will have to be addressed either through further groundwater investigation, remediation, and/or institutional controls.

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APPENDIX A
(ANALYTICAL METHODS)

INORGANIC ANALYSIS

Metals Fractional Narrative
USACE, Tulsa District (ACET)
SDG 139693

Method/Analysis Information

Analytical Batch:	438948, 439081
Prep Batch:	438947, 439079
Standard Operating Procedures:	GL-MA-E-014 REV# 10, GL-MA-E-010 REV# 16, GL-MA-E-009 REV# 13
Analytical Method:	SW846 6020, SW846 7471A
Prep Method:	SW846 3050B, SW846 7471A

Sample Analysis

Sample ID	Client ID
139693001	CLNWR292a
139693002	CLNWR293a
139693003	CLNWR295a
139693004	CLNWR296a
139693005	CLNWR296aDUP
139693006	CLNWR297a
139693007	CLNWR298a
139693008	CLNWR299a
139693009	CLNWR300a
139693010	CLNWR301a
139693011	CLNWR302a
139693012	CLNWR304a
139693013	CLNWR305a
139693014	CLNWR306a
139693015	CLNWR307a
139693016	CLNWR294a
139693017	CLNWR303a
1200878890	Method Blank (MB) **ICP-MS**

1200878891	Laboratory Control Sample (LCS)
1200878894	139693016(CLNWR294aL) Serial Dilution (SD)
1200878897	139693017(CLNWR303aL) Serial Dilution (SD)
1200878892	139693016(CLNWR294aS) Matrix Spike (MS)
1200878895	139693017(CLNWR303aS) Matrix Spike (MS)
1200878893	139693016(CLNWR294aSD) Matrix Spike Duplicate (MSD)
1200878896	139693017(CLNWR303aSD) Matrix Spike Duplicate (MSD)
1200879157	Method Blank (MB) **CVAA**
1200879164	Laboratory Control Sample (LCS)
1200879158	139693016(CLNWR294aL) Serial Dilution (SD)
1200879159	139693017(CLNWR303aL) Serial Dilution (SD)
1200879160	139693016(CLNWR294aS) Matrix Spike (MS)
1200879161	139693017(CLNWR303aS) Matrix Spike (MS)
1200879162	139693016(CLNWR294aSD) Matrix Spike Duplicate (MSD)
1200879163	139693017(CLNWR303aSD) Matrix Spike Duplicate (MSD)

Preparation/Analytical Method Verification

The SOP stated above has been prepared based on technical research and testing conducted by General Engineering Laboratories, LLC. and with guidance from the regulatory documents listed in this "Method/Analysis Information" section.

System Configuration

The ICP-MS analysis was performed on a Perkin Elmer ICP-MS ELAN 9000. The instrument is equipped with a cross-flow nebulizer, quadrupole mass spectrometer, and dual mode electron multiplier detector. Internal standards of scandium, germanium, indium, and tantalum were utilized to cover the mass spectrum. Operating conditions are set at 1400W power and combined argon pressures of 3607 kPa for the plasma and auxiliary gases, and 0.85 L/min carrier gas flow, and an initial lens voltage of 5.2.

The Mercury analysis was performed on a Perkin-Elmer Flow Injection Mercury System (FIMS-400) automated mercury analyzer. The instrument consists of a cold vapor atomic absorption spectrometer set to detect mercury at a wavelength of 254 nm. Sample introduction through the flow injection system is performed via a peristaltic pump at 9 mL/min and nitrogen carrier gas rate of 80mL/min.

Calibration Information

Instrument Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

CRDL Requirements
All CRDL standard(s) met the referenced advisory control limits.

Continuing Calibration Blank (CCB) Requirements
All continuing calibration blanks (CCB) bracketing this batch met the established acceptance criteria.

Continuing Calibration Verification (CCV) Requirements
All continuing calibration verifications (CCV) bracketing this SDG met the acceptance criteria.

ICSA/ICSAB statement
All interference check samples (ICSA and ICSAB) associated with this SDG met the established acceptance criteria.

Quality Control (QC) Information

Method Blank (MB) Statement
The MBs analyzed with this SDG met the acceptance criteria.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

Quality Control (QC) Sample Statement
The following samples were selected as the quality control (QC) samples for this SDG: 139693016 (CLNWR294a) and 139693017 (CLNWR303a) for CVAA and ICP-MS.

Matrix Spike (MS) Recovery Statement
The percent recoveries (%R) obtained from the MS analyses are evaluated when the sample concentration is less than four times (4X) the spike concentration added. The MS met the recommended quality control acceptance criteria for percent recoveries for all applicable analytes, with the exception of chromium, selenium, arsenic, lead, nickel, vanadium, and zinc, as indicated by the "*" qualifiers.

Matrix Spike Duplicate (MSD) Recovery Statement
The percent recovery (%R) obtained from the MSD analyses are evaluated when the sample concentration is less than four times (4X) the spike concentration added. The MSD met the recommended quality control acceptance criteria for percent recoveries for all applicable analytes, with the exception of chromium, nickel, lead, and strontium, as indicated by the "*' qualifiers.

MS/MSD Relative Percent Difference (RPD) Statement
The relative percent difference (RPD) obtained from the designated matrix spike duplicate (MSD) is evaluated based on acceptance criteria of 20%. The RPD between qualifying elements results in the MS and MSD were within the acceptance limits of

20%, with the exception of chromium, iron, vanadium, arsenic, and barium, as indicated by the "*" qualifiers.

Serial Dilution % Difference Statement
The serial dilution is used to assess matrix suppression or enhancement. Raw element concentrations 25x the IDL for CVAA, 50X the IDL for ICP and 100X the IDL for ICP-MS analyses are applicable for serial dilution assessment. All applicable analytes met the established criteria of less than 10% difference (%D), with the exception of aluminum, barium, copper, iron, lead, magnesium, manganese, and nickel.

Technical Information

Holding Time Specifications
GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration. All samples in this SDG met the specified holding time.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions

Dilutions are performed to minimize matrix interferences resulting from elevated mineral element concentrations present in soil samples and/or to bring over range target analyte concentrations into the linear calibration range of the instrument. Sample 139693001 required a 10x dilution in order to bring over range aluminum, beryllium, chromium, copper, iron, manganese, nickel, vanadium, and magnesium concentrations within the linear calibration range of the instrument. 139693003 required a 10x dilution in order to bring over range aluminum concentrations within the linear calibration range of the instrument. The samples in this SDG were diluted the standard 2x for soils on the ICPMS. Per the SOP, samples 139693001 and 139693003 required dilution due to relatively high native sample concentration of an internal standard.

Preparation Information
The samples in this SDG were prepared exactly according to the cited SOP.

Miscellaneous Information

Nonconformance Documentation

Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. The following NCR was generated for this SDG: NCR ID 223376. A copy is included in the Miscellaneous Data section of this package.

Additional Comments
Additional comments were not required for this SDG.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Kristan M. McMay **Date:** 7-27-05

Metals Analysis

Metals Fractional Narrative
USACE, Tulsa District (ACET)
SDG 139693-1

Method/Analysis Information

Analytical Batch:	438952, 439085
Prep Batch:	438951, 439082
Standard Operating Procedures:	GL-MA-E-014 REV# 10, GL-MA-E-010 REV# 16, GL-MA-E-009 REV# 13
Analytical Method:	SW846 6020, SW846 7471A
Prep Method:	SW846 3050B, SW846 7471A

Sample Analysis

Sample ID	Client ID
139696001	CLNWR276a
139696002	CLNWR277a
139696003	CLNWR279a
139696004	CLNWR280a
139696005	CLNWR281a
139696006	CLNWR281aDUP
139696007	CLNWR282a
139696008	CLNWR283a
139696009	CLNWR284a
139696010	CLNWR285a
139696011	CLNWR286a
139696012	CLNWR287a
139696013	CLNWR288a
139696014	CLNWR288aDUP
139696015	CLNWR289a
139696016	CLNWR290a
139696017	CLNWR291a
139696018	CLNWR278a

1200878898	Method Blank (MB) **ICP-MS**
1200878899	Laboratory Control Sample (LCS)
1200878902	139696018(CLNWR278aL) Serial Dilution (SD)
1200878900	139696018(CLNWR278aS) Matrix Spike (MS)
1200878901	139696018(CLNWR278aSD) Matrix Spike Duplicate (MSD)
1200879169	Method Blank (MB) **CVAA**
1200879170	Laboratory Control Sample (LCS)
1200879173	139696018(CLNWR278aL) Serial Dilution (SD)
1200879171	139696018(CLNWR278aS) Matrix Spike (MS)
1200879172	139696018(CLNWR278aSD) Matrix Spike Duplicate (MSD)

Preparation/Analytical Method Verification

The SOP stated above has been prepared based on technical research and testing conducted by General Engineering Laboratories, LLC. and with guidance from the regulatory documents listed in this "Method/Analysis Information" section.

System Configuration

The ICP-MS analysis was performed on a Perkin Elmer Elan 6100E inductively coupled plasma mass spectrometer (ICP-MS). The instrument is equipped with a cross-flow nebulizer, quadrupole mass spectrometer, and dual mode electron multiplier detector. Internal standards of scandium, germanium, indium, and tantalum were utilized to cover the mass spectrum. Operating conditions are set at 1400W power and combined argon pressures of 3607 kPa for the plasma and auxiliary gases, and 0.85 L/min carrier gas flow, and an initial lens voltage of 5.2.

The Mercury analysis was performed on a Perkin-Elmer Flow Injection Mercury System (FIMS-400) automated mercury analyzer. The instrument consists of a cold vapor atomic absorption spectrometer set to detect mercury at a wavelength of 254 nm. Sample introduction through the flow injection system is performed via a peristaltic pump at 9 mL/min and nitrogen carrier gas rate of 80mL/min.

Calibration Information

Instrument Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

CRDL Requirements
All CRDL standard(s) met the referenced advisory control limits.

Continuing Calibration Blank (CCB) Requirements

All continuing calibration blanks (CCB) bracketing this batch met the established acceptance criteria.

Continuing Calibration Verification (CCV) Requirements
All continuing calibration verifications (CCV) bracketing this SDG met the acceptance criteria.

ICSA/ICSAB statement
All interference check samples (ICSA and ICSAB) associated with this SDG met the established acceptance criteria.

Quality Control (QC) Information

Method Blank (MB) Statement
The MBs analyzed with this SDG met the acceptance criteria.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

Quality Control (QC) Sample Statement
The following samples were selected as the quality control (QC) samples for this SDG: 139696018 (CLNWR278a) for CVAA and ICP-MS.

Matrix Spike (MS) Recovery Statement
The percent recoveries (%R) obtained from the MS analyses are evaluated when the sample concentration is less than four times (4X) the spike concentration added. The MS met the recommended quality control acceptance criteria for percent recoveries for all applicable analytes, with the exception of chromium, magnesium, strontium, and zinc, as indicated by the "*" qualifiers.

Matrix Spike Duplicate (MSD) Recovery Statement
The percent recovery (%R) obtained from the MSD analyses are evaluated when the sample concentration is less than four times (4X) the spike concentration added. The MSD met the recommended quality control acceptance criteria for percent recoveries for all applicable analytes, with the exception of arsenic, chromium, magnesium, strontium, and zinc, as indicated by the "*" qualifiers.

MS/MSD Relative Percent Difference (RPD) Statement
The RPD(s) between the MS and MSD met the acceptance limits, with the exception of iron and strontium, as indicated by the "*" qualifiers.

Serial Dilution % Difference Statement
The serial dilution is used to assess matrix suppression or enhancement. Raw element concentrations 25x the IDL for CVAA, 50X the IDL for ICP and 100X the IDL for ICP-MS analyses are applicable for serial dilution assessment. All applicable analytes met the established criteria of less than 10% difference (%D).

Technical Information

Holding Time Specifications

GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration. All samples in this SDG met the specified holding time.

Preparation/Analytical Method Verification

All procedures were performed as stated in the SOP.

Sample Dilutions

Dilutions are performed to minimize matrix interferences resulting from elevated mineral element concentrations present in soil samples and/or to bring over range target analyte concentrations into the linear calibration range of the instrument. All samples were diluted originally 2x for soil matrix. Samples 139696002, 139696003, 139696005, 139696006, 139696007, 139696008, 139696009, 139696013, 139696014, 139696016, 139696018 and associated quality control (QC) samples required further dilution to 10x due to internal standard 45 failure. The samples in this SDG were diluted the standard 2x for soils on the ICPMS.

Preparation Information

The samples in this SDG were prepared exactly according to the cited SOP.

Miscellaneous Information

Nonconformance Documentation

Nonconformance reports are generated to document any procedural anomalies that may deviate from referenced SOP or contractual documents. The following NCR was generated for this SDG: NCR ID 224380. A copy is included in the Miscellaneous Data section of this package.

Additional Comments

Additional comments were not required for this SDG.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Kristen M. Murray **Date:** 7-29-05

General Chemistry Analysis

General Chemistry Narrative
USACE, Tulsa District (ACET)
SDG 139693

Method/Analysis Information

Product: **Perchlorate**
Analytical Batch: 440206 **Method:** EPA 314.0
Prep Batch : 440205 **Method:** EPA 314.0

Sample Analysis

The following samples were analyzed using the analytical protocol as established in EPA 314.0:

Sample ID	Client ID
139693001	CLNWR292a
139693002	CLNWR293a
139693003	CLNWR295a
139693004	CLNWR296a
139693005	CLNWR296aDUP
139693006	CLNWR297a
139693007	CLNWR298a
139693008	CLNWR299a
139693009	CLNWR300a
139693010	CLNWR301a
139693011	CLNWR302a
139693012	CLNWR304a
139693013	CLNWR305a
139693014	CLNWR306a
139693015	CLNWR307a
139693016	CLNWR294a
139693017	CLNWR303a
1200881925	Method Blank (MB)
1200881928	Laboratory Control Sample (LCS)
1200881936	139693016(CLNWR294a) Sample Duplicate (DUP)
1200881937	139693017(CLNWR303a) Sample Duplicate (DUP)
1200881938	139693016(CLNWR294a) Matrix Spike (MS)
1200881939	139693017(CLNWR303a) Matrix Spike (MS)

SOP Reference

Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-GC-E-096 REV# 4.

Preparation/Analytical Method Verification

The SOP stated above has been prepared based on technical research and testing conducted by General Engineering Laboratories, LLC. and with guidance from the regulatory documents listed in this "Method/Analysis Information" section.

Calibration Information

The Ion Chromatography analysis was performed on a Dionex Ion Chromatograph.

Initial Calibration
All initial calibration requirements have been met for this SDG.

Continuing Calibration Blanks
All continuing calibration blanks (CCBs) associated with reported data from this batch were within acceptance limits.

Calibration Verification Information (CCV)
One or more of the calibration verification standards was above the required limits. The results for the following samples bracketed by the failing CCV were less than the PQL. Therefore, the data was deemed acceptable. 1200881936 (CLNWR294a), 1200881937 (CLNWR303a), 139693009 (CLNWR300a), 139693010 (CLNWR301a), 139693011 (CLNWR302a), 139693012 (CLNWR304a), 139693013 (CLNWR305a), 139693014 (CLNWR306a), 139693015 (CLNWR307a), 139693016 (CLNWR294a) and 139693017 (CLNWR303a).
One or more of the calibration verification standards was above the required limits. The results for the following spikes bracketed by the failing CCV were associated with samples which were all less than the PQL. Therefore, the data was deemed acceptable. 1200881938 (CLNWR294a) and 1200881939 (CLNWR303a).

Quality Control (QC) Information

Method Blank (MB) Statement
The MB analyzed with this SDG met the acceptance criteria.

Laboratory Control Sample (LCS) Recovery
The LCS spike recovery met the acceptance limits.

Quality Control (QC) Designation
Samples 139693016 (CLNWR294a) and 139693017 (CLNWR303a) were designated for QC analysis.

Matrix Spike (MS)/Post Spike (PS) Recovery Statement
The MS/PS recoveries for this sample set were within the required acceptance limits.

Duplicate Relative Percent Difference (RPD) Statement
The RPD between the sample and its duplicate met the acceptance limits.

Technical Information

GEL assigns holding times based on the date and time of sample collection. Those holding times expressed in hours are calculated in the AlphaLims system by hours. Those holding times expressed as days expire at midnight on the day of expiration.

Holding Times
The initial runs for sample were in holding, but the holding time had elapsed prior to reruns due to reruns and power outage. 139693017 (CLNWR303a).

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions
The samples in this SDG did not require dilutions.

Sample Re-analysis
The following samples were re-analyzed due to prefilter treatment failure: 1200881936 (CLNWR294a), 1200881937 (CLNWR303a), 1200881938 (CLNWR294a), 1200881939 (CLNWR303a), 139693002 (CLNWR293a), 139693003 (CLNWR295a), 139693004 (CLNWR296a), 139693005 (CLNWR296aDUP), 139693006 (CLNWR297a), 139693012 (CLNWR304a), 139693013 (CLNWR305a), 139693015 (CLNWR307a), 139693016 (CLNWR294a) and 139693017 (CLNWR303a).
The following samples were reanalyzed due to sample misidentification. 1200881937 (CLNWR303a), 1200881939 (CLNWR303a) and 139693017 (CLNWR303a).

Miscellaneous Information

Nonconformance (NCR) Documentation
NCR ID 223467 was submitted for missed holding times. 1200881937 (CLNWR303a), 1200881939 (CLNWR303a) and 139693017 (CLNWR303a).

Manual Integrations
The following sample from this sample group had to be manually integrated due to errors in the instrument software peak integration: 1200881938 (CLNWR294a).

Additional Comments
Additional comments were not required for this SDG.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Tom Lewis, Jr **Date:** 1 Aug 05

General Chemistry Analysis

General Chemistry Narrative
USACE, Tulsa District (ACET)
SDG 139693-1

Method/Analysis Information

Product: **Perchlorate**
Analytical Batch: 440208 **Method:** EPA 314.0
Prep Batch : 440207 **Method:** EPA 314.0

Sample Analysis

The following samples were analyzed using the analytical protocol as established in EPA 314.0:

Sample ID	Client ID
139696001	CLNWR276a
139696002	CLNWR277a
139696003	CLNWR279a
139696004	CLNWR280a
139696005	CLNWR281a
139696006	CLNWR281aDUP
139696007	CLNWR282a
139696008	CLNWR283a
139696009	CLNWR284a
139696010	CLNWR285a
139696011	CLNWR286a
139696012	CLNWR287a
139696013	CLNWR288a
139696014	CLNWR288aDUP
139696015	CLNWR289a
139696016	CLNWR290a
139696017	CLNWR291a
139696018	CLNWR278a
1200881929	Method Blank (MB)
1200881930	139696001(CLNWR276a) Sample Duplicate (DUP)
1200881931	139696018(CLNWR278a) Sample Duplicate (DUP)
1200881932	139696001(CLNWR276a) Matrix Spike (MS)
1200881933	139696018(CLNWR278a) Matrix Spike (MS)
1200881934	Laboratory Control Sample (LCS)

SOP Reference
Procedure for preparation, analysis and reporting of analytical data are controlled by General Engineering Laboratories, LLC as Standard Operating Procedure (SOP). The data discussed in this narrative has been analyzed in accordance with GL-GC-E-096 REV# 4.

Preparation/Analytical Method Verification

The SOP stated above has been prepared based on technical research and testing conducted by General Engineering Laboratories, LLC. and with guidance from the regulatory documents listed in this "Method/Analysis Information" section.

Calibration Information

The Ion Chromatography analysis was performed on a Dionex Ion Chromatograph.

Initial Calibration
All initial calibration requirements have been met for this SDG.

Continuing Calibration Blanks
All continuing calibration blanks (CCBs) associated with reported data from this batch were within acceptance limits.

Calibration Verification Information (CCV)
All continuing calibration verification standards (CCVs) associated with reported data from this batch were within acceptance limits.

Quality Control (QC) Information

Method Blank (MB) Statement
The MBs analyzed with this SDG met the acceptance criteria.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

Quality Control (QC) Designation
Samples 139696001 (CLNWR276a) and 139696018 (CLNWR278a) were designated for QC analysis.

Matrix Spike (MS)/Post Spike (PS) Recovery Statement
The MS/PS recoveries for this sample set were within the required acceptance limits.

Duplicate Relative Percent Difference (RPD) Statement
The RPD between the sample and its duplicate met the acceptance limits.

Technical Information

GEL assigns holding times based on the date and time of sample collection. Those holding times expressed in hours are calculated in the AlphaLims system by hours. Those holding times expressed as days expire at midnight on the day of expiration.

Holding Times
All samples in this SDG met the specified holding time.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions

The samples in this SDG did not require dilutions.

Sample Re-analysis
The following samples were re-analyzed due to instrument failure no injection for the CCB: 1200881929 (MB), 1200881930 (CLNWR276a), 1200881932 (CLNWR276a), 1200881934 (LCS), 139696001 (CLNWR276a), 139696002 (CLNWR277a), 139696003 (CLNWR279a), 139696004 (CLNWR280a), 139696005 (CLNWR281a) and 139696006 (CLNWR281aDUP).

Miscellaneous Information

Nonconformance (NCR) Documentation
A NCR was not required for this SDG.

Manual Integrations
The following samples from this sample group had to be manually integrated due to errors in the instrument software peak integration: 1200881933 (CLNWR278a) and 139696007 (CLNWR282a).

Additional Comments
Additional comments were not required for this SDG.

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Tom Lewis, Jr **Date:** 29 July 05

GC SEMIVOLATILE PESTICIDE ANALYSIS

Pesticide Case Narrative
USACE, Tulsa District (ACET)
SDG 139718

Method/Analysis Information

Procedure:	**Organochlorine Pesticides and Chlorinated Hydrocarbons by ECD**
Analytical Method:	SW846 8081A
Prep Method:	SW846 3550B
Analytical Batch Number:	440227
Prep Batch Number:	440224

Sample Analysis

The following samples were analyzed using the analytical protocol as established in SW846 8081A:

Sample ID	Client ID
139718001	CLNWR292b
139718002	CLNWR293b
139718003	CLNWR295b
139718004	CLNWR296b
139718005	CLNWR296Dup
139718006	CLNWR297b
139718007	CLNWR298b
139718008	CLNWR299b
139718009	CLNWR300b
139718010	CLNWR301b
139718011	CLNWR302b
139718012	CLNWR304b
139718013	CLNWR305b
139718014	CLNWR306b
139718015	CLNWR307b
139718016	CLNWR294b
139718017	CLNWR303b

1200881979	Method Blank (MB)
1200881980	Laboratory Control Sample (LCS)
1200881981	139718016(CLNWR294b) Matrix Spike (MS)
1200881982	139718016(CLNWR294b) Matrix Spike Duplicate (MSD)
1200881988	139718017(CLNWR303b) Matrix Spike (MS)
1200881989	139718017(CLNWR303b) Matrix Spike Duplicate (MSD)

Preparation/Analytical Method Verification

Procedures for preparation, analysis, and reporting of analytical data are documented by General Engineering Laboratories, LLC. (GEL) as Standard Operating Procedures (SOP).

Calibration Information

Initial Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

Continuing Calibration Verification (CCV) Requirements
All calibration verification standards (CVS, ICV, or CCV) requirements have not been met for this SDG.

One of five peaks failed with a positive bias on both columns in the Chlordane (tech.) standard analyzed on 07/19/05 at 0823 in this SDG; however, the average amount of the five peaks met the acceptance criteria.

Some target analytes failed acceptance criteria with a positive and negative bias on one or both analytical columns in the standard bracketing the sample in this SDG. The positive and negative bias for the analytical data is a result of instrument response increasing or decreasing after the initial calibration. Samples 1200881988 (CLNWR303bMS), 1200881989 (CLNWR303bMSD), 139718007 (CLNWR298b), 139718008 (CLNWR299b), 139718009 (CLNWR300b), 139718010 (CLNWR301b), 139718011 (CLNWR302b), 139718012 (CLNWR304b), 139718013 (CLNWR305b), 139718014 (CLNWR306b), 139718015 (CLNWR307b), 139718016 (CLNWR294b) and 139718017 (CLNWR303b) were re-analyzed. The bracketing standard failed in the same manner; therefore, the standard failure is attributed to matrix interference.

Decachlorobiphenyl (DCB) surrogate failed acceptance criteria in the standard bracketing the samples in this SDG. However, this non-compliance has no adverse effects on the data.

Quality Control (QC) Information

Method Blank (MB) Statement
The MB(s) analyzed with this SDG met the acceptance criteria.

Surrogate Recoveries
All surrogate recoveries were within the established acceptance criteria for this SDG.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries did not meet the acceptance limits. Beta-BHC failed spike recovery high. Beta-BHC was not detected in the samples. The MS and MSD passed spike recoveries. See NCR # 224016 located in the Miscellaneous Section.

QC Sample Designation
Samples 139718016 (CLNWR294b) and 139718017 (CLNWR303b) were selected for the matrix spike and matrix spike duplicate analysis.

Matrix Spike (MS) Recovery Statement
The MS recoveries for this SDG were within the established acceptance limits.

Matrix Spike Duplicate (MSD) Recovery Statement
The MSD recoveries for this SDG were within the established acceptance limits.

MS/MSD Relative Percent Difference (RPD) Statement
The RPD(s) between the MS and MSD met the acceptance limits.

Technical Information:

Holding Time Specifications
GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration. All samples in this SDG met the specified holding time.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions
Samples 1200881981 (CLNWR294bMS), 1200881982 (CLNWR294bMSD), 1200881988 (CLNWR303bMS), 1200881989 (CLNWR303bMSD), 139718001 (CLNWR292b), 139718002 (CLNWR293b), 139718003 (CLNWR295b), 139718004 (CLNWR296b), 139718005 (CLNWR296Dup), 139718006 (CLNWR297b), 139718007 (CLNWR298b), 139718008 (CLNWR299b), 139718009 (CLNWR300b), 139718010 (CLNWR301b), 139718011 (CLNWR302b), 139718012 (CLNWR304b), 139718013 (CLNWR305b), 139718014 (CLNWR306b), 139718015 (CLNWR307b), 139718016 (CLNWR294b) and 139718017 (CLNWR303b) were diluted at 1:10 due to their oily-like consistency.

Sample Re-extraction/Re-analysis
Re-extractions or re-analyses were not required in this SDG.

Miscellaneous Information:

Electronic Package Comment

This package was generated using an electronic data processing program referred to as "virtual packaging". In an effort to increase quality and efficiency, the laboratory is developing systems to eventually generate all data packages electronically. The following change from "traditional" packages should be noted:

Analyst/peer reviewer initials and dates are not present on the electronic data files. Presently, all initials and dates are present on the original raw data. These hard copies are temporarily stored in the laboratory. The data validator will always sign and date the case narrative.

Nonconformance (NCR) Documentation
Nonconformance Reports (NCRs) are for documentation of any procedural anomalies that may deviate from referenced SOP or contractual document. NCR # 224016 was generated for this SDG. A copy is included in the Miscellaneous Data section of this package.

Manual Integrations
Certain standards and samples may have required manual integration to correctly position the baseline as set in the calibration standard injections. If manual integration was performed, copies of all manual integration peak profiles are included in the raw data section of this pesticide fraction.

Additional Comments
The additional comments field is used to address special issues associated with each analysis, clarify method/contractual issues pertaining to the analysis, and to list any report documents generated as a result of sample analysis or review. The following additional comments were required:

Due to software limitation, the Form VIIs will display the results either in the % difference or % drift depending on the type of the calibration curve. If the curve of all analytes is generated using an average response factor (RF), the Form VII will display results using the difference calculation (RF). If the curve of one or more analytes is generated using a linear curve, the Form VII will display results using the % drift calculation (by concentration) for all analytes.

System Configuration

The Semi-Volatiles-Pesticide analysis was performed on a HP Gas Chromatograph.

Instrument ID	System Configuration	Column ID	Column Description
ECD7A.I_1	HP6890 Series ECD	Rtx-CLP I	30m x 0.25mm, 0.25um (Rtx-CLPesticide I)
ECD7A.I_2	HP6890 Series ECD	Rtx-CLP II	30m x 0.25mm, 0.20um (Rtx-CLPesticide II)

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: _____ **Date:** 7/22

GC SEMIVOLATILE PESTICIDE ANALYSIS

Pesticide Case Narrative
USACE, Tulsa District (ACET)
SDG 139718-1

Method/Analysis Information

Procedure:	**Organochlorine Pesticides and Chlorinated Hydrocarbons**
Analytical Method:	SW846 8081A
Prep Method:	SW846 3550B
Analytical Batch Number:	440240
Prep Batch Number:	440238

Sample Analysis

The following samples were analyzed using the analytical protocol as established in SW846 8081A:

Sample ID	Client ID
139720001	CLNWR276b
139720002	CLNWR277b
139720003	CLNWR279b
139720004	CLNWR280b
139720005	CLNWR281b
139720006	CLNWR281bDup
139720007	CLNWR282b
139720008	CLNWR283b
139720009	CLNWR284b
139720010	CLNWR285b
139720011	CLNWR286b
139720012	CLNWR287b
139720013	CLNWR288b
139720014	CLNWR288bDup
139720015	CLNWR289b
139720016	CLNWR290b

139720017	CLNWR291b
139720018	CLNWR278b
1200882006	Method Blank (MB)
1200882007	Laboratory Control Sample (LCS)
1200882008	139720018(CLNWR278b) Matrix Spike (MS)
1200882009	139720018(CLNWR278b) Matrix Spike Duplicate (MSD)

Preparation/Analytical Method Verification
Procedures for preparation, analysis, and reporting of analytical data are documented by General Engineering Laboratories, LLC. (GEL) as Standard Operating Procedures (SOP).

Calibration Information

Initial Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

Continuing Calibration Verification (CCV) Requirements
The calibration verification standards (CVS, ICV, or CCV) requirements have not been met for this SDG.

One of five peaks failed with a positive bias in Chlordane (tech.) standard analyzed at the beginning of the sequence in which the samples in this batch were analyzed; however, the average concentration of the five quantitated peaks met the acceptance criteria.

Several target analytes failed to meet the acceptance criteria with a negative bias on one or both analytical columns. All samples were reanalyzed, and the braketing standard failed in the same manner; therfore, the standard failure is attributed to sample matrix interference.

Quality Control (QC) Information

Method Blank (MB) Statement
The MB(s) analyzed with this SDG met the acceptance criteria.

Surrogate Recoveries
Sample 139720010 (CLNWR285b) failed to meet the acceptance criteria for the surrogate recovery due to dilution and matrix interference.

Laboratory Control Sample (LCS) Recovery
LCS spike recovery was not within the acceptance limits for Mehtoxychlor; however this non-compliance had no adverse effects on the data. See NCR#223319 in the Miscellaneous Data section.

QC Sample Designation
Sample 139720018 (CLNWR278b) was selected for analysis as the matrix spike and matrix spike duplicate.

Matrix Spike (MS) Recovery Statement
The MS recoveries for this SDG were within the established acceptance limits.

Matrix Spike Duplicate (MSD) Recovery Statement
The MSD recoveries for this SDG were within the established acceptance limits.

MS/MSD Relative Percent Difference (RPD) Statement
The RPD(s) between the MS and MSD met the acceptance limits.

Technical Information:

Holding Time Specifications
All samples in this SDG met the specified holding time. GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions

The following samples were diluted due to the thick and oily matrix of the extracts: 139720001 (CLNWR276b)(1:10), 139720002 (CLNWR277b)(1:5), 139720003 (CLNWR279b)(1:10), 139720004 (CLNWR280b)(1:10), 139720005 (CLNWR281b)(1:10), 139720006 (CLNWR281bDup)()1:10, 139720007 (CLNWR282b)(1:10), 139720008 (CLNWR283b)(1:5), 139720009 (CLNWR284b)(1:10), 139720010 (CLNWR285b)(1:5), 139720011 (CLNWR286b)(1:5), 139720012 (CLNWR287b)(1:10), 139720013 (CLNWR288b)(1:10), 139720014 (CLNWR288bDup)(1:10), 139720015 (CLNWR289b)(1:10), 139720016 (CLNWR290b)(1:10),139720017 (CLNWR281b)(1:10), 139720018 (CLNWR278b)(1:10).

Sample Re-extraction/Re-analysis
All samples were re-analyzed due to failing bracketing standards.

Miscellaneous Information:

Electronic Package Comment

This package was generated using an electronic data processing program referred to as "virtual packaging". In an effort to increase quality and efficiency, the laboratory is developing systems to eventually generate all data packages electronically. The following change from "traditional" packages should be noted:

Analyst/peer reviewer initials and dates are not present on the electronic data files. Presently, all initials and dates are present on the original raw data. These hard copies are temporarily stored in the laboratory. The data validator will always sign and date the case narrative.

Nonconformance (NCR) Documentation
Nonconformance (NCRs) are for documentation of any procedural anomalies that may deviate from referenced SOP or contractual document. NCR # 223319 was generated for this SDG. A copy is included in the Miscellaneous Data section of this package.

Manual Integration
Certain standards and samples may have required manual integration to correctly position the baseline as set in the calibration standard injections. If manual integration was performed, copies of all manual integration peak profiles are included in the raw data section of this pesticide fraction.

Additional Comments
The additional comments field is used to address special issues associated with each analysis, clarify method/contractual issues pertaining to the analysis, and to list any report documents generated as a result of sample analysis or review. The following additional comments were required:

Due to software limitation, the Form VIIs will display the results either in the % difference or % drift depending on the type of the calibration curve. If the curve of all analytes is generated using an average response factor (RF), the Form VII will display results using the difference calculation (RF). If the curve of one or more analytes is generated using a linear curve, the Form VII will display results using the % drift calculation (by concentration) for all analytes.

System Configuration

The Semi-Volatiles-Pesticide analysis was performed on a HP Gas Chromatograph.

Instrument ID	System Configuration	Column ID	Column Description
ECD3A.I_1	HP6890 Series ECD	Rtx-CLP I	30m x 0.25mm, 0.25um (Rtx-CLPesticide)
ECD3A.I_2	HP6890 Series ECD	Rtx-CLP II	30m x 0.25mm, 0.20um (Rtx-CLPesticide II)

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Jimmi Cao **Date:** 7/29/05

GC SEMIVOLATILE PCB ANALYSIS

PCB Case Narrative
USACE, Tulsa District (ACET)
SDG 139718

Method/Analysis Information

Procedure:	**Polychlorinated Biphenyls**
Analytical Method:	SW846 8082
Prep Method:	SW846 3550B
Analytical Batch Number:	443593, 445856
Prep Batch Number:	443592, 445855

Sample Analysis

The following samples were analyzed using the analytical protocol as established in SW846 8082:

Sample ID	Client ID
139718001	CLNWR292b
139718002	CLNWR293b
139718003	CLNWR295b
139718004	CLNWR296b
139718005	CLNWR296Dup
139718006	CLNWR297b
139718007	CLNWR298b
139718008	CLNWR299b
139718009	CLNWR300b
139718010	CLNWR301b
139718011	CLNWR302b
139718012	CLNWR304b
139718013	CLNWR305b
139718014	CLNWR306b
139718015	CLNWR307b
139718016	CLNWR294b

139718017	CLNWR303b
1200890261	Method Blank (MB) in Batch 443593
1200895592	Method Blank (MB) in Batch 445856
1200890262	Laboratory Control Sample (LCS) in Batch 443593
1200895593	Laboratory Control Sample (LCS) in Batch 445856
1200890263	139718016(CLNWR294b) Matrix Spike (MS) in Batch 44593
1200895596	139718017(CLNWR303b) Matrix Spike (MS) in Batch 445856
1200890264	139718016(CLNWR294b) Matrix Spike Duplicate (MSD) in Batch 443593
1200895597	139718017(CLNWR303b) Matrix Spike Duplicate (MSD) in Batch 445856

Preparation/Analytical Method Verification

Procedures for preparation, analysis, and reporting of analytical data are documented by General Engineering Laboratories, LLC. (GEL) as Standard Operating Procedures (SOP).

Calibration Information

Initial Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

Continuing Calibration Verification (CCV) Requirements
All associated calibration verification standard(s) (ICV or CCV) met the acceptance criteria.

Surrogate Decachlorobiphenyl (DCB) failed to meet the acceptance criteria in several of the standards bracketing the samples in this SDG; however this non-compliance had no adverse effects on the data.

Quality Control (QC) Information

Method Blank (MB) Statement
The Method Blank was contaminated with Aroclor-1254 in batch 443593. See NCR#227413 in the Miscellaneous Data section.

Surrogate Recoveries
Samples 1200890263 (CLNWR294bMS), 1200890264 (CLNWR294bMSD) and 139718016 (CLNWR294b) failed to meet acceptance criteria for surrogate recovery. Since the MS and MSD were performed on this sample and the surrogate recovery failed in the same manner, this failure is attributed to sample matrix interference.

Sample 139718015 (CLNWR307b) failed to meet acceptance criteria for surrogate recovery. This sample was extracted twice and the surrogate recovery failed in both extractions; therefore, the failure is attributed to matrix interference.

QC sample 1200890261 (MB) failed to meet the acceptance criteria for the surrogate recovery due to extraction error.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

QC Sample Designation
Sample 139718017 (CLNWR303b), 139718016 (CLNWR294B) were selected for the matrix spike and matrix spike duplicate analysis.

Matrix Spike (MS) Recovery Statement
The MS spike recoveries for this SDG were within the acceptance limits.

Matrix Spike Duplicate (MSD) Recovery Statement
The MSD spike recoveries for this SDG were within the acceptance limits.

MS/MSD Relative Percent Difference (RPD) Statement
The RPD(s) between the MS and MSD met the acceptance limits.

Technical Information

Holding Time Specifications
All samples in this SDG met the specified holding time. GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. All samples in this SDG were re-extracted out of holding.

Preparation/Analytical Method Verification
All procedures were performed as stated in the SOP.

Sample Dilutions
Samples 139718002 (CLNWR293b) (1:10), 139718005 (CLNWR296Dup) (1:5), 139718006 (CLNWR297b) (1:5), 139718007 (CLNWR298b) (1:5), 139718010 (CLNWR301b) (1:5), 139718011 (CLNWR302b) (1:5), 139718012 (CLNWR304b) (1:10), 139718013 (CLNWR305b) (1:10), 139718014 (CLNWR306b) (1:5), 139718017 (CLNWR303b) (1:5), 1200895596 (CLNWR303bMS) (1:5) and 1200895597 (CLNWR303bMSD) (1:5) were diluted prior to analysis due to the oily matrix of the extracts.

Sample Re-extraction/Re-analysis
All samples in this SDG were re-extracted due to Method Blank contamination during the first extraction. Samples 139718002 (CLNWR293b), 139718005 (CLNWR296Dup), 139718006 (CLNWR297b), 139718007 (CLNWR298b), 139718010 (CLNWR301b), 139718011 (CLNWR302b), 139718012 (CLNWR304b), 139718013 (CLNWR305b), 139718014 (CLNWR306b) and 139718017 (CLNWR303b) were extracted the third time due to Method Blank contamination. See NCR#227413 and NCR#227645 in the Miscellaneous Data section.

Miscellaneous Information

Electronic Package Comment

The following package was generated using an electronic data processing program referred to as "virtual packaging". In an effort to increase quality and efficiency, the laboratory is developing systems to eventually generate all data packages electronically. The following change from "traditional" packages should be noted:

Analyst/peer reviewer initials and dates are not present on the electronic data files. Presently, all initials and dates are present on the original raw data. These hard copies are temporarily stored in the laboratory. An electronic signature page inserted after the case narrative of each electronic package will indicate the analyst, reviewer, and report specialist names associated with the generation of the data and package. The data validator will always sign and date the case narrative. Data that are not generated electronically, such as hand written pages, will be scanned and inserted into the electronic package.

Nonconformance (NCR) Documentation
Nonconformance reports (# 227413 and 227645) have been generated for this SDG.

Manual Integration
Certain standards and QC samples may have required manual integration to correctly position the baseline as set in the calibration standard injections. If manual integration was performed, copies of all manual integration peak profiles are included in the raw data section of this PCB fraction.

Additional Comments
The additional comments field is used to address special issues associated with each analysis, clarify method/contractual issues pertaining to the analysis, and to list any report documents generated as a result of sample analysis or review. The following additional comments were required:

The back column has been chosen as the primary column. All data is reported from the back column.

Aroclors quantitated on the raw data report by the Target data system do not necessarily represent positive Aroclor identification. In order for positive identification to be made, the Aroclor must match in pattern and retention time; as well as quantitate relatively close between the primary and confirmation columns, as specified in SW846 method 8000. When these conditions are not met, the Aroclor is reported as a non-detect on the data report. These situations will be noted on the raw data as DMP, representing does not match pattern, or DNC does not confirm.

Due to software limitation, the Form VIIs will display the results either in the % difference or % drift depending on the type of the calibration curve. If the curve of all analytes is generated using an average response factor (RF), the Form VII will display results using the %difference calculation (RF). If the curve of one or more analytes is generated using a linear curve, the Form VII will display results using the % drift calculation (by concentration) for all analytes.

System Configuration

The Semi-Volatiles-PCB analysis was performed on a HP Gas Chromatograph.

Instrument ID	System Configuration	Column ID	Column Description
ECD2A.I_1	HP6890 Series ECD	Rtx-CLP I	30m x 0.25mm, 0.25um (Rtx-CLPesticide)
ECD2A.I_2	HP6890 Series ECD	Rtx-CLP II	30m x 0.25mm, 0.20um (Rtx-CLPesticide II)

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Jimi Cao **Date:** 8/4/05

GC SEMIVOLATILE PCB ANALYSIS

PCB Case Narrative
USACE, Tulsa District (ACET)
SDG 139718-1

Method/Analysis Information

Procedure:	**Polychlorinated Biphenyls**
Analytical Method:	SW846 8082
Prep Method:	SW846 3550B
Analytical Batch Number:	448118
Prep Batch Number:	448115

Sample Analysis

The following samples were analyzed using the analytical protocol as established in SW846 8082:

Sample ID	Client ID
139720001	CLNWR276b
139720002	CLNWR277b
139720003	CLNWR279b
139720004	CLNWR280b
139720005	CLNWR281b
139720006	CLNWR281bDup
139720007	CLNWR282b
139720008	CLNWR283b
139720009	CLNWR284b
139720010	CLNWR285b
139720011	CLNWR286b
139720012	CLNWR287b
139720013	CLNWR288b
139720014	CLNWR288bDup
139720015	CLNWR289b
139720016	CLNWR290b

139720017	CLNWR291b
139720018	CLNWR278b
1200901346	Method Blank (MB)
1200901347	Laboratory Control Sample (LCS)
1200901348	139720018(CLNWR278b) Matrix Spike (MS)
1200901349	139720018(CLNWR278b) Matrix Spike Duplicate (MSD)

Preparation/Analytical Method Verification
Procedures for preparation, analysis, and reporting of analytical data are documented by General Engineering Laboratories, LLC. (GEL) as Standard Operating Procedures (SOP).

Calibration Information

Initial Calibration
All initial calibration requirements have been met for this sample delivery group (SDG).

Continuing Calibration Verification (CCV) Requirements
All calibration verification standards (CVS, ICV, or CCV) requirements have not been met for this SDG.

Aroclor 1260 failed acceptance criteria with a negative bias on both analytical columns in the standards bracketing the samples in this SDG. The negative bias for the analytical data is a result of instrument response decreasing after the initial calibration. All samples bracketed by the failing standards were reanalyzed and the braketing standards failed in the same manner; therefore, the standard failure is attributed to matrix interference.

Quality Control (QC) Information

Method Blank (MB) Statement
The MB(s) analyzed with this SDG met the acceptance criteria.

Surrogate Recoveries
Samples 139720005 (CLNWR281b) and 139720006 (CLNWR281bDup) failed to meet acceptance criteria for surrogate recovery. These samples were extracted twice and the surrogate recovery failed in both extractions, therefore, the failure is attributed to matrix interference.

Laboratory Control Sample (LCS) Recovery
The LCS spike recoveries met the acceptance limits.

QC Sample Designation
Sample 139720018 (CLNWR278b) was selected for the matrix spike and matrix spike duplicate analysis.

Matrix Spike (MS) Recovery Statement
The MS spike recoveries were within the established acceptance limits.

Matrix Spike Duplicate (MSD) Recovery Statement
The MSD spike recoveries were within the established acceptance limits.

MS/MSD Relative Percent Difference (RPD) Statement
The RPD(s) between the MS and MSD did not meet the acceptance limits for Aroclor-1016 due to relatively low spike recovery in the MSD.

Technical Information

Holding Time Specifications

GEL assigns holding times based on the associated methodology, which assigns the date and time from sample collection of sample receipt. Those holding times expressed in hours are calculated in the AlphaLIMS system. Those holding times expressed as days expire at midnight on the day of expiration. All samples were re-extracted out of holding due to contamination in the MB during the first extraction.

Preparation/Analytical Method Verification

All procedures were performed as stated in the SOP. All sample extracts were cleaned using alumina.

Sample Dilutions

The samples in this SDG did not require dilutions.

Sample Re-extraction/Re-analysis

All samples in this SDG were re-analyzed due to failing bracketing standards. All samples in this SDG were also re-extracted due to laboratory contamination during the first extraction. The results of the re-extracted samples were reported.

Miscellaneous Information

Electronic Package Comment

The following package was generated using an electronic data processing program referred to as "virtual packaging". In an effort to increase quality and efficiency, the laboratory is developing systems to eventually generate all data packages electronically. The following change from "traditional" packages should be noted:

Analyst/peer reviewer initials and dates are not present on the electronic data files. Presently, all initials and dates are present on the original raw data. These hard copies are temporarily stored in the laboratory. An electronic signature page inserted after the case narrative of each electronic package will indicate the analyst, reviewer, and report specialist names associated with the generation of the data and package. The data validator will always sign and date the case narrative. Data that are not generated electronically, such as hand written pages, will be scanned and inserted into the electronic package.

Nonconformance (NCR) Documentation

NCR#227503 was generated for this SDG.

Manual Integration

Certain standards and samples may have required manual integration to correctly position the baseline as set in the calibration standard injections. If manual integration was performed, copies of all manual integration peak profiles are included in the raw data section of this PCB fraction.

Additional Comments

The additional comments field is used to address special issues associated with each analysis, clarify method/contractual issues pertaining to the analysis and to list any report documents generated as a result of sample analysis or review. The following additional comments were required for this SDG:

The front column has been chosen as the primary column. All data is reported from the front column.

Aroclors quantitated on the raw data report by the Target data system do not necessarily represent positive Aroclor identification. In order for positive identification to be made, the Aroclor must match in pattern and retention time; as well as quantitate relatively close between the primary and confirmation columns, as specified in SW846 method 8000. When these conditions are not met, the Aroclor is reported as a non-detect on the data report. These situations will be noted on the raw data as DMP, representing does not match pattern, or DNC does not confirm.

Due to software limitation, the Form VIIs will display the results either in the % difference or % drift depending on the type of the calibration curve. If the curve of all analytes is generated using an average response factor (RF), the Form VII will display results using the %difference calculation (RF). If the curve of one or more analytes is generated using a linear curve, the Form VII will display results using the % drift calculation (by concentration) for all analytes.

System Configuration

The Semi-Volatiles-PCB analysis was performed on a HP Gas Chromatograph.

Instrument ID	System Configuration	Column ID	Column Description
ECD1A.I_1	HP6890 Series ECD	Rtx-CLP I	30m x 0.25mm, 0.25um (Rtx-CLPesticide)
ECD1A.I_2	HP6890 Series ECD	Rtx-CLP II	30m x 0.25mm, 0.20um (Rtx-CLPesticideII)

Certification Statement

Where the analytical method has been performed under NELAP certification, the analysis has met all of the requirements of the NELAC standard unless otherwise noted in the analytical case narrative.

Review Validation:

GEL requires all analytical data to be verified by a qualified data validator. In addition, all data designated for CLP or CLP-like packaging will receive a third level validation upon completion of the data package.

The following data validator verified the information presented in this case narrative:

Reviewer: Jimi Cao **Date:** 8/4/05

APPENDIX B
(ANALYTICAL RESULTS)

Table 1. Results of metals, PCB, pesticides, and perchlorate analyses in dry weight for soil samples collected from 32 sites at Caddo Lake National Wildlife Refuges in 2005 (Note: B indicates that the target analyte was detected in the associated method blank as well as in the sample, H indicates that the analytical holding time was exceeded, and J indicates an estimated value; D in the site name indicates a duplicate sample).

Analyte	Fraction	Units	Site 276	Site 277	Site 278	Site 279	Site 280	Site 281	Site 281 D	Site 282	Site 283	Site 284	Site 285	Site 286	Site 287
Moisture content	Moisture	%	5.3	11	6.7	9.9	5.4	12	14	8.1	5	14	7.2	4.5	7
Aluminum	Metal	mg/kg	7090	11400	9290	15500	6130	20600	19900	8970	5650	6600	9840	4680	5360
Arsenic	Metal	mg/kg	1.46	2.31	2.14	3.16	2.90	2.08	1.28	1.85	2.63	1.63	1.15	2.88	1.88
Barium	Metal	mg/kg	76.9	333	124	154	99.0	173	158	134	83.9	388	75.6	109	104
Beryllium	Metal	mg/kg	0.513	2.79	0.810	1.38	0.459	0.925	0.718	0.769	0.444	0.541 J	0.405	0.551	0.342
Boron	Metal	mg/kg	1.16 J	5.12 J	< 16.0	< 16.5	1.65 J	< 16.9	< 17.0	< 16.1	0.952 J	7.18 J	1.79 J	1.05 J	1.78 J
Cadmium	Metal	mg/kg	0.129 J	0.423	0.294 J	0.278	0.187 J	0.283	0.257	0.195 J	0.140 J	0.504 J	0.108 J	0.161 J	0.160 J
Chromium	Metal	mg/kg	8.09	12.5	13.5	19.1	10.9	19.8	18.8	12.5	10.2	9.63	12.8	7.60	11.0
Copper	Metal	mg/kg	1.90	4.92	2.68	3.70	4.81	8.31	7.78	5.28	3.08	7.73	3.89	1.89	2.59
Iron	Metal	mg/kg	5080	7040	7740	12100	11100	12100	10100	6930	6080	6380	5990	3440	7350
Lead	Metal	mg/kg	16.0	20.9	14.4	54.7	21.0	20.8	20.4	15.6	13.9	17.9	14.7	11.9	17.0
Magnesium	Metal	mg/kg	461	697	605	911	448	1000	1020	625	385	902	513	275	476
Manganese	Metal	mg/kg	647	3190	1660	294	709	262	203	793	413	1690	315	827	1180
Mercury	Metal	mg/kg	0.0405	0.092	0.0643	0.0637	0.045	0.117	0.0882	0.0594	0.041	0.0702	0.0518	0.0406	0.0602
Molybdenum	Metal	mg/kg	0.164	0.305	0.209 J	0.811	0.285	0.387	0.274	0.244	0.161	0.222 J	0.256	0.141	0.243
Nickel	Metal	mg/kg	3.80	16.2	8.68	11.7	5.61	9.79	9.29	7.37	4.58	10.2	5.70	4.03	5.58
Selenium	Metal	mg/kg	0.875 J	1.11 J	< 1.07	1.08 J	< 1.04	< 1.13	< 1.13	< 1.07	< 1.05	< 1.14	< 1.07	< 1.04	< 1.07
Silver	Metal	mg/kg	0.100 J	0.124 J	< 1.07	0.127 J	0.0614 J	0.104 J	0.0927 J	0.0948 J	0.0502 J	< 1.14	0.0474 J	0.0499 J	0.121 J
Strontium	Metal	mg/kg	11.5	25.1	14.3	10.6	17.2	21.5	19.4	18.8	13.0	87.8	13.1	8.49	22.2
Vanadium	Metal	mg/kg	15.5	19.0	21.9	29.9	21.0	33.9	28.0	19.5	15.8	14.6	18.9	10.6	18.4
Zinc	Metal	mg/kg	12.4	35.1	17.1	25.9	21.0	36.0	34.7	16.2	10.4	39.3	15.2	11.9	16.5
Aroclor-1016	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	< 3.61
Aroclor-1221	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	< 3.61
Aroclor-1232	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	< 3.61
Aroclor-1242	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	< 3.61
Aroclor-1248	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	< 3.61
Aroclor-1254	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	20.8 H
Aroclor-1260	PCB	ug/kg	< 3.48	< 3.68	< 3.59	< 3.72	< 3.59	< 3.82	< 3.87	< 3.64	< 3.51	< 3.89	< 3.57	< 3.48	< 3.61
4,4'-DDD	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
4,4'-DDE	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
4,4'-DDT	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
Aldrin	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
alpha-BHC	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
beta-BHC	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
Chlordane (tech.)	Pesticide	ug/kg	< 87.1	< 46.0	< 89.6	< 46.6	< 89.7	< 95.4	< 96.8	< 91.1	< 43.8	< 97.4	< 44.6	< 43.4	< 90.2
delta-BHC	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
Dieldrin	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
Endosulfan I	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
Endosulfan II	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
Endosulfan sulfate	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
Endrin	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
Endrin aldehyde	Pesticide	ug/kg	< 13.9	< 7.36	< 14.3	< 7.45	< 14.3	< 15.3	< 15.5	< 14.6	< 7.01	< 15.6	< 7.14	< 6.95	< 14.4
gamma-BHC (Lindane)	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
Heptachlor	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
Heptachlor epoxide	Pesticide	ug/kg	< 6.97	< 3.68	< 7.17	< 3.72	< 7.17	< 7.63	< 7.75	< 7.29	< 3.51	< 7.79	< 3.57	< 3.48	< 7.22
Methoxychlor	Pesticide	ug/kg	< 69.7	< 36.8	< 71.7	< 37.2	< 71.7	< 76.3	< 77.5	< 72.9	< 35.1	< 77.9	< 35.7	< 34.8	< 72.2
Toxaphene	Pesticide	ug/kg	< 348	< 184	< 359	< 186	< 359	< 382	< 387	< 364	< 175	< 389	< 179	< 174	< 361
Perchlorate	Perchlorate	ug/kg	< 42.2	< 44.7	< 42.9	< 44.4	< 42.3	< 45.4	< 45.6	< 43.5	< 42.1	< 46.5	< 43.1	< 41.9	< 43.0

Table 1 (continued). Results of metals, PCB, pesticides, and perchlorate analyses in dry weight for soil samples collected from 32 sites at Caddo Lake National Wildlife Refuges in 2005 (Note: B indicates that the target analyte was detected in the associated method blank as well as in the sample, H indicates that the analytical holding time was exceeded, and J indicates an estimated value; D in the site name indicates a duplicate sample).

Analyte	Fraction	Units	Site 288	Site 288 D	Site 289	Site 290	Site 291	Site 292	Site 293	Site 294	Site 295	Site 296	Site 296 D	Site 297	Site 298
Moisture content	Moisture	%	8.6	7.5	7.6	6.4	6.5	8.9	2.8	9.3	13	1.9	1.7	3.8	5.9
Aluminum	Metal	mg/kg	11500	12100	3420	12800	6610	41300	6890	11200	14500	6960	6150	4330	5410
Arsenic	Metal	mg/kg	1.57	1.85	0.963 J	2.71	2.39	4.07	7.81	2.95	2.72	2.05	2.35	2.06	2.40
Barium	Metal	mg/kg	73.0	73.0	38.9	84.7	178	67.6	224	291	280	73.6	69.9	113	202
Beryllium	Metal	mg/kg	0.423 J	0.467 J	0.178	0.403 J	0.450	0.865	0.438	0.558	0.619	0.337	0.357	0.761	0.660
Boron	Metal	mg/kg	< 16.4	< 16.1	1.02 J	< 15.7	1.30 J	< 16.3	1.27 J	3.07 J	3.38	1.54 J	1.20 J	1.81 J	2.40 J
Cadmium	Metal	mg/kg	0.154 J	0.146 J	0.0619 J	0.151 J	0.696	0.128 J	0.0976 J	0.202 J	0.309	0.0917 J	0.081 J	0.139 J	0.183 J
Chromium	Metal	mg/kg	12.5	13.9	5.80	15.4	9.64	34.0	20.3	14.3	13.6	9.42	11.1	9.53	6.81
Copper	Metal	mg/kg	4.06	4.02	1.56	3.91	4.81	7.78	3.66	4.67	5.75	2.42	2.30	1.96	2.30
Iron	Metal	mg/kg	8050	9250	3820	12600	7570	31900	17400	13700	12100	6940	7810	4920	5230
Lead	Metal	mg/kg	9.88	9.76	10.0	13.3	15.8	14.4	11.2	14.2	12.8	9.01	8.16	17.2	33.1
Magnesium	Metal	mg/kg	750	840	250	790	543	2120	383	927	1000	367	363	321	430
Manganese	Metal	mg/kg	249	203	204	261	836	64.1	92.5	715	552	465	477	797	1500
Mercury	Metal	mg/kg	0.0445	0.0461	0.0338	0.0338	0.0478	0.103	0.019	0.0534	0.0454	0.0245	0.025	0.0431	0.0871
Molybdenum	Metal	mg/kg	0.245	0.258	0.141	0.246	0.191	0.335	0.483	0.274	0.270	0.209	0.196	0.200	0.267
Nickel	Metal	mg/kg	6.23	6.49	3.09	6.11	7.36	14.7	5.24	11.2	10.8	4.49	4.31	5.61	5.24
Selenium	Metal	mg/kg	< 1.09	< 1.07	< 1.08	< 1.05	< 1.07	1.50	1.30	< 1.09	1.01 J	0.597 J	0.616 J	< 1.04	0.671 J
Silver	Metal	mg/kg	0.0544 J	0.0558 J	< 0.215	0.056 J	0.0602 J	0.0819 J	< 0.205	0.0601 J	0.0729 J	0.0728 J	0.0647 J	0.0424 J	0.0557 J
Strontium	Metal	mg/kg	13.9	13.0	6.62	14.3	22.4	13.7	8.26	31.1	37.5	7.34	6.89	12.7	13.1
Vanadium	Metal	mg/kg	21.0	23.6	10.3	29.0	16.0	63.4	43.4	25.7	24.4	17.2	18.9	13.9	16.5
Zinc	Metal	mg/kg	18.3	19.3	9.94	26.5	70.8	40.2	39.8	36.9	45.9	15.3	16.4	11.0	13.6
Aroclor-1016	PCB	ug/kg	< 3.60	< 3.60	< 3.51	< 3.57	< 3.55	< 3.59	< 34.1	< 3.66	< 3.79	< 3.39	< 17.0	< 17.2	< 17.8
Aroclor-1221	PCB	ug/kg	< 3.60	< 3.60	< 3.51	< 3.57	< 3.55	< 3.59	< 34.1	< 3.66	< 3.79	< 3.39	< 17.0	< 17.2	< 17.8
Aroclor-1232	PCB	ug/kg	< 3.60	< 3.60	< 3.51	< 3.57	< 3.55	< 3.59	< 34.1	< 3.66	< 3.79	< 3.39	< 17.0	< 17.2	< 17.8
Aroclor-1242	PCB	ug/kg	< 3.60	< 3.60	< 3.51	< 3.57	< 3.55	< 3.59	< 34.1	< 3.66	< 3.79	8.50 H	< 17.0	< 17.2	< 17.8
Aroclor-1248	PCB	ug/kg	< 3.60	< 3.60	< 3.51	< 3.57	< 3.55	< 3.59	< 34.1	< 3.66	< 3.79	< 3.39	< 17.0	< 17.2	< 17.8
Aroclor-1254	PCB	ug/kg	23.8 H	23.3 H	65.1 H	11.5 H	9.90 H	5.20 BH	< 34.1	< 3.66	2.40 BJH	2.40 BJH	< 17.0	7.20 JH	11.5 JH
Aroclor-1260	PCB	ug/kg	< 3.60	< 3.60	14.4 H	< 3.57	< 3.55	< 3.59	< 34.1	< 3.66	< 3.79	< 3.39	< 17.0	< 17.2	< 17.8
4,4'-DDD	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
4,4'-DDE	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
4,4'-DDT	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
Aldrin	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
alpha-BHC	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
beta-BHC	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
Chlordane (tech.)	Pesticide	ug/kg	< 89.9	< 90.1	< 87.6	< 89.2	< 88.8	< 89.7	< 85.3	< 91.5	< 94.6	< 84.6	< 84.8	< 86.0	< 89.0
delta-BHC	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
Dieldrin	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
Endosulfan I	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
Endosulfan II	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
Endosulfan sulfate	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
Endrin	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	4.66 J	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
Endrin aldehyde	Pesticide	ug/kg	< 14.4	< 14.4	< 14.0	< 14.3	< 14.2	< 14.4	< 13.6	< 14.6	< 15.1	< 13.5	< 13.6	< 13.8	< 14.2
gamma-BHC (Lindane)	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
Heptachlor	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
Heptachlor epoxide	Pesticide	ug/kg	< 7.20	< 7.21	< 7.01	< 7.13	< 7.11	< 7.18	< 6.82	< 7.32	< 7.57	< 6.77	< 6.78	< 6.88	< 7.12
Methoxychlor	Pesticide	ug/kg	< 72.0	< 72.1	< 70.1	< 71.3	< 71.1	< 71.8	< 68.2	< 73.2	< 75.7	< 67.7	< 67.8	< 68.8	< 71.2
Toxaphene	Pesticide	ug/kg	< 360	< 360	< 351	< 357	< 355	< 359	< 341	< 366	< 379	< 339	< 339	< 344	< 356
Perchlorate	Perchlorate	ug/kg	< 43.8	< 43.3	< 43.3	< 42.7	< 42.8	< 43.9	< 41.2	< 44.1	< 45.9	< 40.8	< 40.8	< 41.6	< 42.5

Table 1 (concluded). Results of metals, PCB, pesticides, and perchlorate analyses in dry weight for soil samples collected from 32 sites at Caddo Lake National Wildlife Refuges in 2005 (Note: B indicates that the target analyte was detected in the associated method blank as well as in the sample, H indicates that the analytical holding time was exceeded, and J indicates an estimated value; D in the site name indicates a duplicate sample).

Analyte	Fraction	Units	Site 299	Site 300	Site 301	Site 302	Site 303	Site 304	Site 305	Site 306	Site 307
Moisture content	Moisture	%	3.9	6	5	9.7	4.3	7.6	3.4	6.5	6.5
Aluminum	Metal	mg/kg	5270	5120	4470	9920	3250	9740	3680	5600	5480
Arsenic	Metal	mg/kg	2.68	1.42	1.25	4.65	1.42	3.88	2.16	4.54	1.79
Barium	Metal	mg/kg	121	169	176	241	142	150	75.1	54.7	108
Beryllium	Metal	mg/kg	1.01	0.670	0.885	1.61	0.799	0.765	0.567	0.194	0.548
Boron	Metal	mg/kg	1.59 J	2.27 J	2.74 J	3.27 J	1.94 J	2.81 J	1.92 J	1.80 J	2.28 J
Cadmium	Metal	mg/kg	0.130 J	0.217	0.147 J	0.298	0.131 J	0.335	0.0837 J	0.114 J	0.173 J
Chromium	Metal	mg/kg	13.9	6.33	6.69	18.9	7.86	10.9	11.9	19.3	8.26
Copper	Metal	mg/kg	2.29	3.74	2.81	9.71	2.61	6.55	1.85	1.89	2.39
Iron	Metal	mg/kg	6360	4420	3240	11700	4340	9720	4910	15400	5580
Lead	Metal	mg/kg	13.3	11.5	12.9	19.4	10.4	23.5	11.8	9.38	16.9
Magnesium	Metal	mg/kg	390	455	393	521	307	763	291	306	511
Manganese	Metal	mg/kg	751	893	915	488	1010	1590	453	301	1060
Mercury	Metal	mg/kg	0.0392	0.0504	0.051	0.0785	0.0465	0.0942	0.0308	0.0357	0.0637
Molybdenum	Metal	mg/kg	0.196	0.145	0.141	0.501	0.136	0.336	0.156	0.200	0.175
Nickel	Metal	mg/kg	6.29	7.87	6.48	10.5	7.18	9.75	4.62	2.38	7.13
Selenium	Metal	mg/kg	< 1.03	0.586 J	< 1.05	0.647 J	< 1.04	0.679 J	< 1.03	< 1.07	< 1.06
Silver	Metal	mg/kg	0.0492 J	0.0631 J	< 0.210	0.122 J	0.0426 J	0.0744 J	< 0.207	0.0429 J	0.0635 J
Strontium	Metal	mg/kg	9.25	19.9	24.9	16.9	12.9	16.4	7.94	10.6	17.9
Vanadium	Metal	mg/kg	15.8	10.8	9.32	27.6	10.7	18.3	12.3	34.8	14.1
Zinc	Metal	mg/kg	15.9	23.4	12.9	85.6	9.96	55.5	18.0	9.58	18.1
Aroclor-1016	PCB	ug/kg	< 3.48	< 3.54	< 17.4	< 18.3	< 17.5	< 36.3	< 34.4	< 17.8	< 3.55
Aroclor-1221	PCB	ug/kg	< 3.48	< 3.54	< 17.4	< 18.3	< 17.5	< 36.3	< 34.4	< 17.8	< 3.55
Aroclor-1232	PCB	ug/kg	< 3.48	< 3.54	< 17.4	< 18.3	< 17.5	< 36.3	< 34.4	< 17.8	< 3.55
Aroclor-1242	PCB	ug/kg	< 3.48	< 3.54	< 17.4	< 18.3	< 17.5	< 36.3	< 34.4	< 17.8	< 3.55
Aroclor-1248	PCB	ug/kg	< 3.48	< 3.54	< 17.4	< 18.3	< 17.5	< 36.3	< 34.4	< 17.8	< 3.55
Aroclor-1254	PCB	ug/kg	< 3.48	6.00 BH	< 17.4	< 18.3	5.61 JH	29.0 JH	22.4 JH	< 17.8	7.30 BH
Aroclor-1260	PCB	ug/kg	< 3.48	< 3.54	< 17.4	42.1 H	< 17.5	192 H	< 34.4	< 17.8	< 3.55
4,4'-DDD	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
4,4'-DDE	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
4,4'-DDT	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
Aldrin	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
alpha-BHC	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
beta-BHC	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
Chlordane (tech.)	Pesticide	ug/kg	< 87.0	< 88.4	< 87.2	< 91.3	< 87.6	< 90.7	< 86.1	< 89.1	< 88.9
delta-BHC	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
Dieldrin	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
Endosulfan I	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
Endosulfan II	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
Endosulfan sulfate	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
Endrin	Pesticide	ug/kg	12.5 J	6.47 J	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
Endrin aldehyde	Pesticide	ug/kg	< 13.9	< 14.1	< 14.0	< 14.6	< 14.0	< 14.5	< 13.8	< 14.3	< 14.2
gamma-BHC (Lindane)	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
Heptachlor	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
Heptachlor epoxide	Pesticide	ug/kg	< 6.96	< 7.07	< 6.98	< 7.31	< 7.01	< 7.26	< 6.89	< 7.13	< 7.11
Methoxychlor	Pesticide	ug/kg	< 69.6	< 70.7	< 69.8	< 73.1	< 70.1	< 72.6	< 68.9	< 71.3	< 71.1
Toxaphene	Pesticide	ug/kg	< 348	< 354	< 349	< 365	< 350	< 363	< 344	< 357	< 355
Perchlorate	Perchlorate	ug/kg	< 41.6	< 42.5	< 42.1	< 44.3	< 41.8	< 43.3	< 41.4	< 42.8	< 42.8